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din Brașov

HABILITATION THESIS

RESEARCH ON BANKING STABILITY, CORPORATE PERFORMANCE AND ECONOMIC GROWTH IN THE CONTEXT OF CURRENT GLOBAL CHALLENGES

Domain: FINANCE

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CONTENTS

(A) Rezumat

Teza actuală de abilitare rezumă o parte semnificativă a cercetărilor întreprinse de candidat după finalizarea tezei de doctorat la Universitatea "Babeș-Bolyai" din Cluj Napoca și confirmată prin Ordinul Ministrului Educației și Cercetării nr. 4900 din 11.11.2002.

Prima parte a tezei de abilitare (B-i) evidențiază principalele realizări și contribuții științifice ale autorului, care sunt structurate pe două secțiuni, și anume: **Secțiunea I.** Cercetări privind impactul democrației, factorilor macroeconomici și crizelor (pandemia de covid-19 și economică) asupra stabilității bancare; **Secțiunea II.** Cercetări privind performanța corporativă și creșterea economică durabilă.

În *prima parte a secțiunii I (Capitolul I.1)*, am furnizat dovezi empirice ale influenței democrației și libertății economice asupra performanței bancare folosind un eșantion de 27 de țări între 2001 și 2020, și măsuri de performanță bazate pe rentabilitatea activelor (ROA) și rentabilitatea capitalului propriu (ROE). Rezultatele studiului subliniază că democrația este asociată pozitiv cu performanța bancară, în timp ce libertatea economică o afectează negativ în țările eșantion. În plus, acest studiu contribuie la literatura în creștere privind relația între variabilele de control (determinanți macroeconomici, factori specifici băncilor, sau regimul legislativ al unei țări) și performanța bancară.

A doua parte a secțiunii I (Capitolul I.2), examinează, empiric, determinanții macroeconomici care afectează rata creditelor neperformante (NPL) în România. Rezultatele au arătat că toate variabilele independente selectate (ratele de schimb ale monedelor cele mai utilizate - EUR, USD și CHF, rata șomajului și rata inflației) au un impact semnificativ asupra variabilei dependente NPL. Studiul dezvăluie corelații puternice între creditele neperformante și factorii macroeconomici studiați și că economia românească este clar conectată la calitatea portofoliilor de împrumuturi. În plus, o analiză econometrică a cauzelor empirice ale creditelor neperformante arată că rata de schimb RON-CHF a fost principalul factor care a dus la creșterea ratei creditelor neperformante în România.

Ultima parte a secțiunii I (Capitolul I.3), identifică influența unor indicatori economici asupra sistemelor bancare în timpul crizelor economice, analizând în mod specific criza financiară din 2008, folosind date din șase țări din Europa Centrală și de Est. Studiul investighează dependența scorurilor Z ale băncilor de indicatorii economici. Creditele neperformante (NPL), rentabilitatea activelor (ROA) și rentabilitatea capitalului propriu (ROE) sunt examinate în mod specific pentru a evalua impactul lor asupra scorului Z, alături de creșterea economică, concentrarea bancară, raportul cost-venit și venitul din activități non-dobândă. Rezultatele indică că scorurile Z ale băncilor sunt semnificativ influențate de creditele neperformante și concentrarea bancară; iar indicatori precum creșterea economică, raportul cost-venit și rentabilitatea activelor demonstrează efecte notabile asupra stabilității băncilor în timpul crizei economice.

În *Secțiunea II a tezei de abilitare*, am prezentat cele mai semnificative contribuții la analiza cercetărilor privind performanța corporativă și creșterea economică durabilă. Mai multe dintre studiile prezentate în această secțiune au făcut contribuții importante la dezvoltarea literaturii academice, așa cum o dovedește numărul mare de citări. *Prima parte a acestei secțiuni (Capitolul II.1)*, oferă o analiză aprofundată a principalelor crize ale secolului 21 și efectele lor asupra creșterii economice. Studiul a examinat impactul semnificativ al principalelor crize economice ale secolului 21, inclusiv criza economică din 2008 și pandemia COVID-19 din 2020, asupra creșterii economice. A implicat dezvoltarea a două modele de regresie empirice pentru a

analiza influența indicatorilor macroeconomici asupra creșterii economice în țările membre UE din Europa Centrală și de Est pe perioada din 2001 până în T2 2020. Introducerea cazurilor COVID-19 ca variabilă independentă a modificat semnificativ direcția și magnitudinea impactului anumitor indicatori macroeconomici asupra creșterii economice, subliniind în mod particular efectele negative exacerbate pentru variabilele cu coeficienți negativi. În *a doua parte a secțiunii (Capitolul II.2)*, examinez și explic dacă există o relație liniară pozitivă sau negativă între raportarea sustenabilității, gestionarea inadecvată a factorilor economici, sociali și de guvernanță (ESG) și performanța corporativă și creșterea durabilă. Rezultatele obținute din studiul nostru empiric sugerează că gestionarea inadecvată a factorilor de sustenabilitate legați de ESG are un efect negativ substanțial asupra performanței financiare a firmelor care raportează. Rezultatele indică faptul că diversele aspecte ale sustenabilității (guvernanță, social și environmental) nu sunt aplicabile în mod egal performanței financiare.

În *a treia parte a secțiunii (Capitolul II.3)*, am estimat și comparat mecanismul de transmitere a volatilității în randamentele futures a mărfurilor agricole în perioade de criză, cu un accent specific pe pandemia COVID-19. Principalele constatări dezvăluie perturbări semnificative și o volatilitate accentuată în aceste piețe în perioada COVID-19, cu abateri notabile de la comportamentele tradiționale ale pieței. *A patra parte a acestei secțiuni (Capitolul II.4)*, explorează efectele profunde, dar insuficient studiate, ale inteligenţei artificiale (AI) asupra aspectelor societale, economice și de mediu; examinează în special modul în care exodul de creiere influențează capacitățile guvernamentale de implementare ale AI, abordând o lacună în literatura existentă. Studiul investighează interacțiunea dintre implementarea AI guvernamentală și exodul de creiere, luând în considerare condițiile macroeconomice, calitatea guvernanței, nivelurile educaționale și eforturile de cercetare și dezvoltare. Folosind date din 2022 din țările Uniunii Europene, cercetarea folosește regresii ale variabilelor instrumentale (2SLS și LIML) pentru a contracara endogeneitatea și utilizează metode de grupare pentru clasificarea țărilor pe baza nivelurilor lor guvernamentale de inteligență artificială, alături de analiza spațială pentru a detecta răspândirea și interacțiunile transnaționale. Descoperirile dezvăluie efectul dăunător al exodului de creiere asupra pregătirii guvernamentale pentru inteligența artificială, evidențiază tendințele de grupare și identifică interdependențele spațiale. Acest document subliniază necesitatea elaborării politicilor strategice și a reformelor instituționale pentru a consolida capacitățile guvernamentale de inteligență artificială. Pledează pentru o schimbare de paradigmă în cadrele guvernamentale după era *post-New Public Management,* adaptată noilor provocări prezentate de inteligența artificială.

A cincea parte a acestei secțiuni (Capitolul II.5), se concentrează pe analiza impactului schimbărilor climatice, exprimat prin temperatură și emisiile de CO2, asupra cheltuielilor pentru sănătate în statele membre ale Uniunii Europene folosind date disponibile din 2000 până în 2020. În plus față de cercetările anterioare, acest articol incorporează variabile suplimentare de control precum guvernanța, factorii macroeconomici (PIB și inflație) și indicele dezvoltării umane. Rezultatele empirice sugerează că o creștere a temperaturii și a nivelurilor de emisii de CO2, împreună cu îmbunătățirile în guvernanță, creșterea economică, inflația și dezvoltarea umană, contribuie la creșterea cheltuielilor pentru sănătate. Creșterea temperaturii și emisiile de CO2 cresc direct povara sănătății (suportată de cetăţeni) și obligă guvernele să sporească cheltuielile pentru sănătate. Articolul este notabil pentru abordarea sa comprehensivă, umplând un gol semnificativ în literatura existentă prin combinarea variabilelor schimbării climatice cu indicatori de guvernanță, economici și de dezvoltare umană.

Ultima parte a secțiunii II (Capitolul II.6), analizează dacă cheltuielile militare influențează PIB-ul în 27 de state membre ale Uniunii Europene (UE) din 1998 până în 2021 studiind două clustere specifice: membrii NATO și membrii non-NATO. Rezultatele indică faptul că valorile curente ale cheltuielilor militare influențează pozitiv PIB-ul în ambele clustere, în timp ce valorile anterioare ale cheltuielilor militare influențează pozitiv PIB-ul în țările UE NATO și afectează negativ PIB-ul în țările UE non-NATO. Există diferențe cheie între membrii UE NATO și non-NATO, în special în ceea ce privește angajamentele lor de securitate și cheltuielile pentru apărare.

A doua parte a tezei de abilitare **(B-ii)** prezintă planul de dezvoltare a carierei, care include perspectivele candidatului asupra activităților de predare și cercetare. Direcțiile viitoare de cercetare includ: investigarea impactului digitalizării asupra volumului și calității masei monetare; impactul guvernanței asupra internat bankingului în Uniunea Europeană cu progresul tehnologic ca moderator; și investițiile guvernamentale în sănătate și impactul factorilor macroeconomici.

A treia parte a tezei de abilitare **(B-iii)** cuprinde referințele bibliografice care stau la baza cercetărilor incluse în teza curentă de abilitare.

(B) Scientific and professional achievements and the evolution and development plans for career development

(B-i) Scientific and professional achievements

SECTION I.

RESEARCH ON THE IMPACT OF DEMOCRACY, MACROECONOMIC FACTORS, AND CRISES (COVID-19 PANDEMIC AND ECONOMIC) ON BANKING STABILITY

Chapter I.1. DOES DEMOCRACY MATTER IN BANKING PERFORMANCE? EXPLORING THE LINKAGE BETWEEN DEMOCRACY, ECONOMIC FREEDOM AND BANKING PERFORMANCE IN THE EUROPEAN UNION MEMBER STATES[1]

The degree of democracy in various nations is a complex attribute to quantify. Specialized literature has recently insisted on, and developed different models to capture its essence, as well as its interactions with different economic, social, or political phenomena. In general, if we study the values assigned to democracy using various measurement units, the world has become much more democratic in the last 200 years. However, there are still considerable differences among countries regarding the degree of democracy (Herre, 2022). It is challenging to estimate the influence of democracy on economic life primarily because it takes various forms; this is primarily because democracy is an evolving socio-historical process of autonomy, participatory governance, social learning, and institutionalization (Scholz-Wäckerle, 2016).

Democracy has been recognized as a major influencing factor in various economic sectors (Ben Ali, 2020), including the banking sector. As recent literature shows, the soundness and, implicitly, the banking system's profitability depend not only on economic and financial factors but also on institutional factors (Barth et al., 2007).

The stability of contemporary banking systems is acutely scrutinized, especially in the context of the financial crisis that began in 2008, the recent COVID-19 pandemic of 2020, and the generalized energy crisis of 2022. The erosion of banking profitability is likely to affect the stability of the economic system; therefore, the examination of banking profitability is becoming an increasingly important topic, with implications for a sound banking sector. The relationship between banking performance and different determinants (especially macroeconomic and bank-specific) has been established in the literature, but a specific and detailed approach aimed at analyzing how democracy influences banking performance has not been identified in prior studies.

Democratic values are intrinsically associated with free manifestation in the economic field, making the association between democracy and economic freedom a fundamental binomial of democratic regimes. Democracy is a core value in many modern societies (Li et al., 2019), and significant economic freedom is often considered a catalyst for increased economic profitability

[1] This section is based on the article: Adela Socol, **Iulia Cristina Iuga**. 2023. Does democracy matter in banking performance? Exploring the linkage between democracy, economic freedom and banking performance in the European Union member states, *International Journal of Finance & Economics*. https://doi.org/10.1002/ijfe.2911. WOS:001103368100001

(Farr et al., 1998). The positive effect of democracy occurs mainly through the consolidation of economic liberalization (Fidrmuc, 2000). A democratic political regime encourages liberalization because countries that have introduced greater democracy subsequently progress in economic freedom (Fidrmuc, 2003). In terms of democracy, an adequate financial regulatory framework generates profitability benefits for the banking system. There is evidence that democracy substantially affects a country's economic freedom. Economic freedom increases in countries with more liberal democracies (De Haan & Sturm, 2003), given that democracy is intimately linked to trust (Kim, 2015).

This research investigates the influence of democracy and economic freedom on the EU's banking sector performance. Centered on the EU's unique context, the study uses a comprehensive set of variables to illuminate how democratic institutions and regulatory frameworks affect bank profitability. This study investigates the following fundamental question*: Does democracy increase the banking sector's performance in EU member countries?* A secondary question is: *Do democracy and economic freedom statistically and significantly affect bank performance?*

The study encompasses the period 2001-2020, analyzing the banking sector performance across 27 EU member states. Starting in 2001 allows capturing the EU's entirety before ten states' accession in 2004. It underscores the unique banking dynamics in ex-communist EU countries and the Euro Zone's influence, particularly highlighting the emerging banking systems in Central and Eastern Europe (CEE). Their regulatory endeavors differ from developed banking systems, making the region a compelling study area.

I.1.1. Democracy, Economic Freedom, and Banking Performance: A Concise Literature Overview

The theoretical context of the link between democracy and banking performance is developed in a unified field of discussion of the basic components, i.e., democracy, economic freedom, and the indicators that express the banking system's performance, represented by two profitability indicators (ROA, i.e., Banking Return on assets and ROE, i.e., Banking Return on equity). ROA is the proportion of net income after tax to the total assets of a commercial bank, whereas ROE is the proportion of a commercial bank's net post-tax income to its annual equity.

I.1.1.1. Democracy and banking performance

Democracy, as a system of governance, is very important in shaping the economic landscape of nations around the world. Its influence on banking profitability is of significant interest to researchers, policymakers, and industry practitioners.

One of the primary ways in which democracy influences banking profitability is through the establishment of a robust regulatory environment and political stability (Girma & Shortland, 2008). Democratic nations tend to have transparent and accountable regulatory systems that promote fair competition and reduce corruption (Huang, 2010). The resulting stability and predictability provide a favorable business environment for banks, fostering trust and confidence among customers and investors. A stable regulatory framework ensures that banks operate within well-defined rules and guidelines, leading to more effective risk-management practices, improved asset quality, and enhanced profitability. Democracy is considered a prerequisite for financial liberalization and the establishment of an adequate and efficient financial regulatory framework (Agoraki et al., 2020). In democratic regimes, executive (political) constraints are more significant

than autocratic constraints. The political economy theory of financial development suggests that democratic regimes lead to deeper and more profitable banking sectors than autocratic (authoritarian) ones (Aluko et al., 2021). Democratic countries have better regulatory leverage than autocratic countries; therefore, they tend to have lower credit risk and, implicitly, a more profitable banking system. Nevertheless, the level of democracy differs significantly among banking systems and is linked to financial regulation and competition (Agoraki et al., 2020).

A significant body of research supports the hypothesis that democracy positively impacts banking performance (Agoraki et al., 2020; Ben Ali & Ben Mim, 2022; Lavezzolo, 2020; Apergis, 2017; Baum & Lake, 2003). Studies have found that countries with higher levels of democracy tend to have more profitable banking systems. This relationship can be attributed to the presence of robust regulatory frameworks, effective supervision, and improved governance practices in democratic nations (Ashraf, 2017). The greater political stability and lower corruption levels associated with democracy also contribute to a positive association with banking performance.

The deepening of liberal democracy (Coppedge et al., 2021) can produce favorable development results (Apergis, 2017; Baum & Lake, 2003) in all economic activities, including banking. First, the political regime matters for banks' interest margins; banks generate low interest margins in autocratic regimes because of inherent credibility problems and lack of supervision (Lavezzolo, 2020). Higher interest income positively impacts bank performance in democratic countries, whereas the opposite is true in autocratic regimes (Ben Ali & Ben Mim, 2022).

Second, democracy often encourages policies that promote financial inclusion and market competition. Democratic countries with better regulatory frameworks have been more successful in strengthening banking competition (Agoraki et al., 2020) and, implicitly, profitable banking systems. Access to financial services for individuals and businesses is crucial for economic growth and development. In democratic countries, governments often prioritize financial inclusion initiatives, such as expanding access to banking services and promoting financial literacy. Increased financial inclusion translates into a broader customer base for banks, expanding their lending opportunities, customer deposits, and revenue streams. In addition, democratic systems tend to foster market competition because regulations are designed to prevent monopolistic practices and promote a level playing field. Increased competition compels banks to enhance their efficiency, innovate, and offer competitive products and services, ultimately leading to higher profitability.

Third, liberal democracy views the state as an impartial and neutral intermediary of power concerning the interests of capital and labor. This theory argues that the capitalist state exists primarily to promote, defend, and oversee institutions that facilitate the accumulation and maximization of profits (Okolie et al., 2021). Property rights, political stability, human development, and innovation, as inherent characteristics of liberal democracy, create the necessary climate for capital and profitability in the economic sector. A profitable economic sector also implies a profitable banking system. However, the existing literature shows that democratic countries offer a higher level of financing (Yang, 2011), with a direct impact on banking profitability. In addition, countries with better institutional and regulatory settings tend to have lower credit risk, and a more stable (Agoraki et al., 2020) and better-performing banking system.

Fourth, democracy should enhance banking stability by limiting moral hazard, and pushing banks to avoid excessive risk-taking (considering the risk-efficiency relationship, banks tend to undertake riskier operations but with high efficiency). Democratic systems promote better risk management practices and corporate governance in the banking sector. Independent regulatory

bodies, central banks, and supervisory authorities, which are characteristic of democratic systems, play vital roles in ensuring that banks operate prudently and manage risks effectively (Zampara et al., 2017). Through regular monitoring and supervision, these institutions help maintain financial system stability and reduce the likelihood of banking crises. Thus, democracy can determine how governments respond to banking crises. Some studies have demonstrated that bailouts are less likely to occur in democracies than in autocracies, because governments in democratic regimes are less likely to bail out private banks at the expense of taxpayers (Rosas, 2006).

Taking a different approach, other authors have argued that democratic regimes fuel moral hazards, generating expectations of rescue from governments. However, despite their apparent benefits, democratic regimes are often associated with intense financial crises (Ashraf, 2017). Delis et al. (2020) use global lending data and discover that democratization exerts a significantly negative effect on credit spreads. Therefore, they point out that lower cost of borrowing is a relevant mechanism through which democracy can affect bank profitability. Moreover, the financial crisis broke out mainly in democratic countries (Reinhart & Rogoff, 2009) with repercussions on banking systems. Even the recent subprime crisis of 2008 affected democratic countries, such as the US and the Eurozone. Lipscy (2018) argues that democratic countries were the most affected by the 2008 financial crisis. Furthermore, he states that increased financial instability often accompanies a transition to democracy. One argument is that democratic countries tend to favor financial liberalization and trade openness and, thus, are highly exposed to spillover effects during periods of turbulence. However, the level of democracy and the degree of public commitment to public interest differ significantly between banking systems (Agoraki et al., 2020).

I.1.1.2. Nexus between economic freedom and banking performance

As a system of governance, democracy plays a crucial role in shaping a nation's economic environment. This has a profound impact on banking profitability by influencing various interconnected factors. Democracy and economic freedom often go hand-in-hand as democratic nations tend to promote free market principles, competition, and entrepreneurship. Economic freedom is crucial for banking profitability because it enables banks to operate in a liberalized environment, offer innovative products and services, attract customers, and expand their market share. Economic freedom fosters healthy competition among banks and encourages efficiency, cost management, and customer satisfaction (Liu et al., 2018).

The interest in economic freedom is related not only to the fact that individuals have a right to conduct economic actions freely, but also to its effect on different financial indicators, including bank profitability. Over the last few decades, interesting studies have focused on the relationship between economic freedom and banking performance. Economic freedom plays a decisive role in financial systems through various channels (Altman, 2008). The index of economic freedom has been used as an essential variable in various contexts, and numerous studies have been conducted to provide evidence of the influence of economic freedom on financial performance in banking (Sufian & Habibullah, 2010; Bekaert et al., 2005; Jones & Stroup, 2010).

Several studies demonstrate that economic freedom has a positive and significant impact on banking performance (Abbas & Ali, 2022; Asteriou et al., 2021; Mavrakana & Psillaki, 2019; Lin et al., 2016; Gropper et al., 2015; Sufian, 2014; Chortareas et al., 2013). Economic freedom can positively impact bank profitability for multiple reasons. Therefore, greater economic freedom, by granting new domestic and foreign entrants, can increase efficiency and allow a broader range of products to improve banking profits (Claessens & Laeven, 2004).

Moreover, economic freedom is understood to allow more permissive entry barriers in various economic sectors. As a result, more firms compete in the economy, and there are more opportunities for banks to lend to foreign companies and financial institutions. Therefore, banks tend to grant more loans and diversify their loan portfolios, which directly influences their profitability (Asteriou et al., 2021).

The effects of economic freedom on bank profitability may be positive, but there could be some ways in which greater economic freedom could undermine bank performance. For example, more accessible entry into the sector and greater competition could undermine the average bank profitability. Economic freedom can fuel unhealthy competition and lead to negative outcomes. While competition usually enhances efficiency and spurs innovation, extreme competition in the banking sector could lead to the thinning of profit margins, as banks might engage in aggressive pricing strategies to attract customers. Over time, this could compromise banks' profitability and long-term sustainability. Additionally, greater economic freedom may lead to more significant competition between the banking sector and other financial intermediaries (Asteriou et al., 2021).

Papanikolaou (2019) showed that greater competition in the credit market can lower bank loan rates. Additionally, it can increase the probability of insolvent borrowers gaining access to loans, which could undermine bank profitability; however, this can be compensated for by improving bank regulations regarding credit monitoring systems. To the extent that greater economic freedom is associated with greater competition in the banking sector, his results suggest a potentially negative effect on overall bank profitability.

One potential negative impact is excessive risk-taking. In a highly deregulated environment, banks may be incentivized to undertake excessively risky investments or lending activities, aimed at higher returns (Abbas & Ali, 2022). While these risks could potentially lead to substantial profits, they could also result in significant losses, jeopardizing the financial stability of banks, and consequently, of the entire banking sector.

Furthermore, economic freedom can lead to consumer exploitation in the absence of sufficient protective regulations (Nugraha et al., 2022). Banks might introduce hidden fees, arbitrarily increase interest rates, or engage in unfair lending practices, affecting their reputation and customer trust. These practices could lead to legal issues, customer loss, and eventually a decline in banking performance.

Economic freedom without appropriate regulations may exacerbate income inequality. With less regulatory control, banks might focus more on high-net-worth individuals or large corporations, leaving underserved or marginalized sections of society out of the financial system (Jones, 2016). Such practices may lead to a reputation that adversely affects the bank's performance.

Finally, international economic freedom can expose domestic banks to exchange rate risks and potential losses from international operations, especially in politically or economically unstable countries. While opportunities for international expansion may appear attractive, inherent risks could significantly affect banks' financial stability (Olson & Zoubi, 2017).

I.1.1.3. The influence of macroeconomic determinants on banking performance

Democracy is synonymous with long-term economic stability, fostering a favorable environment for bank profitability. Key elements like low unemployment and steady economic growth create conditions conducive for banks. Democratic systems emphasize policies that drive consistent economic growth, enhancing lending opportunities and bank profitability (Alhassan et al., 2016).

Such countries often favor policies ensuring stability, including fiscal discipline and investor-friendly regulations (Vu & Nahm, 2013), integral for a thriving banking sector.

GDP growth, an essential macroeconomic indicator, reflects a country's economic health. Democracies, characterized by stability and transparent governance, generally promote policies spurring economic development. An uptick in GDP signifies heightened economic activity and a surge in loan demands, thereby boosting bank profitability (Nguyen & Nghiem, 2016; Buch et al., 2015). Numerous studies have shown that macroeconomic indicators influence bank profitability (Chan & Karim, 2010), and that there is a positive relationship between GDP growth and bank profitability (Maudos et al., 2002; Hasan et al., 2009; Vu & Nahm, 2013; Alhassan et al., 2016).

Another pivotal macroeconomic factor is the unemployment rate (Horobet et al., 2021). In democracies, lower unemployment signifies a robust economy, leading to reduced non-performing loans (NPLs) for banks and improved profitability. This is due to decreased credit risks and higher consumer spending (Zampara et al., 2017). Conversely, high unemployment, indicating labor market issues (Okafor, 2011), can escalate NPLs, reduce loan demands (Berge & Boye, 2007), and negatively impact bank profitability (Pesola, 2005).

I.1.1.4. Bank-specific determinants of banking performance

Analyzing bank-specific factors affecting performance, we categorize them as: market structure and quality (cost-to-income ratio, nonperforming loans, net interest margin); banking depth and capital (domestic credit to private sector % of GDP, bank capital to assets ratio); competition and expansion factors (concentration assets of the top three commercial banks as a share of total assets, bank branches); and ownership status (foreign banks' assets relative to total bank assets).

Democracy has a pronounced influence on the cost-to-income ratio (CIR). Through transparent governance and efficient resource allocation, democratic systems bolster bank profitability (Francis, 2004). By advocating for competition, banks are nudged to refine operational processes and boost cost-effectiveness (Kumar et al., 2020). A low CIR is an indicator of operational efficiency, directly correlating with profitability. Empirical studies have consistently identified the impact of CIR on bank profitability (Athanasoglou et al. 2008; Kumar et al., 2020; Dietrich & Wanzenried 2014).

Democratic systems indirectly modulate non-performing loan (NPL) levels in banks. Robust legal frameworks and transparent regulations in democracies curtail defaults and elevate recovery rates, ensuring bank profitability remains unaffected by credit risks (Almekhlafi et al., 2016; Zhang et al., 2013).

Banks' net interest margins (NIM) are also affected by democracy. A democratic environment that fosters competition and curbs monopolies leads to better interest rates for loans and deposits (Haddad et al., 2022), expanding the NIM (Puspitasari et al., 2021).

Democracy's effect on domestic credit to the private sector (DCP) is tied to the broader economic environment. Democracies advocate lending practices that spur economic growth. However, some studies indicate potential negative implications of DCP on bank profitability (Haddad et al., 2022; Jílková & Kotěšovcová, 2022).

The bank capital-to-assets ratio (CAR) in democratic nations is influenced by their inherent stability and transparency. Regulatory frameworks in these nations mandate banks to retain ample capital, ensuring stability. A robust CAR signifies banks' potential to secure funding at preferable terms, which enhances profitability (Molyneux & Forbes, 1995).

In democratic settings, concentration in the banking sector (COMP) is vital for assessing its effect on profitability. Regulatory measures in democracies aim to avert excessive banking concentration, promoting competition and innovation (Jílková & Kotěšovcová, 2022). Elevated concentration levels can boost profitability by appealing to a broader clientele (Tan & Tsionas, 2022).

Democracy's significance in the context of bank branches (BRS) pertains to its accessibility. Democracies emphasize financial inclusivity, propelling banks to establish more branches, enhancing profitability (Swanson & Zanzalari, 2021).

Lastly, democracy's impact on profitability, gauged through foreign banking assets (FRGNA), is intricate. Different bank ownership structures exist in democracies (Haldarov et al., 2022). The profitability influence depends on regulatory oversight and market dynamics. Foreign banks bring expertise, while domestic banks understand local market nuances (Dekle & Lee, 2015). Democracies ensure a balanced regulatory landscape, benefiting all banks.

I.1.1.5. Country's legislation regime and banking performance

Democracy's impact on banking performance is influenced by regional variations, legal systems, and cultural norms. Specifically, countries with robust legal frameworks and advanced financial markets may experience enhanced banking benefits from democratic governance. The electoral system and legislative regime (ELEC) significantly shape banking profitability by dictating policy and regulatory priorities. A democratic system prioritizes stability and long-term planning, fostering an environment that boosts investor confidence and economic growth (Baum et al., 2010), thereby positively influencing banking profitability (Barth et al., 2000).

I.1.2. Investigating the Connection Between Democracy, Economic Freedom, and Banking Efficiency in EU Member States

I.1.2.1. Data and sample considerations

To study the influence of democracy and economic freedom on banking performance, we use data from European Union (EU) countries over the period 2001-2020.

The motivation to choose the time interval 2001-2020 lies in the common history of many EU countries' after the 2000s. Certain states experienced democratic regimes after several decades of totalitarian rule, which they renounced at the end of the 1990s, and joined the European Union after 2000 (as is the case for the Czech Republic, Cyprus, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovak Republic, and Slovenia in 2004; Romania and Bulgaria in 2007; and Croatia in 2013). The conglomerate of states of the European Union represents a grouping with special characteristics in terms of common economic, social and external policies, which makes these countries an interesting and challenging sample to be studied from the perspective of the impact of democracy and economic freedom on banking activities, because they represent an association of economically strong states in relation to the rest of the world and which experience increasing levels of democratic values. On the other hand, the national specificity in implementing European policies, the different national options allowed in transposing community legislation in the member states, as well as their different historical context, make the studied sample include states with different stages of development of both economies and democratic valences, which prove to be extremely fragile and volatile in the current period.

The future of the European Union is influenced by the quality of the democracies of the member states, burdened by community skepticism, extremist risks, populism, xenophobic attitudes, conspiracy theories, fake news, geopolitical tensions, weaknesses of institutions, corruption or changes in civic participation and citizens' activism. The economic and social aspects represent basic items monitored in the European construction, which is intended to be one of real cohesion and convergence, but which, upon detailed analysis, shows different speeds of the member states in achieving the common convergence objectives. The banking system, as an object of our research, appears as a decisive element in the future of the European community and which influences and is influenced in turn by complex economic, social and political mechanisms.

For an analysis of the link between democracy and banking performance, this study considers the liberal democracy index (DEM-LIB) from the Varieties of Democracy (V-Dem) project (2022) as the main explanatory indicator. It combines information on voting rights, freedom and the fairness of elections, freedom of association and expression, civil liberties, and executive restraint. The index ranges from 0 to 1 (most democratic) and represents the sum of five sub-indices: electoral democracy, liberal political institutions, individual liberties and equality before the law, judicial constraints on the executive, and legislative constraints on the executive.

The second main explanatory indicator whose impact on banking performance was analyzed is economic freedom, which we consider in its form issued by the Fraser Institute (2022). This index measures the degree of economic freedom in five major areas: size of government, legal system, security of property rights, sound money, freedom to trade internationally, and regulations. Of these five major areas, 26 components were included in the index. Many of these are composed of several sub-components, and in total, the index comprises 44 distinct variables.

Table I.1.2.1-1. Variables and data sources

Symbol / Variables	Description / Unit	Data source
Dependent		
ROA	Banking Return on assets (Commercial banks' pre-tax income to yearly averaged total assets). / Ratio (%)	The Global Economy, via Bankscope, https://www.theglobaleconomy.com/rankings/bank_return_assets/
ROE	Banking Return on equity (Commercial banks' pre-tax income to yearly averaged equity). / Ratio (%) /	The Global Economy, via Bankscope, https://www.theglobaleconomy.com/rankings/bank_return_equity/
Core explanatory		
	Socio-political factor	
Democracy		
DEM-LIB	Liberal democracy V-Dem (The estimation of the extend of suffrage, the freedom and fairness of elections, freedoms of association and expression, individual and minority rights, equality before the law, and executive constraints). It ranges from 0 to 1 (most democratic). / Index	Our World in Data, https://ourworldindata.org/democratic-world, via Varieties of Democracy (V-Dem) Institute https://www.v-dem.net/
DEM-EIU	Democracy EIU (Aspects of societies that are relevant to democracy universal suffrage for all adults, voter participation, perception of human rights protection and freedom to form organizations and parties). The index is published based on a scale from 0 to 10 (most democratic), but Gapminder has converted it to	Economist Inteligence Unit, http://gapm.io/ddemocrix_eiu

Symbol / Variables	Description / Unit	Data source
	0 to 100 to make it easier to communicate as a percentage. / Index	
DEM-DEL	Deliberative democracy V-Dem (It combines information on voting rights, the freedom and fairness of elections, freedoms of association and expression, as well as the extent to which citizens and leaders discuss different views and seek the public good). It ranges from 0 to 1 (most democratic). / Index	Our World in Data, https://ourworldindata.org/grapher/deliberative-democracy-vdem?country=ARG~AUS~BWA~CHN, via Varieties of Democracy (V-Dem) Institute https://www.v-dem.net/
	Quality of political-economic institutions	
Economic freedom		
EFI-F	Economic freedom Fraser (The degree of economic freedom in 5 major areas: size of government, legal system and security of property rights, sound money, freedom to trade internationally and regulation). / Index	The Fraser Institute, https://www.fraserinstitute.org/resource-file?nid=14828&fid=18374
EFI-H	Economic freedom Heritage (The degree of economic freedom based on 12 quantitative and qualitative factors, grouped into 4 broad pillars: rule of law (property rights, government integrity, judicial effectiveness), government size (government spending, tax burden, fiscal health), regulatory efficiency (business freedom, labor freedom, monetary freedom), open markets (trade freedom, investment freedom, financial freedom)). / Index	The Heritage Foundation, https://www.heritage.org/index/about
Control variables		
	Macroeconomic determinants	
GDPG	Gross Domestic Product growth rate. / Annual rate (%)	The World Bank, World Development Indicators database, https://databank.worldbank.org/source/world-development-indicators
UNEMP	Unemployment (The share of the labor force that is without work but available for and seeking employment of total labor force). / Annual rate (%)	The World Bank via International Labour Organization, ILOSTAT database, (https://data.worldbank.org/indicator/SL.UEM.TOTL.ZS)
	Bank-specific determinants	
CIR	Efficiency - Bank cost to income ratio (Operating expenses of a bank as a share of sum of net-interest revenue and other operating income). / Ratio (%)	The World Bank, Global Financial Development database, https://www.worldbank.org/en/publication/gfdr/data/global-financial-development-database
CAR	Stability - Bank capital to assets ratio (Ratio of bank capital and reserves to total assets). / Ratio (%)	The World Bank, Global Financial Development database, https://www.worldbank.org/en/publication/gfdr/data/global-financial-development-database
NPL	Bank nonperforming loans to gross loans (Ratio of defaulting loans (payments of interest and principal past due by 90 days or more) to total gross loans). / Ratio (%)	The World Bank, Global Financial Development database, https://www.worldbank.org/en/publication/gfdr/data/global-financial-development-database

Symbol / Variables	Description / Unit	Data source
DCP	Domestic credit to private sector (% of GDP). / Ratio (%)	The World Bank, Global Financial Development database, https://www.worldbank.org/en/publication/gfdr/data/global-financial-development-database
NIM	Bank net interest margin (Accounting value of bank's net interest revenue as a share of its average interest-bearing (total earning) assets). / Ratio (%)	The World Bank, Global Financial Development database, https://databank.worldbank.org/source/global-financial-development
COMP	Competition, concentration (Assets of three largest commercial banks as a share of total commercial banking assets). / Ratio (%)	The World Bank, Global Financial Development database, https://databank.worldbank.org/source/global-financial-development
FRGNA	Foreign banking assets (Assets of foreign banks divided by total banks' assets). / Ratio (%)	The European Central Bank, https://sdw.ecb.europa.eu/
BRS	Bank branches per 100.000 adults (Number of commercial bank branches per 100.000 adults). / Number	The World Bank, Global Financial Development database, https://www.worldbank.org/en/publication/gfdr/data/global-financial-development-database
	Country's legislation regime	
ELEC	Electoral system - Dummy variable (0 if a country has proportional representation; 1 if a country has mixed system and 2 if a country has single winner / majoritarian system).	Authors' calculation, based on the ACE Electoral Knowledge Network, https://aceproject.org/about-en/

Table I.1.2.1-1 describes the variables and data sources from which the information was gathered. The descriptive analysis of the variables is presented in Table I.1.2.1-2. Several macroeconomic and banking-specific indicators were considered as control variables, based on the results of previous studies. Macroeconomic variables manage different economic growth rates between states and the structural characteristics of the labor market, while banking control variables are chosen to control for the differences in banks' costs, revenue, and capital. We develop a dummy variable based on each country's electoral regime, to study the impact of legislative regime on banking performance.

To control the macroeconomic level, this study uses annual Gross Domestic Product growth rates and annual unemployment rates, while to control the bank level, several bank-specific factors are employed. These control proxies capture the market structure and quality of the banking sector (cost-to-income ratio, nonperforming loans, net interest margin), banking depth and capital (domestic credit to private sector % of GDP, bank capital to assets ratio), aspects of competition and expansion (concentration of assets of the three largest commercial banks as a share of total commercial banking assets, bank branches), and ownership status (assets of foreign banks divided by total bank assets). To render the characteristics of each country's electoral system, we create a dummy variable that shows whether a country has a proportional representation, mixed system, or single-winner/majoritarian system.

Table I.1.2.1-2 Descriptive statistics

Variables	Obs.	Mean	Std. Dev.	Minimum	Maximum	Skewness	Kurtosis
ROA	516	0.652	1.630	-19.300	4.370	-5.420	55.243

ROE	509	8.262	16.367	-116.93	42.42	-3.634	23.595
DEM-LIB	540	0.761	0.102	0.362	0.896	-1.382	4.557
DEM-EIU	404	79.677	8.247	63.800	98.800	0.275	2.262
DEM-DEL	540	0.734	0.119	0.243	0.887	-1.483	5.322
EFI-F	540	7.630	0.393	5.730	8.360	-1.307	5.186
EFI-H	520	68.376	6.403	48.700	82.600	-0.335	2.958
GDPG	540	2.079	3.821	-14.840	25.180	-0.506	7.466
UNEMP	540	8.614	4.348	1.810	27.470	1.511	5.626
CIR	525	58.796	11.524	19.370	97.170	0.218	3.847
CAR	501	7.674	2.557	2.700	14.860	0.648	2.883
NPL	510	6.064	7.134	0.100	47.750	2.810	12.876
DCP	507	85.194	43.342	0.190	255.31	1.076	4.633
NIM	524	2.227	1.322	0.180	9.485	1.327	6.194
COMP	537	71.707	16.241	28.560	100.000	-0.183	2.418
FRGNA	360	46.712	32.966	1.291	98.943	0.077	1.474
BRS	455	48.986	78.854	4.020	517.140	4.606	24.591
ELEC	540	0.222	0.567	0.000	2.000	2.428	7.464

Source: Authors' processing. Notes: ROA (Banking Return on assets), ROE (Banking Return on equity), DEM-LIB (Liberal democracy V-Dem), DEM-EIU (Democracy EIU), DEM-DEL (Deliberative democracy V-Dem), EFI-F (Economic freedom Fraser), EFI-H (Economic freedom Heritage), GDPG (Gross Domestic Product growth rate), UNEMP (Unemployment), CIR (Efficiency - Bank cost to income ratio), CAR (Stability - Bank capital to assets ratio), NPL (Bank nonperforming loans to gross loans), DCP (Domestic credit to private sector), NIM (Bank net interest margin), COMP (Competition, concentration), FRGNA (Foreign banking assets), BRS (Bank branches per 100.000 adults), ELEC (Electoral system - Dummy variable).

To check the robustness and sensitivity of our findings, we used two other indicators to measure the degree of democracy in countries: the democracy index published by the Economist Intelligence Unit (EIU, 2022) and the deliberative democracy index developed by the project Varieties of Democracy (V-Dem) (2022). The EIU democracy index is calculated from 60 indicators that consider different aspects of societies relevant to democracy, universal suffrage for all adults, voter participation, perception of human rights protection, and freedom to form organizations and parties. The index is presented on a scale of 0-100 (initial 0-10, but extended by Gapminder, who disclosed the index) and divided into five categories (electoral pluralism index, government index, political participation index, political culture index, and civil liberty index). Unfortunately, the democracy index from the EIU contains data only for the period 2006-2020. The third democracy index that has been considered for sensitivity tests is the deliberative democracy index (V-Dem, 2022), which combines information on voting rights, freedom and fairness of elections, freedom of association and expression, and the extent to which citizens and leaders discuss different points of view and seek the public good. It ranges from 0 to 1 (the most democratic).

To ensure sensitivity and robustness, we used another available index that captures economic freedom, namely, the one developed by the Heritage Foundation. Economic freedom is based on 12 issues grouped into four broad categories: the rule of law (property rights, judicial effectiveness, and governmental integrity), government dimension (tax burden, government spending, and tax health), regulatory efficiency (business, labor, and monetary freedom), and market opening (trade, investment, and financial freedom).

I.1.2.2. Model and econometric specification

This section presents the econometric approach. In the first phase of the research, we examine whether data are affected by heteroscedasticity and serial correlation to determine which

types of models are suitable, because these estimation errors generally affect the reliability of the models and lead to misleading results (Kumar et al., 2022; Attari et al., 2016; Simpson, 2012). To maintain the data validity and robustness of the regression results, other basic classical linear regression model assumptions were tested (Maladjian & Khoury, 2014) before using panel regression models, to identify and correct any misspecifications (stationarity of the variables, possible occurrence of multicollinearity, and cointegration between the variables).

In addition to the above tests, we study cross-sectional dependence to determine whether the EU countries are susceptible to intercountry effects due to unobservable common factors or comparable economic features (Burdisso & Sangiacomo, 2016; Sarafidis & Wansbeek, 2012). Cross-sectional dependence analysis in economic panels is important because it provides evidence of correlations among cross-sectional units (countries in our case) due to competition, spillover effects, externalities, and so on (Xu et al., 2016), which affect the type of model suitable for the study of selected variables.

Endogeneity represents the next key studied aspect in the second stage of research because econometric modelling encounters the major challenge of adequately establishing the explanatory variables of the model and necessarily involves studying the endogeneity between variables. Previous research presents endogeneity and omitted variable biases as the main sources of inconsistency in banking profitability study methods (Asteriou et al., 2021; Naceur & Omran, 2011; Poghosyan & Hesse, 2009). Ignoring endogeneity increases the risk of including not only very few explanatory, but also some irrelevant, variables in the model, leading to the so-called omitted variable bias (Ibrahim & Arundina, 2022). Failure to consider endogeneity biases produces inconsistent estimates, and numerous studies published in recent years have adequately managed endogeneity concerns, given the concerns of scientific journals that require authors to fully address them in their research (Ullah et al., 2018).

Endogeneity is common in the relationship between economic variables, affects the estimates of parameters that become uncertain and biased, and can occur in different forms: unobserved heterogeneity (when the relationship between two or more variables is influenced by an unobservable factor) (Chatterjee & Nag, 2023; Wintoki et al., 2012), simultaneity (when two variables simultaneously influence each other), and dynamic endogeneity (when the present value of a variable is influenced by it's own, or other variables' past values). Endogeneity can be interpreted as the effect of the past on the present, both on the model (dependent variable) and on the independent variables, or as the causal relationship between regressors and the explained variable over time (Labras and Torrecillas, 2018). It can also arise from the omission of certain unobserved factors from the model, that could affect the relationships between the studied variables.

Based on these considerations, and in line with previous research, our strategy is to identify the risk of endogeneity initially through theoretical judgement, followed by statistical tests: situations of influence between variables through the Durbin-Wu-Hausman test (Ullah et al., 2018), and reverse causality between variables using the panel Granger causality tests (Granger, 1969; Lopez and Weber, 2017). We also considered possible sources of endogeneity because we did not capture all factors that might affect the banking performance models developed in this study.

Based on the results obtained from the above-mentioned tests, and because the sample size was not large, we initially applied several static panel models for the primary regression analysis, starting with the pooled ordinary least squares (OLS) regression, which is considered more suitable

than OLS for such data (Driscoll & Kraay, 1998). The specific problems of non-fulfilment of classical regression assumptions lead to the further use of fixed and random effects models, which, unlike pooled OLS, have the potential to better control for unobservable heterogeneities across countries over time, which could affect the relationship between the variables (Gerged et al., 2023).

However, neither the pooled OLS model nor the static panel methods (as fixed or random effect) can solve endogeneity problems (Chatterjee & Nag, 2023), rendering the generalized method of moments (GMM) the most effective for addressing endogeneity biases by considering the lagged endogenous variables as valid instruments (Nzimande & Ngalawa, 2017). The GMM system proves to be suitable in terms of its ability to efficiently manage cross-sectional dependence (Sarafidis & Wansbeek, 2012).

To capture the dynamic impact of democracy and economic freedom on banking performance, we use the generalized method of moments (GMM) technique (Roodman, 2009; Blundell & Bond, 1998; Arellano & Bond, 1991), based on its potential to generate a more efficient estimator to solve for heteroscedasticity, serial correlation, and endogeneity than the difference GMM or static panel methods (Kumar et al., 2022). As static panel models do not consider the dynamics of time-varying and endogeneity of the variables, we applied GMM, which proves to be suitable in endogenous conditions and can solve reverse causality problems, allowing the use of the lag of the dependent variable as an instrument, which permits a parsimonious number of instruments (Gerged et al., 2023; Srairi et al., 2021; Forgione and Migliardo, 2020; Zeqiraj et al., 2020; Kalifa & Bektas, 2018). In addition, the GMM technique is adequate for datasets with small T and large N, as is the analyzed panel data (Asteriou et al., 2023).

The choice of GMM as the appropriate research method for our data is based on its capability to solve dynamic panel data problems, namely, that the independent variables chosen this year can affect banking performance, but those of the previous year could play a substantial role. The GMM method uses the lags of the dependent variable as explanatory variables, and as an instrument to control for endogenous relationships (Ullah et al., 2018). Specifically, the application mechanisms of the GMM technique involve the so-called internal transformation of data as a statistical process by which the past value is extracted from the present one; thus, by reducing the number of observations, the efficiency of the method is obtained (Roodman, 2009; Wooldridge, 2012). Of the two methods of applying GMM, i.e., one-step and two-step, the second proves to be much more efficient because it applies forward orthogonal deviations by extracting previous values of variables from current ones, and because it is based on the average of future available observations (Ullah et al., 2018; Wooldridge, 2012; Roodman, 2009; Blundell & Bond, 1998; Arellano & Bond, 1991).

To unearth the causal nexus between the banking performance ratios (ROA and ROE) and the proxies for democracy and economic freedom in the European Union (2001-2020), we employ the following dynamic panel data model:

$$ROA_{i,t} = \propto_0 + \propto_1 ROA_{i,t-1} + \propto_2 Democracy_{i,t} + \propto_3 Economic\ freedom_{i,t} + \propto_4 Control_{i,t} + u_{i,t} \quad (1)$$

$$ROE_{i,t} = \propto_0 + \propto_1 ROE_{i,t-1} + \propto_2 Democracy_{i,t} + \propto_3 Economic\ freedom_{i,t} + \propto_4 Control_{i,t} + u_{i,t} \quad (2)$$

where *i* represents the country, *t* is the period (years), *ROA* represents banking Return of assets, *ROE* is banking Return of equity, $ROA_{i,t-1}$ represents 1-year lag of ROA, $ROE_{i,t-1}$ represents

1-year lag of ROE, *Democracy* reflects the degree of democracy of a country (measured with one of the indicators published by V-Dem or EIU, as in Table I.1.2.1-1), *Economic freedom* shows the index of economic freedom (published by the Fraser Institute or the Heritage Foundation, as in Table I.1.2.1-1), *Control* denotes control variables (as they are set in Table I.1.2.1-1), α_1 is constant (intercept), $\alpha_{2,3,4}$ are the coefficients of the estimated parameters and $u_{i,t}$ is the error term.

For robustness purposes, we follow two approaches: first, we focus on alternative variables that capture core explanatory proxies developed by other issuers; second, we use econometric modelling techniques other than the GMM system. The alternative variables chosen for democracy are DEM-EIU (Democracy EIU obtained from the Economist Intelligence Unit) and DEM-DEL (Deliberative democracy prepared by V-Dem), while for economic freedom, in line with the prior literature (Asteriou et al., 2021) we use EFI-H (Economic freedom issued by the Heritage Foundation). We compute the feasible generalized least square (FGLS) estimator, considered suitable between static models for the studied data, under heteroscedasticity, cross-sectional dependence conditions and endogeneity (Ozili & Iorember, 2023; Bai et al., 2021; Westerlund and Narayan, 2012; Hansen, 2007).

I.1.2.3. Overall Analysis Results

The preliminary investigation of the variables involves the study of heteroscedasticity, based on the modified Wald test and the Breusch-Pagan test (Breusch & Pagan, 1979), that suggest heteroscedasticity in the residuals in both the ROA and ROE models.

The Wooldridge test (Wooldridge, 2002; Drukker, 2003) proves the serial correlation in the idiosyncratic error term in both models.

The stationarity of the variables, both in level and first difference, is studied through Fisher tests based on the Phillips-Perron approach (Perron & Vogelsang, 1992) and the Augmented Dickey-Fuller tests (Maddala & Wu, 1999; Lanne & Lutkepohl, 2002). All the variables were stationary at the first difference.

We check the data for multicollinearity, and the results suggest that the dependent and explanatory variables are not correlated, as they result from the correlation matrix, which displays low values (less than 0.5) of the correlation coefficients between the variables for both models, ROA and ROE. The absence of multicollinearity was also confirmed by the variance inflation factor (VIF), whose threshold level is approximately 5 (Koengkan et al., 2019).

To study whether there is a long-term equilibrium among variables, we apply the co-integration Kao test (Kao, 1999), whose outcomes confirm the existence of a long-term co-integration relationship between variables.

We use Pesaran tests (Pesaran & Xie, 2021; Pesaran, 2015; Pesaran, 2004) to check the cross-sectional dependence of the variables. The results display strong cross-sectional dependence for the variables (except for FRGNA. This variable is interpolated in our analysis due the reduced number of available observations (Meijering, 2002)). The cross-sectional dependence item in errors requires attention because of the presence of common shocks and unobserved components that ultimately become part of the error term, spatial dependence, and idiosyncratic pairwise dependence in disturbances with no specific pattern of common components or spatial dependence (De Hoyos & Sarafidis, 2006). The results reveal that the changes in the variables in the analyzed countries could generate the so-called spillover intercountry effects in others, due to unobservable common factors, thereby requiring a test model that considers possible effects of the interconnected economies.

Following the strategy outlined in Section 3.2, we started with theoretical judgement and identified three sources of endogeneity that may bias the effects of independent variables on banking performance; we then applied statistical tests to identify possible endogeneity between variables.

The most important source of endogeneity is omitting, or not observing, factors that affect and explain the relationship between the dependent variable (banking performance), core explanatory variables (democracy and economic freedom), and the control variables that we established and used in this study. The literature shows that this source of endogeneity can be managed through panel data analysis and fixed-effect estimators, which can consider this bias under certain assumptions (Dang et al., 2020; Wooldridge, 2002), but this approach is not sufficient if there is a second source of endogeneity, namely reverse causality (Dang et al., 2020; Adams & Ferreira, 2009). Democracy, economic freedom, and the selected control variables may affect bank performance, but it is also possible that bank performance affects these variables, indicating reverse causality or simultaneity. To analyze the situations of influence between variables, we computed the Durbin-Wu-Hausman test and studied the existence of reverse causality between variables, using the Granger causality test for both the ROA and ROE models. The third source of endogeneity, namely dynamic endogeneity, occurs when past banking performance influences current performance and explanatory variables, or when current explanatory variables are influenced by past values of the variables (Li et al., 2021).

To detect the endogeneity of individual regressors, we applied the Durbin-Wu-Hausman test (Ullah et al., 2018) after OLS regressions, wherein each independent variable is considered dependent on others. We analyzed the residuals (error terms), which are then included in the OLS regression equation for both models (ROA and ROE). The results indicate whether explanatory variables are correlated with residuals. Since, in our case, we have signals of endogeneity in the ROA model (taking as reference model 1.2) only for DEM-LIB (at the 1% significance level), while in the ROE model (taking as reference model 2.2), all studied variables are endogenous (at the 1% significance level), we have to apply superior techniques that lead to more consistent results than OLS.

For the same purpose as endogeneity testing, to study reverse causality between the analyzed variables, we computed the first-generation panel Granger causality test (Granger, 1969; Lopez and Weber, 2017). The most important outputs of the Granger causality technique for the ROA model are the unidirectional relationships between several variables (GDPG causes UNEMP, EFI-F causes NPL, CIR causes NPL, and FRGNA causes NPL). In the ROE model, DCP causes ROE, UNEMP causes DEM-LIB, UNEMP causes COMP, BRS causes DEM-LIB, GDPG causes UNEMP, DCP causes UNEMP, BRS causes CAR, UNEMP causes DCP, and GDPG causes FRGNA.

The results of the Granger causality test correlated with the Durbin-Wu-Hausman test, and the theoretical judgement (of omitting or not observing factors that could affect and explain the relationship between the variables) led to the establishment of a diagnosis of endogeneity between several mentioned variables. We must identify a study method to manage endogeneity, and the GMM system proves suitable for this goal (Roodman, 2009; Asteriou et al., 2021).

To obtain accurate regression results, after testing the data and interpreting the obtained results based on the above assumptions specific to classical regressions, cross-sectional dependence, and endogeneity, the next stage of the research involved the effective development of regression models considered to be adequate for the data of the proposed model. The synthetic

results of the classical assumption testing of linear regression show the stationarity of the data, absence of multicollinearity, heteroscedasticity in the residuals, serial correlations, and cointegration relations between variables. Additionally, we proved the cross-sectional dependence and endogeneity of the variables in several cases.

To explore the relationship between the variables, we first started with a pooled Ordinary Least Squares (OLS) analysis to provide an initial basis for comparison of the results obtained, even if statistical tests prior to the regression models resulted in the OLS model being unsuitable for our data (Gerged et al., 2023; Hoeckle, 2007). We progressively applied the sets of control variables in distinct phases and continued with the fixed effects (FE) and random effects (RE) models, whose characteristics render them better for controlling unobservable heterogeneities across countries over time, which could influence the relationship between the variables (Gerged et al., 2023).

Table I.1.2.3-1. The Effect of Democracy and Economic freedom on Bank Performance: ROA models (Pooled OLS, FE, RE)

Dependent variable: ROA	**Pooled OLS**	**Pooled OLS**	**FE**	**FE**	**RE**	**RE**
(Model)	**(1.1)**	**(1.2)**	**(1.3)**	**(1.4)**	**(1.5)**	**(1.6)**
DEM-LIB	2.442**	2.441**	3.199*	3.178*	2.552**	2.537**
	(1.107)	(1.108)	(1.886)	(1.912)	(1.141)	(1.172)
EFI-F	-0.314***	-0.305***	-0.961**	-0.956**	-0.520*	-0.537*
	(0.080)	(0.082)	(0.370)	(0.371)	(0.275)	(0.280)
GDPG	0.101***	0.101***	0.104***	0.104***	0.102***	0.102***
	(0.019)	(0.020)	(0.017)	(0.017)	(0.017)	(0.017)
UNEMP	-0.065***	-0.065***	-0.057*	-0.055*	-0.063***	-0.626***
	(0.020)	(0.020)	(0.030)	(0.030)	(0.022)	(0.023)
CIR	-0.017**	-0.017**	-0.024***	-0.025***	-0.019***	-0.020***
	(0.006)	(0.007)	(0.007)	(0.008)	(0.006)	(0.007)
CAR	0.079**	0.083**	0.123***	0.132***	0.088**	0.093**
	(0.030)	(0.031)	(0.044)	(0.045)	(0.035)	(0.037)
NPL	-0.054**	-0.053**	-0.064***	-0.063***	-0.057***	-0.057***
	(0.016)	(0.017)	(0.018)	(0.019)	(0.014)	(0.014)
NIM	0.381***	0.386***	0.303***	0.304***	0.359***	0.361***
	(0.100)	(0.105)	(0.097)	(0.097)	(0.078)	(0.082)
COMP	0.003	0.002	0.010	0.009	0.005	0.005
	(0.002)	(0.003)	(0.009)	(0.009)	(0.005)	(0.005)
ELEC	0.301***	0.308***	-	-	0.313*	0.323*
	(0.080)	(0.082)			(0.166)	(0.175)
FRGNA		-0.0003		-0.001		-0.0005
		(0.001)		(0.006)		(0.003)
BRS		0.0003		0.003		0.0004
		(0.0002)		(0.003)		(0.001)
Constant	1.174	1.098	5.338	5.250	2.566	2.708
	(1.025)	(1.042)	(3.307)	(3.343)	(2.347)	(2.426)
Observations	447	447	447	447	447	447
Number of countries	27	27	27	27	27	27
R2	0.318	0.318	0.288	0.266	0.316	0.316
Hausman test	-	-	0.016	-	-	0.667

Source: Authors' processing. Notes: Standard errors in parentheses; ***, ** and * denote significance at 1, 5 and 10 percent level respectively. This table reports results of pooled OLS, fixed effects and random effect models (each column represents a separate regression model).

For the ROA model, the static panel models (Table I.1.2.3-1) illustrated robust and statistically significant results for the core explanatory variables (DEM-LIB and EFI-F), whereas for the control variables, no statistical significance was found for COMP, FRGNA, and BRS, while

the rest of the control variables were statistically significant. The application of the Hausman test (Hausman & Taylor, 1981) reveals that the fixed and random effects models are suitable for the 1.3/1.5 and 1.4/1.0 models respectively.

Table I.1.2.3-2. The Effect of Democracy and Economic freedom on Bank Performance: ROE models (Pooled OLS, FE, RE)

Dependent variable: ROE	**Pooled OLS**	**Pooled OLS**	**FE**	**FE**	**RE**	**RE**
(Model)	**(2.1)**	**(2.2)**	**(2.3)**	**(2.4)**	**(2.5)**	**(2.6)**
DEM-LIB	23.595***	23.958***	46.423**	42.720**	30.612***	27.467***
	(5.465)	(5.508)	(18.255)	(18.334)	(11.627)	(10.590)
EFI-F	-9.561***	-8.733***	-12.090***	-11.784***	-10.716***	-9.706***
	(2.177)	(2.263)	(2.981)	(2.976)	(2.505)	(2.376)
GDPG	0.989***	0.946***	0.981***	0.943***	1.025***	0.987***
	(0.292)	(0.277)	(0.194)	(0.192)	(0.186)	(0.185)
UNEMP	-1.268***	-1.242***	-1.436***	-1.345***	-1.364***	-1.311***
	(0.235)	(0.234)	(0.234)	(0.234)	(0.196)	(0.187)
CIR	-0.195**	-0.145*	-0.283***	-0.283***	-0.224***	-0.180**
	(0.073)	(0.083)	(0.082)	(0.083)	(0.067)	(0.072)
CAR	0.345	0.371	0.081	0.413	0.290	0.384
	(0.647)	(0.656)	(0.441)	(0.450)	(0.378)	(0.365)
DCP	-0.030*	-0.023	-0.104**	-0.099**	-0.047*	-0.034
	(0.017)	(0.024)	(0.040)	(0.039)	(0.025)	(0.024)
COMP	0.064**	0.047	-0.019	-0.058	0.051	0.036
	(0.027)	(0.031)	(0.088)	(0.088)	(0.059)	(0.053)
ELEC	2.123***	2.708***	-	-	2.570	3.103*
	(0.630)	(0.659)			(0.188)	(1.613)
FRGNA		0.036		0.030		0.032
		(0.030)		(0.060)		(0.033)
BRS		0.027***		0.100***		0.031***
		(0.007)		(0.031)		(0.011)
Constant	78.691***	66.194***	101.842***	94.893***	87.348***	74.972***
	(21.760)	(21.475)	(27.157)	(27.364)	(19.633)	(19.308)
Observations	433	433	433	433	433	433
Number of countries	27	27	27	27	27	27
R2	0.252	0.271	0.214	0.200	0.250	0.270
Hausman test	-	-	-	0.027	0.427	-

Source: Authors' processing. Notes: Standard errors in parentheses; ***, ** and * denote significance at 1, 5 and 10 percent level respectively. This table reports results of pooled OLS, fixed effects and random effect models (each column represents a separate regression model).

For the ROE model (Table I.1.2.3-2.), statistical significance was obtained for the core explanatory variables (DEM-LIB and EFI-F), whereas the control variables showed mixed results (CAR, COMP, and FGRGNA did not show statistical significance in the analyzed models). The Hausman test (Hausman & Taylor, 1981) established that the random effects method is adequate for Models 2.3/2.5, and the fixed effects technique is appropriate for Models 2.4/2.6.

However, neither the pooled OLS model nor static panel methods (as fixed effect or random effect) can manage cross-sectional dependence (Sarafidis & Wansbeek, 2012) and endogeneity challenges (Chatterjee & Nag, 2023; Zeqiraj et al., 2020; Hakimi et al., 2018; Nzimande & Ngalawa, 2017), so that static panel models act only as precursors to the dynamic system GMM model developed in this study.

To estimate the dynamic effects of democracy and economic freedom on banking performance, we applied a two-step GMM technique, using lagged values of the dependent variables as regressors (ROA in the ROA models based on equation 1, and ROE in the ROE models

based on equation 2). Our empirical analysis estimated the effects of democracy and economic freedom on banking performance, using macroeconomic determinants and progressive bank-specific factors as control variables. The GMM system also deals with the endogeneity of variables and allows for the use of exogenous stand-alone and explanatory instruments to identify endogenous variables (Roodman, 2009; Blundell and Bond, 1998; Arellano and Bond, 1991). We configure the instruments in every model and present them in the notes of the table that discloses the system's GMM results (see Tables I.1.2.3-3. and I.1.2.3-4.). For the validity of each estimated model, we present the Hansen J test of over-identifying restrictions, first AR(1) and second-order no-autocorrelation criterion AR(2).

Table I.1.2.3-3. The Effect of Democracy and Economic freedom on Bank Performance: ROA two-step System GMM models

Dependent variable: ROA	**System GMM**						
(Model)	**(1.7)**	**(1.8)**	**(1.9)**	**(1.10)**	**(1.11)**	**(1.12)**	**(1.13)**
$ROA_{i,t-1}$	0.217***	0.188***	0.210***	0.186***	0.181***	0.182***	0.180***
	(0.044)	(0.030)	(0.032)	(0.030)	(0.031)	(0.026)	(0.026)
DEM-LIB	1.801***	1.808***	2.582***	1.524**	2.142***	2.221***	2.311***
	(0.627)	(0.679)	(0.589)	(0.675)	(0.753)	(0.743)	(0.728)
EFI-F	-0.783***	-0.314**	-0.437**	-0.396***	-0.384***	-0.391***	-0.404***
	(0.180)	(0.135)	(0.201)	(0.122)	(0.122)	(0.105)	(0.105)
GDPG	0.101***	0.084***	0.066***	0.085***	0.086***	0.090***	0.091***
	(0.026)	(0.023)	(0.019)	(0.022)	(0.021)	(0.024)	(0.024)
UNEMP	-0.080***	-0.039**	-0.075***	-0.042***	-0.041***	-0.040***	-0.040***
	(0.020)	(0.015)	(0.020)	(0.014)	(0.014)	(0.015)	0.015
CIR	-0.012**	-0.014***	-0.018***	-0.014***	-0.016***	-0.015***	-0.015***
	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)	(0.004)
CAR	0.089***	0.056***	0.038	0.060***	0.071***	0.069***	0.070***
	(0.019)	(0.020)	(0.023)	(0.019)	(0.022)	(0.021)	(0.021)
NPL		-0.048*		-0.047*	-0.047*	-0.051**	-0.052**
		(0.027)		(0.026)	(0.025)	(0.025)	(0.025)
NIM		0.258***	0.200***	0.238***	0.269***	0.281***	0.281***
		(0.048)	(0.049)	(0.054)	(0.047)	(0.048)	(0.048)
COMP				0.006**	0.004**	0.004*	0.004*
				(0.002)	(0.002)	(0.002)	(0.002)
ELEC					0.260***	0.256***	0.259***
					(0.054)	(0.059)	(0.059)
DCP			-0.002*				
			(0.001)				
FRGNA						0.0002	0.0002
						(0.002)	(0.002)
BRS						0.00004	0.00003
						(0.0002)	(0.0002)
Constant	5.712***	1.888	2.990*	2.297**	1.723	1.720*	1.757*
	(1.629)	(1.191)	(1.651)	(1.080)	(0.054)	(1.001)	(1.002)
Observations	444	426	416	426	426	426	426
No. of countries	27	27	27	27	27	27	27
No. of instruments	25	27	27	28	29	31	32
AR(1) test (p-value)	0.075	0.077	0.078	0.077	0.079	0.077	0.077
AR(2) test (p-value)	0.208	0.129	0.243	0.124	0.122	0.123	0.122
Hansen test (p-value)	0.468	0.500	0.437	0.541	0.500	0.658	0.721
Chi2 test (p-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Source: Authors' processing. Notes: Standard errors in parentheses; ***, ** and * denote significance at 1, 5 and 10 percent level respectively. This table reports results of two-step system GMM (each column represents a separate regression model), based on xtabond2 Stata command, with orthogonal (to use the forward orthogonal deviations transform instead of first differencing), collapse (to create one instrument for each variable and lag distance, rather than one for each period, variable and lag distance) and robust (with Windmeijer's finite-sample correction for two-step covariance matrix) options. The instruments are the independent variables and in the last model the lag1 of endogenous variable DEM-LIB is additionally used as instrument.

Table I.1.2.3-4. The Effect of Democracy and Economic freedom on Bank Performance: ROE two-step System GMM models

Dependent variable: ROE	**System GMM**						
(Model)	**(2.7)**	**(2.8)**	**(2.9)**	**(2.10)**	**(2.11)**	**(2.12)**	**(2.13)**
$ROE_{i,t-1}$	0.334***	0.215***	0.361***	0.369***	0.206***	0.347**	0.340***
	(0.085)	(0.050)	(0.094)	(0.096)	(0.053)	(0.069)	(0.068)
DEM-LIB	15.137**	20.034**	17.861***	12.743**	25.911**	22.324*	27.162**
	(5.915)	(9.228)	(6.685)	(6.376)	(10.121)	(11.889)	(11.385)
EFI-F	-6.593***	-3.719*	-5.222***	-5.367***	-2.280	-9.217***	-5.775**
	(1.345)	(2.238)	(1.568)	(1.583)	(3.890)	(3.365)	(2.554)
GDPG	1.053***	0.989***	0.664***	0.660***	0.972***	0.687***	0.635***
	(0.262)	(0.319)	(0.217)	(0.225)	(0.304)	(0.174)	(0.131)
UNEMP	-0.651***	-0.438**	-0.478**	-0.469**	-0.392*	-0.599**	-0.442**
	(0.181)	(0.217)	(0.204)	(0.213)	(0.230)	(0.249)	(0.190)
CIR	-0.155*	-0.181***	0.196**	-0.169**	-0.178**	-0.257**	-0.323**
	(0.084)	(0.067)	(0.087)	(0.074)	(0.076)	(0.125)	(0.131)
CAR	0.157	-0.098	0.027	-0.082	0.035	-0.099	-0.155
	(0.211)	(0.274)	(0.212)	(0.224)	(0.299)	(0.361)	(0.370)
NPL		-0.311*			-0.329*		
		(0.179)			(0.175)		
NIM		2.224**			2.674**		
		(1.041)			(1.094)		
COMP				0.045*	-0.003	0.038	-0.022
				(0.025)	(0.036)	(0.038)	(0.078)
ELEC			1.853***		2.618***	1.888***	7.008
			(0.602)		(0.572)	(0.697)	(6.150)
DCP			-0.038**	-0.039***		-0.049***	-0.058
			(0.014)	(0.015)		(0.017)	(0.036)
FRGNA						-0.004	0.001
						(0.039)	(0.045)
BRS						0.010*	0.016**
						(0.005)	(0.006)
Constant	55.980***	30.004	48.838***	50.476***	11.817	79.728***	56.445**
	(11.231)	(21.855)	(13.668)	(13.557)	(38.155)	(30.577)	(22.108)
Observations	437	419	412	412	419	412	397
No. of countries	27	27	27	27	27	27	27
No. of instruments	25	27	27	27	29	29	39
AR(1) test (p-value)	0.010	0.014	0.015	0.014	0.015	0.014	0.014
AR(2) test (p-value)	0.381	0.112	0.582	0.567	0.099	0.644	0.707
Hansen test (p-value)	0.421	0.271	0.521	0.547	0.330	0.809	0.999
Chi2 test (p-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Source: Authors' processing. Notes: Standard errors in parentheses; ***, ** and * denote significance at 1, 5 and 10 percent level respectively. This table reports results of two-step system GMM (each column represents a separate regression model), based on xtabond2 Stata command, with orthogonal (to use the forward orthogonal deviations transform instead of first differencing), collapse (to create one instrument for each variable and lag distance, rather than one for each period, variable and lag distance) and robust (with Windmeijer's finite-sample correction for two-step covariance matrix) options. In addition, the models 2.12 and 2.13 use the e(level) passthru option for GMM style (to create instruments for the levels equation that use not the first-differences of the specified variables but the original levels of the same dates). The instruments are the independent variables and in the last model the lag1 of all independent variable (established to be endogenous) are additionally used as instruments.

The post-estimation analysis of the two-step system GMM models, both for ROA and ROE, shows that the p-values of the Hansen tests accept the null hypothesis of overidentifying restrictions (because values do not exceed 0.8). Thus, the instruments are adequate and all the restrictions of overidentification are valid, based on prior literature (Labras & Torrecillas, 2018) (there is an exception to the ROE 2.13 model, where a large number of instruments, even if the collapse option is applied, leads to an almost unitary value of the Hansen test, showing that the model has at least one invalid restriction). Additionally, the value of the Wald tests sustains the goodness of fit models, and the second-order no-autocorrelation hypothesis is not rejected by the

Arellano and Bond tests for autocorrelation AR(2), whereas AR(1) is significant, confirming the serial autocorrelation in the errors.

We obtained the dynamic persistence of ROA (or ROE) and confirmed the dynamic specification of the models with statistically significant lag1 for ROA (and ROE), which provides a positive correlation between ROA_{it-1} and ROA itself (as well as between ROE_{it-1} and ROE itself).

The research has as temporal reference the period 2001-2020, approached at the level of the 27 states of the European Union. Given the availability of public data, the first year of the COVID-19 pandemic - 2020 - is contained in the analyzed time frame. The empirical analysis of the values of dependent variables – ROA and ROE – in dynamics, in 2020, as well as of macroeconomic variables (economic growth and unemployment), compared to the previous year / years, shows the generalized decrease of banking performance indicators in all analyzed states and worsening macroeconomic conditions, with relatively low decline rates recorded. The analysis of the data panel for the period 2000-2019, prior to the pandemic period, revealed the same meanings and directions of the evolutions of the relationships between the analyzed variables and statistical significance for the analyzed variables (similar to the results obtained in the models 1.13 ROA and 2.13 ROE). As the COVID-19 pandemic manifested itself strongly with global restrictions on the mobility of people only since March 2020, lower levels of face-to-face banking activities with customers have been compensated by an unprecedented expansion of digital banking services, especially in the emerging countries of the European Union. In this way, the operating income obtained compensated for the low level of interest income on granted loans, affected by the generalized worsening of borrowers' repayment capacity.

The importance and influence of democracy on banking profitability are multifaceted, interconnected, and significant in all estimated models. Regarding the ROA and ROE measures of banking profitability and the impact of democracy, we find evidence of a positive relationship (both static panel and GMM-based models). Democracy fosters a transparent regulatory environment, political stability, economic freedom, and competitive markets. It influences variables, such as economic freedom, GDP growth, unemployment, nonperforming loans, cost-to-income ratio, capital-to-assets ratio, net interest margin, concentration, domestic credit to the private sector, ownership status, and the electoral system, all of which contribute to the profitability of the banking sector.

The following sections present separately the results obtained.

The Role of Democracy

Our analysis revealed several important findings: the results based on system GMM models (also on estimated static previous panels) reveal that democracy (DEM-LIB) has a positive and significant impact on banking performance in the sample countries, both in the ROA and ROE models.

Increased democracy positively stimulates banking performance. As the coefficient of democracy is statistically and positively significant, bank profitability also increases as the level of democracy increases. The results can be explained as follows: the higher the level of democracy, the stronger the reform of financial and bank regulations. This means that more democratic countries have better regulatory and institutional frameworks, in turn, leading to lower credit risk and, implicitly, a more profitable banking system (Ben Ali & Ben Mim, 2022).

The role of democracy's role in banking performance is multifaceted and dynamic. Banks in democratic societies tend to generate higher interest margins because of their credibility and supervision (Puspitasari et al., 2021). Moreover, democratic regimes often promote financial inclusion and market competition, leading to a broader customer base for banks, enhanced banking competition, and ultimately, higher profitability (Agoraki et al., 2020). In contrast, stable democratic systems tend to have more predictable and transparent economic policies that reduce business uncertainty. This stability fosters investment and creates job opportunities, thereby lowering the unemployment rate. Furthermore, democratic governance often emphasizes social welfare and labor-market reforms, which can contribute to reducing unemployment and improving job security (Apergis, 2017).

Democracy has implications for various bank-level variables that influence banking performance. Democratic systems that prioritize financial stability and regulatory frameworks may lead to more efficient banking systems, potentially resulting in lower cost-to-income ratios. A democratic system with strong governance and transparency can reduce corruption and promote the rule of law (Huang, 2010). This may improve loan quality, lower nonperforming loan ratios, and increase confidence in the banking sector. Democracy can promote a stable macroeconomic environment, which in turn enhances banks' ability to maintain adequate capital levels. This may lead to higher capital-to-assets ratios, indicating a stronger financial position. Democracy facilitates access to credit for the private sector by ensuring a level-playing field, leading to higher domestic credit and promoting economic growth (Zeqiraj et al., 2020).

Transparent and accountable regulatory systems, which promote fair competition and reduce corruption, tend to be established in democratic societies (Asteriou et al., 2021). Such systems provide a favorable business environment for banks by fostering trust among customers and investors. A well-defined regulatory framework also ensures effective risk management practices, leading to improved asset quality and enhanced profitability (Ben Ali & Ben Mim, 2022).). Democratic regimes are associated with political stability and foster a predictable operating environment for banks.

The Importance of Economic freedom

We find that the effects of economic freedom on bank profitability are negative, which suggests that greater economic freedom undermines bank performance. This argument is based on stronger entry into the sector and greater competition, which could undermine banks' profitability. Economic freedom often promotes competition by removing barriers to entry and encouraging market liberalization. Although competition can benefit consumers and promote efficiency, it can also lead to margin compression for banks. With increased competition, banks may be compelled to lower interest rates on loans and offer better terms to attract customers (Mavrakana & Psillaki, 2019). This can reduce net interest margins and, ultimately, impact profitability.

Another argument is that greater economic freedom can also imply greater competition for the banking sector from other financial intermediaries, such as hedge funds and private banks competing for bank deposits. These financial intermediaries also provide funds to companies, which can reduce bank profitability (Chortareas et al., 2013).

It has also been argued that a decrease in economic freedom can substantially increase a government's borrowing costs, with implications for bank performance; thus, the risk and

expenditure faced by corporate debtors could increase, and the increase in performing loans in the banking sector would undermine profitability (Roychoudhury & Lawson, 2010).

On the other hand, greater economic freedom can sometimes lead to reduced regulatory oversight or the relaxation of regulatory standards. In such cases, banks may face less stringent regulations, which can create an environment prone to excessive risk-taking and permissive lending practices (Gropper et al., 2015). Weaker regulatory oversight may increase the likelihood of financial crises or defaults, thus negatively affecting bank profitability.

Finally, although economic freedom generally promotes efficiency, it is possible that an excessively free market can lead to resource misallocation. In some cases, market forces may not efficiently direct capital to the most productive sectors of an economy (Abbas & Ali, 2022). Banks operating in economies with distorted market signals may face challenges in optimal deployment of funds, which negatively impacts their profitability.

The Influence of Macroeconomic determinants: GDP growth and Unemployment

Our study's findings align with prior literature, indicating that GDP growth (GDPG) positively impacts banking performance (Asteriou et al., 2021; Alhassan et al., 2016; Vu & Nahm, 2013; Hasan et al., 2009; Maudos et al., 2002). Enhanced GDP growth boosts banks' returns on assets (ROA) through mechanisms like increased lending opportunities, stemming from heightened economic activity (Nguyen & Nghiem, 2016; Buch et al., 2015), reduced non-performing loans (NPLs) due to improved borrower creditworthiness, and bolstered efficiency and cost management.

Conversely, there's a significant negative relationship between Unemployment (UNEMP) and banking performance, consistent with previous studies (Horobet et al., 2021; Berge & Boye, 2007; Pesola, 2005). Elevated unemployment levels amplify loan defaults, impacting ROA and return on equity (ROE). As individuals face job losses or financial challenges, rising non-performing loans (NPLs) occur, leading to augmented credit losses for banks (Zampara et al., 2017). Economic downturns, often accompanied by high unemployment (Huang et al., 2022), further strain businesses' profitability and ability to repay loans, deteriorating banks' asset quality and adversely affecting their performance metrics.

The Role of Banking Factors

The performance and health of banking sectors are often evaluated using specific variables associated with market structure and quality, specifically the bank non-performing loans to gross loans ratio (NPL), bank cost to income ratio (CIR), and bank net interest margin (NIM). The NPL ratio provides insights into the bank's asset quality and credit risk; the CIR assesses operational efficiency and cost management, and the NIM gauges the bank's profitability and efficiency from interest-earning activities. Together, these metrics offer a comprehensive view of the banking sector's competitiveness, risk management, and financial standing.

Our study underscores that bank profitability can be negatively impacted by credit risk, as indicated by the NPL ratio. Supporting this notion, research by Almekhlafi et al. (2016), Zhang et al. (2013), and Lin et al. (2012) also found similar detrimental effects. Elevated NPL ratios suggest a potential decline in profitability due to risks in the bank's loan portfolio, potentially leading to significant losses.

The bank's cost-to-income ratio (CIR) is revealed to have a significant negative correlation with banking performance, affecting both ROA and ROE models. High CIRs, indicative of elevated costs relative to income, can diminish profitability. This aligns with findings from prior studies, such as those by Dietrich & Wanzenried (2014), Athanasoglou et al. (2008), and Francis (2004).

Net interest margins (NIM) play an integral role in determining a bank's profitability. Banks with higher NIMs have the edge in generating more revenue from their assets than their liabilities, potentially leading to increased ROA (Puspitasari et al., 2021). Furthermore, competition, represented by the concentration metric (COMP), exerts a positive influence on ROA and ROE. This is attributed to factors like enhanced efficiency, improved risk management (Uddin et al., 2022), reduced borrowing costs (Kanas et al., 2018), and market expansion.

In our study, we also examine banking depth, focusing on the bank capital-to-assets ratio (CAR) and domestic credit to the private sector (DCP). CAR significantly impacts banking performance, with higher capital relative to assets improving ROA. This observation aligns with research findings from Molyneux & Forbes (1995) and Goddard et al. (2004). However, the DCP ratio can potentially reduce equity (ROE) due to increased credit risks, lower interest incomes, and economic downturns (Haddad et al., 2022; Jílková & Kotěšovcová, 2022; Akbar, 2021).

Our research also emphasizes the positive impact of Bank Branches (BRS) on ROE. An expansive bank branch network increases market reach, bolstering profitability. Leveraging localized market insights can enhance customer satisfaction and loyalty, further positively affecting ROE (Swanson & Zanzalari, 2021).

Lastly, the ownership status, represented by the foreign bank assets proportion (FRGNA), doesn't show a direct correlation with banking performance measures, ROA or ROE. This aligns with findings from Yildirim and Philippatos (2007). The bank's ownership, whether foreign or domestic, might not be a significant determinant of its financial performance. All banks, regardless of ownership, operate under the local regulatory framework, ensuring adherence to set standards, which minimizes ownership's impact on performance.

The Influence of Country's Legislative Regime

The electoral system dummy variable (ELEC) has a notable positive impact on both ROE and ROA in our banking model. Different electoral systems influence regulatory frameworks, affecting policy approaches. For instance, a mixed electoral system might foster a competitive banking environment and innovation (Baum et al., 2010), boosting performance metrics like ROE and ROA. Furthermore, the type of electoral system can sway political stability. While proportional representation might introduce policy instability due to fragmented politics, majoritarian systems often ensure steadier governance. Such stability benefits the banking sector, enhancing ROE and ROA.

Further Robustness Tests

To check the robustness and sensitivity of our baseline results, we use two alternative core explanatory variables for democracy (DEM-EIU: Democracy EIU obtained from the Economist Intelligence Unit and DEM-DEL: Deliberative democracy prepared by V-Dem) and one

alternative variable for economic freedom (EFI-H, Economic freedom issued by the Heritage Foundation).

Based on these alternative variables, we re-estimate the models using the aforementioned alternative variables and the system GMM technique, as originally applied in our research, and verify whether the main outcomes are sensitive to alternative estimation. In line with prior research, we re-estimate the main regression results using the feasible generalized least squares (FGLS) estimator (Ozili & Iorember, 2023), whose outcomes remain significant compared with those achieved through the GMM system.

Our overall robustness check suggests that democracy positively influences banking performance, while economic freedom negatively affects the performance of the banking systems. All the models presented in Tables I.1.2.3-5. and I.1.2.3-6. confirmed these results.

Table I.1.2.3-5. The results of robustness tests: ROA models

Dependent variable: ROA							
(Model)	**System GMM (1.14)**	**System GMM (1.15)**	**System GMM (1.16)**	**FGLS (1.17)**	**FGLS (1.18)**	**FGLS (1.19)**	**FGLS (1.20)**
$ROA_{i,t-1}$	0.180***	0.174***	0.214*				
	(0.035)	(0.032)	(0.122)				
DEM-LIB				2.485***	2.697***		
				(0.523)	(0.547)		
DEM-EIU	0.032**	0.038***				0.023***	0.026***
	(0.014)	(0.012)				(0.008)	(0.008)
DEM-DEL			2.570***				
			(0.536)				
EFI-F	-0.556**		-0.481**	-0.350***		-0.371***	
	(0.199)		(0.196)	(0.111)		(0.160)	
EFI-H		-0.035**			-0.020***		-0.023**
		(0.016)			(0.007)		(0.009)
GDPG	0.074***	0.063***	0.069***	0.066***	0.060***	0.050***	0.047***
	(0.024)	(0.020)	(0.024)	(0.007)	(0.007)	(0.008)	(0.008)
UNEMP	-0.029	-0.033**	-0.079***	-0.047***	-0.051***	-0.028***	-0.031**
	(0.018)	(0.016)	(0.029)	(0.010)	(0.012)	(0.012)	0.012
CIR	-0.015**	-0.014*	-0.019***	-0.019***	-0.019***	-0.017***	-0.016***
	(0.007)	(0.007)	(0.006)	(0.002)	(0.002)	(0.002)	(0.002)
CAR	0.103**	0.098***	0.041*	0.064***	0.064***	0.080***	0.078***
	(0.039)	(0.034)	(0.021)	(0.014)	(0.014)	(0.017)	(0.017)
NPL	-0.041*	-0.048*		-0.056***	-0.061***	-0.052**	-0.056**
	(0.022)	(0.027)		(0.010)	(0.010)	(0.011)	(0.011)
NIM	0.257***	0.262***		0.371***	0.384***	0.305***	0.289***
	(0.044)	(0.047)		(0.039)	(0.044)	(0.060)	(0.060)
COMP	0.002	0.001	0.006*	0.005***	0.004**	0.003	0.003*
	(0.004)	(0.003)	(0.003)	(0.001)	(0.001)	(0.002)	(0.002)
ELEC	0.248	0.213	0.191**	0.260***	0.219***	0.245***	0.194***
	(0.173)	(0.167)	(0.096)	(0.041)	(0.048)	(0.057)	(0.062)
DCP			-0.002*				
			(0.001)				
FRGNA	-0.001	0.0003	-0.0001	-0.0002	0.0003	-0.002	-0.001
	(0.002)	(0.003)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
BRS	-0.0007	-0.0007**	-0.0001	0.00004	-0.0002	-0.0005	-0.0004
	0.0005	(0.0004)	(0.0003)	(0.0002)	(0.0002)	(0.0003)	(0.0003)
Constant	1.989	-0.277	2.895*	1.473	0.131	1.579	0.153
	(1.537)	(1.449)	(1.664)	(0.913)	(0.644)	(1.234)	(0.819)
Observations	315	315	416	447	428	337	337
No. of countries	27	27	27	27	27	27	27
No. of instruments	27	27	31	na	na	na	na
AR(1) test (p-value)	0.093	0.091	0.091	na	na	na	na
AR(2) test (p-value)	0.096	0.094	0.348	na	na	na	na

Hansen test (p-value)	0.721	0.777	0.731	na	na	na	na
Chi2 test (p-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Source: Authors' processing. Notes: Standard errors in parentheses; ***, ** and * denote significance at 1, 5 and 10 percent level respectively; na – not applicable. This table reports results of two-step system GMM and FGLS methods (each column represents a separate regression model). System GMM is based on xtabond2 Stata command, with orthogonal (to use the forward orthogonal deviations transform instead of first differencing), collapse (to create one instrument for each variable and lag distance, rather than one for each period, variable and lag distance) and robust (with Windmeijer's finite-sample correction for two-step covariance matrix) options. For the system GMM methods, the instruments are the independent variables and the lag1 of variables that capture democracy. For the FGLS technique, the option panels(heteroscedastic) is used.

Table I.1.2.3-6. The results of robustness tests: ROE models

Dependent variable: ROE	**System GMM**						
(Model)	**System GMM (2.14)**	**System GMM (2.15)**	**System GMM (2.16)**	**FGLS (2.17)**	**FGLS (2.18)**	**FGLS (2.19)**	**FGLS (2.20)**
$ROE_{i,t-1}$	0.264***	0.374***	0.354***				
	(0.056)	(0.090)	(0.072)				
DEM-LIB				25.250***	32.855***		
				(5.428)	(6.026)		
DEM-EIU	0.291*	0.268*				0.207**	0.221**
	(0.154)	(0.146)				(0.090)	(0.100)
DEM-DEL			21.144**				
			(10.306)				
EFI-F	-4.320*		-9.112***	-8.447***		-6.216***	
	(2.298)		(3.453)	(1.163)		(1.643)	
EFI-H		-0.262*			-0.539**		-0.305***
		(0.145)			(0.087)		(0.109)
GDPG	0.659**	0.335***	0.642***	0.819***	0.710***	0.714***	0.625***
	(0.308)	(0.084)	(0.165)	(0.103)	(0.107)	(0.111)	(0.109)
UNEMP	-0.361	-0.436**	-0.588**	-0.764**	-0.947***	-0.508***	-0.637**
	(0.274)	(0.204)	(0.227)	(0.117)	(0.132)	(0.139)	(0.144)
CIR	-0.224**	-0.178*	0.238*	-0.261**	-0.238**	-0.243***	-0.225***
	(0.088)	(0.091)	(0.143)	(0.040)	(0.040)	(0.046)	(0.046)
CAR	0.721	0.408	-0.030	-0.148	-0.095	-0.015	-0.023
	(0.456)	(0.427)	(0.338)	(0.185)	(0.198)	(0.235)	(0.236)
NPL	-0.217						
	(0.212)						
NIM	1.524						
	(1.055)						
COMP	-0.016	0.023	0.039	0.064***	0.051**	0.058**	0.048*
	(0.044)	(0.042)	(0.048)	(0.022)	(0.021)	(0.027)	(0.026)
ELEC	2.612*	1.512	1.183	2.254***	1.452**	1.540**	0.928
	(1.582)	(1.091)	(0.812)	(0.594)	(0.610)	(0.725)	(0.778)
DCP		-0.034*	-0.049**	-0.061***	-0.057***	-0.056***	-0.057***
		(0.020)	(0.017)	(0.014)	(0.014)	(0.017)	(0.016)
FRGNA	-0.018	0.014	-0.002	0.014	0.044**	-0.0007	0.011
	(0.039)	(0.027)	(0.052)	(0.016)	(0.017)	(0.019)	(0.020)
BRS	0.006	0.003	0.009	0.021***	0.017***	0.011*	0.013**
	(0.013)	(0.007)	(0.006)	(0.005)	(0.005)	(0.006)	(0.005)
Constant	23.362	11.078	78.776**	74.140***	39.694***	56.318***	28.793***
	(21.730)	(9.473)	(34.671)	(9.161)	(7.074)	(12.735)	(8.868)
Observations	308	313	412	433	421	337	337
No. of countries	27	27	27	27	27	27	27
No. of instruments	27	26	30	na	na	na	na
AR(1) test (p-value)	0.026	0.036	0.015	na	na	na	na
AR(2) test (p-value)	0.056	0.267	0.636	na	na	na	na
Hansen test (p-value)	0.645	0.574	0.808	na	na	na	na
Chi2 test (p-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Source: Authors' processing. Notes: Standard errors in parentheses; ***, ** and * denote significance at 1, 5 and 10 percent level respectively. This table reports results of two-step system GMM and FGLS methods (each column represents a separate regression model). System GMM is based on xtabond2 Stata command, with orthogonal (to use the forward orthogonal deviations transform instead of first differencing), collapse (to create one instrument for each variable and lag distance, rather than one for each period, variable and lag distance) and robust (with Windmeijer's

finite-sample correction for two-step covariance matrix) options. In addition, the model 2.16 use the e(level) passthru option for GMM style (to create instruments for the levels equation that use not the first-differences of the specified variables but the original levels of the same dates). The instruments are the independent variables and their lag1 are additionally used as instruments.

I.1.2.4. Micro and Macroeconomic Implications

Delving into the nexus between democracy and banking performance unveils profound microeconomic and macroeconomic dimensions, illuminating their complex interrelation.

On the *microeconomic* front, our study underscores several strategies for banks to elevate their profitability, notably in ROA and ROE terms:

- Emphasizing economic freedom with caution: While pivotal for broad economic progression, unchecked economic freedom may dent profitability. Banks should harmonize economic freedom and competitiveness, employing innovative tactics, refining risk management (Papanikolaou, 2019), and bolstering operational efficacy.
- Capital adequacy and risk management: A robust capital foundation, epitomized by the capital to assets ratio (CAR), ensures banks procure funding on favorable terms and curtail borrowing overheads (Jílková & Kotěšovcová, 2022). Coupled with rigorous risk assessment and credit monitoring, this strategy curbs non-performing loans (NPLs), enhancing profitability.
- Cost control and operational efficiency: By digitally revolutionizing operations (Theiri & Hadoussa, 2023), eradicating inefficiencies, and judiciously managing expenses, banks can fine-tune the cost-income ratio (CIR), driving up their ROA and ROE.
- Nurturing customer relationships and market expansion: Prioritizing customers through competitive rates, tailored services, and state-of-the-art digital tools, and broadening bank branch networks (BRS), can magnify market penetration and profitability.
- Managing credit risk and asset quality: Proactive loan oversight and risk detection minimize credit losses, trim NPLs, and fortify asset health, subsequently boosting profitability.
- Political stability and policy continuity: Banks thrive in stable political climates, enabling long-term strategic foresight and informed investments (Klomp & De Haan, 2014), reinforcing customer trust and fiscal outcomes.

On the *macroeconomic* spectrum, several implications emerge, suggesting mechanisms to buttress banking profitability:

- Democracy's Essence: A robust democratic framework correlates with superior banking performance. Thus, nations should fortify democratic tenets like transparency, accountability, and legal adherence, cultivating an ideal environment for banking (Li et al., 2019). This encompasses stringent financial norms, equitable competition, and a consistent policy structure.

- Harmonizing Economic Liberty: While excessive economic freedom can dent banking profitability, nations should strike a balance. Ensuring a milieu that fosters entrepreneurship, alongside prudent regulatory checks, safeguards financial equilibrium (Chortareas et al., 2013).

- Economic Proliferation: Policies accentuating economic growth and curbing unemployment boost banking profitability. Such strategies encompass infrastructural advancements, educational investments, and a conducive entrepreneurial atmosphere (Alhassan et al., 2016).

- Risk Governance: States should emphasize stringent risk-management norms and practices. This encompasses meticulous bank supervision, loan loss provisioning, and endorsing responsible lending. These measures, by curtailing NPLs, augment bank profitability (Psaila et al., 2019).

- Operational Prowess: Governments can bolster bank efficiency through digital transitions and procedural simplification, culminating in a reduced cost-to-income ratio (CIR) and enhanced profitability (Jílková & Kotěšovcová, 2022).

- Market Competition: Fostering competition, by preventing monopolistic tendencies, nudges banks towards innovation and efficiency, catalyzing profitability.

This analytical framework bequeaths policymakers with invaluable insights. It demystifies the intricate balance between democratic governance, economic autonomy, and banking dynamics, revealing how varying governmental actions influence economic liberty. By considering a plethora of variables—from broad macroeconomic indicators to intricate banking facets—policymakers can grasp the nuances of national policies over decades. The spotlight on the electoral regime's effect on banking outcomes emphasizes the symbiotic relationship between political choices and financial stability. Armed with this knowledge, they can craft policies that harmonize economic liberty with banking system robustness. A robust regulatory architecture, underpinned by government action, remains paramount to instill banking system confidence.

I.1.3. Concluding remarks

This study investigates the impact of democracy and economic freedom on bank performance and examines the moderating roles of macroeconomic determinants, banking-specific factors, and a country's legislative regime of the given relationship.

The choice of democracy and economic freedom as core explanatory variables for banking performance is explained through the features of these indicators because they are valuable not only individually, from the perspective of human dignity, but also in that together they form a philosophy of governance and an essential tandem of economic progress and prosperity, both at the individual and organizational levels.

We find that democracy improves the performance of the banking sector in the European Union, whereas economic freedom worsens it. The results highlight the role of democracy and economic freedom in ensuring banking performance as an essential prerequisite for the sound banking system and financial stability of 27 European Union countries over the last 20 years (2001–2020).

The results were obtained through a progressive series of data testing through static panel models (pooled OLS, fixed effects, random effects, FGLS – feasible generalized least squares (FGLS)) and the dynamic two-step system GMM method, suitable because of its capability to deal with heteroscedasticity, serial correlation, and endogeneity, and because it allows a dynamic approach based on estimating the effect of the lagged dependent variables (ROA and ROE). The results show a positive correlation between ROA_{it-1} and ROA (as well as between ROE_{it-1} and ROE), which underlines the dynamic persistence of ROA (or ROE) and confirms the dynamic specification of the models. To ensure model stability, we include macroeconomic determinants (GDP growth and unemployment), bank-specific factors, and a dummy variable that captures the electoral country's system. We consider several bank-specific factors that could affect banking performance, grouped into the following categories: market structure and quality of the banking sector (cost-to-income ratio, nonperforming loans, net interest margin), banking depth and capital (domestic credit to private sector % of GDP, bank capital to assets ratio), aspects regarding competition and expansion (concentration assets of the three largest commercial banks as a share of total commercial banking assets, bank branches), and ownership status (assets of foreign banks divided by total bank assets).

This study presents a generally positive effect of democracy on bank profitability, addresses the issue of sensitivity, and provides a comprehensive analysis of three indicators of democracy: the liberal democracy index (DEM-LIB, issued by V-Dem), the Democracy index released by the Economist Intelligence Unit (DEM-EIU), and deliberative democracy (DEM-DEL, prepared by V-Dem), each offering unique insights into the democratic landscape of the studied states. These findings suggest that as a country's level of democracy increases, banking performance also improves. This positive effect can be attributed to several factors. First, stronger financial and banking regulations are notable attributes of democratic societies. As democracy levels increase, regulatory frameworks become more robust, leading to reduced credit risk, improved institutional frameworks, and ultimately, a more profitable banking system. Additionally, democratic regimes emphasize financial inclusion, market competition, and social welfare, which result in a broader customer base, enhanced competition among banks, and increased profitability. Democracy plays a significant role in the promotion of macroeconomic stability. This stability enhances banks' ability to maintain sufficient capital levels, resulting in stronger financial positions, as indicated by higher capital-to-asset ratios. Democratic societies have established transparent and accountable regulatory systems that foster fair competition, reduce corruption, and build trust between customers and investors. These factors collectively contribute to a favorable business environment for banks, leading to improved asset quality, effective risk management practices, and enhanced profitability. Political stability is an important aspect of democratic governance. Stability encourages investment, lowers unemployment rates, and improves job security. By ensuring a level-playing field, democracy facilitates access to credit for the private sector and promotes economic growth. This analysis suggests that democracy plays a multifaceted and dynamic role in shaping banking performance. These findings underscore the importance of strong regulatory frameworks, financial stability, and good governance in driving positive outcomes in the banking sector. Democratic societies tend to prioritize these aspects, resulting in efficient banking systems, lower cost-to-income ratios, improved loan quality, reduced nonperforming loan ratios, and increased confidence in the banking sector. These characteristics contribute to the overall growth and stability of the economy, benefiting both, banks and the societies in which they operate.

In terms of economic freedom, our results show that greater economic freedom is associated with a decrease in bank profitability. The mechanisms that determine such a relationship are multiple and arise from the complexity with which economic freedom is captured and the number of facets of the quality of political-economic institutions it illustrates. The main findings are based on the Economic Freedom Index (EFI-F) issued by the Fraser Institute, and the Economic Freedom Index disclosed by the Heritage Foundation was used as a robustness check. In countries where the degree of economic freedom is increasing, access to credit for low-quality borrowers is easier, leading to a decrease in banking performance generated by non-performing loans and loan losses. Better economic freedom can lead to increased competition in banking systems and potentially lower bank profitability. High degrees of economic freedom are associated with deregulated legislative environments, with lax and permissive normative acts for bank operations; thus, they may be tempted to engage in high-risk operations at the limit of legality, which can generate huge revenues. However, many of these high-risk operations can lead to major losses for banks. In addition, a permissive legislative environment leaves banks free to act discretionarily in dealing with customers, often harming them, and the subsequent legal suits won by clients can lead to bank expenses. Media coverage of such behaviors can erode customers' confidence in the

banking environment and banking reputation, which implicitly leads to a decrease in access to banking services, impacting banks' earnings. Finally, the membership of the studied states to the European Union, with a general framework of freedom of capital movement, makes international banking operations common, but seven of the 27 analyzed states have not yet adopted the euro as their national currency, which exposes them to exchange rate losses. In addition, if, against the backdrop of economic freedom that allows banks to engage in international operations, they turn to countries with political or economic instability, it may lead to losses. In summary, even if economic freedom shows numerous benefits, there are situations in which a high degree of economic freedom is associated with excessive risk-taking, unhealthy competition, consumer exploitation, income inequality, and exposure to international risks. These factors could negatively affect banking performance, emphasizing the need for a balanced approach.

This study has theoretical and practical implications. From a theoretical perspective, it estimates the impact of several variables (socio-political, quality of political-economic institutions, macroeconomic, bank-specific, and legislative proxies) on banking performance.

Understanding the relationship between democracy and these variables is crucial for policymakers, regulators, and industry practitioners, especially managers, to create a conducive environment that supports sustainable and profitable banking operations. Other categories directly interested in the studied issues are investors, other stakeholders, and academia, whose interests converge towards bank performance.

Our study's outcomes, particularly in the context of contemporary events with geo-political tensions and threats to democracy at the Eastern border of the European Union, amid the military conflict in Ukraine, suggest several policy implications:

- *Democratic Governance:* There's a clear link between robust democratic structures and improved banking performance. The current global focus on democratic challenges signifies potential impacts on the banking sector. Hence, emphasizing transparency, the rule of law, and financial regulations is crucial for a stable banking environment.
- *Economic Freedom Regulation:* While fostering economic freedom enhances competition and innovation, it may have side effects on banking. Policymakers should merge economic liberalization with protective measures for banks. Given the growth of diverse financial intermediaries and global integration, a reexamination of the balance between market freedom and oversight is imperative.
- *Macroeconomic Strategies:* The positive effect of GDP growth on banking underscores policies promoting economic growth, such as fiscal incentives and pro-business regulations. With the adverse implications of unemployment on banks, job creation and labor reforms become pivotal, especially during global crises or economic slumps.
- *Response to Global Events:* The banking sector's vulnerability to macroeconomic shifts and governance dynamics means that significant global incidents can influence banking robustness. Proactive policy adjustments in response to such events are essential.
- *Regulatory Evolution:* The changing global scenario necessitates regular revisions of banking and financial regulations to ensure both sectoral stability and growth.

Chapter I.2. MACROECONOMIC DETERMINANTS OF NONPERFORMING LOANS OF ROMANIAN BANKS[2]

The connection between nonperforming loans (NPLs) and bank losses has been analysed by authors from around the world and is considered a very important chapter in banking literature. Rising NPLs are often referred to as the failure of banks to manage credit policy.

In the last two decades, there has been a significant increase in the volume of loans granted by banks (Cingolani, 2013). This increase was due to the process of deregulation of financial markets and the development of information technologies in the banking field. These processes have led to improved financial intermediation (Panopoulou, 2005; Rinaldi & Sanchis-Arellano, 2006).

However, the financial crisis is also the result of the high NPL rate in the banking sector. The financial crisis of 2008 started in the USA and spread all over the world because all countries had trade relations with the USA. That crisis has been labelled as a cause of default on mortgages and loans. Increasing the NPL rate is the main reason for reducing bank revenues and, implicitly, for decreasing profits or recording losses. The reason for the NPL separation is the low repayment capacity of debtors, coupled with a high interest rate. Since 2008, the year of the onset of the global financial crisis, NPL levels have risen significantly.

As the existence of nonperforming loans, being a special category of loans, cannot be ignored, it is necessary to manage and separate this type of loan to a special portfolio of nonperforming loans. The negative aspects and impact of these loans affect not only on the bank and its customers but also the economy on a macroeconomic level.

Bank practice has identified a multitude of causes generating nonperforming credits, grouped as follows, depending on the factors generating them:

- Macro level causes: political causes, economic causes, market causes, legislative causes, and competition causes.
- Causes generated by the loan beneficiaries: the weak management of the debtor companies.
- Causes independent of the customer's activity: fraud, takeovers, failure to comply with the provisions of the loan.
- Causes entirely due to the fault of the bank: a mistaken analysis of the customer's situation.

A flexible credit policy may also be the reason for a high volume of national credit, as happened in Romania. The bank sector serves the biggest part of the Romanian economy. The Romanian banks offer a large range of services to companies and individuals: conventional banking services, a variety of instruments for investments, and solutions for specialised financing. As the cornerstone of the national financial system and through its functions, the bank sector has special importance for the Romanian economy. The manner in which the bank sector develops its activity becomes an essential condition for the maintenance of financial stability and the insurance of sustainable economic development.

Therefore, it is clear why the NPL rate is crucial for banks. After the crisis in Romania in 2008, the unemployment rate increased significantly, the level of salaries of employees in state

[2] This section is based on the article: Hada T, Bărbuță-Mișu N, **Iuga IC**, Wainberg D. 2020. Macroeconomic Determinants of Nonperforming Loans of Romanian Banks. *Sustainability*, 12(18):7533. https://doi.org/10.3390/su12187533. WOS: 000584311700001

institutions decreased significantly—with a direct impact on NPLs (a large part of employees had contracted bank loans at that time)—and the inflation rate recorded significant changes. The exchange rates of RON–CHF, RON–EURO, and RON–USD almost doubled, affecting the repayment of loans (loans in progress and contracted before 2008) granted by banks in these currencies.

In this context, our study analyses the influence of certain macroeconomic factors from the category of the economic factors (the RON–CHF exchange rate, the RON–EUR exchange rate, the RON–USD exchange rate, the unemployment rate, the inflation rate) on the NPLs in the Romanian banking system. We mention that we chose the EUR, USD and CHF currencies due to their high proportion in Romanian foreign-currency credit granted to individuals and companies. Our paper compares the analysis before the initiation of the process of writing-off the unrecoverable NPLs (in 2014) and after 2014. Thus, the goal of this study is to present the most important aspects related to NPLs and to analyse the sensitivity of NPLs with respect to macroeconomic indicators in Romania. In particular, it uses regression analysis and a time series data set covering around 10 years (in the period 2009–2019) to examine the relationship between the nonperforming loan rate and some key macroeconomic variables that have changed significantly since 2008.

I.2.1. NPL and Macroeconomic Determinants: a brief literature review

There are many articles that have studied the links between the financial system and the economy. The most important examples are Bernanke and Gertler (1989) and Bernanke, Gertler and Gilchrist (1998) who developed the concept of the financial accelerator, arguing that credit markets are cyclical and that information asymmetry between creditors and debtors has an effect on amplifying and spreading shocks on the credit market. The Kiyotaki and Moore (1997) model showed that if credit markets are imperfect, then relatively small shocks might be sufficient to explain business cycle fluctuations.

Competition has increased in the domestic and European banking markets, being strengthened by the deregulation process (Salas and Saurina, 2002). Banks have created permissive lending conditions to attract customers. Low interest rates, rising house prices and a stable economic environment characterised the precrisis period. This situation has led to the expansion of credit from both supply and demand. In our paper, we focus on the postcrisis period, characterised by high interest rates, falling house prices, and an unstable economic environment (rising unemployment, rising inflation, declining wages).

Several studies have examined the causes of NPLs and problem loans (e.g., Fernandez de Lis, Pagés & Saurina, 2000; Boudriga, Taktak & Jellouli, 2009; Espinoza & Prasad, 2010).
An important number of studies in the literature on NPLs have focused exclusively on the role of macroeconomic or country-specific causes and have found that they have had the most significant effect. Espinoza and Prasad (2010) tried to distinguish the determinants of NPLs for the Gulf Cooperative Council (GCC) banking system. The result of their study was that the NPL ratio increases when economic growth slows and risk aversion decreases, but also when interest rates rise. It is important to note that exchange rates and unemployment were not used as regressors due to the exchange rate regime and low and stable unemployment in the GCC countries.

Nkusu (2011) used a methodology similar to that of Espinoza and Prasad (2010). He tested an econometric model that explains NPLs using only macrovariables and found that a worsening of the macroeconomic environment (i.e., a higher unemployment rate) is closely related to the

problems of repayment/nonrepayment of loans and improving the macroeconomic environment implies a decrease in nonperforming loans. In recent years, interest in nonperforming loans and their determinants has increased significantly as we encounter more data published at the banking level by each country and at the level of the aggregate banking system. Many NPL studies have been published, whose results reveal important information about the quality of loan portfolios and, in general, the fragility of banks. Many researchers view NPLs as financial pollution with huge effects on both economic development and social life (e.g., Gonzales-Hermosillo, 1999; Barseghyan, 2010; Zeng, 2012).

In the studies of Baboučak and Jančar (2005) for the Czech Republic and Hoggarth, Logan and Zicchino (2005) for the United Kingdom, the VAR methodology was used. They found that the important factors influencing financial stability and the quality of the loan portfolio were the dynamics of inflation and interest rates. Baboučak and Jančar (2005) found evidence of a positive correlation between NPLs, unemployment rates and consumer price inflation, while GDP growth decreases the NPL rate. They also found that the actual appreciation of the effective exchange rate did not have an exaggerated influence on the NPL ratio. Regarding the Greek banking market, Louzis, Vouldis and Metaxas (2012) examined the effect of various macroeconomic factors on NPLs, studying each type of loan in the nine largest Greek banks. The authors found that the real GDP growth rate, unemployment rate and lending rates have a strong negative effect on the NPL level, interpreting them as a sign of poor banking management.

Vogiazas and Nikolaidou (2011) investigated the determinants of nonperforming creditors in the Romanian banking sector during the Greek crisis (December 2001–November 2010) and found that inflation and external GDP information are proportional and influence the credit risks of the banking system in the country. Our study is distinguished from the previous ones by investigating the impact of the exchange rate of the most used currencies (EUR, USD and CHF) on the granting of credit in Romania and the impact of unemployment and inflation rates on nonperforming loans after the crisis of 2008 (i.e., in the period 2009–2019, when the effects of the crisis were visible in all sectors of activity and especially on the banking system). We also present the most important determinants used in the literature for studying nonperforming loans, considering that the continuous analysis of the quality of the loans is a repetitive action, with several stages that are more important, namely, the stages before granting the credit, the granting of credit stage and the postgrant stage. Many studies have analysed various factors that can influence NPLs. In the next subsections, we present these factors grouped into the major factors of influence.

I.2.1.1. NPLs and NPL Data Analytics

Previous studies have examined the economic determinants of the NPL: “Greater capitalization, liquidity risks, poor credit quality, greater cost inefficiency and banking industry size significantly increase NPLs, while greater bank profitability lowers NPLs” (Ghosh, 2015). The following variables significantly impact the NPL level: GDP real growth, share price, exchange rate and interest rate (Beck et al, 2015). The assumption is that the macroeconomic variables and also the variables specific to the banks have an impact on the loan quality, depending on the loan category. For example, the NPLs from the Greek bank system can be mainly explained by macroeconomic variables (GDP, unemployment, interest rates, and public debts) and by the quality of the management (Louzis et al., 2012).

Studies from various countries have identified the following factors that determine NPLs: inflation rate, unemployment rate, GDP level, ROA, ROE, liquidity, capital adequacy, size of the bank, volume of the deposits and interest rate (Salas & Saurina, 2003). For the saving banks, the GDP, the nonguaranteed loans and the net margins of interest affect NPLs, while for the commercial banks, the factors that affect NPLs are the size of the banks, their capital ratios and the expansion of their branches (Salas & Saurina, 2002).

Knowledge-sharing processes and innovation processes of Islamic banks are integral parts of the survival and progress of business organisations. Another article conducted an empirical evaluation of the Czech public START program (funded by the European Regional Development Fund), a program that supported new entrepreneurs through zero-interest loans and credit guarantees. The obtained findings could not support the hypothesis of a positive impact of the programme on a firm's performance (Dvouletý, 2017).

A model was created using latent variables of capital adequacy, operations, asset quality, size and profile of the countries in which they were based—this model can predict bank profitability. The study was conducted on the 100 largest banks between 2011 and 2015 (Gemar et al., 2019).

I.2.1.2. NPLs and Macro Level Factors

Most studies considered macroeconomic factors as factors influencing NPLs.

The real *GDP*: Some authors have stated a negative relationship between GDP and NPLs (Bofondi & Ropele, 2011; Jiménez et al., 2006). Another study uses the data from the USA bank sector and takes into consideration real GDP per capita, inflation and total loans as independent variables, and the NPL ratio as a dependent variable. All the selected independent variables have a significant impact on the dependent variable, but, still, the values of the coefficients are not too high (Saba et al., 2012).

The *economic growth*: Another idea showed that NPLs affect the economy by slowing economic growth (Bock & Demyanets, 2012). A study that analysed the situation in Hong Kong remarked that the NPL ratio grows together with the growth of the nominal interest rate but decreases once the inflation increases with economic growth (Gerlach et al., 2005).

The *lending rate*: Research on Italy found that the lending rate has a negative relationship with NPLs (Bofondi & Ropele, 2011).

The *unemployment rate*: Some studies concluded that NPLs grow when the unemployment rate is high, while (Klein, 2013) showed that the unemployment rate has a negative impact on the quality of the bank loans (Bofondi & Ropele, 2011). NPLs increase when the unemployment rate grows and the debtors are confronted with difficulties related to the return of the loan (Jiménez et al., 2006).

The *inflation*: Inflation is positively connected to NPLs (Klein, 2013), while a lower inflation rate has a positive influence on the debtors' financial conditions and, eventually, on the recovery of the loans, meaning that it presents a positive relationship between the inflation rate and NPLs (Abid et al., 2014).

The *market competition*: The economic development of the country results in market growth. Market competition compels enterprises to increase their activity, i.e., to concentrate it (Ginevičius, 2007). Rehman et al. (2016) sustained that taking effective measures to increase bank competition can create a level playing field for other banks and may reduce strict collateral requirements for companies.

The *exchange rate*: The high number of NPLs leads to a depreciation of the exchange rate (Bock & Demyanets, 2012) and hence NPLs have, as a result, a depreciation of the exchange rate (Klein, 2013). At the same time, some authors affirmed that a depreciation of the national currency can lead to more NPLs (Chaibi & Ftiti, 2015).

The *boom/recession/expansion period in the economy*: The quality of bank loans of Italian banks is lower during recession periods and higher during expansion periods. The internal factors that influence NPLs are efficiency, the indicator of income from interest to total assets, and the slow growth of loans. The external factors affecting NPLs are the GDP and the interest rates (Quagliariello, 2007).

The *governance indicators*: The governance indicators are significant factors influencing NPLs (Anastasiou et al., 2019). Using techniques for the estimation of data, a study examined the determinant factors of NPLs in the Turkish bank system. The results of the study showed that the determinant factors of NPLs changed after the crisis and that the macroeconomic and political determinant factors have a higher significance (Vuslat, 2017).

The *bank concentration*: Bank concentration may reduce NPLs by enhancing market power and boosting bank profits so that high profits can provide a "buffer" against adverse shocks (Beck et al., 2006). Çifter (2015) examined the effect of bank concentration on nonperforming loans (NPLs) for ten Central and Eastern European (CEE) countries and concluded that the relationship between the concentration of banks and NPLs, with regard to CEE countries, is ambiguous.

I.2.1.3. NPL and Nonspecific Factors

There is still a group of factors that we have included in the group of nonspecific factors because their influence differs from country to country. This group of factors would be the factors that influence trust in internet banking (such as provided information, e-banking system, a bank's website and bank characteristics). Another factor that falls into this group is perceived value. The results of the studies show that three components of perceived value (economic value, comfort value and emotional value) increase the intention to use banks that are only on the internet (Ahn &Lee, 2019). Another study contributed to the specialised literature on the correlation between ecological lending and credit risks and concluded that the institutional pressure of green credit policy has a positive effect on both the environmental performance and financial performance of banks (Cui et al., 2008). Some authors combined the two large groups of factors in their studies. They found a positive relationship between GDP growth, inflation and bank performance, whereas a negative relationship between tax burden and performance (Demirgüç-Kunt & Huizinga, 1999). The bad-management and moral-hazard hypotheses explain a significant part of NPLs (Berger & DeYoung, 1997).

I.2.2. Materials and methods

I.2.2.1. The Dependent and Independent Variables

As defined in the literature, nonperforming loans are the loans that are delayed for a long period, according to the loan contract. According to Tesfaye (2012), any loan that is not recovered in due time is known as nonperforming. The rate of nonperforming loans, according to the ABE definition, is calculated using the following formula: nonperforming exposures from loans and advances/ exposures from loans and advances. According to the ABE definition, which was nationally implemented through Order 6/2014 of the National Bank of Romania, nonperforming

exposures are the one of the following criteria: (1) there are significant exposures, with over 90 days' delay from the recovery date, and (2) it is considered that lacking a real guarantee, it is improbable for the debtor to integrally return his debts, disregarding the existence of a certain sum or a certain number of delays in payment.

In this study, we used the rate of nonperforming loans (NPLs) from the Romanian bank system as a dependent variable. With regard to the independent variables, we used the following macroeconomic factors: RON–CHF exchange rate (RON_CHF), RON–EUR exchange rate (RON_EUR), RON–USD exchange rate (RON_USD), the unemployment rate (UR) and the harmonised index of consumer prices (HICP) inflation rate.

The variables used in this study were selected from the total of possible variables based on the criterion of impact on nonperforming loans of the population, and, moreover, these variables changed significantly during the analysed period compared to the other variables listed above. Thus, following the documentation at a series of banks in Romania, we found that:

- the variable unemployment rate influences the outstanding loans of the individuals because the credited persons have fewer possibilities to repay the loan taken due to a lack of income, the unemployment benefits being small in Romania (below 100 euro/month). We have considered this variable in the study because of the consequences of the crisis, which led to more bankruptcies, the reduction of activity in many sectors, followed by staff lay-offs or a reduction of monthly salaries, both from the private and public sectors. This situation increased the unemployment rate and implicitly reduced the income of individuals. In Romania, the majority of active persons used real estate loans, mortgage loans or personal loans for purchasing buildings or other durable goods that were granted in CHF, EUR and USD, and the individuals that were laid off or had their salaries cut found it impossible to reimburse credits and this generated the increase in NPLs;
- the inflation rate influenced the level of outstanding loans by the fact that a high inflation rate reduces the purchasing power of the population, generating the decrease of the population's real income because a great part of the income is used for consumption. Therefore, the reduction of the individuals' incomes leads to a reduction in the ability to repay loans. Thus, inflation can negatively affect the debtor's service capacity (Erdinc & Abazi, 2014). Inflation negatively affects the ability of debtors to repay creditors (Nkusu, 2011). We expect a negative impact of inflation on NPLs as a rapid rise in prices exacerbates market frictions, forcing banks to exercise caution in lending (Boyd et al., 2001).
- the RON–EUR, RON–USD and RON–CHF exchange rates significantly reduced the population's income and influenced a decrease in the credit repayment capacity by the fact that during the analysed period, the RON–CHF, RON–EUR, and RON–USD exchange rates increased permanently. The reduction of the population's income was generated by the fact that Romanian individuals received their salaries in RON and had to pay loans granted in EUR, USD and CHF. The increase in the exchange rate of these currencies generated an increase of monthly credit rate, and this situation made it impossible for individuals to pay their debts to banks.

I.2.2.2. Data

The study used an explanatory analysis and also an econometric analysis based on the data from 2009 until January 2019 in order to investigate the relationship between NPLs and the 5

macroeconomic factors selected and presented in Section I.2.1. For each variable, 110 monthly values were considered. The data for our study were taken from the metadata database of the National Institute of Statistics of Romania (www.insse.ro), from the database of the National Bank of Romania (www.bnr.ro), and from the Eurostat database (https: //ec.europa.eu/eurostat/data/database). For econometric analysis, we used the statistical package EViews.

A summary table of statistics for these variables is given below (Table I.2.2.2-1.).

Table I.2.2.2-1. Descriptive statistics for the considered variables

Variable	Mean	Std. Dev.	Min.	Max.
NPL	13.04	4.79	4.95	22.52
RON_CHF	3.75	0.38	2.80	4.28
RON_EUR	4.44	0.15	4.09	4.70
RON_USD	3.60	0.41	2.84	4.28
UR	6.29	1.09	3.70	7.90
HICP	97.62	4.90	84.03	105.98

Source: authors' estimations

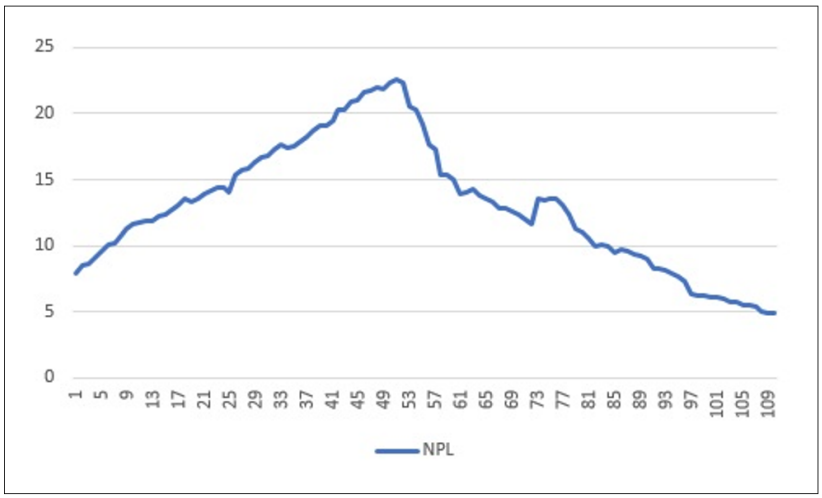
Analysing data presented in Table I.2.2.2-1., we found that the average rate of NPLs is 13.04%, the maximum value being 22.52%. Related to the evolution of the exchange rate, we can see that the RON–CHF exchange rate increased by 52.86% in the period analysed, the RON–EUR exchange rate increased by 14.91%, and the RON–USD exchange rate increased by 50.70%. The average unemployment rate was 6.29%, and the maximum value of the inflation rate was 5.98%.

A graphic representation of the NPL rate with 110 values (calculated monthly, starting at 1 December 2009 until 31 January 2019) is presented in Figure I.2.2.2-1. We observe that the trend increases for the period 2009–2014 and decreases between 2015 and 2019. This makes us think that there may be a structural break in the NPL ratio.

The novelty element in the general representation of banking activity from 2014 is the initiation of the process of writing-off the uncollectable nonperforming loans, following the recommendations of the National Bank of Romania, a process considered a necessary condition for the sustainable relaunch of credit. The year 2014 registered a significant decrease in nonperforming loans registered in the balance of the banks because of the operations of direct decrease in the value of unrecoverable loans, covered in a high percentage with adjustments for depreciation, that were made at the recommendation of the National Bank of Romania. Considering the limited efficiency of the techniques previously used by commercial banks in order to diminish the number of nonperforming loans – most often restructuration/rescheduling and foreclosure—the National Bank of Romania recommended the cleaning of portfolios in four stages:

- Writing-off the entirely provisioned nonperforming loan (the banks reserved their right to recover the loan).
- The integral forecasting and write-off of loans with a payment delay longer than 360 days.
- The integral forecasting and write-off of loans to companies in insolvency.
- An external audit of the provisions constituted according to IFRS and the guarantees.

The result of these activities was a decrease in the NPL rate from 20.4% in March to 13.9% in December 2014 (see Figure I.2.2.2-1).



Source: database of the National Bank of Romania (www.bnr.ro)

Figure I.2.2.2-1. The evolution of the NPL rate for the 2009–2019 period

In our analysis, the dependent variable rate of NPLs is studied by considering as independent variables the exchange rates (RON–CHF, RON–EUR, RON–USD), the unemployment rate (UR) and the inflation rate (HICP), measured in the same statistic interval. As noted on the National Institute of Statistics of Romania website (www.insse.ro), we observe an upward trend of the inflation rate and a downward trend of the unemployment rate during the analysed period (starting on 1 December 2009 until 31 January 2019). From the National Bank of Romania website (www.bnr.ro), we observed an upward trend, with small oscillations for all three exchange rates (RON–CHF, RON–EUR, RON–USD).

The model chosen for studying the influence of the independent variables selected on the NPL rate is the multiple regression model, presented in the form of a linear relation:

$$y_i = \beta_1 x_{1i} + \beta_2 x_{2i} + \ldots + \beta_p x_{pi} + u_i, \quad (1)$$

where $i = 1, \ldots, n$, y_i represents the values of the explained variable Y, and $x_{1i}, x_{2i}, \ldots, x_{pi}$ are the values of the independent variables $X_1, \ldots, X_p$. The coefficients $\beta_1, \beta_2, \ldots, \beta_p$ are the parameters of the regression model, and u_i are the values of the residual variable.

I.2.2.3. The Estimation of the Parameters and the Validation of the Regression Model

In this section, we made a univariate analysis of the series analysing the presence of unit roots through the augmented Dickey–Fuller (ADF) test in order to determine the order of integration of each series. The results of the augmented Dickey–Fuller test is presented in Table I.2.2.3.

Table I.2.2.3. Unit root test

Unit Root Test—ADF		
H0 = There is a Unit Root		
Variable	Statistical Value of the Series in First Differences	Reject H0 at 95%
NPL	−1.931625	Yes
RON_CHF	−1.695445	Yes
RON_EUR	−2.885321	Yes
RON_USD	−2.969274	Yes
UR	−4.433165	Yes
HICP	−1.359764	Yes

Notes: The number of lags was determined according to the Akaike criterion.
Source: authors' estimations

From the information provided in Table I.2.2.3., we conclude that all the variables are first-order integrated, I(1).

I.2.3. Results and discussions

I.2.3.1. Interpretation of the Obtained Results

In this section, we obtain the elements of the multiple regression model, as well as the values of certain indicators and tests for the appreciation of the validity and quality of the equation attached to the model. Therefore, after creating the group formed from the variables presented above, we defined the equation corresponding to the multiple regression model, with the rate of the nonperforming loans (NPLs) as the dependent variable and RON–CHF, RON–EUR, RON–USD, UR and HICP as independent variables, also defining the constant variable C, corresponding to the impact of other exogenous variables influencing NPLs, which are not considered in the present analysis. The estimation of the parameters in the equation of the regression model was made using the method of least squares.

The obtained values, representing, at the same time, the coefficients of the variables in the regression model and the results from the tests, are presented in Table I.2.3.1-1.

Table I.2.3.1-1. Estimations results

Dependent Variable: NPL				
Explanatory Variable	Coefficient	Std. Error	t-Statistic	Prob.
RON_CHF	1.695445	1.820228	0.931447	0.3538
RON_EUR	15.50740	3.957474	3.918510	0.0002
RON_USD	5.969274	1.460210	4.087956	0.0001
UR	4.433165	0.333343	13.29911	0.0000
HICP	0.339662	0.111708	3.040627	0.0030
C	−101.6536	13.38608	−7.593980	0.0000
R-squared	0.781285			
Adjusted R-squared	0.770770			
Prob(F-statistic)	0.000000			

Source: authors' estimations

One of the most important assumptions of any time series model is that the underlying process is the same across all observations in the sample. It is, therefore, necessary to analyse carefully the time series data that include periods of violent change (as we observed for the NPL ratio, in Figure I.2.2.2-1.). A tool that is particularly useful in this regard is the Chow test. The null hypothesis for the test is that there is no breakpoint (i.e., that the data set can be represented with a single regression line). We assumed that there is no structural break between the first five years and the last five years of the period.

As the content of Table I.2.3.1-2. confirms, the null hypothesis is rejected, i.e., the regression is not stable over the considered data sets. Because of this structural break, we will estimate the model for the 2009–2014 period and 2015–2019 period separately.

Table I.2.3.1-2. Regression stability test (Chow test)

Score	C.V.	*p*-Value	Stable?	5.0%
21.813	2.461	0.00%	FALSE	

Source: authors' estimations

I.2.3.2. An Overview of the Period 2009–2019

From Table I.2.3.1-1., we find a linear relationship between NPLs and their explanatory factors, statistically significant at a significance level of 1% (Prob(F-statistic) = 0.000). The sign of each coefficient is the expected one, being positive. If each of the considered macroeconomic components increases, nonperforming loans will also increase. All the variables studied place the level of NPLs at 78.12% (R-squared = 0.7812).

Therefore, based on the values above, we can affirm that the model of linear multiple regression can be accepted for the correlation and interdependence between the NPL rate and the macroeconomic indicators: the exchange rate, the unemployment rate, and inflation. However, as we mentioned before, this regression is not stable, according to the Chow test, and because of that, we have split the 2009–2019 period into two parts and will study each part separately.

In the Coefficient column from the results presented in Table I.2.3.1-1, we have the coefficients of the equation of the regression model. The Variable column shows the names of the variables to which the coefficient corresponds. Each parameter estimated in this manner measures the contribution of the independent variable to the dependent variable. Hence, the regression equation is:

$$NPL = 1.69 * RON/CHF + 15.50 * RON/EUR + 5.96 * RON/USD + 4.43 * UR + 0.33 * INFL - 101.65 \quad (2)$$

Additionally, another method to verify the reliability of the regression parameters is represented by the method of confidence intervals. The confidence intervals are presented in Table I.2.3.2. We have intervals with a confidence coefficient of 90% and 95%. Therefore, we can affirm with a confidence of 95% that the growth of one percent in the unemployment rate leads to the growth of NPLs between 3.77% and 5.09%.

Table I.2.3.2. The confidence intervals

Coefficient Confidence Intervals					
		90% CI		95% CI	
Variable	Coefficient	Low	High	Low	High
RON_CHF	1.695	−1.325	4.716	1.914	5.305
RON_EUR	15.50	8.939	22.075	7.659	23.355
RON_USD	5.969	3.545	8.392	3.073	8.864
UR	4.433	3.879	4.986	3.772	5.094
INFL	0.339	0.154	0.525	0.118	0.561
C	−101.653	−123.869	−79.437	−128.198	−75.108

Source: authors' estimations

An evaluation obtained for the considered values of this formula is given in Figure I.2.3.2.

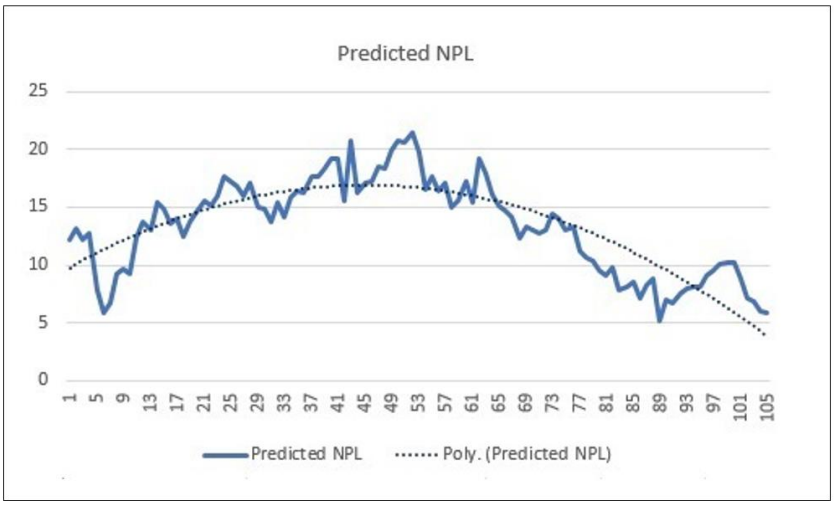


Figure I.2.3.2. The graphic representation of the regression model for the 2009–2019 period.

As we can see, the trend line for the predicted NPL rate is described by a second-degree polynomial curve. This will sustain a separate study for each of the periods of 2009–2014 and 2015–2019.

I.2.3.3. A Model for the 2009–2014 period

As we observed in Figure 1, NPL had an upward trend in the 2009–2014 period. The values of the regression model for this period are given in Table I.2.3.3-1**.**

Table I.2.3.3-1. Estimation results for the 2009–2014 period

Dependent Variable: NPL				
Explanatory variable	Coefficient	Std. Error	t-Statistic	Prob.
RON_CHF	1.716	1.686	1.018	0.113
RON_EUR	9.502	2.359	4.474	0.000
RON_USD	2.405	1.858	1.909	0.005
UR	2.550	1.602	0.913	0.265
INFL	1.547	1.087	6.270	0.000
Const.	−94.207	10.566	−7.950	0.000
R-squared	0.860568			
Adjusted R-squared	0.847893			
Prob(F-statistic)	0.000000			

Source: authors' estimations

Here, we have the elements of the multiple regression model and also the values of certain indicators and tests for the appreciation of the reliability and quality of the equation attached to this model. Thus, based on the values of these tests, we can affirm that the correlation and interdependence between the NPL and the considered independent variables are represented very well by a model of linear multiple regression.

Hence, the regression equation is

$$NPL = 1.76 * RON\_CHF + 9.50 * RON\_EUR + 2.40 * RON\_USD + 2.55 * UR + 1.54 * INFL - 94.207 \quad (3)$$

From here, we can affirm that a growth of one unit in the RON–EUR exchange rate leads to a growth of the NPL rate by 9.5%. Our result is consistent with the study of Farhan et al. (2012), who found that unemployment, inflation and exchange rates have a significant positive

relationship with NPLs of the Pakistani banking sector. The findings obtained by Bock and Demyanets (2012) imply that the exchange rate is one of the main determinants of NPLs.

Our results show that a growth of 1% in the unemployment rate will lead to a growth in the NPL rate by 2.55%. These are in line with the studies of Popa et al. (2018), Ghosh (2015), Makri et al. (2014), Messai and Jouini (2013) and Skarica (2014). This result is also reinforced by Louzis et al. (2012), who found in their study that NPLs can be explained mainly by macroeconomic variables such as unemployment. The unemployment rate is one of the major determinants of NPLs, as stated by Nkusu (2011). According to Cifter's (2015) study, the unemployment rate is the most important macroeconomic factor for NPLs, and a percentage increase in the unemployment rate increases NPLs by 3.61 percentage points for the group of countries analysed by him. Using GMM and quarterly data of Euro-area banks in the 1990–2015 period, Anastasiou et al. (2016) found that macrovariables such as unemployment and growth exert a strong influence.

A growth of 1% in the inflation rate will determine a growth of the NPL rate by 1.54%. This result is similar to the study of Charalambakis et al. (2017), who found that the key factors that can explain the movements in NPLs are the unemployment rate and the inflation rate. The results of the study by Donath et al. (2014) showed that the variation of NPLs had a positive correlation with inflation as well as unemployment rates, which is the result found in our study.

In Table I.2.3.3-2, we have the confidence coefficients intervals of 90% and 95% for our model. Hence, we can say, with a confidence of 95%, that an increase of 1% in the unemployment rate leads to an increase in the NPL rate of between 1.33% and 3.75%.

Table I.2.3.3-2. The confidence intervals

Coefficient Confidence Intervals					
		90% CI		95% CI	
Variable	Coefficient	Low	High	Low	High
RON_CHF	1.716	−1.105	4.537	−1.663	5.095
RON_EUR	9.502	2.209	16.796	0.766	18.239
RON_USD	2.405	−1.297	5.513	−2.682	6.127
UR	2.550	1.443	3.557	1.334	3.756
INFL	1.547	1.401	1.693	1.372	1.722
Const.	−94.207	−113.558	−74.857	−117.386	−71.028

Source: authors' estimations

In Figure I.2.3.3, we have the representation of the predicted NPL rate according to (3) for 61 values (calculated monthly, starting on 1 December 2009 until 31 December 2014). Here, the trend line for the predicted NPL rate is an upward linear one.

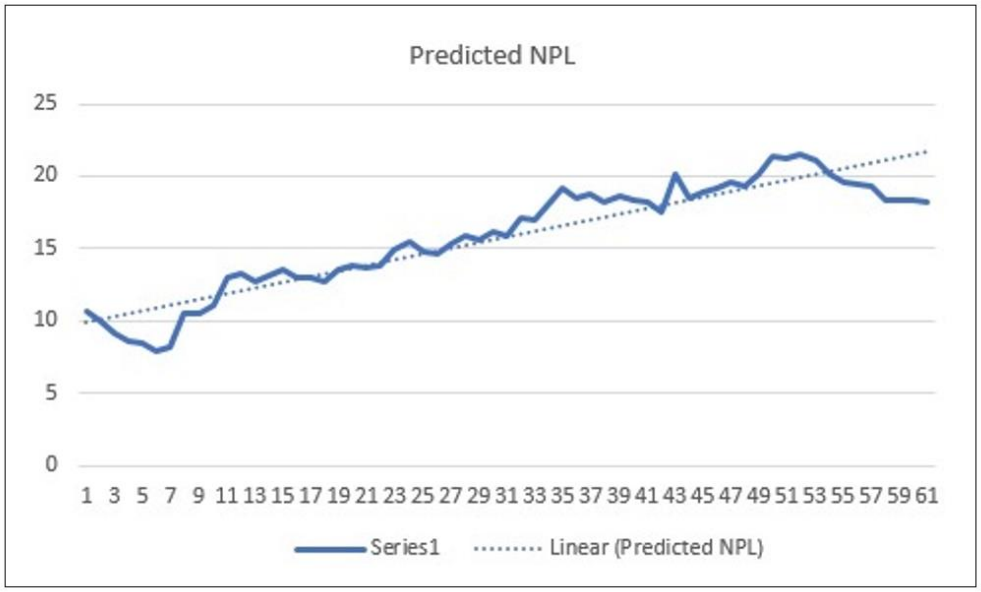


Figure I.2.3.3. The graphic representation of the regression model for the 2009–2014 period.

I.2.3.4. A Model for the 2015–2019 Period

We observed in Figure 1 that NPL had an upward trend in the 2009–2014 period. The NPL level started to decrease in June 2014. The novelty element in the general view on the bank activity in 2014 was the initiation of the write-off process for uncollectible NPLs, following the recommendations of the National Bank of Romania to credit institutions. We formulated below the model of multiple regression based only on the data from the period 2015–2019 (the years when the NPL rate decreased) in order to observe if the same independent variables have a stronger impact on the NPL, similar to the previously formulated model.

We used the same techniques as above to study the mentioned period. Hence, in order to formulate the regression model, we defined the rate of nonperforming loans (NPLs) as a dependent variable.

The independent variables that are taken in consideration are the same: the exchange rates (RON–CHF, RON–EUR, RON–USD), the unemployment rate (UR) and the inflation rate (HICP), measured in the same statistic interval (from 1 December 2009 to 31 January 2019).

Using the same technique that we have described above, with the help of the software EViews, we obtained the elements of the multiple regression model and also the values of certain indicators and tests for the appreciation of the reliability and quality of the equation attached to this model. The obtained values, representing the coefficients of the variables in the model of linear multiple regression and, at the same time, the results of the tests on the model, are presented in Table I.2.3.4-1.

We will further present the manner in which we use these values in the study of linear regression with the five considered explanatory variables. The R-squared statistic: In the present case, we can appreciate that 95.4% of the NPL rate value is explained by the five considered independent variables. S.E. of regression (S): The fact that we have a value of S = 0.69 in the present case is another confirmation of the fact that the regression model is representative of the relationships between the considered variables. Another confirmation of the obtained model is given by the Fisher test, F-statistic, and its associated probability, Prob(F-statistic). The econometric model of multiple regression using the NPL rate as a dependent variable is a correct

one and can be used in the analyses of macroeconomic forecasts. The statistic of the Durbin–Watson test (Durbin–Watson stat): In the present case, the value of the test is 0.85, corresponding to a positive linear dependence, meaning that a general growth of the values of the independent variables leads to a growth of the NPL rate.

Table I.2.3.4-1. Estimations results

Dependent Variable: NPL				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
RON_CHF	2.224377	1.824114	1.219429	0.2293
RON_EUR	−5.691265	3.409805	−1.669088	0.1024
RON_USD	−0.706060	1.189802	−0.593426	0.5560
UR	2.000545	0.218424	9.159005	0.0000
HICP	0.194019	0.075723	2.562230	0.0140
C	37.83326	15.77087	2.398933	0.0209
R-squared	0.954209			
Adjusted R-squared	0.948885			
Prob(F-statistic)	0.000000			

Source: authors' estimations

Thus, based on the values of these tests, we can affirm that the correlation and interdependence between the NPL rate and macroeconomic indicators—the exchange rate, the unemployment rate and inflation—is represented very well in the model of linear multiple regression.

Hence, the regression equation is

$$NPL = 2.22 * RON/CHF - 5.69 * RON/EUR - 0.70 * RON/USD + 2 * UR + 0.19 * INFL + 37.83 \quad (4)$$

We observe that the signs of the coefficients are different in this case. This will give us the right to say that the model has not given us consistent estimates and we expect endogeneity for this five-year period of 2015–2019.

An evaluation of this formula, obtained for the values of the independent variables considered for the calculation period, e.g., for 49 values (calculated monthly, starting on 1 January 2015 until 31 January 2019), is represented in Figure I.2.3.4. We can affirm that for a growth of one unit in the RON-CHF exchange rate, the NPL rate will increase by 2.22%, while a growth of one percent in the unemployment rate will lead to a growth of 2% in the NPL rate. At the same time, we observe that the influence of the constant variable is important. Therefore, the factors taken into consideration in our analysis have an important impact on the dependent variables, determining its decrease by 37.83 units.

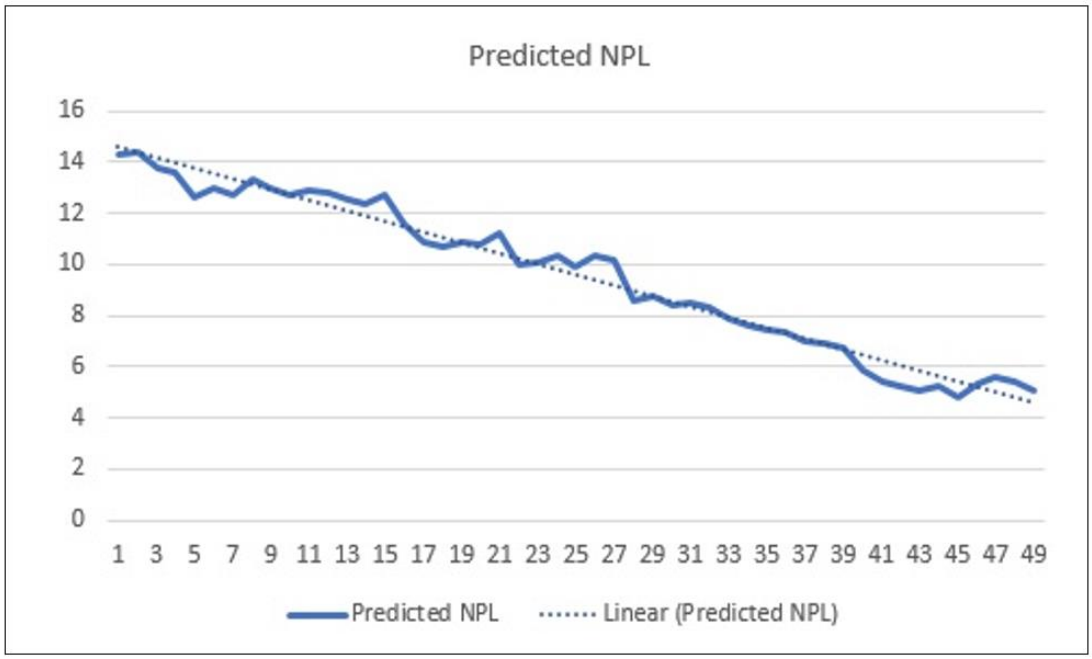


Figure I.2.3.4. The graphic representation of the regression model for the 2015–2019 period.

Here, the trend line for the predicted NPL rate is a downward linear one. In order to establish the significance level for each coefficient, we use the values of the Prob. column from Table I.2.3.4-1. Another method for the confirmation of the validity of the regression parameters is the method of confidence intervals. We obtained the following intervals:

Table I.2.3.4-2. The confidence intervals

Coefficient Confidence Intervals					
		90% CI		95% CI	
Variable	Coefficient	Low	High	Low	High
RON_CHF	2.224377	−0.842087	5.290842	−1.454299	5.903054
RON_EUR	−5.691265	−11.42339	0.040859	−12.56779	1.185263
RON_USD	−0.706060	−2.706201	1.294081	−3.105524	1.693405
UR	2.000545	1.633359	2.367731	1.560051	2.441039
HICP	0.194019	0.066724	0.321314	0.041310	0.346728
C	37.83326	11.32131	64.34521	6.028265	69.63825

Source: authors' estimations

We obtained, as Table 9 I.2.3.4-2. shows, the intervals with a confidence coefficient of 90% and 95%. Therefore, in the example given, we can affirm with a confidence of 95% that an increase of 1% in the inflation rate leads to an increase of the NPL rate between 1.56% and 2.44%.

I.2.3.5. Comparative Analysis for Periods Analysed

If we compare the influencing factors of the NFL rate analysed in this paper for both periods of 2009–2014 and 2015–2019, we may conclude that:

- in the period 2009–2014, an increase in the RON–CHF exchange rate of 1% leads to an increase in the NPL rate of 1.70%, while, in the period 2015–2019, the same increase leads to an increase in the NPL rate of 2.22%, which shows that after the recommendations of the National Bank of Romania, the credits granted in CHF still remain a generating factor of NPLs in Romania.

This is explained by the fact that due to the increase in the RON–CHF exchange rate, many debtors, after paying the monthly rate of the credit for 8–10 years, have a debt higher than the initial value of the credit.

- in the period 2009–2014, an increase in the RON–EUR exchange rate of 1% leads to an increase in the NPL rate of 9.50%, while in the period 2015–2019, the same increase leads to a decrease in the NPL rate of 5.69%, which shows that after the recommendations of the National Bank of Romania, the RON–EUR exchange rate is not a generating factor of NPLs in Romania.
- in the period 2009–2014, an increase in the RON–USD exchange rate of 1% leads to an increase in the NPL rate of 2.40%, while in the period 2015–2019, the same increase leads to a decrease of NPL rate with 0.71%, which shows that after the recommendations of the National Bank of Romania, the RON–USD exchange rate is not a generating factor of NPLs in Romania.
- in the period 2009–2014, an increase in the unemployment rate of 2.55% leads to an increase in the NPL rate of 2.40%, while in the period 2015–2019, the same increase leads to a decrease in the NPL rate of 2.00%, which shows that after 2014, the unemployment rate still remains a generating factor of NPLs in Romania.
- in the period 2009–2014, an increase in the inflation rate of 1% leads to an increase in the NPL rate of 1.55%, while in the period 2015–2019, the same increase leads to a decrease in the NPL rate of 0.19%, which shows that after 2014, the inflation rate is not a generating factor of NPLs in Romania, especially due to the Romanian government's efforts to maintain the inflation rate within the limits recommended by the European Union.

I.2.4. Concluding remarks

The present paper identifies several macroeconomic factors influencing the nonperforming loans rate in the Romanian banking system. The results are, in general, comparable to the results from other countries. The econometric analysis of the empirical determinants of the NPL rate presented in this paper shows that the exchange rate and the unemployment rate were the main causes for the growth of NPLs for both analysed periods of 2009–2014 and 2015–2019 (after 2014, what took place was the write-off of uncollectable NPLs at the recommendation of the National Bank of Romania). We applied in the present study an econometric model that helped us to identify the factors influencing the NPL rate in Romania, and we observed strong relations between the NPL rate and various macroeconomic factors. Our results are in general agreement with the literature because, from a macroeconomic perspective, the exchange rate, the unemployment rate and the inflation rate seem to be three supplementary factors affecting the NPL index, showing that the situation of the Romanian economy is clearly connected to the quality of loan portfolios. Related to the causes of nonperforming loans, after a literature review, we can conclude that nonperforming loans depend on several factors. We cannot make a list of all the causes because there are multiple causes, and these depend on macro-level factors and the specificity of each bank and its customers.

The writing-off process was individually transposed by a decrease of the number of banks registering NPL rates above the threshold for high risk, according to the ABE (up to 14% of the total number of Romanian credit institutions). The foreign currency loans continue to represent approximately 45% of total loans registered in Romania. An uncontrolled transaction of the exposure of RON to foreign currencies could have dramatic consequences on the situation of the foreign currency of the country and on the stability of the banking sector. The volatility of exchange rates, combined with the impact of the continued cutting of the workforce in Romania,

along with the over-indebtedness of a significant part of the population, contribute to a growth of the causes for concern of the customers and the disturbance of the market, generating supplementary legislative and administrative pressure on the banks. In order to rectify the situation, during the last two years, Romanian banks have made new efforts in financial education and, supported by new regulations, mainly changed their position related to RON. The negative effects of COVID-19 on the Romanian economy are associated with expectations of increasing the probability of default in the real sector, as well as expectations of moderation of lending activity. In addition, the risk regarding uncertain and unpredictable legislative framework in the Romanian financial-banking field remains high, having the potential to put pressure on bank solvency and to limit access to the financing of potential borrowers.

The econometric analysis of the empirical causes of the NPL rate presented in this paper shows that the RON/CHF exchange rate has been the main factor in increasing the NPL ratio in the last 5 years in Romania. The coefficient of this explanatory variable is high from an economic point of view, proving that excessive credit in Swiss francs in the period 2006–2008 has significantly affected financial stability. High levels of NPLs are a legacy of the 2008 crisis.

The literature shows that the level of nonperforming loans must be at a low a level as possible because it affects the profitability of banks. For this aspect to become achievable, bank institutions must approach a prudent credit policy and create a connected environment between the present economic–financial context and the aspects related to the classification of risk.

Sustainable development needs to be applied in all the fields of activity, including the banking sector. Referring to the present context in the development of the credit system, we can easily observe the fact that credit operations are profitable and risky at the same time. In relation to international experience before the world crisis and to European experience in the recent past, we observed that a global strategy is more efficient in order to solve nonperforming loans. A multilateral strategy for solving nonpayment in the European bank system could combine more attentive supervision, institutional reforms for insolvency and the expansion of markets for the debts in difficulty. These measures need to be supported by an exchange of the fiscal regime and by reforms for the improvement of the access to information.

The problem of nonperforming loans is serious, and the recommended measures need to be applied as soon as possible. Some measures, such as stricter supervision, can be immediately implemented. Other measures, as the judicial reforms and the development of market infrastructure, will take more time to be implemented. As a result of our analysis performed on a period of ten years, 2009 to 2019, we can observe a series of transformations that have taken place in the evolution of nonperforming loans. The greatest challenge in fulfilling of the objectives of the sustainable development of banks is represented, on the one hand, by the understanding of the concept in relation to the business field, and, on the other hand, by the exclusive placement of sustainability within the exclusive responsibility of NGOs and governments. There is a need to understand that bank responsibility does not mean only philanthropic actions and sponsorships; there is more to it. The international bank community has proven, through the examples to be followed, that it understands the importance, necessity and reliability of sustainable development.

Chapter I.3. ECONOMIC CRISIS INFLUENCE ON BANKING SYSTEMS[3]

Many factors influence the formation of a potential crisis in the economic system. Due to their interconnected dynamics, some factors can be treated superficially, when in fact they have created a major influence. As a rule, any crisis presents a new version with an unfavourable combination of factors. In this chapter, the authors set out to analyse the dependence of banks' Z scores from six Central and Eastern European countries: Bosnia and Herzegovina, Bulgaria, Croatia, Hungary, Poland, and Romania. The influence of general factors on the crisis is known, but by shaping them we set out to present an equation that would show cumulative dependence on the banking system.

The influence of the nonperforming loans on the banking system during the 2008 crisis is known. Throughout this chapter, we want to demonstrate that this ratio was only one of the factors of influence. The equation created by linear regression allowed the understanding of the coefficients of the influence of independent variables on the dependent one, which is the banks' Z scores. Thus, factors neglected by the influence of the 2008 crisis, such as the banking concentration in which banks' aggregate assets are included, economic growth including the value of GDP, are elements and factors that are not taken into account as factors of influence, but which by their cumulative interdependence affect the stability of banks.

The chosen indicators are those that were among some measures influenced by the 2008 crisis directly or indirectly. The *banking concentration* indicator is linked to the 2008 crisis because it indicates the aggregate assets of banks, and during the crisis, many banks went bankrupt. The *economic growth* indicator is also dependent on the crisis, with the onset of the crisis this indicator tends to decrease. It is based on the calculation of the difference between the present and past GDP, and the 2008 financial crisis contributed to the creation of negative values for it, with most countries recording below zero values in the years after the crisis. The cost to income ratio was also influenced by the crisis, with higher values. After the 2008 crisis, banks' spending increased, due to the increase in non-performing loans that proved to be destructive, and banks produced fewer profits than their expenses. A small value of this indicator shows greater profitability, and by observing the values of countries in the years after the crisis we can say that most banks in those countries had very little profitability.

One of the most important indicators of the 2008 financial crisis is the *non-performing loans* that contributed to the collapse of the banking system. Non-performing loans have accumulated as a result of the default of mortgages and the devaluation of the asset market. The ratios chosen for the analysis relate to the stability and efficiency of the banking system, they do not have constant values because of the crisis, if this had not happened, certainly, our econometric model would not have presented such an image, and we may not even know of the cumulative influence of all these factors.

We used the EViews software to analyse indicators and determine the degree of dependency. The built model allows us to create our conclusions on the interdependence of the factors of the economic system and to obtain relevant observations for comparing this model

[3] This section is based on the book: **Iuga Iulia**, Mihalciuc Anastasia, *ECONOMIC CRISES. EFFECTS ON BANKING SYSTEMS AND INVESTMENT DECISION***,** LAP Lambert Academic Publishing, 2020, ISBN: 978-620-2-92090-2

between the countries listed above. The linear regression model was studied with several factors presented along the way, removing those who represented collinearity for the given model.

I.3.1. Analysed ratios

A crisis influences all aspects of a country and in particular its economic sector. After studying the opinions of various specialists and experts, we have concluded that the crisis is characterised by a significant decrease in workers' wages, massive job cuts, employment problems, and a lack of job supply for graduates. In addition to this, the most significant macroeconomic indicators of a country are decreasing. As a result, economic growth will be falling and unemployment and inflation will rise. A very important part of the 2008 crisis was its destructive aspect of the banking system. In this chapter, we decided to analyse and to understand which factors of the crisis have influenced the banking system the most.

The countries we decided to choose for the analysis are Romania, Bosnia and Herzegovina, Croatia, Bulgaria, Hungary, and Poland. These Countries of Central and Eastern Europe are part of the European Union, except Bosnia and Herzegovina, but they are also those that have retained their currency. The analysis of these countries will show us the true dependency of the factors through the prism of each one's economy.

As main factors for the analysis, we decided to choose banks' Z scores, non-performing loans or NPL rate, return on assets or ROA, return on equity or ROE, economic growth, bank concentration, cost-to-income ratio, and non-interest income.

The rate of banks' Z scores measures the profitability and insolvency of a bank. In statistics, this shows us the standard deviation of a value from its average.

A formula is provided after a study carried out in New Zealand on the subject of: *Measuring bank risk: An exploration of z-score* (Xiping et al., 2017) presenting us the formula thus:

$$Banks' \ Z \ Score = \frac{ROA+(Equity/Assets)}{\sigma ROA},$$

where ROA represents the return on assets,

σROA- standard deviation of the return on assets

The interpretation of this indicator being the following:

Z > 2,99	secure area, bank or company is financially stable
1,8 < Z < 2,99	uncertain area, the risk of bankruptcy is possible,
Z < 1,8	risky zone, the risk of bankruptcy is most likely

Source: Ştefan Daniel Armeanu, Georgeta Vintilă, Maricica Moscalu, Maria-Oana Filipescu, Paula Lazăr, *Using Quantitative Data Analysis Techniques for Bankruptcy Risk Estimation for Corporations*, Economie teoretică şi aplicată, Vol. 26, Nr.1(566), 2012, p. 88, http://www.store.ectap.ro/articole/681_ro.pdf

This indicator has a decreasing trend for all countries at the beginning of 2008, but it is recovering rapidly and we are seeing an increasing trend in the post-crisis years (see Chart I.3.1-1.)

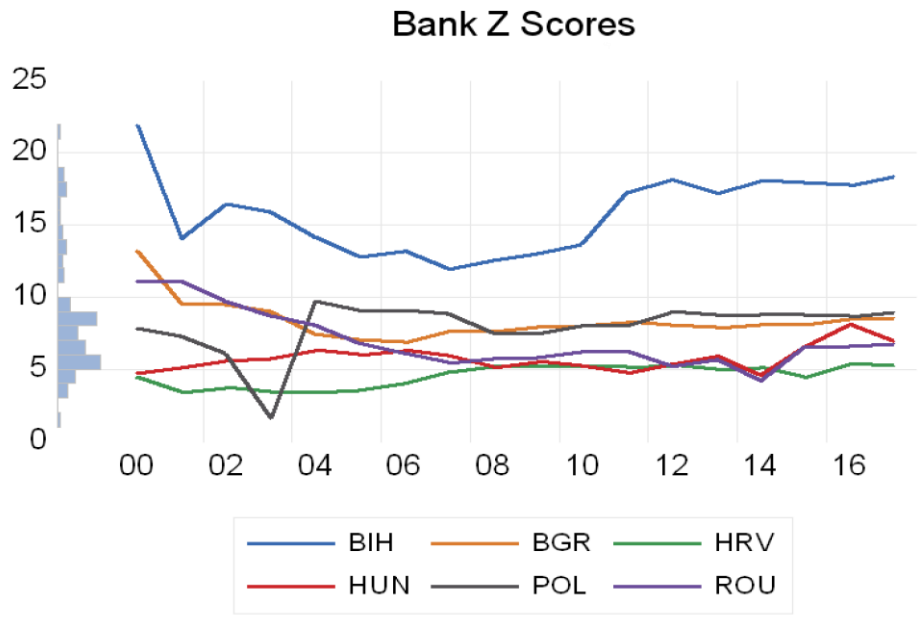


Chart I.3.1-1. Evolution of bank Z-Score 2000-2017 (Romania=ROU, Bosnia and Herzegovina=BIH, Croatia=HRV, Bulgaria=BGR, Hungary=HUN, and Poland=POL). Source: Author's processing

ROA or the return on assets is expressed by $\frac{Net\ Income}{Total\ Assets}$, which shows us how efficient management is and how profitable a company or bank is from the assets it reinvests. The ROA indicator has an increasing trend from 2004 to 2007, and after a decreasing trend with variable increases from 2010 to 2013 for each of the countries begins and a sharp decrease in 2014 for Bulgaria, Romania, and Hungary (see Chart I.3.1-2.).

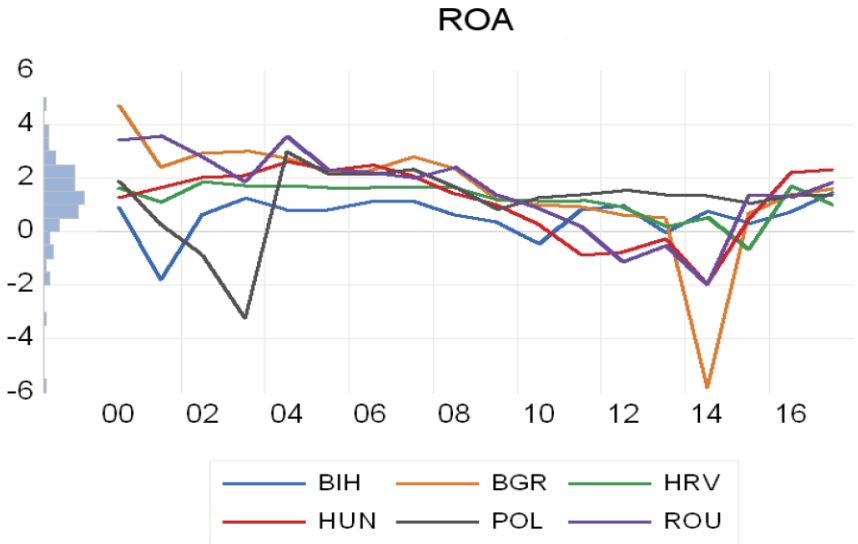


Chart I.3.1-2. Evolution of the ROA 2000-2017 (Romania=ROU, Bosnia and Herzegovina=BIH, Croatia=HRV, Bulgaria=BGR, Hungary=HUN, and Poland=POL). Source: Author's processing

ROE or return on equity is how efficient a company or bank is in generating profits and is calculated by $\frac{Net\ Income}{Equity}$. This indicator shows very low values for Poland in 2003 and an increasing trend for the coming years in all countries. Since 2008 we can see a slow common decrease for all countries with a recovery in 2010 for Poland, in 2011 and 2012 for Hungary, Bosnia, Croatia, and Romania (see Chart I.3.1-3).

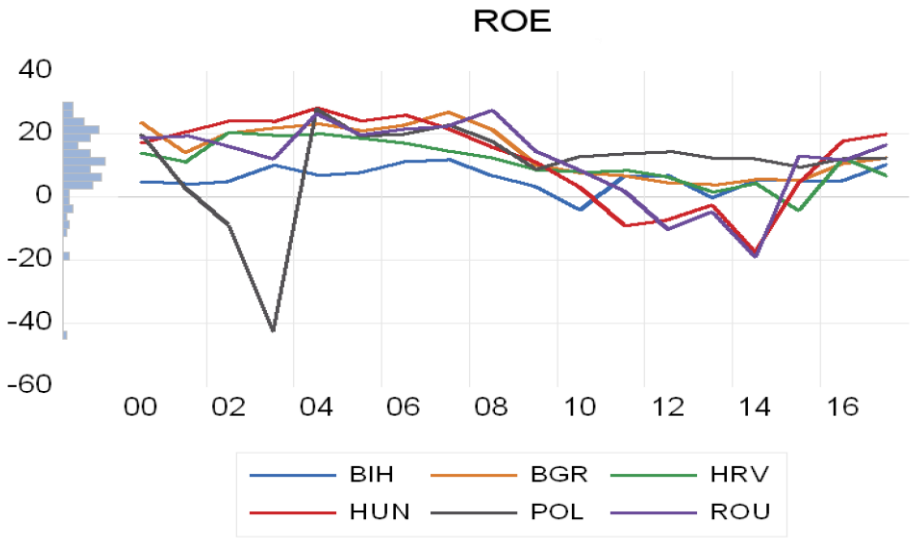


Chart I.3.1-3. Evolution of the ROE 2000-2017 (Romania=ROU, Bosnia and Herzegovina=BIH, Croatia=HRV, Bulgaria=BGR, Hungary=HUN, and Poland=POL). Source: Author's processing

Rate of non-performing loans, or **NPL**, represents a claim with the likelihood of non-payment, a bank loan is considered non-performing when more than 90 days pass without the debtor paying the agreed rates or interest.

According to Chart I.3.1-4 we are seeing a sharp increase in the NPL rate from 2008 to 2012-2013 in all countries (except Poland), which shows us a weak policy of credit risk management in other countries.

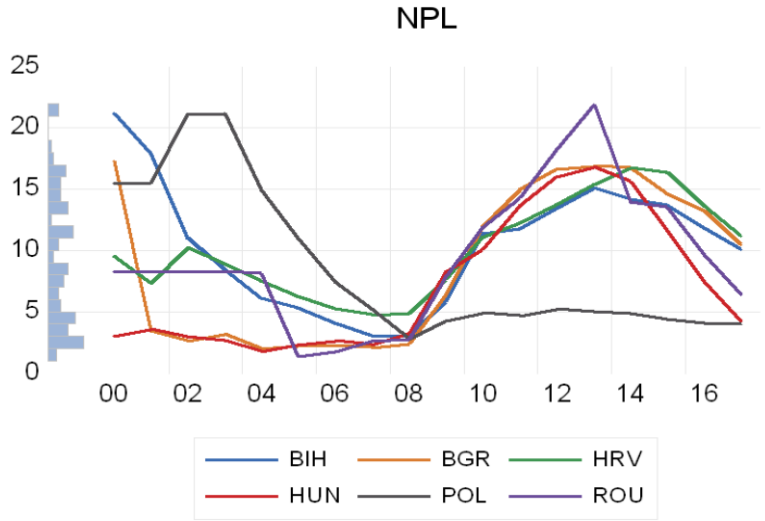


Chart I.3.1-4. Evolution of the NPL 2000-2017 (Romania=ROU, Bosnia and Herzegovina=BIH, Croatia=HRV, Bulgaria=BGR, Hungary=HUN, and Poland=POL). Source: Author's processing

Economic growth, is a comparison value of present and past GDP, to check whether the economy has improved or worsened. This can be represented by the following formula:

$Ec_{growth} = \frac{GDP_2 - GDP_1}{GDP_1}$	Where: Ec_{growth} = Economic growth GDP_1 = past GDP GDP_2 = present GDP

According to Chart I.3.1-5, economic growth has fallen sharply in the years since the beginning of the crisis, reaching negative levels of up to -8. It was not until the end of 2009 that the beginning of 2010 was slowly growing, but negative values continued until 2012 when the first values above 0 appeared. Poland remaining the only country whose values did not fall below 0, probably also due to the lower rate of non-performing loans.

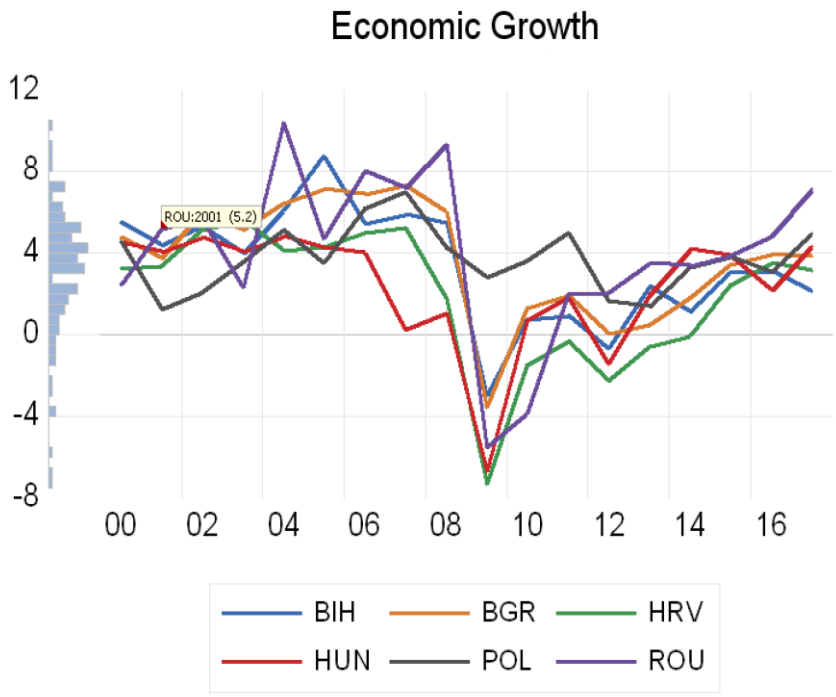


Chart I.3.1-5. Evolution of the Economic growth ratio 2000-2017 (Romania=ROU, Bosnia and Herzegovina=BIH, Croatia=HRV, Bulgaria=BGR, Hungary=HUN, and Poland=POL). Source: Author's processing

Another indicator is the **Banking Concentration**, which tells us whether the banking system is composed of several small banks, or a smaller number of large banks. The higher this indicator, the greater the competition in that system.

The following formula shall be used to calculate this formula:

$B_c = \frac{A_k}{A_t * 100}$	Where B_c = banking concentration, A_k= aggregate assets of the first k banks in the banking system A_t= aggregate assets of banks

Source: http://www.efin.ro/credite/glosar_economic_G

According to Chart I.3.1-6, the evolution of the *bank concentration* indicator was indeed chaotic, with values increasing and decreasing over the years of crisis, so the lowest values were recorded by Poland in 2008 and the highest values were recorded by Bosnia and Herzegovina, Romania and Croatia.

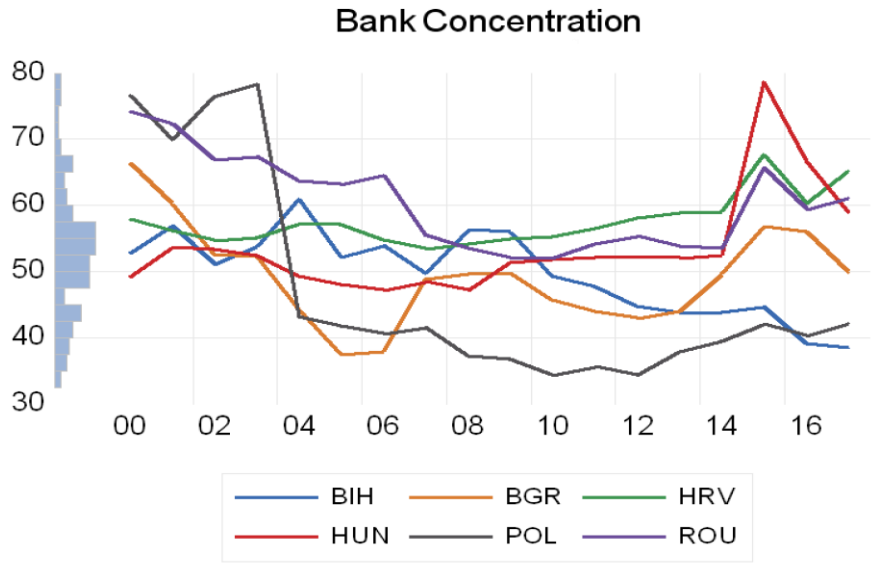


Chart I.3.1-6. Evolution of the Bank Concentration ratio 2000-2017 (Romania=ROU, Bosnia and Herzegovina=BIH, Croatia=HRV, Bulgaria=BGR, Hungary=HUN, and Poland=POL). Source: Author's processing

The other two indicators are the **Cost to Income** ratio that tells us how well a company manages its expenses, a lower amount indicating greater profitability in banks and **Non-interest income** are the profits of banks with various fees.

The sharply increasing values of this indicator in Hungary and Romania in the years after the crisis indicate a faster increase in expenditure than in revenues. Bulgaria, Croatia, Poland, Bosnia, and Herzegovina maintain their values consistently throughout the years after the crisis (Chart I.3.1-7).

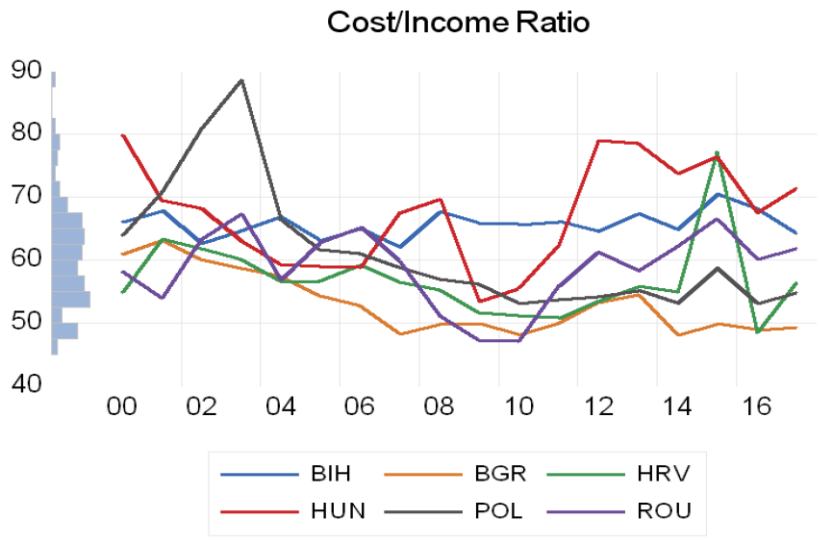


Chart I.3.1-7. Evolution of the Cost/Income ratio 2000-2017 (Romania=ROU, Bosnia and Herzegovina=BIH, Croatia=HRV, Bulgaria=BGR, Hungary=HUN, and Poland=POL). Source: Author's processing

According to Chart I.3.1-8, *non-interest income* is the only source of profit when banks' interest rates are very low. With the onset of the 2008 crisis, this indicator is falling for all countries because during the crisis interest rates fall, and this becomes the only source of profit for banks.

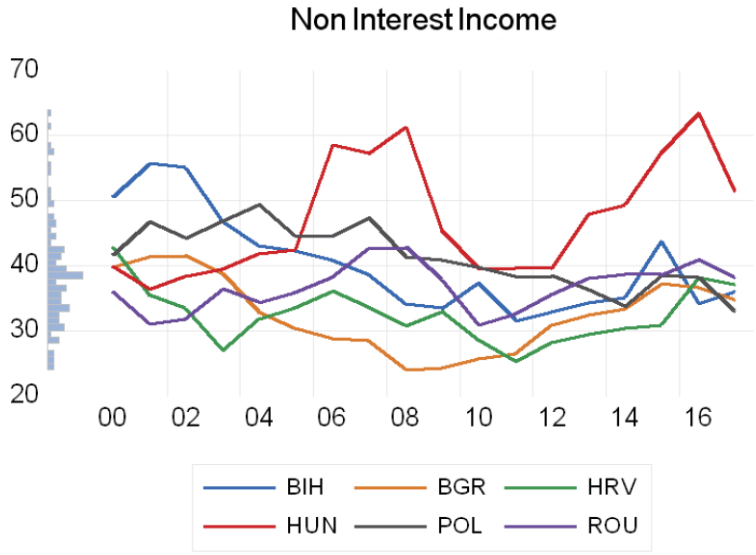


Chart I.3.1-8. Evolution of the Non-interest income ratio 2000-2017 (Romania=ROU, Bosnia and Herzegovina=BIH, Croatia=HRV, Bulgaria=BGR, Hungary=HUN, and Poland=POL). Source: Author's processing

I.3.2. Statistical data

For the systematization and effective analysis of these indicators, we will use descriptive statistics, graphs, and try to compare the equation of linear regression to determine the most optimal dependent variable. Descriptive statistics are a way of analysing large amounts of information and data for efficient modelling and an easier understanding of the analysed data. This describes the data in a way understood for all.

Table I.3.2. Descriptive statistics

	Banks' Z-Score	Banking Concentration	Cost/Income	Economic Growth	Non-Interest Income	NPL	ROA	ROE
Mean	8.246019	52.95380	60.49093	3.191019	38.42713	9.077593	1.182222	11.05398
Median	7.455000	52.63500	59.94000	3.690000	38.09000	8.300000	1.330000	11.98000
Maximum	21.94000	78.70000	88.70000	10.43000	63.50000	21.87000	4.700000	28.25000
Minimum	1.600000	34.32000	47.05000	-7.360000	24.07000	1.400000	-5.840000	-42.64000
Std. Dev.	4.004555	9.975302	8.242604	3.068244	7.908090	5.484248	1.398538	11.00614
Skewness	1.319671	0.421788	0.702457	-0.932718	0.879165	0.408798	-1.534959	-1.425568
Kurtosis	4.261605	3.103799	3.542794	4.752900	3.944663	2.080459	8.679535	7.386090
Jarque-Bera	38.51000	3.250779	10.20785	29.48529	17.92849	6.813084	187.5668	123.1504
Probability	0.000000	0.196835	0.006073	0.000000	0.000128	0.033156	0.000000	0.000000
Sum	890.5700	5719.010	6533.020	344.6300	4150.130	980.3800	127.6800	1193.830
Sum Sq. Dev.	1715.901	10434.81	7269.636	1007.311	6691.554	3218.236	209.2823	12961.47
Observations	108	108	108	108	108	108	108	108

Source: Author's processing

The "mean" indicator is a central trend of data. This is achieved by summarising them and dividing them by the total number of data. Thus, analysing Table I.3.2. we can deduct for the Z score an average of around 8.24, for bank concentration 52.95, for expenses/income 60.49, for economic growth 3.19, an average of 38.4 for non-interest income, 9.07 for the NPL rate, 1.18 for ROA and 11.05 for ROE.

The "median" indicator shows the value that divides the data into two equal parts when the data are ordered in ascending or descending order. For the Z score this is a value of 7.45, for the banking concentration 52.63, 59.94 for expenditure/income, for economic growth 3.69, an average of 38.09 for non-interest income, 8.30 for the NPL rate, 1.33 for ROA and 11.98 for ROE.

The indicators "minimum" and "maximum" indicate the maximum and minimum values of each indicator, so the Z score is between 1.60-21.94, the banking concentration between 34.32 and 78.70, cost/income between 47.05 and 88.70, economic growth is between -7.36 and 10.43, non-interest income 24.07-63.50, the rate of non-performing loans 1.40 and 21.87, -5.84 and 4.70 for ROA and -42.64 and 28.25 for ROE.

The "standard deviation" indicator is the deviation or the way the data is spread across the environment. For the banks' Z score indicator, it records a value of 4, for bank concentration 9.87, for cost/income 8.24, for economic growth 3.06, a value of 7.90 for non-interest income, 5.48 for the NPL rate, 1.39 for ROA and 11 for ROE.

As measures of data normality, are considered "skewness" and "kurtosis". The "skewness", or degree of asymmetry, is a measure to verify the probability distribution of a variable random to the actual value on its mean. The lower the value of this indicator, the closer the value of the distribution is to normality, so the value 0 indicates a normal skewness and that the distribution is symmetrical around its mean, positive skewness with higher values and negative skewness with lower values. In the case of The banks' Z Score, the banking concentration, cost/income, non-interest income, and the NPL rate, a skewness is observed higher than 0, so our data have more extreme values on the right, with the distribution tilted to the left, and economic growth, ROA and

ROE show values lower than 0, with extreme values on the left and the distribution tilted to the right.

The "kurtosis" is a measure of whether the data has a surplus or lack of a normal distribution, also if it is with a peak or is flat. There are three types of kurtosis, mesokurtic- this distribution is considered a normal one with kurtosis of 3, leptokurtic- or a positive kurtosis with a peak curve, indicating that there are values higher than the sample average for this variable or values greater than 3, and platykurtic- or a negative kurtosis, a more flat curve, indicating that there are no values higher than the sample average for this variable or values below 3. Thus all indicators other than NPL, record values greater than 3, belong to a positive kurtosis with a peak curve, leptokurtic. The rate of non-performing loans with a value of 2.08 shows a platykurtic distribution with a more flat curve.

The "Jarque-Bera" is a test to verify the normality of distribution by measuring the difference between skewness and kurtosis of variables with those in a normal distribution. The probability or p-value after this indicator helps us decide whether we accept or reject the hypothesis that we have a normal distribution.

H_0: A normal distribution is present
H_1: An abnormal distribution is present

If it is greater than 0.05, then we accept the hypothesis and have a normal distribution, but if it is less than 0.05 then we reject the hypothesis, and we have an abnormal distribution. In the case of the indicators we have, only the banking concentration has the value of the coefficient p greater than 0.05, so we accept the null hypothesis and can say that we have a normal distribution. In the case of the other indicators, the p-value is less than 5%, so we reject the null hypothesis and accept the alternative hypothesis, assuming an abnormal distribution for the other indicators. Although most indicators have an abnormal distribution, it is not an indication that we will not be able to achieve a dependency correlation between indicators, because we have a series of chronological data, a normal distribution is not so important for our regression.

I.3.3. Linear regression equation

Before we begin analysing different factors we need to build dependency graphs to check which of them are of greater importance, and which are the correlations between variables. For this, we will look only at the factors of systemic importance, which serve as primary indicators in the evaluation of the banking system, following the crisis that manifested itself in 2008. These are: banks' Z-score, non-performing loans, and economic growth.

If the dependent variable is the Z score of the banks:

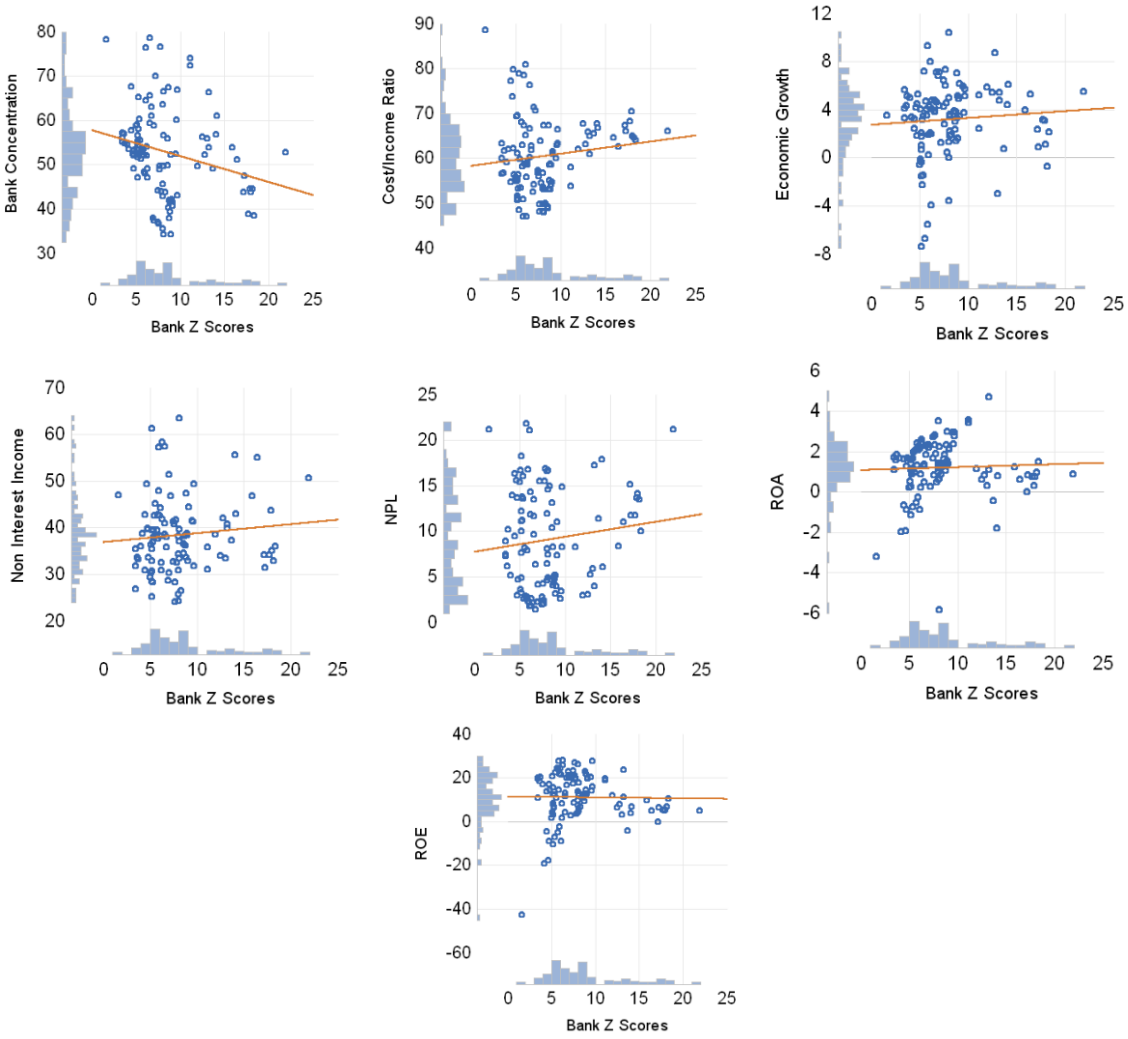


Chart I.3.3-1. Dispersion chart for the Z Score indicator. Source: Author's processing

For this indicator, we see a weak positive correlation with the Cost/Income indicators, the rate of non-performing loans, non-interest income, and economic growth. A negative correlation with the bank concentration is observed, and a null correlation with the return on assets and the return on equity (see Chart I.3.3-1.).

A positive correlation can be found with Cost/Income, Z Score, and Banking Concentration. There is a negative correlation with economic growth, return on assets, and return on equity and a null correlation with non-interest income (see Chart I.3.3-2). If the dependent variable is the NPL Rate:

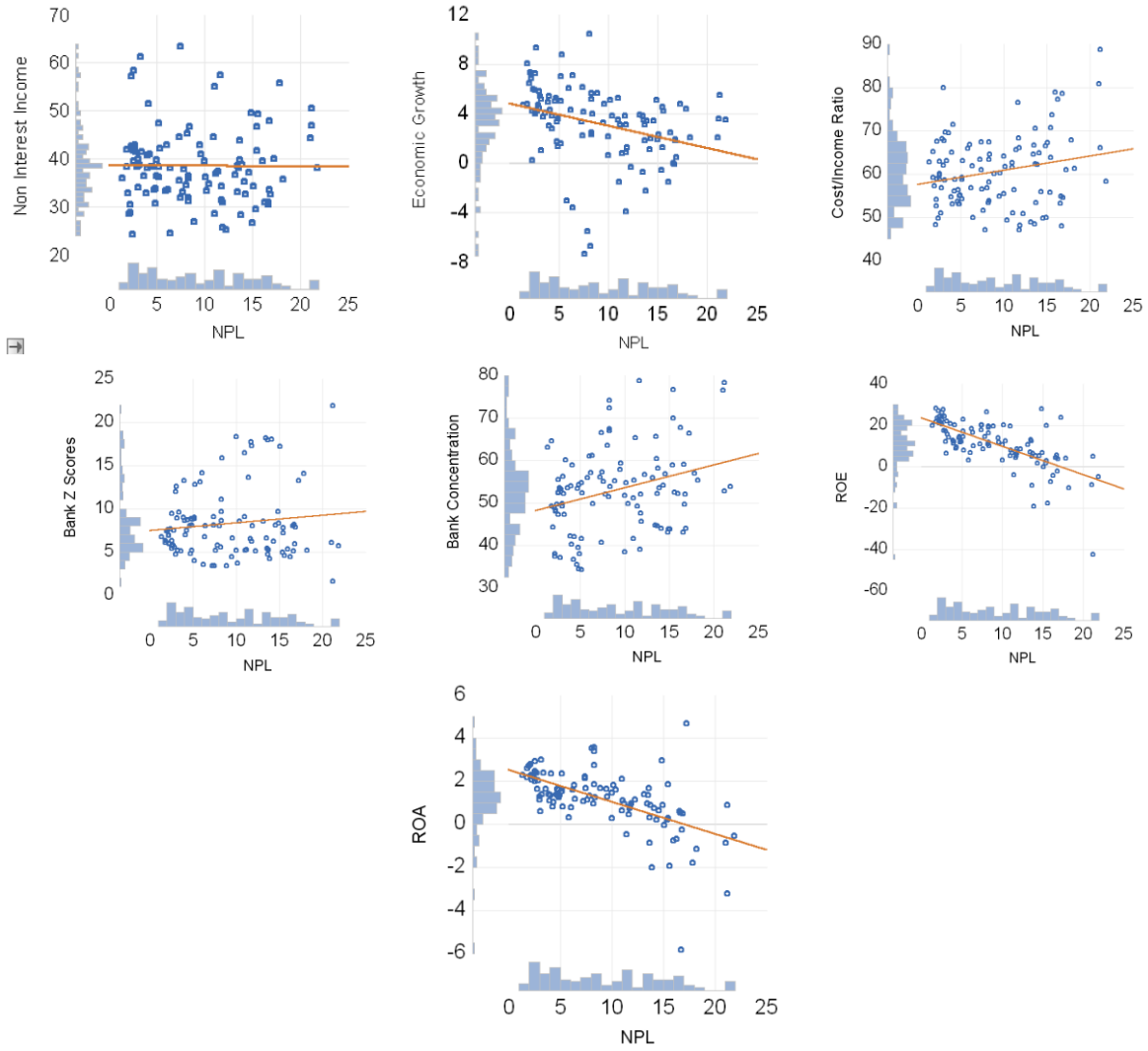


Chart I.3.3-2. Dispersion chart for NPL Rate indicator. Source: Author's processing

If the dependent variable is Economic Growth:

The *Economic Growth* Indicator has a positive relationship with the cost/income ratio, non-interest income, return on assets, and return on equity. It has a negative correlation with the NPL rate, and a null correlation with the bank concentration and the Z score (see Chart I.3.3-3).

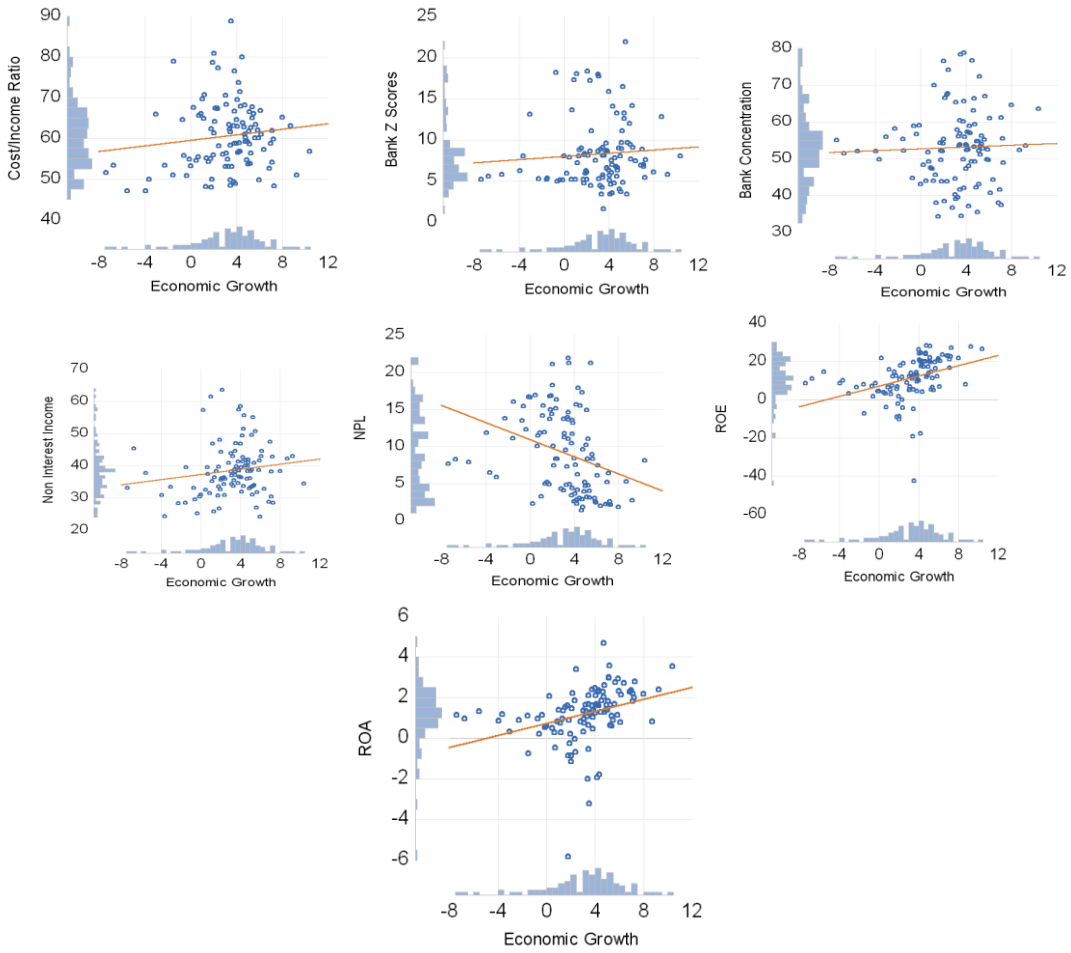


Chart I.3.3-3. Dispersion chart for Economic Growth indicator. Source: Author's processing

From the factors analyzed above, as a dependent factor we decided to choose the Z scores of the banks because it has the most positive correlations, and as independent factors, we considered to be: non-performing loans or NPL rate, return on assets or ROA, return on equity, or ROE, economic growth, banking concentration, cost/income ratio, non-interest income.

For this, we will use the Least Squares Method (Table I.3.3-1.), this being the most common method of approximating a dependency y=y(x), through an analytical function. This method allows us to achieve effective results of our linear regression equation, with the least dispersion for estimators.

Table I.3.3-1. Estimation of parameters for the linear regression model

Dependent Variable: BANK_Z_SCORES. Method: Panel Least Squares. Sample: 2000 2017

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.115261	3.460832	1.766991	0.0803
NPL	0.282434	0.093751	3.012618	0.0033
ROA	0.910243	0.471715	1.929646	0.0565
ROE	-0.013785	0.070513	-0.195494	0.8454
BANK_CONCENTRATION	-0.178367	0.041148	-4.334734	0.0000
NON_INTEREST_INCOME	0.013565	0.054153	0.250503	0.8027
ECONOMIC_GROWTH	0.118425	0.132416	0.894345	0.3733
COST_INCOME_RATIO	0.118848	0.060180	1.974890	0.0510

Root MSE	3.552636	R-squared	0.205612

Mean dependent var	8.246019	Adjusted R-squared	0.15004
S.D. dependent var	4.004555	S.E. of regression	3.692008
Akaike info criterion	5.521405	Sum squared resid	1363.092
Schwarz criterion	5.720081	Log likelihood	-290.1559
Hannan-Quinn criter.	5.601961	F-statistic	3.697573
Durbin-Watson stat	0.220556	Prob(F-statistic)	0.001351

Source: Author's processing

By performing the linear regression equation for the z-score, we observe that only the NPL rate and the banking concentration are significant with a probability of less than 5%, and the rest of the variables seem insignificant, suggesting that we may have multicollinearity in our model.

Table I.3.3-2. Estimating correlations between independent variables

	Bank Concentration	Cost/Income	Economic Growth	Non-Interest Income	NPL	ROA	ROE
Bank Concentration	1.000000	0.348332	0.037932	0.124814	0.298267	-0/035247	-0.181946
Cost/Income	0.348332	1.000000	0.126509	0.506086	0.217992	-0.262207	-0.370137
Economic Growth	0.037932	0.126509	1.000000	0.154949	-0.322062	0.325655	0.373074
Non-Interest Income	0.124814	0.506086	0.154949	1.000000	-0.001254	-0.038729	-0.008003
NPL	0.298267	0.217992	-0.322062	-0.001254	1.000000	-0.583517	-0.684168
ROA	-0.035247	-0.26220-0.2622077	0.325655	-0.038729	-0.583517	1.000000	0.828772
ROE	-0.181946	-0.370137	0.373074	-0.008003	-0.684168	0.828772	1.000000

Source: Table generated by the authors through the EViews program

After checking the correlations (Table I.3.3-2.) we see the following: the correlation coefficient between ROA and ROE is the highest, 82.87% because of this, most variables have become insignificant. Because of this high correlation coefficient, we have a multicollinearity problem. To solve this problem, one of these variables must be removed and we have decided to remove the one with the highest probability, its size indicates the importance for regression, the smaller the more significant it is, and of the two variables, ROE has a higher p coefficient value and therefore is less significant. After we remove the ROE variable, we again build the equation for linear regression with the dependent coefficient Z score.

Table I.3.3-3. Estimation of parameters for the linear regression model after removal of the independent ROE variable

Dependent Variable: BANK_Z_SCORES. Method: Panel Least Squares. Sample: 2000 2017

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	7.979255	1.384274	5.764215	0.0000
BANK_CONCENTRATION	-0.024540	0.018626	-1.317569	0.1908
COST_INCOME_RATIO	-0.030017	0.024853	-1.207779	0.2301
ECONOMIC_GROWTH	-0.047162	0.050756	-0.929180	0.3551
NON_INTEREST_INCOME	0.015444	0.023075	0.669306	0.5049
NPL	0.193390	0.032982	5.863457	0.0000
ROA	1.001108	0.120116	8.334481	0.0000
Root MSE	1.237268	R-squared		0.903648
Mean dependent var	8.246019	Adjusted R-squared		0.892608

S.D. dependent var	4.004555	S.E. of regression	1.312321
Akaike info criterion	3.485911	Sum squared resid	165.3299
Schwarz criterion	3.783925	Log likelihood	-176.2392
Hannan-Quinn criter.	3.606745	F-statistic	81.85007
Durbin-Watson stat	0.985145	Prob(F-statistic)	0.000000

Source: Author's processing

A new test shows us again multicollinearity and after an additional check of the correlations between independent factors, we have the results present in Table I.3.3-4.

Table I.3.3-4. Estimating correlations between independent variables

	Bank Concentration	NPL	ROA	Economic growth	Cost/Income	Non-interest income
Bank Concentration	1.000000	0.298267	-0.035247	0.037932	0.348332	0.124814
NPL	0.298267	1.000000	-0.583517	-0.322062	0.217992	-0.001254
ROA	-0.035247	-0.583517	1.000000	0.325655	-0.262207	-0.038729
Economic growth	0.037932	-0.322062	0.325655	1.000000	0.126509	0.154949
Cost/Income	0.348332	0.217992	-0.262207	0.126509	1.000000	0.506086
Non-interest income	0.124814	-0.001254	-0.038729	0.154949	0.506086	1.000000

Source: Author's processing

A high value is observed in the correlation between the Cost/Income and Non-interest income ratio. From the two independent variables, Non-interest income has a higher p coefficient value, it follows that we will remove this one because it is not so significant for our linear regression equation.

A new equation shows us most variables with significant values, so with a p-value below 5%.

Table I.3.3-5. Estimation of parameters for the linear regression model after removal of the independent variable: Non-interest income

Dependent Variable: BANK_Z_SCORES. Method: Panel Least Squares. Sample: 2000 2017

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.910157	3.017648	1.958531	0.0529
BANK_CONCENTRATION	-0.178339	0.040649	-4.387247	0.0000
COST_INCOME_RATIO	0.128861	0.048774	2.642013	0.0095
ECONOMIC_GROWTH	0.114409	0.127897	0.894540	0.3731
NPL	0.288186	0.086267	3.340624	0.0012
ROA	0.848874	0.333273	2.547084	0.0124
Root MSE	3.554135	R-squared		0.204941
Mean dependent var	8.246019	Adjusted R-squared		0.165968
S.D. dependent var	4.004555	S.E. of regression		3.657174
Akaike info criterion	5.485211	Sum squared resid		1364.242
Schwarz criterion	5.634219	Log likelihood		-290.2014
Hannan-Quinn criter.	5.545628	F-statistic		5.258483
Durbin-Watson stat	0.214741	Prob(F-statistic)		0.000245

Source: Author's processing

Because the Least Squares Method "is generally not effective" (Wooldridge, 2009), it does not recognise the heterogeneous nature of cross-sections. For this reason, we will also test the

Fixed Effects method as well as the Random Effects method. A fixed-effect meta-analysis estimates a single effect that is assumed to be common to every study, while a random-effects meta-analysis estimates the mean of a distribution of effects.

Table I.3.3-6. Estimating parameters for the linear regression model Fixed Effects

Dependent Variable: BANK_Z_SCORES. Method: Panel Least Squares. Sample: 2000 2017

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	8.357839	1.259836	6.634071	0.0000
BANK_CONCENTRATION	-0.022144	0.018226	-1.214956	0.2273
COST_INCOME_RATIO	-0.029412	0.024766	-1.187616	0.2379
ECONOMIC_GROWTH	-0.039927	0.049451	-0.807420	0.4214
NPL	0.195868	0.032680	5.993497	0.0000
ROA	1.006030	0.119549	8.415184	0.0000
Root MSE	1.240151	R-squared		0.903199
Mean dependent var	8.246019	Adjusted R-squared		0.893219
S.D. dependent var	4.004555	S.E. of regression		1.308581
Akaike info criterion	3.472048	Sum squared resid		166.1014
Schwarz criterion	3.742048	Log likelihood		-176.4906
Hannan-Quinn criter.	3.582812	F-statistic		90.50535
Durbin-Watson stat	0.982759	Prob(F-statistic)		0.000000

Source: Author's processing

Table I.3.3-7. Estimating parameters for the linear regression model Random Effects

Dependent Variable: BANK_Z_SCORES. Method: Panel Least Squares. Sample: 2000 2017

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.910157	1.079751	5.473629	0.0000
BANK_CONCENTRATION	-0.178339	0.014545	-12.26131	0.0000
COST_INCOME_RATIO	0.128861	0.017452	7.383801	0.0000
ECONOMIC_GROWTH	0.114409	0.045763	2.50028	0.0140
NPL	0.288186	0.030867	9.336251	0.0000
ROA	0.848874	0.119249	7.118496	0.0000
Root MSE	3.554135	R-squared		0.204941
Mean dependent var	8.246019	Adjusted R-squared		0.165968
S.D. dependent var	4.004555	S.E. of regression		3.657174
Sum squared resid	1364.242	F-statistic		5.258483
Durbin-Watson stat	0.214741	Prob(F-statistic)		0.000245

Source: Author's processing

To decide which of these two models, the Fixed Effects or Random Effects is more suitable, we will perform the Hausman test.

Thus we formulate the following hypotheses: H_0: The preferred model is random effects

H_1: The preferred model is fixed effects

Table I.3.3-8. The Hausman Test

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	699.691322	5	0.0000
Cross-section random effects tests comparisons:			
Variable	Fixed	Random	Var (Diff.)	Prob.
BANK_CONCENTRATION	-0.022144	-0.178339	0.000121	0.0000
COST_INCOME_RATIO	-0.029412	0.128861	0.000309	0.0000
ECONOMIC_GROWTH	-0.039927	0.114409	0.000351	0.0000
NPL	0.195868	0.288186	0.000115	0.0000
ROA	1.006030	0.848874	0.000072	0.0000

Source: Author's processing

Following this test, we compared the linear regression pattern between fixed and random effects, obtaining a value of less than 5% for p-value, meaning that we reject the null hypothesis and accept the alternative hypothesis, a linear regression model with fixed effects.

Analysing Table I.3.3-8 we will analyse the following indicators:

"Coefficient"- this indicator shows us the estimates of the independent variables as well as the constant-coefficient "c" in the regression equation. Its positive or negative sign indicates the direction between the relationship of variables. Thus, the Banking Concentration has a coefficient of -0.022, the Cost/Income Rate -0.0294, Economic Growth -0.039, the NPL Rate 0.195, and ROA 1.006.

"Standard error" indicates the value of the deviation from the prediction of the slope coefficient. For our variables, these values are relatively low, with the highest of 1,259 for constant c, and the lowest of 0.018 for the banking concentration.

"T-statistics" is the ratio between "coefficient" and "standard error" and measures the number of standard errors of the coefficient against 0. It shows the deviation of the coefficient of 0.

"Probability" variable or "p-value" is presented as insignificant with a value of more than 5 % and significant with a value of less than 5 %. Most variables in this model with fixed effects have values above 5%, but this only determines that they cannot influence the dependent variable individually. The R-squared shows us, cumulatively these variables influence 90%.

"R-squared" or R^2indicates the value of the variation that can be explained using cumulative independent variables. For a good linear regression, the R-squared value must be greater than 60 % or 0.6. Thus the indicators of bank concentration, Cost/Income, economic growth, the rate of non-performing loans, and ROA explain 90% of the z-score variation and present a successful estimate for the regression equation.

"Adjusted r-squared" is an adjustment of R-squared. This gives us a more precise view of the variation of independent variables being 89%, it decreases with the increase in the number of independent variables. The other 11% is assumed to be the external influence on the dependent variable.

"S.E. of regression" standard error of the entire regression which is significantly low with a coefficient of 1.30.

"Sum squared resid"- In making the econometric model the variables can be explained by independent or sometimes random ones, and this indicator explains the sum of independent and random squares, being of a value of 166.10.

"Log-likelihood" of -176.49, is the difference we will get if we run a restricted version of the model or one without restrictions, so this is the difference between the value we will get from the restricted version and the value obtained from the original version.

For a suitable linear regression, all independent variables must be cumulatively significant for the dependent variable. To do this we need to analyse the f-statistic indicator and prob F-statistic.

"F-statistic" underlines the significance of independent variables in explaining the variation of the dependent one. A value of 90.50 is quite high for the number of independent variables we have, and we consider a high significance. "Prob(F-statistic)" or the probability of the Fisher test expresses the statistical significance of the F value above. In our model, it is 0, and we can consider this model successful, the lower the value, the better the model.

"Mean dependent var" represents the average of the dependent variable and "S.D. dependent var" shows us the standard deviation of the average dependent variable that was also presented in the descriptive statistics of the variables.

"Akaike info criterion", "Schwarz criterion", "Hannan-Quinn criterion" criteria in choosing the best model. The lower this indicator, the better the model. Akaike info criterion is 3.47, Schwarz criterion 3.74, Hannan-Quinn criterion 3.58, so the Akaike info criterion is the lowest for the given model.

"Durbin-Watson stat" illustrates the presence of self-correlation in residual values. A coefficient of 0.98 in the case of this model has a positive self-correlation, being below the standard value for this indicator which is 2.

Following the analysis of these indicators, we determined that the linear regression equation using the fixed effects method is successful, with the significant parameters of the Durbin-Watson state of 0.98, R square of 90%, and the probability of the Fisher test with the value 0. This way we can build the regression equation. For this, we will use the general equation of linear regression in which we will replace our variables.

The general linear regression equation is:

$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n,$

where Y is the dependent variable

$\beta_0, \beta_1, \beta_2, \beta_n$ are the coefficients

X_0, X_1, X_2, X_n are the independent variables

This is how we get the following equation:

$$Z - Score = 8.357839 - 0.022144 * Bank\ Concentration - 0.029412 * \frac{Cost}{Incomei} -$$

$$-0.039927 * Economic\ growth + 0.195868 * NPL + 1.006030 * ROA$$

Through this equation, we can say that with each increase of independent variables with a negative coefficient, the dependent variable will decrease, so when the Bank Concentration increases, the Z Score will decrease by 0.02, with the increase in the Cost/Income ratio Z score will decrease by 0.029, when the coefficient of economic growth increases, the Z Score will decrease by 0.039. For variables with positive coefficients the dependent variable will increase with them, thus, when the rate of non-performing loans increases by one unit, the Z Score will increase by 0.19, and when the ROA increases by one unit, in other words, 1%, Z score will increase by 1.006.

We generated graphs to observe the trend of this indicator as real value and estimated value. So we obtained the following graphs:

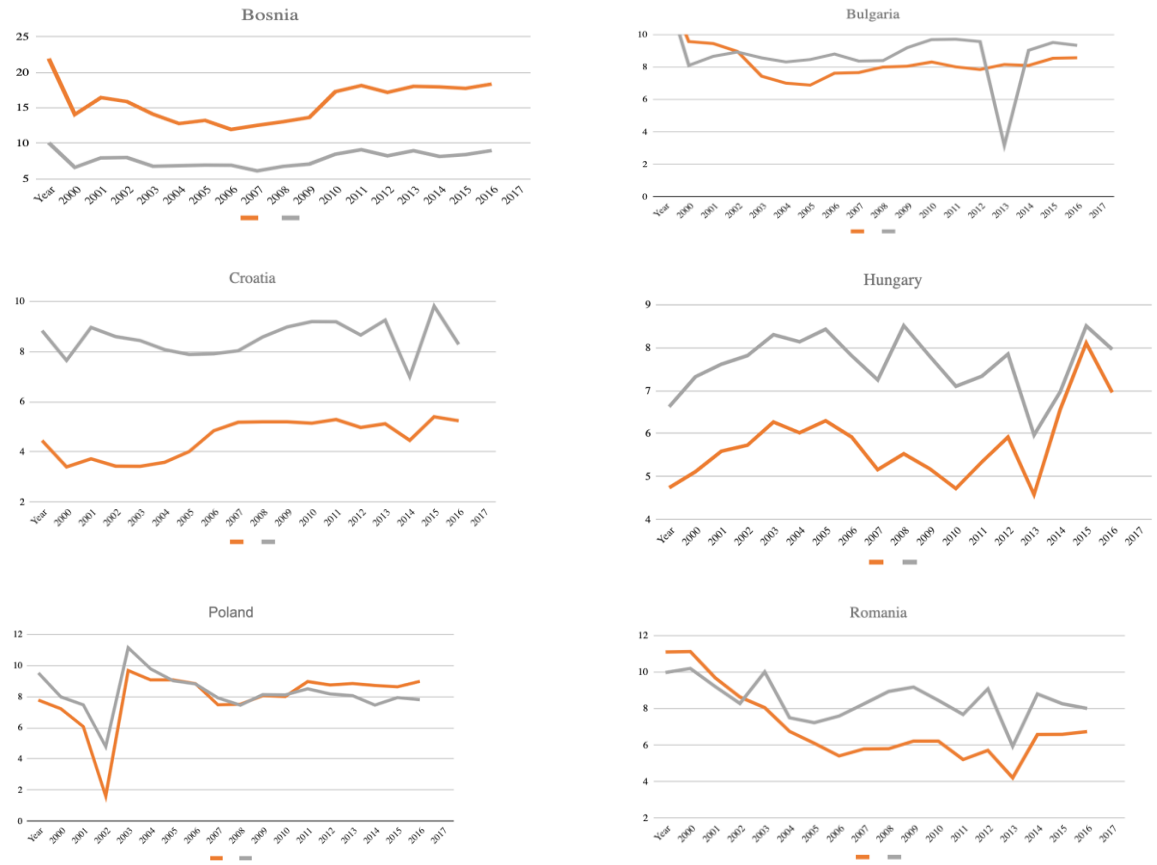


Chart I.3.3-4. Comparison of real data on the evolution of the banks' Z-Score and those obtained using the econometric model within the banking system in Bosnia and Herzegovina, Bulgaria, Croatia, Hungary, Romania, and Poland. Source: Author's processing

In the graphs (Chart I.3.3-4) generated for comparing values, the actual one is represented by the orange colour while the one that is estimated with grey colour. In all countries we see a similar movement between these two variables, meaning that our econometric model has been successful. The linear regression equation is representative of the description of the analysed variables. We can certainly argue that banks' Z-score is dependent on the representative variables of bank profitability and stability, as well as economic growth, thus being impacted by financial crises.

Thanks to different indicators for each country with its monetary economy and policy, we have demonstrated a cumulative dependency. As the r-squared index has shown us, the dependence of the banks' Z-Scores for Bosnia and Herzegovina, Bulgaria, Croatia, Hungary, Romania, and Poland is 90%.

I.3.4. Conclusions of the study

In conclusion, we can say that the financial crisis is a deep frustration of the financial system, accompanied by inflation, the volatility of share prices, manifested by instability and a decrease in the exchange rate of the national currency, mutual payments of economic entities and the mismatch of the supply of money to the requirements of movement in the law of monetary circulation. This is a violation of normal economic activity, which is accompanied by the

destruction of ordinary economic ties, a decrease in business activity, an inability to repay debts, and the accumulation of debts. To this, we should add that the crisis inevitably leads to a decrease in production, an increase in unemployment, and a decrease in the standard of living of the population. They are the main reason for reducing economic growth and the impact of the banking system. We can certainly argue that 90% of banks' Z scores are the result of the influence of internal factors of our econometric model, so the factors of return on assets, the rate of non-performing loans, economic growth, the banking concentration, the rate of Cost/Income, and 10% is an external influence of our model.

SECTION II. RESEARCH ON CORPORATE PERFORMANCE AND SUSTAINABLE ECONOMIC GROWTH

Chapter II.1. MAJOR CRISES OF THE XXIST CENTURY AND IMPACT ON ECONOMIC GROWTH[4]

The 2019-2020 pandemic has led to countries engaging in a war on three key fronts: firstly, in the health system plan, which has been allocated massive funds to fight the spread of the virus and to treat the sick. At present, all countries focus on epidemiological measures to slow the spread of the virus. Secondly, economically, countries face serious problems with great social impact. Budget deficits have increased because large sums have been injected to avoid an economic collapse. Some countries have even increased their ***public debt.*** In most Western countries the economy relies primarily on domestic consumption. Isolation of people in March, April, and May through "social distance" has had an unfavorable impact on the economies of those countries (Hada et al., 2020). Thirdly, in terms of how to work in the future ("telework" or work from home).

Countries are working on protecting their citizens in quarantine or isolation at home by increasing the capacity to maintain essential supply chains, such as those in the areas of food supply, energy, and medicines. The economy contracted in the first half of 2020 due to the COVID-19 pandemic. Businesses have closed and consumers have been isolated, slowing ***consumption***. ***Retail sales*** recorded negative values in Q1 and Q2 2020. The same happened in 2008-2009. The negative economic impact generated by the pandemic, already existing, is impressive. Probably like in 2008, there will be an economic recession. Less clear is its scale. There have been massive falls on the stock exchanges, some even dramatic. Companies were temporarily closed, employees were introduced to the "technical unemployment" system, and production was zero in some sectors. Under these conditions, the ***investments*** are very low or almost none. The crisis can be caused not only by a decrease in demand but also by one in supply due to the decrease in production, the consequences being a generalised shortage of products and a rapid increase in prices. Thus, the supply-side shock was induced by aggregate demand massive reduction, in conjunction with the decline of people income (and future insecurity of income), uncertainty about the further recovery and the horizon of normalisation. Export volumes have fallen as export markets have collapsed, with countries setting other priorities during this period. But that is just one of the dimensions of the challenge. It will be a severe economic downturn caused by panic and the abandonment of more substantial investments by companies, at least in the short and medium-term, due to uncertainty.

Due to blocking, isolation and quarantine, people faced problems related to food, transport, health, and social activities (Ahmad et al., 2020). As a result, countries in the European Union are facing an unprecedented economic shock resulting from the COVID-19 pandemic. The ***number of coronavirus cases*** is continuously increasing. Healthcare and containment measures and the resulting impact on production, demand and trade have reduced economic activity and led to higher levels of unemployment, a steep fall in corporate incomes, increased ***government spending***, an economic downturn and widening disparities within and between the Member States. The

[4] This section is based on the article: **Iuga IC,** Mihalciuc A. 2020. Major Crises of the XXIst Century and Impact on Economic Growth. *Sustainability,* 12(22):9373. https://doi.org/10.3390/su12229373. WOS: 000594570900001

extraordinary macroeconomic and fiscal impact is still ongoing. This creates exceptional uncertainty in closing the production gap while ensuring the sustainability of public debt and ultimately correcting the excessive deficit. The main objective of countries' policies is to have ***high and sustainable economic growth***. However, to achieve and maintain a high growth rate, policymakers need to understand the drivers of growth, as well as how policies affect economic growth. When analysing the relationship between macroeconomic indicators and economic growth, most researchers analysed the influence of the following indicators: foreign direct investment, inflation, unemployment rates, government spending, labour productivity, government bonds and interest rates on public debt. Over the past two decades, hundreds of empirical studies have tried to identify growth determinants. This is not to say that growth theories are of no use for that purpose. Rather, the problem is that different growth theories are typically compatible with one another.

Given the complexity and range of the problem, from several factors influencing economic growth, in this research we selected indicators whose developments have changed significantly since the emergence of the Covid-19 pandemic: Government debt; Consumption; Consumption growth; Investment; Government spending; Retail sales. The reason for choosing these indicators was that their evolution changed significantly with the coronavirus epidemic which led to population-restrictive measures by state governments. The paper addresses the issue of dependency and the impact of the 6 indicators on economic growth. We have not found studies in the empirical literature that provide a comparative analysis of the impact of the 6 indicators (mentioned above) on economic growth comparing the 2 major crisis periods of the 21st century: 2008 and 2020.

The negative development of economic growth during the two periods (2008-2009 and 2020) may be due to different developments. We examine them in our study, looking for answers to the following questions: To what extent are the two periods similar and different? What were the major factors influencing the evolution of economic growth in the two periods analysed? Comparing the two periods is useful and instructive, not only to better understand the economic and social contexts behind tax phenomena but also because past experiences can provide answers to our questions about current events.

The purpose of this study is to develop 2 models that analyse the influence of macroeconomic indicators on economic growth. The aim is to identify those indicators that most significantly influence economic growth in the Central and Eastern Europe countries (which are EU members) as well as to analyse the intensity of correlations. The first model covers the period 2001-2019 and the second model covers the period 2001-2020 Q2. In Model 2 we added another indicator: coronavirus cases. At last, we try to answer the two questions above. The selected countries are those in Central and South-Eastern Europe: Latvia, Slovakia, Greece, Hungary and Poland, Croatia and Slovenia, Estonia, Bulgaria, Lithuania, Czech Republic, and Romania.

This study strives to cover the above research gap by providing a robust empirical investigation based on well-established theoretical considerations. We identify the macroeconomic factors determining economic growth by using Ordinary Least Square (OLS) method for cross-section data. Firstly, we analysed whether independent variables are not multi collinear by using the correlation matrix. Then, the T-test was used to test the significance of the coefficients. The overall significance of the model was tested by using the F test. R-squared shows the extent to which the variation of the dependent variable is explained by the independent variables in the model.

The study offers a unique approach to comparing the two periods of crisis: the 2008 economic crisis and the pandemic crisis in 2020.

Our study covers EU member countries from Central and Eastern Europe in the period 2001-2020 Q2. In the second section, we presented the revision of scientific literature. In Section 3, we described the data and research methodology, namely the variables used, and specified the empirical results of our model and compared them with different studies. The work concludes with findings and deductions about the results.

II.1.1. Government debt, consumption, and investment: assessing their influence on economic growth - a brief literature review

Assessing global economic growth in real-time is a key point for macroeconomists responsible for monitoring global economic problems, but also a real challenge for economists. Another thing to remember is that the global economic growth was heavily affected by the Great Recession in 2009, reaching its lowest level since the start of the series until 2019, which can also be seen in our model. Its lowest value was exceeded in 2020, suggesting that it may be the case that the level of economic growth in Q1 and Q2 2020 is well below 2009 due to countries' efforts to stop the COVID-19 pandemic. In most of the countries our study is based upon, there is a much lower level of economic growth compared to 2008, 2009 (see Fig.1).

The first line of research focuses on investigating the direct/indirect correlation between public debt and economic growth

Many studies investigate the relationship between public debt and economic growth. Most support a negative effect of public debt on economic growth. Among the works that have addressed the influence of government debt on economic growth are Gómez-Puig et al. (Gómez-Puig and Sosvilla-Rivero, 2018) which indicates that high public debt tends to hinder economic growth by increasing uncertainty about future taxation, eliminating private investment and weakening a country's resilience to shocks. In other works of literature, many empirical studies find a non-linear negative relationship between public debt and economic growth. For example, Kumar and Woo (Woo and Kumar, 2015) confirm that only high levels of debt (rates above 90% of GDP) have a significant negative impact on economic growth. They note that a 10-percentage point increase in the initial debt ratio is associated with a slowdown in the real GDP growth rate per capita of 0.2 percentage points per year. Cecchetti, Mohanty and Zampolli (2011) also note in various growth regression specifications that the threshold beyond which public debt harming economic growth is around 85% of GDP. Checherita-Westphal and Rother (2012) note a non-linear impact of debt on long-term growth, with a turning point of about 90-100% of debt to GDP. Some studies point out that the negative relationship between public debt and growth depends on country-specific factors and the institutions (Kourtellos et al., 2013; Dreger & Reimers, 2013). Moreover, Donayre and Taivan (2017) examine the causal direction between public debt and real economic growth in a sample of 20 OECD countries for the years 1970-2010 and note that rich countries tend to face low real economic growth as a result of rising public debt.

Other studies show the non-linearity of the public debt effect on economic growth. Reinhart and Rogoff (2010) suggest that high debt levels are negatively correlated with economic growth, although there is no link between debt and growth when public debt is below 90% of GDP. Pattillo et al. (2011) used data from 100 developing countries and concluded that there was a non-linear relationship between the net present value of foreign debt and economic growth. Cordella et al. (2010) however, notes a negative relationship between foreign public debt and economic growth

only in developing countries with intermediate levels of debt and in developing countries with very low or very high levels of debt this relationship disappears.

Even though many of previous studies lead to a negative association of public debt with economic growth, there is a contrasting view. Some studies show different results, namely: a positive effect of public debt on economic growth: some authors argue that public loans can improve the economy when it is intended for public investment. Modigliani et al. (1998), Creel and Fitoussi (2002), Le Cacheux (2002) and Blanchard and Giavazzi (2004) support the idea of the "Golden Rule of Public Finance (GRPF)." The main idea behind the Golden Rule is that public loans are harmful only when used for current spending, but not when they accumulate public capital, namely, the purpose and composition of public loan issues. Baum, Checherita-Westphal and Rother (2013) argue that the short-term impact of government debt on economic growth is positive and very statistically significant, but falls to about zero and loses its significance when the ratio of public debt to GDP reaches around 67%. The empirical results of Ahmad et al.'s study (2020) support the assumption that the effect of public debt on economic growth is a function of corruption and concluded that in a very transparent–not corrupt– country, public debt increases economic growth and vice versa.

Some studies show the neutrality of the relationship; for example, Jakobs et al. (2020) investigates the causal relationship between public debt rates and growth rates for 31 EU and OECD countries and have found no causal link between public debt and economic growth, regardless of levels of the public debt ratio.

The second line of research focuses on investigating the direct/indirect correlation *between consumption and economic growth.*

Anghel et al. (2017) argue that the increase in final consumption is directly correlated with economic growth, as measured by the GDP macroeconomic indicator. Alper (2018) investigates the relationship between growth and consumption in Brazil, Russia, India, South Africa and Turkey. He used the panel data method using annual data for the period 2005-2016 and pointed out that a 1% increase in consumer spending leads to a 0.41% increase in economic growth.

The measures introduced by European governments this year (2020) to limit the spread of the COVID-19 epidemic (social distance, closure of most commercial premises) directly or indirectly affected the consumption of the population and therefore consumer price indices. In the case of 2020, the problem is twofold: on the one hand, the steep increase in unemployment, temporary suspension from work or inactivity of self-employed people have led households to reduce consumption. On the other hand, there is no reason for firms to invest in a context where demand for products is low and there is a lot of uncertainty. Many companies have a high risk of bankruptcy being completely "devoid" of forecasted cash flows. The contraction of aggregate demand is also so acute that it could very well explain why rising inflation possible because of supply constraints, do not pose a serious threat for now (2020).

The third line of research focuses on investigating the direct/indirect correlation *between investment and economic growth.*

Investment is one of the main components of aggregate demand. Investment plays an important role in economic growth. The effect of investment on economic growth is recently a strong topic for both developing and developed countries. Separately, public investment and economic growth are heated economic topics. Economic growth depends mainly on public investment (Uddin et al., 2015).

Today, several studies have tested the relationship between investments (in all its forms: public, private, foreign direct investment, etc.) and economic growth, and some have found a link between the two variables. These conclusions or findings vary depending on the methods used in the research, variable options, etc. Uddin et al. (2015) noted that public and private investment simultaneously play an important role in rapid economic growth. Both public and private investment are needed to increase real GDP, where public investment is large compared to private investment. Cucos (2016) in his paper argues that there is a positive relationship between investment and economic growth. Cavallo and Daude (2008) argue in their paper that public investment has a positive effect on economic growth. Zainah (2009) plays the role of public investment in promoting economic growth in an African island country Mauritius from 1970 to 2006, using a vector error correction model (VECM) to analyse the effects. It concluded that public investment makes a significant contribution to economic performance, to economic growth. Haque and Kneller (2008) in their paper concluded that corruption increases public investment but reduces its effects on economic growth. They suggested that policies to deter corruption and increase the efficiency of public investment could give very positive boosts to economic growth. Nguyen and Nguyen (2017) used a quantitative method in their study to assess the impact of public investment on private investment and growth, based on data from 18 developing countries over 21 years (1995-2015). Their findings show that all public investment and investment in public-private partnership affect private investment as well as economic growth, but the effects vary cyclically, depending on the period and the group of countries. For developing countries in Asia, public investment has a positive impact on economic growth, with the inverted U-shaped model, which stimulates growth in the short and medium-term, but in the long term, the effects of increased stimulus tend to decline.

Concerning foreign direct investment, the findings are contradictory, but extensive research shows that FDI has a positive effect on economic growth. Kukeli et al. (2006), on their research, notes a positive relationship between FDI and production in ten Central and Eastern European countries. Pradhan (2009) investigates the relationship between ISD and economic growth in ASEAN countries, namely Indonesia, Malaysia, Thailand, Singapore, and the Philippines, between 1970 and 2007. The study finds a two-way co-integration between FDI and economic growth, except for Malaysia. Cakerri et al. (2020) in their study claim that: a 1% increase in FDI lag (lnFDI) will lead to a 4.35% Gross Domestic Product lag increase.

The fourth line of research focuses on investigating the direct/indirect correlation *between Government spending and economic growth.*

The size of government spending and its effect on long-term economic growth, and vice versa, has been an issue of interest sustained for decades. Macroeconomics, especially Keynesian school of thought, suggests that government spending accelerates economic growth. Thus, public expenditure is considered an exogenous force that alters aggregate production (Loizides & Vamvoukas, 2005).

Gregoriou and Sugata (2008) present a study that analyses the impact of government spending on growth for 15 developing countries. Using GMM techniques, the authors showed that countries with substantial public expenditure have strong growth effects. Cooray's study (2009) investigates the role of government in economic growth by expanding the neoclassical production function to incorporate two dimensions of government – size and quality. Size is measured by government spending and governance quality, and the model is tested on a cross-section of 71 economies.

Empirical results indicate that both the size and quality of government are important for economic growth.

Aschauer (1989) argues that the increase in public spending accelerates economic growth. For example, public spending on social services increases labour productivity and increases the growth of national production. In the same vein, government spending on infrastructure lowers the cost of production, encourages private sector investment, and promotes economic growth.

For high-income economies, empirical results have consistently reported a positive relationship between productive public spending and economic growth (Afonso &and González, 2011; Bleaney et al., 2001; Kneller et al., 1999). In the case of low- and medium-income economies, the findings on the relationship between the level of public spending and economic growth are mixed. In this respect, Gupta et al. (2005) used a group of 39 low-income countries and found that productive public spending increased growth, while non-productive spending failed to do so. Christie (2012) revealed an inverse relationship between productive public spending and real GDP per capita for developing economies.

Several researchers have examined the correlation between public spending and economic growth in different regions, but there is no concrete result on which the components of public spending have a direct effect on economic growth (Muhammed & Asfaw, 2014). For example, Barlas's study (2020) looked at the impact of spending on economic growth in Afghanistan. The results show that dependent and independent variables are stationary at their level and the first difference. Estimated education and infrastructure coefficients directly affect the rate of economic growth. However, security expenditure is negatively linked to economic development.

Babatunde (2007) argues that increasing government spending reduces economic growth. He believes the government can cover this improvement by raising taxes.

The fifth line of research focuses on investigating the direct/indirect correlation *between retail sales and economic growth.*

Retail-based development is often overlooked, but it is a vital component of the local economy. Phillips (2000) makes some arguments for supporting retail-based development:

• Retail is a "clean" development. Retail trade, in general, is less destructive to the natural environment compared to other land uses, such as manufacturing. It is rarely contested by citizens or environmental groups based on possible environmental degradation (Brammer & Tomasik, 1995).

• Retail is a growing industry. While employment has fallen in manufacturing and other sectors due to technology, the retail sector continues to expand.

• Retail is a basic element of local economies. Retail taxes are a major source of revenue for many communities. Besides, property taxes for retail development also generate revenues (Lackey and Eckcnstahler, 1995).

• On average, retail "returns" to the community in the form of tax payments are larger than office, residential or industrial properties.

Pittman and Phillips (1995) explain why retail sales have a positive influence on economic growth: retail sales increase the amount of revenue available in a community and helps reduce retail spending losses in the community.

Therefore, we note that, as more econometric problems are addressed, the effect of the six indicators (Government debt; Consumption; Consumption growth; Investment; Government spending; Retail sales) on economic growth is becoming more robust, corroborating the predictions of the proposed theoretical model. Our empirical analysis controls for heterogeneity

according to time, country-specific, growth rates. We also address endogeneity issues and allow heterogeneity between countries in terms of model parameters and cross-sectional dependencies.

Therefore, our contribution to the empirical literature is twofold. First, unlike previous studies, we do not use panel estimation techniques to combine the power of cross-section mean with all the subtleties of temporal dependence; rather, we explore the size of the time series of the problem to obtain additional evidence based on the historical experience of each country in the sample, to detect potential heterogeneities in the relationship between the countries of Central and Eastern Europe. Secondly, our econometric methodology is data-based and allows us to select the statistical model that best approximates the relationship between the variables studied for a given country and to assess the influence of the 6 indicators (for Model 1) or 7 indicators (for Model 2) on economic growth.

II.1.2. Data and Methodology

To achieve the research objective, the authors used several methodological approaches. The basis of the research was the content-causal analysis of theoretical knowledge and practical research. Concerning theoretical approaches (presented in the previous section of this paper), we have defined the macroeconomic indicators that we have included in the database for analytical processing by econometric methods. Based on an analysis of a set of studies addressing several macroeconomic indicators, the authors decided to use the following indicators (as independent variables) for this empirical research: Government debt; Consumption; Consumption growth; Investment; Government spending; Retail sales. All these indicators are placed in the category of influence variables. The dependent variable is economic growth. The sample includes a cross-section of 12 EU member countries in Central and Eastern Europe. The reason for choosing countries is twofold. One, data for all independent variables are available for this group of countries. Two, the sample is chosen in such a way as to capture the countries of the eastern half of Europe. Moreover, from the 12 countries that make up the sample, 6 countries come from the Euro area and 6 countries have their national currency. The data used for the 2 models cover the period 2001-2020Q2 and are annual (period 2001-2018) and quarterly (period 2019-2020Q2). The data from this study were obtained from the following sources: World bank database; theglobaleconomy.com website; sites of national central banks and governments in the analyzed countries. Proxies and expected relationship of all the variables is provided in Table II.1.2.

Table II.1.2: Variables description and their relationship

Category		Proxy or definition Measurement	Expected sign
		Independent variables	
Government debt	GvD	Government debt as a percent of GDP (Only core debt instruments are included, defined here as comprising (i) currency and deposits; (ii) loans; and (iii) debt securities.)	-
Consumption	Cs	Household Consumption as a percent of GDP	+
Consumption growth	CsGw	The percent change in Household Consumption from the same quarter last year.	+
Investment	Inv	Investment as a percent of GDP (Gross fixed capital formation including land improvements; plant, machinery, and equipment purchases; and the construction of roads,	

		railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings as a percent of GDP)	+
Government spending	GvS	Government spending as a percent of GDP	-
Retail sales	Ret	Retail sales Y-on-Y (The retail sales Y-on-Y is an aggregated measure of the sales of retail goods over a stated period. Because retail sales are a measure of consumer demand for finished goods, they are a leading macroeconomic indicator of the pulse of an economy and its projected path toward expansion or contraction. Retail sales Y-on-Y is calculated as the percent change in the Retail sales index from the same month the previous year. The Retail sales Y-on-Y measures only volume changes, i.e. price level changes are excluded.)	+
Coronavirus cases (this variable is used only in the Model 2)	Cc	Number	-
Dependent variable			
Economic growth	EcGw	the rate of change of real GDP	

Source: Authors' view

We will build 2 models:

- Model 1: we will analyse the influence of six indicators (GvD, Cs, CsGw, Inv, GvS, Ret) on economic growth in the period 2001-2019, a period that also includes the influence of the economic crisis of 2008.
- Model 2: in addition to the six indicators we added another variable (coronavirus cases) for the period 2001-2020Q2 to see the measure of pandemic influence on economic growth. Specifically, the first cases of coronavirus (Cc) occurred in the first quarter of 2020.

Empirical Regression Model

In statistical modelling, regression analysis is used to estimate the relationships between two or more variables. Regression analysis helps us understand how the dependent variable evolves when one of the independent variables varies, thus allowing the mathematical determination of variables that have a greater impact on the dependent variable. Table II.1.2.2-2. show linear regressions between economic growth (EcGw) and coronavirus cases (Cc), government debt (GvD), consumption (Cs), consumption growth (CsGw), investment (Inv), government spending (GvS), retail sales (Ret) for EU countries in Central and Eastern Europe.

The empirical function is posed as follows:

$$EcGw = F(Cc, GvD, Cs, CsGw, GvS, Inv, Ret, Cc) \quad (1)$$

II.1.2.1. Model 1

First step, we move to a brief graphical overview of the level of the dependent variable (Economic growth) of the countries of Central and Eastern Europe for the period 2000-2020Q2. According to Fig. II.1.2.1, we can see a similar trend for all countries analysed. A significant decrease is observed in the crisis years 2008-2009. The same major downward trends are also recorded for the first two quarters of 2020 with an ongoing economic crisis. For 2008-2009 the lowest values are recorded by Latvia, Lithuania, and Estonia. Higher values for 2009 were maintained by Poland, Bulgaria, and the Czech Republic, and in the second quarter of 2020, Lithuania, Estonia, and Bulgaria are better than the other countries but are still negative (-4.2 for

Lithuania, -6.9 for Estonia, and -8.7 for Bulgaria). Economic growth depends on the characteristics of the country, the conditions of the financial market, the behaviour of governments, private agents, the population, and the multiple functions of growth.

Figure II.1.2.1. The economic growth of Central and Eastern European countries (2001-2020Q2)

Table II.1.2.1-1. Descriptive statistics

	Cs	CsGw	EcGw	GvD	GvS	Inv	Ret
Mean	59.35413	6.345568	3.114432	48.52091	18.78686	24.98905	4.025871
Median	60.05000	5.590000	3.510000	39.75500	18.84828	24.66000	4.085000
Maximum	76.01000	50.87000	11.89000	198.5100	23.31000	40.48000	24.46000
Minimum	45.81000	-17.91000	-14.81000	3.800000	13.74000	10.06000	-28.05000
Std. Dev.	6.561088	6.967252	3.789179	38.28335	1.789512	5.369318	7.063894
Skewness	-0.228534	1.436498	-1.564309	2.011208	-0.332486	0.024020	-0.463486
Kurtosis	2.342673	11.93971	8.161289	7.638157	3.055069	3.168700	6.041091
Jarque-Bera	7.050890	969.8984	400.6987	414.6157	4.897424	0.338442	111.1827
Probability	0.029439	0.000000	0.000000	0.000000	0.086405	0.844322	0.000000
Observations	264	264	264	264	264	264	264

Source: author's processing

As measures of normality of data are considered skewness and kurtosis. The skewness indicator, or degree of asymmetry, is a measure to verify the probability distribution of a variable random to the actual value on its mean. The lower the value of this indicator, the closer the value of the distribution is to normality, so the value 0 indicating a normal skewness and that the distribution is symmetrical around its mean, positive skewness with higher values and negative skewness with lower values. In the case of indicators of consumption growth, government debt and investment are observed a skewness greater than 0, so our data have more extreme values on the right, with the distribution tilted to the left, and consumption, economic growth, government spending, and retails are lower than 0, with extreme values on the left and the distribution tilted to the right (see Table II.1.2.1-1). The kurtosis indicator measures whether a normal distribution is present or missing, as well as how flat, or what curve tip this distribution has. Most non-consumption indicators have values greater than 3, belonging to a positive kurtosis with a peak, leptokurtic curve. Consumption with a value of 2.34 has a platikurtic distribution with a flatter curve. Also, the government spending indicator with a value of 3.05 and investments with a value of 3.16 being closer to the value of 3 suggests a normal distribution with a mesokurtic kurtosis. The Jarque-Bera indicator is a test to verify the normality of distribution by measuring the difference between skewness and kurtosis of variables with those in a normal distribution. The probability or p-value after this indicator helps us to create an opinion and decide whether we accept or reject the hypothesis that we have a normal distribution.

H_0: There is a normal distribution

H_1: There is an abnormal distribution

If the value is greater than 0.05, we accept the null hypothesis and we have a normal distribution, however, if it is less than 0.05 then we reject the null hypothesis, and accept the alternative hypothesis that we have an abnormal distribution. In the case of the indicators we have, only government spending and investments that have a p coefficient value of more than 0.05, so we accept the null hypothesis and can say that we have a normal distribution. In the case of the other indicators, the p-value is less than 5%, so we reject the null hypothesis and accept the alternative hypothesis, assuming an abnormal distribution for the other indicators. Although most indicators have an abnormal distribution, this does not mean that we will not be able to achieve a dependency correlation between indicators. Because we have a series of chronological data, a normal distribution is not so important for our regression.

From Table II.1.2.1-2 we can find a statistically significant linear relationship between Cs and EcGw at a significance level of 1% (p-value = 0.0003). The entire statistically significant linear relationship is between CsGw and EcGw and between Ret and EcGw (p-value = 0.0000). The sign of the CsGw and Ret coefficients is the one expected, being positive. Also, considering all the six variables, we found that CsGw and Ret can be a determining factor for economic growth.

Table II.1.2.1-2. Estimation of parameters for the linear regression model. Dependent Variable: EcGw (Included observations: 264)

Variable	Coefficient	t-St.	P-value
C	7.312589	3.048197	0.0025
GvD	0.011444	2.255246	0.0250
Cs	-0.089723	-3.652446	0.0003
CsGw	0.228433	8.230620	0.0000
Inv	0.082274	2.344913	0.0198
GvS	-0.208514	-2.401288	0.0170
Ret	0.244376	10.03939	0.0000
	R-squared	0.681400	
	Adjusted R-squared	0.673962	
	Prob(F-statistic)	0.000000	

Source: author's processing

As a result of this model, we see that all our variables are significant with a probability value of less than 5%. Standard errors have low values which indicate that the variables are indeed significant, but to ensure that we will also check the correlations between variables.

Table II.1.2.1-3. Estimating correlations between variables

	EcGw	**Cs**	**CsGw**	**GvD**	**GvS**	**Inv**	**Ret**
EcGw	1.000000	-0.055315	0.707565	-0.298653	-0.297301	0.381505	0.738383
Cs	-0.055315	1.000000	0.179911	0.349781	-0.091229	-0.372543	0.040570
CsGw	0.707565	0.179911	1.000000	-0.342182	-0.303653	0.369238	0.619229
GvD	-0.298653	0.349781	-0.342182	1.000000	0.364266	-0.614882	-0.238489
GvS	-0.297301	-0.091229	-0.303653	0.364266	1.000000	-0.048986	-0.267493
Inv	0.381505	-0.372543	0.369238	-0.614882	-0.048986	1.000000	0.259505
Ret	0.738383	0.040570	0.619229	-0.238489	-0.267493	0.259505	1.000000

Source: author's processing

The correlation is used to measure the strength of the relationship between two variables. It can be positive, negative, or zero. The correlation coefficient can take any value between +1 and -1. A correlation matrix is a table that shows correlation coefficients between sets of variables. Each random variable (Xi) in the table is related to each of the other values in the table (Xj). Table II.1.2.1-3 shows the paired correlations of economic growth (EcGw), consumption (Cs), consumption growth (CsGw), government debt (GvD), government spending (GvS), investment (Inv), and retail sales (Ret) for the 12 countries analysed. We found a very poor correlation between Cs and EcGw (coef. = -0.055) and a much stronger correlation between CsGw and EcGw (coef. = 0.707) (see Table 4). The strongest correlation is between Ret and EcGw (coef. = 0.738). So, the strongest correlation with EcGw is given by retail. This result is confirmed by other studies: Anghel et al. (2017), Alper (2018).

Although the Panel Least Square Method is one of the best known and used, it does not recognize the heterogeneous nature of cross-sections. To have the most accurate analysis, we will also use linear models of constant and random effects (Table II.1.2.1-4). The first estimates a common single effect and the second estimates using an average effect distribution.

Table II.1.2.1-4. Estimation of parameters for the linear regression model

Variable	**Constant effects**			**Random Effects**		
	Coefficient	t-St.	p-val	Coefficient	t-St.	p-val
C	13.12069	4.121258	0.0001	9.084784	3.610428	0.0004
Cs	-0.179017	-4.026723	0.0001	-0.111485	-3.907688	0.0001
CsGw	0.271017	9.755233	0.0000	0.245741	9.170300	0.0000
GvD	0.016757	1.696574	0.0210	0.015971	2.673912	0.0080
GvS	-0.327059	-3.001909	0.0030	-0.283533	-3.108292	0.0021
Inv	0.133387	3.423250	0.0007	0.107772	3.069969	0.0024
Ret	0.222933	9.467092	0.0000	0.234990	10.11654	0.0000
	R-squared	0.728648		R-squared	0.690720	
	Adjusted R-squared	0.709896		Adjusted R-squared	0.683499	

Source: author's processing

To decide which of these two models, the one with fixed effects or random effects is more suitable, we will perform the Hausman test (Table II.1.2.1-5). Thus, we formulate the following hypotheses:

H_0: The random-effects model is suitable

H_1: The fixed-effects model is suitable

Table II.1.2.1-5 Hausman Test

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	17.465112	6	0.0077
Cross-section random effects tests comparisons:			
Variable	**Fixed**	**Random**	**Var (Diff.)**	**Prob.**
Cs	-0.179017	-0.111485	0.001162	0.0476
CsGw	0.271017	0.245741	0.000054	0.0006
GvD	0.016757	0.015971	0.000062	0.9205
GvS	-0.327058	-0.283533	0.003549	0.4650
Inv	0.133387	0.107772	0.000286	0.1298
Ret	0.222933	0.234990	0.000015	0.0018

Source: author's processing

Following this test (see Table II.1.2.1-5) we compared the linear regression model between fixed and random effects, obtaining a value of less than 5% for p-value, meaning that we reject the null hypothesis and accept the alternative hypothesis, a linear regression model with fixed effects. Therefore, we focus the analysis on the linear regression model with fixed effects. By removing the results obtained from the estimation of parameters for the linear regression model with fixed effects in Table 5 we conclude that the p-value is significant because all variables of the model with fixed effects have values below 5%. As the R-squared shows us, these variables influence 72%. Thus, indicators of consumption, consumption growth, government debt, government spending, investment, and retail sales explain 72% of the change in economic growth and present a successful estimate for the regression equation. Adjusted r-squared has a value of 70.9%. The

other 29.1% is assumed to be the influence of other factors on the dependent variable outside of the model that we did not catch in this model.

The general linear regression equation is:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n, \quad (2)$$

where Y is the dependent variable (EcGw)

$\beta_0, \beta_1, \beta_2, \beta_n$ are the coefficients

X_0, X_1, X_2, X_n are the independent variables (Cs, CsGw, GvD, GvS, Inv, Ret).

According to Data in Table 5 (fixed effects), it appears that the variables CsGw (0.27) and Ret (0.22) have the greatest positive impact on EcGw and the GvS variable (-0.32) has the greatest negative impact on EcGw. The signs of the CsGw and Ret coefficients are the ones expected, being positive. If CsGw increases by one point, EcGw will increase by about 0.27 points. If Ret increases by one point, EcGw will increase by about 0.22 points. The sign of the GvS coefficient is negative, meaning that if GvS increases by one point then EcGw will decrease by 0.32 points.

II.1.2.2. Model 2

Table II.1.2.2-1. Descriptive Statistics

	EcGw	CsGw	Cs	GvD	GvS	Inv	Ret	Cc
Mean	2.411111	5.530729	59.31059	49.47264	18.94242	24.56924	3.480868	612.5000
Median	3.235000	5.365000	60.10000	39.98000	19.00642	24.29000	3.745000	0.000000
Maximum	11.89000	50.87000	76.01000	198.5100	24.34444	40.48000	24.46000	48300.00
Minimum	-15.27000	-20.86000	45.81000	3.800000	13.74000	10.06000	-28.05000	0.000000
Std. Dev.	4.643965	7.592429	6.604935	38.90685	1.839598	5.485310	7.246021	4194.764
Skewness	-1.609860	0.728856	-0.217518	2.038936	-0.264420	0.024777	-0.457502	8.716387
Kurtosis	6.492311	9.777842	2.336081	7.698493	3.158873	3.104734	5.547766	83.83153
Jarque-Bera	270.7541	576.7689	7.560535	464.4585	3.658942	0.161099	87.94015	82051.66
Probability	0.000000	0.000000	0.022817	0.000000	0.160498	0.922609	0.000000	0.000000
Observations	288	288	288	288	288	288	288	288

Source: author's processing

Skewness has values higher than 0 for consumption growth, government debt, investment, and coronavirus cases with left-leaning distribution and values lower than 0 for growth, consumption, government spending, and retail sales with the right-leaning distribution. Kurtosis has values greater than 3 for economic growth, consumption growth, government debt, retail sales, coronavirus cases with a positive kurtosis. Government spending and investments are very close to 3 indicating a normal distribution, whereas the consumption indicator is the only one with a kurtosis below 3 (Table II.1.2.2-1).

Table II.1.2.2-2. Estimation of parameters for the linear regression model

Dependent Variable: EcGw (Included observations: 288)

Variable	Coefficient	t-St.	P-value
C	11.11302	4.079421	0.0001
Cc	-0.000191	-5.056055	0.0000

Cs	-0.106218	-3.799007	0.0002
CsGw	0.320400	11.01639	0.0000
GvD	0.010633	1.898332	0.0587
GvS	-0.340459	-3.462571	0.0006
Inv	0.049920	1.298304	0.1953
Ret	0.183662	6.970800	0.0000
	R-squared	0.705014	
	Adjusted R-squared	0.697639	
	Prob(F-statistic)	0.000000	

Source: author's processing

From Table II.1.2.2-2 we can find a statistically significant linear relationship between Cs and EcGw at a significance level of 1% (p = 0.0002). A significant linear relationship is also observed between GvS and EcGw with a meaning level of 1% (p = 0.0006). As with the previous model (Model 1) and Model 2, there is a statistically significant linear relationship between CsGw and EcGw and between Ret and EcGw (p-value = 0.0000). Also, in this model we have introduced another variable (coronavirus cases - Cc) and with which we find a statistically significant linear relationship (p-value = 0.0000). The sign of the CsGw and Ret coefficients is the one expected, being positive and the Cc coefficient is negative. Also, considering the 7 variables, we found that Cc, CsGw, and Ret may be determining factors for economic growth.

As a result of this model, we see that all our variables are significant with a probability value of less than 5%, With the exception of GvD and Inv. Standard errors have low values which indicate that the variables are indeed significant, but to make sure we will also check the correlations between variables.

Table II.1.2.2-3. Estimating correlations between independent variables

	ECGW	**CsGw**	**Cs**	**GvD**	**GvS**	**Inv**	**Ret**	**Cc**
ECGW	1.000000	0.755964	-0.011564	-0.294952	-0.412440	0.380144	0.663098	-0.380191
CsGw	0.755964	1.000000	0.191320	-0.332164	-0.392176	0.381822	0.597071	-0.256179
Cs	-0.011564	0.191320	1.000000	0.367352	-0.101149	-0.365031	0.035931	-0.024086
GvD	-0.294952	-0.332164	0.367352	1.000000	0.372720	-0.599189	-0.235424	0.008596
GvS	-0.412440	-0.392176	-0.101149	0.372720	1.000000	-0.096229	-0.307602	0.155612
Inv	0.380144	0.381822	-0.365031	-0.599189	-0.096229	1.000000	0.307151	-0.106859
Ret	0.663098	0.597071	0.035931	-0.235424	-0.307602	0.307151	1.000000	-0.177496
Cc	-0.380191	-0.256179	-0.024086	0.0085960	0.1556120	-0.106859	-0.177496	1.000000

Source: author's processing

We found a stronger correlation in this model between CsGw and EcGw (coef. = 0.755) (see Table II.1.2.2-3) comparing it with Model 1, the strongest correlation being between them. After checking the correlations, we can certainly argue that we do not have multicollinearity present in our model although the correlation between consumption growth and economic growth is 0.75, their probability in the model of the least panel squares shows us a value below 0.05. Next, we used the fixed and random effects method, after which we will perform the Hausman Test (Table II.1.2.2-5.).

Table II.1.2.2-4. Estimation of parameters for the linear regression model

Variable	**Fixed Effects**			**Random Effects**		
	Coefficient	t-St.	p-val	Coefficient	t-St.	p-val
C	19.77306	5.553999	0.0000	12.53696	4.575971	0.0000

Cc	-0.000169	-4.590867	0.0000	-0.000182	-5.072206	0.0000
Cs	-0.235004	-4.751683	0.0000	-0.123680	-4.125988	0.0000
CsGw	0.366323	12.62486	0.0000	0.332730	12.02453	0.0000
GvD	0.005853	0.529636	0.5968	0.013181	2.176684	0.0303
GvS	-0.438485	-3.717818	0.0002	-0.391870	-3.987868	0.0001
Inv	0.085279	2.038428	0.0425	0.066489	1.777371	0.0766
Ret	0.165171	6.571557	0.0000	0.177527	7.144270	0.0000
R-squared	0.749943			R-squared	0.712493	
Adjusted R-squared	0.733211			Adjusted R-squared	0.705306	
Prob (F-statistic)	0.000000			Prob (F-statistic)	0.000000	

Source: author's processing

As we carried out the first model, to decide which of these two models, the one with fixed effects or with random effects is more suitable, we will perform the Hausman test. Thus, we formulate the following hypotheses:

H_0: The random-effects model is suitable

H_1: The fixed-effects model is suitable

Table II.1.2.2-5. Hausman Test

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	29.466633	7	0.0001
Cross-section random effects tests comparisons:			
Variable	**Fixed**	**Random**	**Var (Diff.)**	**Prob.**
Cc	-0.000169	-0.000182	0.000000	0.1443
Cs	-0.235004	-0.123680	0.001547	0.0047
CsGw	0.366323	0.332730	0.000076	0.0001
GvD	0.005853	0.013181	0.000085	0.4279
GvS	-0.438485	-0.391870	0.004254	0.4748
Inv	0.085279	0.066489	0.000351	0.3158
Ret	0.165171	0.177527	0.000014	0.0011

Source: author's processing

Following this test, we compared the linear regression model with fixed or random effects, obtaining less than 5% for p-value, meaning that we reject the null hypothesis and accept the alternative hypothesis, a linear regression model with fixed effects (Table II.1.2.2-5). Therefore, we focus the analysis on the linear regression model with fixed effects.

By removing the results obtained from the estimation of parameters for the linear regression model with fixed effects in Table II.1.2.2-4 we conclude that the p-value is significant because all variables of the model with fixed effects have values below 5%, with exception of GvD. As R-squared shows us, these variables' influence is 74%. Thus, the indicators of coronavirus cases, consumption, consumption growth, government debt, government spending, investment, and retail sales explain 74% of the change in economic growth and present a successful estimate for the regression equation. Adjusted R-squared has a value of 73%. Unlike model 1, other factors from this model that we did not take into account have an influence of only 27%. This econometric model is presented with the probability of the Fisher test with a value of 0. This way we can build the regression equation. For this, we will use the general equation of linear regression in which we will replace our variables.

The general linear regression equation is:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n, \quad (3)$$

where Y is the dependent variable (EcGw)

$\beta_0, \beta_1, \beta_2, \beta_n$ are the coefficients

X_0, X_1, X_2, X_n are the independent variables (Cc, Cs, CsGw, GvD, GvS, Inv, Ret).

According to data presented in Table 10 (fixed effects), it appears that the variables CsGw (0.366323) and Ret (0.165171) have the greatest positive impact on EcGw and the variable GvS (-0.438485) has the greatest negative impact on EcGw. The signs of the CsGw and Ret coefficients are the ones expected, being positive. If CsGw increases by one point, EcGw will increase by about 0.36 points. If Ret increases by one point, EcGw will increase by about 0.16 points. The sign of the GvS coefficient is negative, meaning that if gvS increases by one point then EcGw will decrease by 0.43 points. Regarding the variable Cc, the sign is the expected one, negative. If Cc increases by one point (points mean the number of illnesses), EcGw will decrease by 0.000169 points.

II.1.3. Results and Discussion

The graphs generated in figure II.1.3. show a comparison between the estimated economic growth values in the two econometric models. The estimated value in the first model is represented by the green colour and the estimated value in the second one by the blue colour. We observe a lower trend values for estimated economic growth in the second model. Of course, these results presented in Figure II.1.3 could be assessed in the light of the specific economic conditions prevailing in each of the sample countries. Coronavirus cases bring a significant influence on it and paint a more realistic picture of the present economic growth. As the second model showed us, the probability of the influence of independent variables represented by R square increased by 2% from 72% in the first model to 74% in the second. We can certainly argue that the second model allows us to analyse a situation where economic growth is a cumulative influence of the various variables, the number of which can expand more the upcoming years, with new crises and new influence factors.

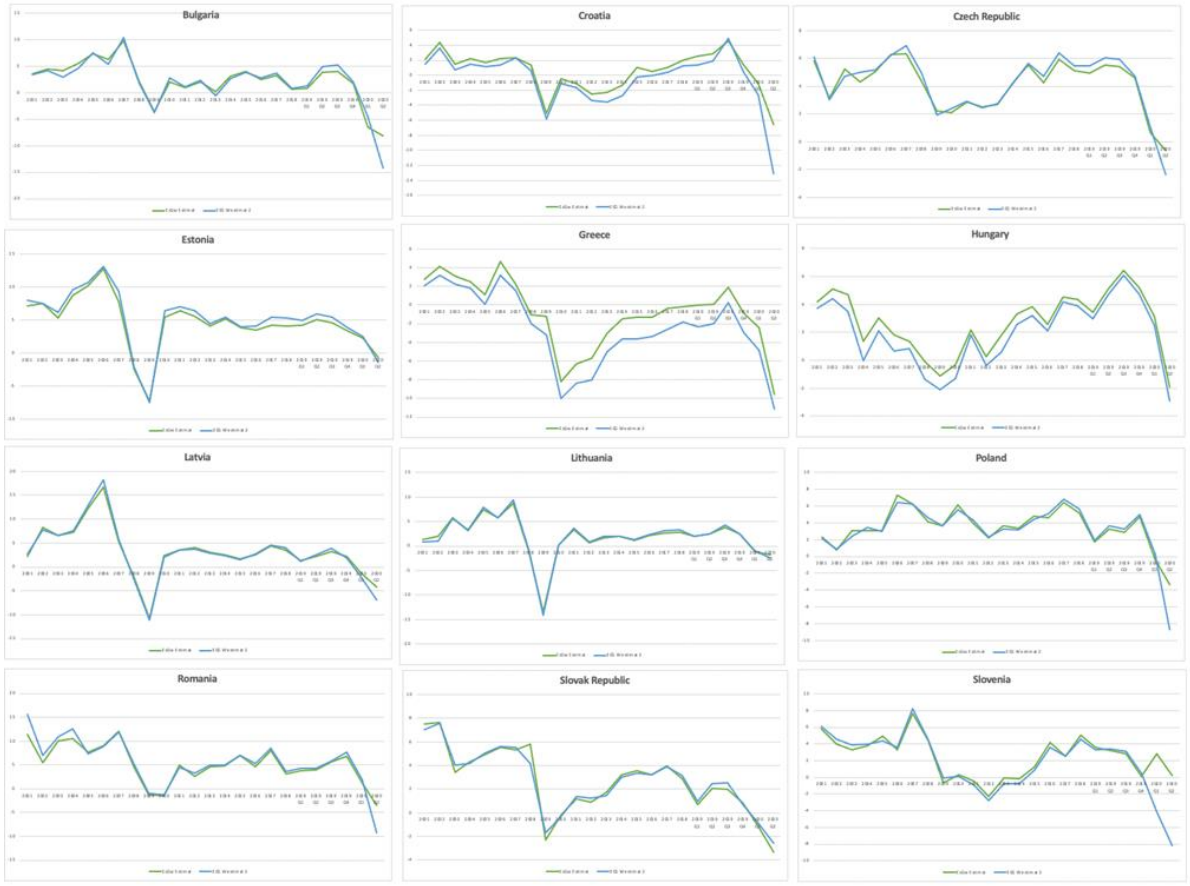


Figure II.1.3. Comparison of the estimated data in Model 1 of the evolution of economic growth in the analysed countries with those estimated in Model 2

Both models present an attempt at analysis and show a cumulative dependence on economic growth. Using the same variables and coefficients for both models, a total of six for model 1 and seven for the second with the addition of coronavirus cases, we see a change in the behaviour of independent variables. We can see that for both models the independent variables with the highest coefficients are the consumption growth, retail sales and investment, and the variables with the lowest values for government spending and consumption. Each of the indicators changes its value, however, it is observed that variables with negative coefficients decrease, while those with positive coefficients are divided into two groups, some increase, and others decrease, so the consumption coefficient decreases from -0.17 to -0.23, government spending from -0.32 to -0.43, and consumption growth increase from 0.27 to 0.36, retail sales decrease from 0.22 to 0.16, as well as investments, decrease from 0.13 to 0.08, and government debt decreases from 0.016 to 0.005. The coefficient of the equation decreases by 3 from 13.12 to 19.77. In both models following the Hausman Test, a probability of less than 5% is observed, indicating a more accurate model by using the fixed effects method.

Table II.1.3. Comparative analysis of models

	Cs	**CsGw**	**GvD**	**GvS**	**Inv**	**Ret**	**Cc**
Model 1	-0.179017	0.271017	0.016757	-0.327059	0.133387	0.222933	-
Model 2	-0.235004	0.366323	0.005853	-0.438485	0.085279	0.165171	-0.000169

Source: author's processing

With the occurrence of coronavirus cases, there was a decrease in Cs, Inv and Ret, caused by the cessation of some companies' activities during the application of the emergency state o by governments. The evolution of some indicators has become acute (e.g. GvS) (see Table II.1.3).

By adding cases of coronavirus, the equation becomes wider and contains several variables that could explain economic growth because the independent variables of model 2 explain and have a cumulative influence of 74% on economic growth, while without it only 72% (shown in model 1). Prob (F-statistic) is suitable for both models, with values suitable for adjusted R-square, greater than 60%. We can certainly argue that the estimated values of the economic growth of the second model are closer to the real ones, so we conclude the importance of the variable: cases of coronavirus (CC).

Cases of coronavirus that have occurred since February – March of this year have started to produce significant effects on economic growth, and the evolution of this indication is in decline for the countries analysed. This independent variable calculated only for the first two quarters of 2020 brings a major impact on economic growth and not through direct influence, but rather indirect, by modifying other indicators related to the Cc. It makes us wonder what is the multitude of external factors that we have not considered in our models that could have an impact and influence economic growth in the future. Also, what will continue to be the direction of economic growth with the multiplication of coronavirus cases, with all the fiscal and economic measures taken by the governments of the countries in our analysis?

II.1.4. Concluding remarks

The rapid expansion of the COVID-19 pandemic in early 2020, with the relocation of the epicentre of the crisis to Europe in March, has generated unprecedented measures in the affected states that tried to slow the spread of the disease and minimize human costs. The study was based on 12 countries with diverse economic and fiscal policies, six of them are in the euro area (Estonia, Greece, Latvia, Lithuania, Slovakia, Slovenia) and the other six countries are not part of the euro area (Bulgaria, Croatia, Czech Rep., Hungary, Poland, Romania). Some of these countries recorded high economic growth and a strong economic regime in 2019, and other countries had huge debts, a low level of economic growth, but all demonstrated a cumulative dependence on economic growth that can also be inferred from our analysis. It should be noted that in the first quarter of 2020, 5 of the 6 countries in the euro area recorded negative economic growth (except Lithuania). Also, in Q1 2020, of the non-euro area countries, 5 of the 6 countries under our analysis recorded positive economic growth (except Czech Rep.). All 12 countries under analysis recorded negative economic growth in Q2 2020 (Figure II.1.2.1).

This paper implies that economic growth is influenced by many indicators, which have already been analysed in various scientific studies. Of all the macroeconomic indicators, the authors focused on Government debt; Consumption; Consumption growth; Investment; Government spending and Retail sales. In addition to the indicators used as a standard for explaining and anticipating economic growth, we also focused on the number of coronavirus cases recorded in the first two quarters of 2020. The authors consider that this variable influences the economic situation in each country because it indirectly led to an unfavourable change in certain macroeconomic indicators with a direct influence on economic growth. By adding cases of coronavirus (Cc) the equation becomes wider and contains several variables that could explain the evolution of economic growth because the independent variables of model 2 explain and have a cumulative influence of 74% on economic growth, while without it only 72% (shown in model 1).

The work contains a comparison between the two models, the synthesis being found in Section 4. Discussion. In response to the two questions in the Introduction, we can see that for both models, independent variables with the highest coefficients are consumption growth, retail, and investment, and the variables with the lowest values are government spending and consumption. Each of the indicators changes its value, but it is noted that variables with negative coefficients decrease further (e.g. Cs, GvS). It is worth noting in Model 2 the evolution of the 2 variables CsGw and Inv, the evolution being directly influenced by the occurrence of coronavirus cases because the states adopted the state of emergency by which the population had to stay at home. Our findings in this study confirm that of all the determinants analysed, CsGw, Ret, GvS, and Cc overwhelmingly influence economic growth.

The results of the study may have some significant implications for countries' decision-makers, as unsustainable economic growth (generated by a very strong fiscal stimulus or a combination of tax cuts and increases in budgetary expenditure) can lead to catastrophic and lasting effects on macroeconomic stability.

In this research, the authors focused primarily on the influence of macroeconomic indicators had on economic growth. This has been confirmed by many studies presented in Section 2. The devastating effects of the 2008 crisis, the remarkable repercussions of climate change, the continued decline in non-renewable resources and the increasingly worrying and gloomy predictions of life on planet Earth are the main reasons to support the urgent need to change current business models around the world. In this context, our modern society urges companies to include sustainability in their business model not only to achieve immediate positive economic results or a substantial competitive advantage but also for efficient and socially responsible economic growth and development, as well as the most necessary social and environmental performance (Popescu et al., 2019). Therefore, a future research direction will consist of analysing the correlation between the major crises of the 21st century and the impact on economic growth and sustainable human development, corporate social responsibility, corporate governance, business performance and the model of excellence, as these are valuable goals for any business and any economy these days.

The results of the research included in this paper can serve as a source of information and help to choose appropriate policy actions for sustainable economic growth and to focus in particular on those economic indicators that have a significant influence on EcGw. The dynamics of the interaction between the sovereign and banking sectors have direct implications for global financial stability, but these interactions are not well understood. The 2008 crisis emphasized the interdependence between the bank and sovereign default risk and showed that major shocks may lead to a self-reinforcing negative spiral (Lovreta and Lopez-Pascual, 2020). There are authors (e.g. Lovreta and Lopez-Pascual) who provide evidence that structural dependence in the system extends to the interaction between the volatility of the bank's default risk and the volatility of the sovereign default risk. We, therefore, consider it necessary to include other factors in future research, such as: the interaction between the bank and sovereign default risk.

Chapter II.2. IMPACT OF SUSTAINABILITY REPORTING AND INADEQUATE MANAGEMENT OF ESG FACTORS ON CORPORATE PERFORMANCE AND SUSTAINABLE GROWTH[5]

The term *sustainability* is one of the most commonly used terms in corporate governance. Sustainability is a major concern for businesses of all sizes in an attempt to preserve capital for future generations (James, 2014). Corporate sustainability can be seen as a modern concept in the field of corporate governance, as an alternative to the traditional model of producing and optimizing income, and as the main goal of the organization. This emerging paradigm considers that, while profit creation and maximization are important, there are other objectives with an impact on society that corporations must follow, such as those related to sustainable development. The sustainability perspective offers a structure for value creation that relates both to achieving adequate income for the business and to meeting the needs of a diverse community of stakeholders (Lopez et al., 2007). Sustainability focuses not only on the needs of investors and shareholders, but also on the responsibility of stakeholders directly or indirectly affected or connected to the company. The concept of sustainability includes what is known as intergenerational equity (Cairms, 2006) as it is not only an effective allocation of resources, but also a fair distribution of resources between present and future generations (Gray, 2002; Gray & Milne, 2002).

Companies operate in a global world that is affected by the past, present, and future. A short-term approach to sustainability is therefore no longer recognized because it aims at both the present and the future (Aras & Crowther, 2008). The principle of sustainability pays attention not only to benefits, but also to the long-term sustainability of the company. The modern architecture of corporate sustainability is based on three pillars: economic integrity, social justice and value, and environmental integrity. It is clear that the combination of these factors will enable businesses to become profitable by achieving long-term growth goals, raising productivity, and optimizing shareholder value. The basic principle of corporate sustainability is that businesses should completely integrate social and environmental goals with financial ones and justify their welfare activities to a broader spectrum of stakeholders through the transparency and reporting mechanism (Gao &Zhang, 2006).

Sustainable reporting helps businesses to set goals, assess success, and implement progress to make them more sustainable. Through reporting, the organization analyzes its position in society, communicates the success and shortcomings of the company, and recognizes efforts to enhance future performance as well as accountability for achieving its objectives (Krzus, 2011).

Why, in addition to the financial information required by law, should companies submit social and environmental information in their annual reports? There are several possible explanations: the presence of a sense of social contract (Matthews, 1997), in order to strengthen their brand position, to differentiate themselves from rivals through the openness of their own activities and knowledge, and to boost their financial results. The issuance of non-financial statements has become a standard practice in the developed world.

Practically businesses do not function in a vacuum, their performance is influenced by the environment; therefore, financial figures targeting the performance of companies should be

[5] This section is based on the article: Oprean-Stan C, Oncioiu I, Iuga IC, Stan S. 2020. Impact of Sustainability Reporting and Inadequate Management of ESG Factors on Corporate Performance and Sustainable Growth. Sustainability, 12(20):8536. https://doi.org/10.3390/su12208536. WOS: 000583137300001

presented in their operating context in order to enable stakeholders to make an accurate assessment (Lipunga, 2015). Investor expectations are increasingly affecting the valuation of a product. In times when non-financial assets are becoming a significant component in assessing the valuation of a corporation, the presentation of non-financial statements as a more comprehensive and accurate source of information than financial statements is becoming an increasingly common subject of discussion in the science and business communities.

A further reason for the increased need for non-financial reporting is based on morality. Current thinking supports the idea that organizations are morally obliged to make a positive contribution to society (Habidin et al., 2012). It is founded on the assumption that organizations exist because society has enabled them to operate, to use natural resources and, through their work, they can have an effect on the quality of the life of citizens (Ávila et al., 2013). As a result, non-financial reporting is required to include information about how a business defines its position in society.

Non-financial reporting is a topical issue, and the adoption of EU Directive 2014/95/EU on non-financial information increases the use of such reporting. Sustainability performance metrics is one of the most recognizable aspects of the principles and criteria that are commonly used for non-financial reporting. Creating a set of sustainability performance metrics helps organizations and stakeholders in the activity and evaluation of corporate sustainability success (Raucci & Lara, 2020), which are valuable tools to help internal decision-making processes and which can provide substantial added value to non-financial corporate communication.

The relationship between sustainability reporting and performance has been empirically explored in a number of previous studies. However, due to variations in methodology, the results were either inconclusive or inconsistent, with research suggesting both a positive and a negative relationship (Margolis et al., 2003; Orlitzky et al., 2003). Two conflicting theories seek to explain the effect of sustainability on the financial results of the company: value development and value destruction (Yu & Zhao, 2015). The approach to value creation theory is based on the premise that corporate risk is minimized by taking on social and environmental responsibility. Instead, the value destruction hypothesis suggests that businesses engaged in social and environmental responsibility lose emphasis on profits (to the detriment of shareholders), and then try to please stakeholders.

This study aims to analyze and clarify whether there is a positive or negative linear relationship between sustainability reporting, the inadequate management of environmental, social, and corporate governance (ESG) factors, and corporate performance and sustainable growth. ESG factors use economic, social, and governance criteria to assess businesses and countries as far as sustainability is concerned. In this analysis, both the financial and market performance of the companies were analyzed. The novelty of this study is that we implemented sustainable growth at the company level as a process that depends on the sustainability factors described above.

Starting from the objective described above, a number of main research questions can be formulated which will be answered by this study:

1. Is there a statistically significant relationship between sustainability reporting, risk exposure to economic, social, and corporate governance (ESG) factors, and financial performance?

2. Is there a statistically significant relationship between sustainability reporting, risk exposure to economic, social, and corporate governance (ESG) factors, and market performance?

3. Is there a statistically significant relationship between sustainability reporting, risk exposure to economic, social, and corporate governance (ESG) factors, and sustainable corporate growth?

To achieve the main objective of the paper, the methodology focuses on the construction of multifactorial linear regressions using the SPSS program, in which the dependent variables are the indicator of financial performance (chosen as, in this analysis, Return on Assets – ROA), the market performance indicator (chosen as the Tobin's Q index), and the indicator that measures the corporate sustainable growth (chosen as the Sustainable Growth Rate – SGR). The independent variables of these regressions are sustainability metrics (sustainability reporting – GRI, the level of undertaken risk associated with inadequate management of ESG factors – ESG Risk and involvement in controversial events – CEI) and the control variables that we included in the models. All these variables will be described in the methodology part of this paper.

The main contributions to this paper shall be presented as follows. This is one of the few research studies to concentrate on sustainable growth at the company level, as a process that depends on the sustainability factors listed above. This study therefore makes a first contribution to the investigation of the impact of ESG risk management not only on performance but also on sustainable growth.

If most impact studies on financial performance are restricted to sustainability performance, in this analysis we refer to the degree of risk associated with the inadequate management of environment, social, and governance factors, which is another novelty of this paper. As it is mentioned, most of the specialist literature focused on the causality between sustainability performance and financial performance; for example, the effect of corporate sustainability on financial results (Alshehhi et al., 2018; Ameer & Othman, 2012), the connection between sustainability performance and firm performance (Goyal et al., 2013), the connection between firm-level sustainable practices and corporate reputation (Gomez- Trujillo et al., 2020; Gangi et al., 2020; Alon & Vidovic, 2015), and the link between corporate sustainability and business efficiency (Mustapha & Hassan, 2018; Appelbaum et al., 2016).

One factor that has not been discussed in previous studies, as far as we know, is the question of the involvement of businesses in controversial events and the way these events affect the success and sustainable growth of the business, so this is an under-researched topic. The involvement of companies in controversial events could have an impact on the environment or on society. Involvement in such evens means that the management systems of an organization are not sufficient to handle the related ESG risks. That is why this is another factor that we are taking into account.

II.2.1. ESG Factors and Sustainability Reporting: Exploring the Impact on Performance and Sustainable Growth - A Literature Synopsis

II.2.1.1. Sustainability Reporting

Historically, sustainability reporting, in the strict sense of the term, has been accompanied by three distinct forms of reports: annual reports, environmental reports, and social reports. Then came *sustainability reporting* as the name for the latest integrated form of cultural, environmental, and social reporting (Daub, 2007). The reporting language (used by companies) varies internationally from the following: environmental reporting, corporate social responsibility (CSR) reporting, and corporate accountability reporting. In the studies conducted by Zorio et al. (2013) and Skouloudis & Evangelinos (2009), CSR reporting and sustainability reporting are used interchangeably, referring to reports addressing economic, environmental, and social aspects of corporate operation and emerging as a new phenomenon in company reporting. Such reports

explain the strategies, plans, and initiatives implemented by the organization, providing quantitative and qualitative information on economic, environmental, and social performance. Indeed, corporate reporting, which was known as environmental reporting and later as CSR reporting, is now being repackaged as sustainability reporting (Aras & Crowther, 2009). The more recent historical trends in sustainability coverage are described, among others, by Hahn and Kühnen (2013). Throughout the 1970s, social studies were often created to supplement traditional financial statements, although exposure to environmental issues took precedence in the 1980s. Joint reports, including environmental and social statistics, along with financial reports, started to appear at the end of the 1990s following the Global Reporting Initiative (GRI) program, and this trend continues (Kolb, 2010). At present, fully integrated reports, containing economic, social, and environmental information in a single text, have been prepared to provide a comprehensive image of the company's activities (Adams & Simnett, 2011).

The non-financial reporting requirement for large companies in the European Union was created with the adoption and publication in the Official Journal of the EU of Directive 2014/95/EU.

Why Technology Impacts the Reporting Process?

Most businesses still do not understand how to apply methodologies in order to obtain superior performance. Modern society needs greater transparency and accountability on the part of organizations. As a result, businesses are under pressure to provide more and more financial and non-financial information on their company and results. We may claim that non-financial information is just as important as financial information. According to research theoretically based on the principle of legitimacy (Branco & Rodrigues, 2008), the option of an information disclosure setting depends on the target audience of the proposed message.

The management comments, as part of the annual reports, are intended for investors (who need different information from other stakeholders), while the CSR reports are intended for the general public. Nevertheless, the reach and consistency of sustainability coverage depends on the contact climate.

Technological advances contribute to more accurate data collection, improved analysis of sensitive and unregulated information, and uniform means of disclosure. Artificial intelligence, Blockchain, and XBRL have become more efficient in reporting sustainability and are starting to be used in the reporting environment. These technologies provide a range of opportunities for organizations to enhance their reporting, activities and decision-making through efficient, more accurate, transparent, and verifiable data. Their widespread use has the potential to make substantial progress on the international sustainability agenda and to reform the non-financial reporting process (WBCSD 2019 Addendum Report).

In addition, as indicated in the Sustainability and Reporting Trends of 2025 (GRI 2015), the new performance indicators, activated by technology development and digitalisation, will enable companies to operate and report in a highly integrated manner in the coming years. There are increased rates of operationalization of their sustainable development (Gasperini & Stefano, 2017).

Non-financial Information Reporting

In addition to rising global environmental consciousness and a sustainable development campaign, the growing pattern of sustainability coverage is also driven by a growing number of

guidelines given by various government and business organizations (Basalamah & Johnny, 2005). There are many non-financial reporting standards: the Global Reporting Initiative (GRI), the International Integrated Reporting Council (IIRC), and the Sustainability Accounting Standards Board (SASB). Consequently, according to some researchers (Hohnen, 2012), reports on GRI standards disclose much of the information about the company's operations, as well as the details demanded by investors. The Global Reporting Initiative (GRI) is an agency that has pioneered the creation of a system for sustainability reporting. Most organizations follow the GRI structure and norm of reporting on sustainability. In their paper, Daizy and Das (2014) point out that the GRI criteria provide more than 90 indicators of social responsibility, whereas other criteria have fewer indicators. GRI includes a reporting system that can be used by businesses of any size or sector. Hohnen (2012) noted that the GRI criteria are the most commonly used by non-financial reporting organizations. According to this study, 95 per cent of American companies, recognized as the most successful in the field of sustainable development, have produced reports in accordance with GRI standards.

Integrated Reporting

Throughout the past two decades, organizations have documented social and environmental problems in different reports (Villiers et al., 2014). Yet over time, they have managed to develop their coverage style. There is recent pressure to publish both financial and non-financial information in a single report (Landau et al., 2020). This so-called Integrated Reporting (IR) is primarily sponsored by the International Integrated Reporting Council (IIRC), which has established a generally recognized conceptual framework (Busco, 2013). The idea that businesses should broaden their reporting to incorporate all the tools they use as inputs for their business operations is fundamental to the principle of integrated reporting (Cheng et al., 2014). According to Abeysekera (2013), integrated reporting (IR) integrates reporting on various aspects of organizational operations on a shared forum with a clear purpose, putting together all the core elements of organizational success in a single article. After the creation of the International Council for Integrated Reporting (IIRC) in 2010, the IR has expanded rapidly worldwide. In several countries, IR is made compulsory for companies listed on the stock exchanges (Cheng et al., 2014). IR is therefore a new issue, and previous non-financial reporting work has mostly concentrated on separate reports. The aim of the IR is to present value creation over time, and thus to provide recipients with more details on the business model of the organization than on periodic financial reporting and non-financial reporting (Busco, 2013). Specifically, comprehensive reporting helps stakeholders to understand the interrelationship between the success of the business and its effect on people and the environment. In addition, it increases the internal decision-makers' comprehension of the relationship between the different roles, their existence, and potential consequences.

The idea of integrated reporting originated in 1977 with the publication of the book entitled *Social Audit for Management* by Clark C. Abt. In 2000, the European Commission published the EU Financial Reporting Strategy: The Way Forward, which proposed that the annual report would include not only the financial dimension of a company, but also an overview of the environmental and social aspects required to understand growth and the company's success or market. The first comprehensive study was published in 2002 by Novozymes, a Danish pharmaceutical firm. In 2006, Directive 2006/46 of the European Commission required all listed companies in Europe to include a corporate governance statement in their annual report. In his paper, Owen (2013) argues

that integrated reporting offers shareholders a clearer and wider view of the company's activities than conventional reporting. James (2014) also indicated that integrated reporting would improve the productivity and operational performance of the organization and would also contribute to the long-term accomplishment of its goals and mission. Research studies, such as those carried out by Frias-Aceituno et al. (2014) and Jensen and Berg (2012), find that businesses that issue an integrated study have substantially different characteristics than other firms. The authors find that the deciding factors, such as the size and competitiveness of the organization, have a positive effect on the decision to create a report.

Reporting in the Next Decade

More than half of the world's 250 largest businesses report on sustainability (White & Fall, 2005). Reporting rates in developed countries such as France, Germany, Japan, the United Kingdom, and the United States are high. According to GRI's Reporting 2025 Project (Sustainability and Reporting Trends in 2025) (GRI, 2015), the study will be digital and will be made in real time. The future report will no longer be a paper written and distributed once a year, but will contain a complex and easily accessible data set. If so, businesses will have less leverage over their performance information than they currently do, as their performance information will be compiled and analyzed using powerful search engines and analysis tools. The fully integrated report is defined as a report on the future. This concept defines the alignment of financial reporting and sustainability of a business with that of its suppliers or regional partners. This also applies to the physical convergence of other systems. There is only one challenge, which is the difficulty of determining which stakeholders to trust and the difficulty for companies to gain the confidence of stakeholders, in the jungle of digital platforms and smart search engines. This risk, if properly handled, does not affect the reputation and profitability of the company. With the advent of information technology, the language of communication will no longer be an obstacle for stakeholders, because the transfer of information from one language to another will be achieved instantly by digital communication.

II.2.1.2. Understanding the Concepts of ESG Factors and ESG Risk Rating

The environmental, social, and governance (ESG) criteria are a set of standards used by socially conscious investors to monitor potential investments in a company's operations. Environmental standards consider how an organization operates as a nature steward. Social standards examine how they relate to employees, vendors, consumers, and the companies in which they operate. Governance is about corporate governance, executive pay, audits, internal controls, and shareholder rights.

Environmental considerations may include the use of electricity, waste, emissions, protection of natural resources, and animal welfare by an enterprise. Parameters may also be used to identify any environmental threats that a business may face and how the organization responds to those threats. Are there concerns that are relevant, for example, to the ownership of polluted property, the disposal of hazardous waste, the handling of toxic emissions, or compliance with government environmental regulations?

Social parameters look at the business relationship within the organization. Will it work with suppliers who still hold the same values? Should the company send a percentage of its income to the local community, or does it allow workers to do voluntary work there? Will the company's

working practices demonstrate strong respect for the health and safety of its employees? Have the interests of the other parties been taken into account?

As far as governance is concerned, investors may want to know that a business uses reliable and consistent forms of accounting and that shareholders have the ability to vote on important issues. They may also like guarantees that corporations avoid conflicts of interest when selecting board members, do not use political donations to receive unduly favorable treatment and, of course, do not indulge in unethical activities.

ESG Risk Ratings is a very interesting concept developed by Sustainalytics (ESG Risk Ratings Methodology, 2019), a leading global provider of ESG and corporate governance products and services, supporting investors in the development and implementation of investment strategies that measure the degree to which ESG factors or, more technically speaking, the magnitude of the company's economic value is at risk. It therefore gives investors a stronger signal of the performance of the company, which cannot be observed in the standard financial statements of the company.

II.2.1.3. Results of Previous Studies on the Relationship between Sustainability and Performance

Recent work has tried to develop the relationship between corporate sustainability performance and financial performance in both theoretical and empirical terms. Yet the findings so far have been either inconclusive or contradictory. Consequently, preceding work is generally divided into two main categories that advocate either a positive or negative relationship.

Many articles state that sustainability has a positive effect on long-term financial performance, return on investment and will ultimately lead to sufficient profits for the company. Companies not participating in their environmental liability could suffer possible collapses in the price of their shares if their investors are rational in considering the future value of the company on the basis of the current state of environmental responsibility (Ngwakwe, 2008). Companies that pollute the environment could also experience a gradual depletion of revenues that could damage their future solvency. Social responsibility behavior or sustainability practices can therefore contribute to the financial performance of a company (Wiwin et al., 2012).

The activities of companies towards sustainable development and the disclosure of non-financial information have both advantages and costs. Depending on the stronger impact, disclosure and reporting of non-financial information may have both a positive and a negative impact on financial performance. In addition, whether a positive impact will be revealed depends on the characteristics of the country as a whole, the specific industry or market in which the company operates and the characteristics of the company. In practice, studies have identified both the presence and the lack of a positive relationship (Borodin et al., 2019).

There are studies that support sustainability reporting and disclosure and suggest that sustainable reporting is more transparent, showing the links between the financial sector of the company and the three components of sustainability (Adams, 2017). There are many articles in the literature that seek to explain the relationship between sustainability and corporate financial performance. These theories relate to the influence (positive, negative, or neutral) and causality (direction) of the relationship. Briefly, we will present some articles that support each type of influence.

(a) Studies that revealed the positive effect of separate non-financial reporting on financial performance

To date, a significant number of studies have been conducted using different methodologies and samples, which have shown that the publication of non-financial reports has had a positive impact on financial performance (Caesaria & Basuki, 2016). Alshehhi et al. (2018) conducted a very extensive study of the literature on the impact of corporate sustainability reporting on the financial performance of the company. He studied 132 papers in top-level journals and concluded that 78% of the publications report a positive relationship between sustainability and financial performance. Only 22 per cent of the analyzed publications report a negative or mixed relationship or do not report any significant relationship between sustainability and financial performance. Ameer and Othman (2012) studied the top 100 sustainable companies and noted a positive association between sustainability reporting and financial performance.

The presentation of the economic, environmental, and social aspects of the sustainability report proved to have a significant impact on the performance of the company's market. These three aspects demonstrate the corporate contribution to economic development both globally and locally, show the company's concern for the environment as well as its social contribution to the community, and improve the company's image in the public eye, thus increasing the company's market performance (Caesaria & Basuki, 2016).

The study conducted by Reddy and Gordon (2010) examined the impact of sustainability reporting on the financial performance of companies in New Zealand and Australia. The results of their empirical study showed that sustainability reporting is statistically significant in explaining the profitability of Australian companies. Steyn (2014) found that sustainability reporting contributes to the improvement of companies with superior financial performance.

Other studies have analyzed the impact of sustainability reporting on different characteristics at the company level, such as: performance, yield, company value, stock prices, reputation, assets, competitive advantages. A few of them are presented below.

In relation to share prices, Ansari (2015) found that sustainability reporting had a positive effect on the share prices of real estate companies. Findings from other studies, such as Loh et al. (2017) and Lourenco et al. (2014), showed the usefulness of sustainability reporting. Lackmann et al. (2012) argue that sustainability reporting can provide recipients with greater investment during the economic downturn. They also claim that the investor takes into account sustainability information while determining the value of the company.

Iatridis' paper (2013) describes the relationship between the quality of disclosure and corporate governance and raises the question of the extent to which the quality of reporting and disclosure of environmental information affects investor perceptions. The results of the study show that the disclosure of environmental information is usually correlated with the size of the company, the need for capital, profitability, and capital expenditure. The author concludes, therefore, that the publication of non-financial statements leads to an improvement in the perception of the investor and an increase in the value of the company.

Waddock and Graves (1997) indicated a strong relationship between integrated reporting, the reputation of a company, and its social policy. Vafaei et al. (2011) studied the impact of non-financial reporting on the net income and assets of companies in four countries: the United Kingdom, Austria, Singapore and Hong Kong. Companies operating in traditional and non-traditional industries have been analyzed. The conclusion of the authors was as follows: in the

United Kingdom, non-traditional industries found a positive effect on both net profit and asset value, while in traditional industries no such dependence was found. In Austria, the positive impact was observed only in non-traditional industries, but the positive impact was only on the value of the assets and not on the net profit. No significant positive impacts were identified in Singapore and Hong Kong. No positive effect was found in the sample for traditional industries (without country differentiation) and a positive relationship was found in non-traditional industries. Studies were also carried out in other international contexts. Aerts, Cormier, and Magnan (2008) analyzed companies in continental Europe (Belgium, France, the Netherlands, and Germany) and North America (Canada and the USA) and concluded that environmental reporting was linked to a more accurate forecast of earnings, but that the relationship was stronger in Europe than in North America. Cormier and Magnan (2007) studied French, Canadian, and German companies, and argued that environmental reporting had a significant moderating effect on the market valuation of German companies, but not on Canadian or French companies.

Buallay's work (2018) aims to investigate the relationship between sustainability reporting and operational banking performance (ROA), banking financial performance (ROE), and market performance (Tobin's Q). The results of the study show that there is a significant positive impact on performance of sustainability reporting. Lee Brown et al. (2009) argue in their paper that sustainability reporting creates significant competitive advantages for companies. Albuquerque et al. (2012) considers sustainability reporting to be a strategic product that brings profits to the company.

Studies conducted by Klassen and McLaughlin (1996) and Lorraine et al. (2004) used the event study method to examine the market impact of sustainability disclosures and to obtain significantly different results. While Klassen and McLaughlin (1996) consider that strong environmental performance is associated with significant positive returns in the United States, Lorraine et al. (2004) argue in the United Kingdom that only poor environmental performance is associated with a significant stock market response. Their report shows a one-week delay in market response (after the release of sustainability reports).

The studies analyzed show that variations in research methodologies and variable measurement lead to divergent opinions on the relationship between non-financial reporting and the profitability of companies. In their article, Reddy and Gordon (2010) support the idea that contextual factors such as the type of industry have a significant impact on the returns of companies reporting non-financial data. Moreover, the literature is slowly replacing overall sustainability with more limited social responsibility (CSR). In this regard, Reddy and Gordon's study (2010) identifies a number of contextual factors, such as the industry and type of sustainability report, which may have an impact on the profitability of companies.

The results of the above studies indicate that there are other important factors involved in assessing the market impact of sustainability information that have not been considered yet. For example, the causal relationship between environmental performance and market efficiency is unclear, as better-performing companies can afford to implement better environmental management systems or more efficient production and operation methods (Cohen et al., 1997). In addition, there is evidence that country-specific contextual factors, the size of the company, the type of economy, and the type of industry have an impact on the relationship between sustainability reporting and financial performance measures, including corporate capital market performance (Alshehhi et al., 2018).

Country-specific factors may play a role in explaining the contradictory findings of Feldman et al. (1996), which identify a significant relationship between environmental reporting and market performance based on US data, and the findings of Murray et al. (2006), which, using data from the United Kingdom, do not establish a significant relationship between environmental reporting and market performance. Feldman et al. (1996) investigated 300 US companies and reported that improved environmental performance leads to a statistically significant reduction in the company's environmental risk, which is assessed by the stock market in the form of a higher share price.

(b) Empirical studies which have not shown a positive effect of the publication of non-financial information on financial performance

We found a number of theories that focus on the downside of non-financial reporting and corporate performance. In contrast to stakeholder theory, Friedman (1962) argues that the main purpose of a firm is only to increase stakeholder wealth, and any other non-financial objectives would make the firm less efficient. Overall, the financial sector appears to be less focused on social issues than on environmental ones (Borodin et al., 2019). The author argues that the reporting of non-financial information to the company did not have a significant impact on short-term or long-term financial indicators. Certain research (Mackey et al., 2007; Zivin & Small, 2005) supports Friedman's arguments and points out that investors expect a company to increase its wealth without sustainable policies and that sustainable policies should be pursued by non-profit organizations. On the other hand, a few researchers, such as Cordeiro and Sarkis (1997), Preston and O'Bannon (1997), Shane and Spicer (1983), report the existence of a negative relationship between sustainability reporting and corporate performance. Hamilton (1995) conducted a study on 463 American firms and found a negative relationship between environmental reporting and price reactions to company shares.

(c) Mixed studies and other studies that showed an unclear relationship between the disclosure of sustainability and financial performance

The results of previous research also show that there are deficiencies in sustainability reporting, and that sustainability reporting is more useful for internal than for external communication (Farneti, & Guthrie, 2009; Lins et al., 2008). Other opinions, such as those of Gray (2006) and Gray and Milne (2002), do not really agree with the usefulness of existing sustainability reporting. In his study, Schreck (2011), based on his own work and on data from 2006 on 300 new companies, develops the OLS regression model, which includes the following control variables among the explanatory ones: level of social responsibility, size of the company, level of risk and leverage. His model shows a positive relationship, but concludes that adherence to the concept of sustainable development does not always lead to improved financial performance.

However, several studies related to the sustainability report show inconsistent results. Research conducted by Waworuntu et al. (2014) and Ioannou and Sarafeim (2014) indicates that the three components of the sustainability report have a significant positive effect, in part, on the performance of the company's market. On the other hand, other research (Wibowo and Sekar, 2014) has shown a negative impact on these things.

Other authors, such as Gilley et al. (2000), King and Lenox (2001), Watson et al. (2004), Link and Naveh (2006), and Arragon-Correa and Lopez (2007), also report an insignificant relationship between the disclosure of information on sustainability and financial performance. Several studies

identified an unclear relationship between disclosure of sustainability and financial performance (Pava & Krausz, 1996; Murray & Vogel, 1997; Godfrey & Hatch, 2007).

Park et al. (2019) note that the CSR practices undertaken lead to the positive performance of the company, but the activities initiated by the company's managers have a negative impact on the company's long-term performance. Sukcharoensin (2012) and Arshad et al. (2015) studied the relationship between CSR practices and firm values–Tobin's Q in Thai and Pakistani firms. They consider that there is no association between the values of the CSR and the economic performance of the companies. Wiwin et al., (2012) divides the sustainability report into three categories: economic performance report, environmental performance report, and social performance report. The test result shows that the disclosure of economic performance does not significantly influence the performance of the company. This result contradicts the result of the Sitepu research (2009), which shows a significant relationship between the disclosure of economic performance and financial performance. Another result of the study shows that the disclosure of environmental performance does not influence the performance of the company. This is also at odds with Sitepu (2009) and Sekarsari (2008) who believe that the disclosure of environmental performance affects the performance of the company. Finally, the last result refers to the disclosure of social performance, which, according to the author, has a significant impact on the performance of the company. Soana's study (2011), conducted on a sample of 68 Italian and international banks, analyzes the same relationship, but in a specific sector: the banking sector. According to the results of the study, there is no statistically significant dependence on the sustainability indicators and the financial performance of companies in the banking sector.

According to Hussain (2015), a company that reports positive/negative information on social and environmental issues may increase/decrease its market value. By presenting environmental and social reports, the performance of companies can be improved/worsened.

In their study, Tariq et al. (2018) argue that factors that have a positive impact on performance include increased disclosure of the business model, strategy, and resource allocation. On the other hand, factors which have had a negative impact on financial performance include the disclosure of risks and opportunities and even the disclosure of financial performance itself. The author argues that companies with negative ROA try to win the advantage of investors by increasing their reporting levels, and that these reports do not function as a presentation of how the company continuously aligns its profitability with key strategies, but as an attempt by management to explain how much it is trying to make a business successful in a turbulent and difficult investment environment.

In summary, findings from studies involving sustainability reporting and financial performance support the idea that there is evidence of improved financial performance through sustainability reporting. The lack of theories supporting such a relationship means that the evidence of any causal relationship remains unclear and inconclusive (Klassen & McLaughlin, 1996; Lorraine et al., 2004; Cohen et al., 1997; Feldman et al., 1996; Murray et al., 2006). Furthermore, the lack of consistency in the reporting of sustainability means that quality data is not available to conduct studies that could address the issue correctly. Horvátová (2010) conducted a meta-analysis of 64 results from 37 empirical studies and concluded that fragmentation and inconsistency prevailed due to method inconsistency. It suggests the use of advanced regression models and a longer period of time to analyze the impact of sustainability reporting on corporate financial performance.

All of these discrepancies are the research gaps that lead researchers involved in carrying out this work to investigate how the effect of sustainability reporting and ESG risk management on performance and sustainable growth is exposed.

II.2.1.4. Introducing the Concept of Sustainable Growth

The concept of *sustainable growth* does not have a long-standing definition in the literature. It has different meanings for different people and groups of people. From a financial perspective, which is also addressed in this paper, sustainable growth means "affordable growth that can be profitably sustained for future benefits." The concept of sustainable corporate growth was popularized by Higgins in 1977 (1977), when he first attempted, by using the sustainable growth rate model, to explain the practical limits of the optimal development of the growing company. The sustainable growth rate (SGR) model explains whether or not the company's proposed development plan can be financed under existing financial parameters (Firer et al., 1995). Specifically, the objective of the sustainable growth rate is to explain the largest annual increase in the percentage of sales that a company can afford without issuing equity (i.e., new) or without changing its financial policies. Thus, according to this model, the value becomes the maximum around the rate of sustainable growth of the organization and falls sharply as soon as the actual growth exceeds the rate of growth (Ataünal et al., 2016). However, in today's global competitive arena, simple maximization of growth can help the company to meet its short-term, but not its long-term, goal of value creation (Ramezani et al., 2001).

II.2.1.5. Statement of Hypotheses

The study will discuss how sustainability reporting and the inadequate management of ESG factors affect the company's financial performance (return on assets), market performance (Tobin's Q-value), and sustainable growth. The publication of non-financial statements is assumed to have a positive effect on ROA, Tobin's Q, and sustainability growth, but ESG risk exposure is expected to have a negative effect on the dependent factors. Why does disclosure of non-financial information have a positive effect on ROA? As mentioned above, many researchers believe that investing in sustainable development programs will lead to the company's growth and a long-term increase in asset-generated profits. The positive effect of the non-financial disclosure on the value of Tobin's Q assumed in this study is due to the fact that this figure takes into account the changing expectations of investors regarding the company's book value (Oprean-Stan et al., 2020), that is to say, it takes into account the changing expectations regarding the different parameters affecting the assessment of future cash flows. It seems logical that the effect on the publication of a non-financial report on Tobin's Q will be more short-term than on ROA. Tobin's Q may change quickly as a result of both investor expectations of future cash flows and the value of the company.

On the other hand, the poor management of ESG risks by the company, as well as its possible involvement in controversial events that may damage its credibility and reputation on the market, may negatively affect both financial and market performance and the sustainable growth of the company concerned.

Based on the above considerations and the research questions presented in the Introduction, the null and alternative hypotheses for this study are presented in Table II.2.1.5.

Table II.2.1.5. Contents of null and alternative hypotheses in the study.

Hypotheses (0: null / a: alternative)	*Content*
H_{01}	There is no significant relationship between sustainability reporting, inadequate management of environmental, social and corporate governance (ESG) factors, and financial performance.
H_{a1}	Companies reporting sustainability and better managing ESG risks achieve higher financial performance
H_{02}	There is no significant relationship between sustainability reporting, inadequate management of environmental, social and corporate governance (ESG) factors and market performance.
H_{a2}	Companies reporting sustainability and better managing ESG risks achieve higher market performance
H_{03}	There is no significant relationship between sustainability reporting, inadequate management of environmental, social and corporate governance (ESG) factors, and sustainable growth.
H_{a3}	Companies reporting sustainability and better managing ESG risks achieve higher sustainable growth

Source: Authors' view

II.2.2. Data and Methodology

II.2.2.1. Sample Design and Data Collection

The analyzed companies are the 50 companies included in the calculation of the STOXX Europe 50 Index, Europe's leading Blue-chip index, which offers a measure of Europe's supersector members. It represents around 50 per cent of the European stock market capitalization. The index covers 50 stocks, most of which are concentrated in France and Germany (17 firms – 34 percent and 16 firms – 32 percent). Except for the banking sector (6 firms – 12 per cent) and the consumer goods and services sector (5 firms – 10 per cent), most industries are represented by one to four firms.

The main reason for choosing this index is the need to improve the generalization of the results obtained, as this study covers a wide range of economic sectors, including financial intermediation and insurance; industrial goods and services; personal and household goods; health care; technology; retail; chemicals; telecommunications; automobiles and parts; utilities; construction and materials. In addition, by including these top companies – the components of the index – into the sample, we have ensured that they are, for the most part, geared towards sustainability objectives and that they invest funds towards meeting them. We started from the idea that drawing up a sustainability report and focusing on sustainability goals are processes that involve additional spending of funds that small and medium-sized enterprises may not be able to afford (Landau et al., 2020; Frias-Aceituno et al., 2014).

The study covers the period from 2013 to 2020 and therefore includes 750 firm annual observations. Please note that due to the elimination of outliers before the regression analysis, the number of observations reported in the empirical regression might not be equal to 750. The data needed for this research was collected from Yahoo Finance Datastream. The financial statements of these companies were compiled from the financial information provided on the Yahoo Finance website. ESG risk ratings (total rating and component ratings: environment, social, and

governance) and involvment in controversial events were also selected from Yahoo Finance using the Sustainalytics methodology (ESG Risk Ratings Methodology, 2019).

We selected information on whether a company reports sustainability by using the GRI Sustainability Disclosure Database as follows: for each company in the sample, we manually checked if at least one sustainability report was published in the period considered. If published, it was marked with 1; otherwise, it received 0 points. Specifically, the data sources and methods for measuring these indicators are described in Table II.2.2.1.

Table II.2.2.1. Source of information and method of measurement for variables in the study

Proposed variables	Source of information and method of measurement
Sustainability reporting	GRI Sustainability Disclosure Database 1: if at least one sustainability report was published during the analysed period 0: if no sustainability report was published during the analysed period
ESG risk rating (total rating and component ratings: environmental, social, and governance)	Yahoo Finance, using the Sustainalytics methodology https://www.sustainalytics.com/esg-ratings. There are five risk categories (negligible, low, medium, high, severe). The rating scale is from 0 to 100, with 100 being the most severe.
Controversial Events Involvment (CEI)	Yahoo Finance, using the Sustainalytics methodology https://www.sustainalytics.com/esg-ratings. Each score for CEI is categorized from Category 1 (low impact on environment and society, posing negligible risks to the company) to Category 5 (severe impact on the environment and society, posing serious risks to the company): Category 1 (low impact); Category 2 (moderate impact); Category 3 (significant impact); Category 4 (high impact); and Category 5 (severe impact).
Financial and market information	Annual financial statements, collected from Yahoo Finance Datastream

Source: Authors' view

II.2.2.2. Substantiating the Variables in the Analysis

A. Measurement of sustainability variables

In this study, we will use three types of sustainability variables. The first variable is ESG Risk Ratings (Total and Components: Environment, Social, Governance), developed by Sustainalytics, a leading global provider of ESG and corporate governance products and services, supporting investors in developing and implementing investment strategies (ESG Risk Ratings Methodology, 2019). The second variable included in the study as a dummy variable shows whether the sampled companies have published sustainability reports on the GRI Sustainability Disclosure Database. The third variable refers to event indicators, i.e., the level of involvement of companies in controversial events that have an impact on the environment or society.

1. Sustainalytics ESG Risk Ratings

The ESG Risk Score for a company consists of a quantitative score and a risk group. The quantitative score reflects units of unmanaged ESG risk with lower unmanaged risk ratings. Companies are classified into one of five risk groups, based on their quantitative scores (negligible, low, medium, high, and severe). The scale of scores ranges from 0 to 100, with the most severe being 100. These categories of risk are absolute, meaning a 'high risk' assessment reflects a comparable degree of unmanaged ESG risk across all covered subindustries. That is the key reason

why we wanted to use this sustainability-related metric, as ESG risk ratings can be used to compare businesses from various subindustries, markets, businesses, and regions.

This variable is based on a two-dimensional basis (see Figure II.2.2.2-1):

- One that measures the exposure of a business to industry-specific ESG risks, indicating the sensitivity or vulnerability of the business or sub-industry to those risks.
- The second is management, or how well a firm manages those risks. Many of these threats are manageable, i.e., by means of effective legislation, programs and projects can be organized and directed. Another aspect is the unmanageable ESG Risk, which is inherent in a company's goods or services and/or the essence of a company's business which the company cannot control.

The assessment framework for ESG risk scores distinguishes the controlled risk from the category of manageable risks, i.e., those specific ESG risks that a business has handled by means of effective policies, programs, or initiatives, as well as the management gap that calculates the disparity between ESG material risk that the organization may face and what the company manages.

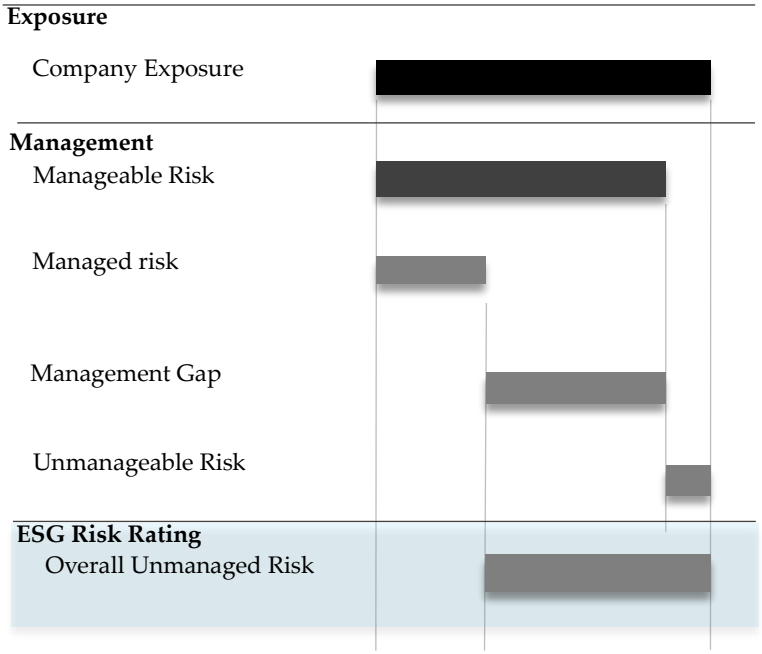


Figure II.2.2.2-1. ESG Risk Ratings, a two-dimensional framework between exposure and management. Source: ESG Risk Ratings Methodology (2019)

The final ESG Risk Ratings are a measure of unmanaged risk, which is described as a material ESG risk not controlled by a firm. It includes two types of risk: the unmanageable risk that cannot be addressed by company initiatives and the management gap. The management gap represents risks that could potentially be managed by a company but are not sufficiently managed according to the assessment. As a result, ESG Risk Ratings show the extent to which a company is exposed to ESG factors and what companies do or do not do to manage risks effectively.

To capture the impact of this metric on financial, market performance and sustainable growth in more detail, we evaluated both the overall score for ESG risk and the score on its components: environmental, social, and governance.

2. Sustainability Reports on GRI Sustainability Database

For all companies in the sample, we checked whether they published at least one sustainability report in the GRI Sustainability Disclosure Database during the period 2013-2020. This sustainability variable was introduced as a dummy variable in the study (companies that obtained a score of 1, if they published at least a sustainability report and 0 otherwise, during the period considered in the study).

3. Event Indicators: the Involvement in Controversial Events

Event Indicator is an indicator that offers a warning about a possible management issue by involvement in controversies. Sustainalytics measures the degree of involvment of businesses in controversial events which have an impact on the environment or society. Involvement in events can mean that the management structures of an organization are unsuitable for managing specific ESG risks. Each event occurrence is classified from Category 1 (low environmental and social impact, posing negligible risks to the company) to Category 5 (severe environmental and social effect, posing serious risks to the company) (see Figure II.2.2.2-2, Significant Controversy level).

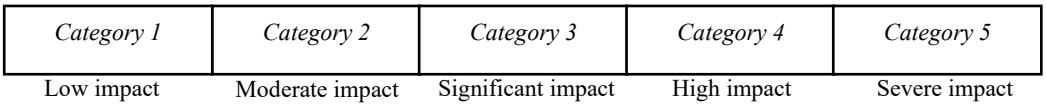


Figure II.2.2.2-2. Significant Controversy level category (Sustainalytics, Inc). Source: ESG Risk Rating Methodology (2019)

B. Selection and measurement of the performance variables

We use both financial and market performance measures to evaluate the impact of sustainability reporting and exposure to environmental, social, and corporate governance (ESG) risks on a firm's performance.

The financial performance of a company is interesting if we link the results obtained (most often in the form of profit) to the capital invested, as it is desired to obtain the highest possible return on the capital invested. As a result, the rate of return has the capacity to measure organizational performance most accurately. In this study, the Return on Assets (ROA) is used as a measure of the financial performance of a company from different perspectives, as considered by other authors (Borodin et al., 2019; Tariq et al., 2018; Wiengarten et al., 2017; Kiessling et al., 2015; Ching et al., 2017; Hussain et al., 2018; Ray & Mitra, 2018; Buallay, 2019; Szegedi et al., 2020). The return on assets (ROA) measures the efficiency of the capital allocated to the assets of the company. Due to the fact that the ROA is not influenced by the types of capital sources used by the firm in the financing process, and therefore does not depend on the financing policy, it becomes the most appropriate ratio for inter-firm comparisons.

Many organizations use ROA along with the Return on Equity (ROE), to support their business decisions. Secondly, both internal and external stakeholders (e.g. employees and shareholders) use these measures to determine how well a firm performs. Thirdly, investors are also using these indicators as the basis for their investment decisions. ROA data are available and can be calculated on the basis of the financial statements of the listed companies. This rate is therefore essential for the profitability of the company and measures the efficiency of the use of assets, taking into account the value of the profit earned.

In order to measure the market performance variable, we select Tobin's Q ratio, in line with other studies (Kang et al., 2016; Delmas et al., 2015). In the calculation of this coefficient, two variables are taken into account: the market value of the asset and the value of the replacement cost of the asset. Thus, the balance is when the market value is equal to the replacement cost. It can be determined not only at the level of the asset, but also at the level of the company as a whole.

For the market value of the company, we calculated the capitalization of the market as a product between the closing price of the shares and the number of shares. As far as the cost of replacing assets is concerned, Tobin used the book value in its analysis to determine it. In this study, we considered the replacement cost as determined by the net accounting asset, calculated by the decrease in the value of the total assets of the total liabilities (representing, in fact, the value of the equity).

However, we note that there are a number of problems related to this model, such as (Curaj, 2012): the market value is often influenced by various factors that are not under the control of the company management (the external perspective of the company). The replacement value also depends on the national or international accounting standards applied by that organization. Another limitation associated with this method is that it uses only financial and accounting data, and, in order to be able to objectively assess the level of efficiency of a company, a more comprehensive tool is needed, which includes both quantitative and financial variables and qualitative ones.

Sustainable Growth Rate (SGR) is the rate at which a company can use its own internal funds without borrowing money from banks or financial institutions (Xu & Wang, 2018) to achieve growth. The SGR is commonly used to plan long-term sustainable growth, capital investments, cash flow forecasts, and borrowing strategies. The SGR formula (Higgins, 1977; Chen et al., 2005; Gómez-Bezares et al., 2016) is as follows:

$$SGR = Net\ profit\ ratio \times Asset\ turnover\ ratio \times Equity\ multiplier \times Retention\ rate \quad (1)$$

The net profit ratio is proportional to how much net income or benefit a percentage of revenue generates. The asset turnover ratio measures the value of the sales or revenues of a business relative to the value of its assets. The asset turnover ratio may be used as a measure of the efficiency with which a business uses its assets to produce revenue. The equity multiplier is a ratio of financial leverage that measures the portion of the assets of the company that is financed by equity of the shareholders. It is determined by dividing a company's total asset value by total shareholder's equity. The retention ratio is the proportion of earnings held as retained earnings back in the company. The retention ratio refers to the percentage of net profits retained in order to grow the company, instead of being paid out as dividends. It is the opposite of the payout ratio which measures the percentage of profit paid out as dividends to shareholders. The retention ratio is also called the plowback ratio.

C. Selection and Measurement of the Control Variables

When examining the relationship between sustainability reporting, exposure to environment, social and corporate governance (ESG) risks and financial performance, market performance, and sustainable growth, it is important to take into account other variables that may affect these contingent factors. Failure to do so could result in biased tests. We also used control variables in our regression models to add value and certainty.

In the first model, as a first control variable, we used Firm Size (FS), determined by the logarithm of total assets, to establish the independent influences on financial performance. Empirical analysis found a link between business size and sustainability efficiency, as well as between firm size and certain financial performance indicators (Fischer & Sawczyn, 2013). Shareholders, for example, may have greater expectations and concerns about the extent of responsibility for actions and activities carried out by larger companies. In addition, the size of the corporation may also impact the availability of tools that can be used to generate performance reports (Herbohn et al., 2014).

Consistent with previous studies (Xu & Wang, 2018; Xu et al., 2017; Nimtrakoon, 2015), financial risk, determined by the Debt Ratio (DR), assessed by total debt to its total assets, was also used as the second control variable. This variable accounts for debt burden related risk. Debt level may have consequences for managerial behaviour. In particular, it can limit the managers' ability to pursue action, and influence them to make decisions that are not in the best long-term interest of the organization (Barnett and Salomon, 2012).

Table II.2.2.2. Presentation of the variables used for the study.

DEPENDENT VARIABLES	
Indicator	**Description**
Return on Assets (ROA)	ROA is calculated by dividing the net income by the total assets of the company. It is an indicator of the effectiveness of the global management of the assets of a company.
Tobin Q	The Q factor can be written as the ratio between the market value and the asset replacement value (in the case of this study, the asset replacement value is the net book asset)
Sustainable Growth Rate (SGR)	SGR is the optimal growth rate of the company, without creating imbalances, due, for example, to the need to access additional capital from banks or financial institutions or by issuing shares. It is calculated as a product between net income ratio, asset turnover ratio, equity multiplier, and retention rate.
INDEPENDENT VARIABLES	
Indicator	**Description**
ESG Risk	ESG Risk Ratings scores are a measure of unmanaged risk, which is defined as material ESG risk that has not been managed by a company.
CEI	This indicator assesses the level of involvement of the companies in controversial events that have an impact on the environment or society.
GRI	This indicator expresses sustainability reporting, i.e., if the companies published at least a sustainability report in the GRI Sustainability Disclosure Database during the period considered in this study.
CONTROL INDEPENDENT VARIABLES	
Indicator	**Description**
Firm Size (FS)	Firm size, measured by the logarithm of the total assets recorded in the balance sheet, is a control variable because investors have greater confidence in the financial potential of a large company and, as a result, the size of the company can influence the profitability of the company.
Debt Ratio (DR)	Debt ratio, measured by the total debt to its total assets, represents the risk associated with the debt burden. It makes it possible to compare the leverage between different companies.
Sales Growth (SG)	Sales growth, measured as a percentage change in sales compared to the previous year's sales. It characterizes the total amount of income received by the company during the year.

Return on Equity (ROE)	ROE is calculated by dividing the net income by shareholder equity. It actually refers to the efficiency with which the capital invested by the owners is used.

Source: Authors' view

In the second model, as a first control variable, we use Firm Size (FS), determined by the logarithm of total assets, in order to establish independent influences on market results. Investors are more confident of a major company's financial success. Return on Equity (ROE), measured by net profit to total shareholders' equity, is also included as the second variable control, because the yield of the shareholders' financial investment in the company is a decisive factor for a company's market value. ROE is a calculation of how efficiently a business makes use of resources to produce revenue. This rate is a measure of the return received by the owners of the company for the funds initially invested in the purchase of shares, which indicates the return on equity.

In the third model, conducted to assess the independent influences on the sustainable growth of companies, we used Sales Growth (SG), calculated as a percentage change in sales relative to the previous year's revenues, as a first control variable, consistent with previous studies (Hussain et al., 2018). ROA was also used as the second control variable, determined by net income to total assets, since the efficiency of using assets will produce maximum growth for the business.

Table II.2.2.2 provides a description of the dependent, independent, and control variables used in this analysis.

II.2.2.3. Empirical Regression Models

In order to investigate the relationship between sustainability reporting, the management of environmental, social, and corporate governance (ESG) risks and financial performance, market performance, and sustainable growth, it is necessary to construct three multi-factorial linear regressions according to the general model represented in equation 2:

Dependent Variable = f (Sustainability Reporting + ESG Risk Rating + Control Variables) (2)

Where the dependent variables are financial performance (ROA), market performance (Tobin's Q), sustainable growth rate (SGR), and the independent factors are the following: environmental, social, and governance (ESG) risk ratings (total: ESG risk and for each of the components: ESG environment, ESG social, ESG governance), sustainability reporting (GRI), and controversial event involvement (CEI). The control variables are firm size (FS), leverage (debt ratio, DR) for the first regression model, FS and Return on Equity (ROE) for the second model, and ROA and Sales Growth (SG) for the third regression model.

More specifically, the multifactorial regression models we are developing in this study are presented below:

Model 1:

$$ROA = \beta_0 + \beta_1 GRI + \beta_2 ESG_{risk} + \beta_3 ESG_{environ} + \beta_4 ESG_{soc} + \beta_5 ESG_{gov} + \beta_6 CEI + \beta_7 FS + \beta_8 DR + \varepsilon \quad (3)$$

Model 2:

$$Tobin\_Q = \beta_0 + \beta_1 GRI + \beta_2 ESG_{risk} + \beta_3 CEI + \beta_4 FS + \beta_5 ROE + \varepsilon \quad (4)$$

Model 3:

$$SSG = \beta_0 + \beta_1 GRI + \beta_2 ESG_{risk} + \beta_3 ESG_{environ} + \beta_4 ESG_{soc} + \beta_5 ESG_{gov} + \beta_6 CEI + \beta_7 SG + \beta_8 ROA + \varepsilon \quad (5)$$

where $\beta_0, \beta_1, \ldots, \beta_8$ are the presumed parameters; and ε denotes the measurement error term.

All data was analyzed using the SPSS statistical program. The statistical techniques used for data analysis, preceded by the validity of the models, are presented more accurately in the next section.

II.2.3. Results and Discussion

II.2.3.1. Model Validity

To test the model validity, we analyzed whether observations are independent (i.e., independence of residuals) by specific tests. The statement about multiple regression we have tested is that: (a) the independent variables are collectively linearly related to the dependent variable; and (b) every independent variable is linearly related to the dependent variable. We have also tested whether the data shows residual homoscedasticity (equal variances in error), whether the data shows no multicollinearity and whether there are any significant outliers, high leverage points, or highly influential points.

For the three regression models, we initially encountered problems with multicollinearity (Hair et al., 2014), in the sense that the CEI and ESG governance variables in model 1, the CEI variable in model 2, and the ESG governance variable in model 3 achieved a VIF value greater than 10. As a result, we decided to remove these variables from the analysis and it was necessary to re-run all the analyzes carried out so far.

The assumption of *independence of observations* in a multiple regression is structured to check for autocorrelation of the 1st order, which implies that adjacent observations (specifically, their errors) are associated (i.e., not independent). There was independence of errors (residuals) in all three models, as measured by a Durbin-Watson statistic of 1.415 in model 1, of 2.278 in model 2, and of 2.236 in model 3 (see Table II.2.3.1), values which are very similar to 2, so it can be agreed that there is independence of residuals.

Table II.2.3.1. Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.750[a]	.562	.501	.0218314421216	1.415
2	.473[b]	.224	.146	169.8385319521568	2.278
3	.678[c]	.460	.368	.0461531554646	2.236

a. Predictors: (Constant), ESG_Risk, ESG_Social, Debt Ratio, GRI, Firm Size, ESG_Environment, Dependent Variable: Return on Assets

b. Predictors: (Constant), ESG_Risk, GRI, Return on Equity, Firm Size, Dependent Variable: Tobin_Q

c. Predictors: (Constant), Return on Assets, ESG_Environment, GRI, Sales Growth, ESG_Risk, Controversial Events Implication, ESG_Social, Dependent Variable: Sustainable Growth

Source: Author's own analysis. Generated by SPSS

To check for *linearity*, we evaluated (a) – whether there is a linear relationship between the dependent and independent variables collectively – by plotting a scatterplot of the studentized residuals against the (unstandardized) predicted values and (b) – whether there is a linear relationship between the dependent variable and each of the independent variables – by using partial regression plots between each independent variable and the dependent variable.

In all three models, since the residuals form a horizontal band, the relationship between dependent variables and independent variables is likely to be linear. Whether there is a linear relationship between the dependent variable and each of the independent variables was established using partial regression plots. We observed that the partial regression plot shows an approximately linear relationship between the dependent variables (ROA, Tobin's Q, SGR) and each independent variable.

Also, there was *homoscedasticity*, as assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted values.

Multicollinearity happens when you have two or more independent variables which are strongly associated. Multicollinearity identification has two stages: inspection of coefficients of correlation and values of tolerance / VIF.

Following the analysis of the correlation between variables in the study, we noted that most of the correlations between independent variables had values of less than 0.7. In model 1 and model 3, only the relationship between the ESG environment and the ESG social is 0.789, while that between firm size and debt ratio is 0.724 (in model 1).

Most importantly, we looked at the "Tolerance" and "VIF" values in the Coefficients table. In models 1 and 2, following the omission of the CEI and ESG governance variables, all tolerance values are greater than 0.1 (the lowest is 0.297 in model 1 and 0.527 in model 2). In model 3, after the omission of the ESG governance variable, all tolerance values are greater than 0.1 (the lowest is 0.357). As a result, we are pretty confident that the models do not have a collinearity problem.

In addition, we performed the *diagnostics of outliers, high-leverage points and influential points*. This was achieved using Cook's distance, the leverage statistic, and other related metrics. It is very significant as all these points may have a negative effect on the equation of regression used to estimate the value of the dependent variable depending on the independent variables. This can alter the performance provided by SPSS Statistics and decrease both the predictive accuracy of the results and the statistical significance.

Casewise diagnostics and the studentized deleted residuals technique were used to identify the outliers. The Casewise Diagnostics table highlights any cases where the standardized residual of that case is greater than ±3 standard deviations. In all the three models, all cases have standardized residuals less than ±3, but from the study of studentized deleted residuals, in the three models, we found variables with values greater than ± 3 standard deviations, resulting in these outliers being excluded from the data set.

To order to be able to run inferential statistics (i.e., to assess statistical significance), the prediction errors – the residuals – need to be *normally distributed*. We used two popular methods to test the assumption of normality of residuals: a histogram with superimposed normal curve and a P-P Plot. Following their analysis, we noticed that although the points are not perfectly aligned along the diagonal line (the distribution is somewhat peaked), they are close enough to indicate that the residuals are sufficiently close to normal for the analysis to proceed. Since multiple regression analysis is fairly robust against deviations from normality, we accepted this result as an indication that no transformations or otherwise would need to occur; it did not violate the assumption of normality.

II.2.3.2. Correlation Analysis

Correlation analysis is used to determine the degree to which the variation of the dependent variable relates to the variation of the independent variables in each model. Tables II.2.3.2-1,

II.2.3.2-2, II.2.3.2-3 present the results of the analysis of the correlation between the variables in the study.

Table II.2.3.2-1. Pearson correlations for main study variables (model 1)

Model 1	Return on Assets	GRI	ESG_Risk	ESG Environment	ESG Social	Firm Size	Debt Ratio
Return on Assets	1						
GRI	.071	1					
ESG_Risk	-.304*	.185	1				
ESG_Environment	-.044	.113	-.119	1			
ESG_Social	-.047	.045	-.041	.789**	1		
Firm Size	-.595**	.069	.357*	.054	.082	1	
Debt Ratio	-.697**	-.138	.120	.106	-.059	.724**	1

*statistically significant at $p < 0.05$ level. **statistically significant at $p < 0.01$ level.

Source: author's own analysis. Generated by SPSS software

Table II.2.3.2-2. Pearson correlations for main study variables (model 2).

Model 2	Tobin_Q	GRI	ESG Risk	Firm Size	ROE
Tobin_Q	1				
GRI	-.349*	1			
ESG_Risk	-.082	.185	1		
Firm Size	-.101	.069	.357*	1	
ROE	-.075	.067	-.278	-.380**	1

*statistically significant at $p < 0.05$ level. **statistically significant at $p < 0.01$ level.

Source: author's own analysis. Generated by SPSS software

Table II.2.3.2-3. Pearson correlations for main study variables (model 3).

Model 3	SGR	GRI	ESG_Risk	ESG Environment	ESG Social	CEI***	Sales Growth	ROA
Sustainable Growth Rate (SGR)	1							
GRI	.258	1						
ESG_Risk	-.040	.185	1					
ESG_Environment	.163	.113	-.119	1				
ESG_Social	.056	.045	-.041	.789**	1			
CEI***	-.130	.036	.282*	-.063	-.124	1		
Sales Growth	-.076	.099	.265	.090	.111	.444**	1	
ROA	.176	.071	-.304*	-.044	-.047	-.308*	-.255	1

*statistically significant at $p < 0.05$ level.
**statistically significant at $p < 0.01$ level.
***CEI = Controversial Events Involvement

Source: author's own analysis. Generated by SPSS software

The product-moment correlation of Pearson was run to assess the relationship between dependent variables (ROA, Tobin's Q, and SGR) and the independent variables. Following the study of Pearson correlation coefficient values, we noted the following:

- In model 1: There was a statistically significant, moderate negative correlation between ROA and ESG with a correlation coefficient of -0.304, $p < .0005$. The increase in exposure to ESG risk

was moderately correlated with a decrease in ROA. ROA shows, as expected, a statistically significant strong and negative correlation with FS and DR. ROA is negatively correlated with FS having a coefficient of correlation of -0.595, $p < .0001$. ROA and DR are also negatively correlated with a correlation coefficient of -0,697, $p < .0001$. The increase in firm size and debt ratio was strongly correlated with the decline in ROA. These results are already reflected in the hypotheses tests, where the linear relationship between the ROA and the other variables in the model was anticipated.

- In model 2: Tobin's Q is negatively correlated with all independent variables in the study, but the only statistically significant correlation is with the GRI variable, showing a moderately negative correlation with a correlation coefficient of -0.349, $p < .0005$. The increase in GRI was moderately correlated with a decrease in Tobin's Q, which is a rather surprising result, as sustainability reporting is expected to have a positive impact on market performance. The relationship with the other variables, including the ESG risk, although negative, is neutral.

- In model 3: there was a statistically significant, small positive correlation between sustainable growth and GRI. There was, however, no statistically significant correlation between the SGR and the independent factors in the model.

II.2.3.3. Estimation Results

Determining whether the multiple regression model is a good fit for the data

There are a number of measures you can use to determine whether the multiple regression model is a good fit for the data. These are (a) the multiple correlation coefficient, (b) the percentage (or proportion) of variance explained; (c) the statistical significance of the overall model; and (d) the precision of the predictions from the regression model.

One of the important findings for the understanding of the regression analysis, the R-square value, reflects how much (percentage) the variation of the dependent variable can be explained by an independent variable. The higher value of the R-square suggests a better linear relationship. For this analysis, we used the classification of regression relationships into four classes, based on the value of this measure, as follows (Cohen et al., 2003): a very strong relationship, if R-square > 0.75, a strong relationship with the value of R-square within the range of 0.5-0.75, a weak relationship with the value of R-square within the range of 0.25-0.5, and a very poor relationship with the value of R-square < 0.25.

R^2 was 56.2 percent for the first iteration, with a modified R^2 of 50.1 percent, suggesting a large size impact. Approximately 56% of the ROA volatility for the sampled companies can be explained by the selected dependent variables (GRI, ESG Risk, ESG Environment, ESG Social, Firm Size, Debt Ratio). R^2 was 22.4 percent for the second model, with a modified R^2 of 14.6 per cent, suggesting a very small size impact. Approximately 22 percent of the Tobin's Q volatility in the case of the sampled firms can be explained by the selected dependent factors (GRI, ESG Risk, Firm Size, Return on Equity). R^2 for the third model was 46 percent with a modified R^2 of 36.8 percent, indicating a small to large impact. Approximately 46% of the sustainable growth volatility of the sampled companies can be explained by selected dependent factors (GRI, ESG Risk, ESG Environment, ESG Social, Controversial Events Involvement, Sales Growth, and Return on Assets).

However, R^2 is based on the sample and is considered a positively-biased estimate of the proportion of the variance of the dependent variable accounted for by the regression model (i.e., it

is larger than it should be when generalizing to a larger population). Despite this criticism, it is still considered by some to be a good starting measure to understanding the results (Draper and Smith, 1998).

Statistical significance of the model - Application of the ANOVA method to the null hypothesis test

In the results given by the SPSS software, the test coefficient F in the ANOVA table is used to determine the general predictive value of the regression model. Unless the results of the F test are not statistically important, the regression model does not have a reasonable predictive value.

The rule we applied in the calculations, taking into account the 5 percent significance point, is that if the likelihood of the F test is less than the 5 percent significance level, then at least one of the coefficients is statistically important, and the study rejects the null hypothesis. In other words, if the likelihood is higher, then all the coefficients have a value of zero from a statistical point of view, and in this case, there is not enough proof to refute the null hypothesis. Nevertheless, the lack of evidence to refute the null hypothesis is not proof of acceptance of the null hypothesis (Laerd Statistics, 2015).

Null Hypothesis H01: There is no significant correlation between ROA and independent factors

The ANOVA analysis indicates that the regression model of the dependent variable (ROA) is statistically important, since F (6, 42) = 11,499, and the likelihood associated with the test is lower than the significance level (of .05), p = .00, as the null hypothesis is therefore rejected. There is a statistically significant correlation between the dependent variable and the independent factors considered in the predictive utility model for ROA (GRI, ESG Risk, ESG Environment, ESG Social, Debt Ratio, and Firm Size).

Null Hypothesis H02: There is no significant correlation between Tobin Q and independent factors

The ANOVA study indicates that the regression model of the dependent variable (Tobin's Q) is statistically important since F (4,40) = 2,887, and the likelihood associated with the test is lower than the significance level (of .05), p = 0,34 as a consequence of which the null hypothesis is rejected. As a result, the independent factors considered in the Tobin Q predictive utility model have a statistically significant relation between this measure and the independent factors (GRI, ESG Risk, Return on Equity, and Firm Size).

Null Hypothesis H03: There is no significant correlation between SGR and independent factors

The ANOVA analysis indicates that the regression model of the dependent variable (SGR) is statistically important, since F (7,41) = 4,995, and the likelihood associated with the test is lower than the significance level (of .05), p = 0,00, as the null hypothesis is therefore rejected. There is a statistically significant correlation between this predictor and the independent factors considered in the predictive utility model for SG (GRI, ESG Risk, ESG Climate, ESG Social, Controversial Events Implication, Return on Assets, and Sales Growth).

Interpreting and displaying the regression model coefficients

The regression coefficients and standard errors for all three models can be found in Tables II.2.3.3-1, II.2.3.3-2, II.2.3.3-3.

Table II.2.3.3-1. Multiple regression results for ROA

ROA	B	95% CI for B		SE B	β	R^2	ΔR^2
		LL	UL				
Model						.56	.50***
Constant	.108	-.01	.22	.06			
GRI	-.003	-.02	.01	.01	-.04		
ESG_Environment	.001	.00	.00	.00	.21		
ESG_Social	-.001	-.00	.00	.00	-.25		
ESG Risk	-.001*	-.00	.00	.00	-.23*		
Firm Size	.006	-.01	.02	.01	.10		
Debt Ratio	-.143***	-.20	-.09	.03	-.83***		

Note. Model = "Enter" method in SPSS Statistics; B = unstandardized regression coefficient; CI = confidence interval; LL = lower limit; UL = upper limit; SE B = standard error of the coefficient; β = standardized coefficient; R^2 = coefficient of determination; ΔR^2 = adjusted R^2.
*p < .05. **p < .01. ***p < .001.

Source: author's own analysis. Generated by the SPSS software

Table II.2.3.3-2. Multiple regression results for Tobin's Q

Tobin's Q	B	95% CI for B		SE B	β	R^2	ΔR^2
		LL	UL				
Model						.22	.15*
Constant	1135.557*	89.10	2182.01	517.77			
GRI	-214.632**	-356.04	-73.23	69.97	-.45**		
ESG_Risk	3.329	-5.61	12.27	4.42	.13		
Firm Size	-108.706	-238.40	20.98	64.17	-.33		
ROE	-795.787	-1704.65	113.08	449.69	-.30		

Note. Model = "Enter" method in SPSS Statistics; B = unstandardized regression coefficient; CI = confidence interval; LL = lower limit; UL = upper limit; SE B = standard error of the coefficient; β = standardized coefficient; R^2 = coefficient of determination; ΔR^2 = adjusted R^2.
*p < .05. **p < .01. ***p < .001.

Source: author's own analysis. Generated by the SPSS software

Table II.2.3.3-3. Multiple regression results for Sustainable Growth Rate

SGR	B	95% CI for B		SE B	β	R^2	ΔR^2
		LL	UL				
Model						.46	.37***
Constant	.085*	.017	.152	.033			
GRI	-.018	-.053	.018	.018	-.118		
ESG Risk	-.001	-.002	.001	.001	-.097		
ESG_Environment	.004**	.002	.007	.001	.686**		
ESG_Social	-.003**	-.005	-.001	.001	-.522**		
CEI	-.018	-.036	.001	.009	-.258		
Sales Growth	3.062E-10	.000	.000	.000	.233		
ROA	.761	.285**	1.237	.236	.409**		

Note. Model = "Enter" method in SPSS Statistics; B = unstandardized regression coefficient; CI = confidence interval; LL = lower limit; UL = upper limit; SE B = standard error of the coefficient; β = standardized coefficient; R^2 = coefficient of determination; ΔR^2 = adjusted R^2.
*p < .05. **p < .01. ***p < .001.

In the tables above, the model fit statistics and values of the coefficients were rounded to 2 decimal places.

The description of the coefficients for independent variables is as follows:

Within model 1, the ESG environment and firm size independent variables are positively related to the dependent ROA variable. Nevertheless, other independent variables such as GRI, ESG social, debt ratio, and ESG risk are negatively related to the dependent variable. As a result, an increase in the probability of ESG is associated with a decrease in ROA. There is a reduction in the ROA since the coefficient of slope is negative. ESG Risk and Debt Ratio are the only independent variables that are statistically relevant (i.e., $p < .05$), which means that they are distinct from 0 (zero). There are slope coefficients that are not statistically significant, which indicates that there are independent variables that are not statistically significant because the p value is greater than .05: GRI, ESG climate, ESG social, and firm size.

For model 2, independent variables GRI and control variables firm size and ROE are negatively related to the dependent Tobin Q variable. The ESG risk is positively linked to the dependent variable. As a result, an increase in ESG risk is correlated with an increase in Tobin Q. GRI is the only independent factor that is statistically relevant (i.e., $p<.01$). There are slope coefficients which are not statistically significant: ESG risk, firm size, and ROE.

In model 3, the independent variable ESG environment and control variables sales growth and ROA are positively related to dependent variable sustainable growth. However, other independent variables, such as GRI, ESG risk, ESG social, and CEI, are negatively related to the dependent variable. As a result, an increase in the value of such variables is correlated with a decrease in sustainable growth. The only independent variables that are statistically relevant (i.e., $p < .01$), which means that they are different from 0 (zero), are the ESG environment and the ESG social. There are slope coefficients that are not statistically significant: GRI, ESG risk, CEI, sales growth, and ROA.

II.2.3.4. Robustness Check

The next section deals with robustness tests to review the sensitivity of the results reported, in order to identify potential issues related to the collection of data samples or the specification of model valuation.

In line with other studies (Xu et al., 2017), we intended to examine additional measures for dependent variables in the three models. We consider the return on equity (ROE), measured by the reporting of the net profit generated by the company and the value of the equity, to be another measure of financial performance. Next, Price Earnings Ratio (PER), as a ratio between price and earnings, is considered as another measure of market performance and the assets growth (AG) (compared to the previous year) as an alternative measure of sustainable growth.

We regressed all models again using these different dependent variables. The results of this robustness check are consistent with the basic results and confirm the findings in our models, which suggests that the statistical findings presented in this paper are fairly robust.

II.2.3.5. Discussion

The aim of this study is to provide a clear understanding of the relationship between sustainability reporting, the performance of managing ESG factors and financial performance, market performance, and the sustainable growth of the sampled companies. Three linear

relationships have been established between the indicators of financial, market performance and sustainable growth (ROA, Tobin's Q, and SGR) and related sustainability indicators (GRI, ESG overall risk and components – ESG governance, ESG social, ESG environment, and CEI).

The first multiple regression was used to predict ROA from GRI, ESG Risk, ESG Environment, ESG Social, ESG Governance, CEI, and control variables: firm size and debt ratio. Linearity was assessed by partial regression plots and the studentized residual plot against the predicted values. Residual independence was assessed in the Durbin-Watson statistic of 1,415. Homoscedasticity was assessed by visual inspection of the studentized residual plot versus non-standardized predicted values. We first encountered problems with multicollinearity for this model. To remedy this problem, we decided to remove the CIE and ESG governance variables from the analysis, and it was necessary to re-run all the analyzes carried out so far. All cases have standardized residuals less than ± 3, but in the analysis of the studentized deleted residual values, variables with values greater than ± 3 standard deviations were detected, resulting in the reduction of these outliers in the data set. The assumption of normality as assessed by the Q-Q plot was met. The multi-regression model statistically significantly predicted ROA, $F(6, 42) = 11.499$, $p < .0005$, adj. $R^2 = 0.50$. All six variables that remained in the analysis after adjusting for non-multicollinearity assumptions were statistically significant for the forecast in the model, $p<.05$. The individual predictors were further investigated and indicated that ESG risk ($p<.05$) and debt ratio ($p<.001$) were significant predictors of the model.

The second multiple regression was run to predict Tobin Q from GRI, ESG Risk, and control variables: firm size, ROE. Linearity was evaluated by partial regression plots and the studentized residual plot against the predicted values. Residual independence was assessed in the Durbin-Watson statistic of 2,278. Homoscedasticity was assessed by visual inspection of the studentized residual plot versus non-standardized predicted values. We encountered problems with multicollinearity for this model, also. In order to solve this problem, we decided to remove the CEI variable from the analysis, and it was necessary to re-run all the analyzes carried out so far. All cases have standardized residuals less than ± 3, but in the analysis of the studentized deleted residual values, variables with values greater than ± 3 standard deviations were detected, resulting in the reduction of these outliers in the data set. The assumption of normality as assessed by the Q-Q plot has been met. The multi-regression model statistically significantly predicted Tobin Q, $F(4.40) = 2.887$, $p < .0005$, adj. $R^2 = .15$. GRI is the only independent factor that is statistically significant to the forecast (i.e., $p < .05$).

The third regression was to predict sustainable growth from GRI, ESG Risk, ESG Environment, ESG Social, ESG Governance, CEI, and control variables: sales growth and ROA. Linearity was assessed by partial regression plots and the studentized residual plot against the predicted values. Residual independence was assessed in the Durbin-Watson statistic of 2,236. Homoscedasticity was assessed by the visual inspection of the studentized residual plot versus non-standardized predicted values. We first encountered problems with multicollinearity for this model. In order to solve this problem, we decided to remove the variable ESG governance from the analysis, and it was necessary to re-run all the analyzes carried out so far. All cases have standardized residuals less than ± 3, but in the analysis of the studentized deleted residual values, variables with values greater than ± 3 standard deviations were detected, resulting in the reduction of these outliers in the data set. The assumption of normality as assessed by the Q-Q plot was met. The results of the multiple linear regression indicated that there was a significant collective effect between the SG and the independent variables considered in the model, with the result that the

multiple regression model statistically significantly predicted SG, F (7.41) = 4.995, p < .0005, adj. R^2 = 0.37. Together, all seven variables remained statistically significant for the forecast in the model, p<.05. The individual predictors were further investigated and indicated that the ESG environment and the social ESG (p<.01) were significant predictors of the model.

II.2.4. Concluding remarks

The findings obtained from our empirical study suggest that the inadequate management of sustainability-related ESG factors has a substantial negative effect on the financial performance of reporting firms, as we predicted. In particular, our evidence indicates that the various aspects of sustainability (governance, social, and environmental) are not equally applicable to financial performance. The governance dimension is never important enough to justify any change in the financial performance of the company (in line with Hussain, 2015), but the poor management of the social aspect is negatively related to the financial performance, which reinforces our assumptions.

An interesting finding is that sustainability reporting is not important (according to Hussain, 2015 too) for the financial performance metric. King and Lenox (2002) provide the possible reason for this, arguing that information about sustainability can take two years to influence financial performance.

In our analysis, we cannot find evidence that market performance is positively affected by sustainability reporting. Caesaria and Basuki (2016) previously provided the strongest support for the relationship between sustainability disclosure and corporate market performance. We find no support for those findings in our study. According to our findings, an organization that discloses information on sustainability aspects can decrease the market performance assessed by Tobin's Q. The fact that the information on sustainability reporting is not substantially linked to market performance indicates a more integrated and comprehensive reporting system (Hussain, 2015). We assert that reporting alone has less meaning in itself, but it does have the potential to positively impact the market success of the company as it informs about the capacity of the firm to achieve sustainable development goals.

In line with our study findings, sustainable growth is influenced by the environmental and social aspects of sustainability. Improved ESG social management supports the sustainable growth of the companies. Contrary to our assumptions, we see no relationship between the disclosure of sustainability and sustainability growth, between ESG risk and market performance, and between CEI and financial and market performance.

This research study has limitations: we found independent variables that are not statistically significant, among others. Our model-building method was considered in terms of theory-based criteria; more specifically, to assess an independent variable by its theoretical value is to determine whether to hold or delete an independent variable that is not statistically important in the regression model. Previous studies show that the independent variables considered in this study are related to the variables depending on it. In our study, as we have shown in Section 2 of this paper, the dependence between financial and market performance and sustainability indicators is well established in the literature. It therefore made complete sense to include the sustainability reporting variable in the study, even though it was not statistically relevant in the second model.

The fact that the sample size was insufficient to show the true spectrum of the relationship may be a reason for the lack of statistical significance for these independent variables. In this

analysis, the criterion for selecting the company component of the index was necessary due to the need for accessible information on financial statements and sustainability indicators. The selection of samples with these specific criteria restricts the generalization of the findings of this study. Once the data is available, further research using a larger number of measurements can be carried out to check the validity of the findings of this study.

Chapter II.3. AGRICULTURAL COMMODITIES MARKET REACTION TO COVID-19[6]

The emergence of the COVID-19 pandemic in December 2019, originating in China and subsequently proliferating globally, precipitated profound disruptions across the financial spectrum, notably within stock exchanges worldwide (Barro et al., 2020; Goodell, 2020; Czech et al., 2020). This pandemic, characterized by its unprecedented scale and reach, has been a catalyst for significant fluctuations in global financial markets, igniting panic reactions and market volatility (Jabotinsky and Sarel, 2020). The year 2020 will be indelibly marked in history as a period of extreme events, with the pandemic's ramifications permeating every facet of production, economic stability, and daily life (He et al., 2020).

The agricultural commodities market, covering cotton, sugar, rice, wheat, and corn, has faced significant disturbances. The pandemic heightened volatility in these sectors (Bakas et al., 2020), with commodities such as sugar unable to offset pandemic-related losses (Babirath et al., 2020).The prices of other gross merchandises, such as cotton, fell even more than expected because the pandemic was worsening. This period has seen substantial fluctuations in commodity prices, often deviating from economic fundamentals and leading to potential price bubbles (Huang & Xiong, 2020). Furthermore, the global financial markets experienced turbulence unparalleled start with 1930s, Covid pandemic surpassing even the global financial crisis in terms of affected countries (IMF, 2020).This climate of uncertainty has reshaped investor behavior, with an increased inclination towards 'safe-haven' assets like precious metals (Baker et al., 2020).

The onset of COVID-19 has not only posed a formidable challenge to public health systems but also instigated a series of ripple effects across financial markets worldwide. The pandemic's influence on market dynamics is multifaceted, encompassing fluctuations in prices, supply chain disruptions, and shifts in consumer behavior and government policies (Szczepańska-Przekota, 2022). This study employs the Markov Switching model to delve into these complexities, offering a nuanced understanding of how the pandemic has altered the structural behavior of financial markets, thereby increasing their volatility.

This study focuses on globally significant commodities—cotton, sugar, rice, wheat, and corn. These staples are crucial not just in diets but also in driving the global economy. They represent a substantial segment of international trade (Kang et al., 2023)and are critical to the livelihoods of millions worldwide. Hence, understanding their market dynamics during the pandemic is crucial for both policymakers and investors. In periods of economic turbulence, losses become a norm with the increasing volatility of portfolio assets, which, over time, manages to diminish. (Huynh et al., 2020). The COVID-19 period has both brought and benefited from diversification in the stock markets, as seen in the example of the Asian market, where stocks had at least one safe-haven option. (Ali et al., 2023).

[6] This section is based on the article: **Iulia Cristina Iuga**, Syeda Rabab Mudakkar, Larisa Loredana Dragolea. 2024. Agricultural commodities market reaction to COVID-19. Research in International Business and Finance, Vol. 69. DOI: https://doi.org/10.1016/j.ribaf.2024.102287.

The analysis is structured to cover three distinct phases: Pre-COVID (06/01/2006 to 02/28/2020), COVID (03/02/2020 to 03/02/2021), and Post-COVID (03/03/2021 to 10/20/2023). This division of time periods facilitates an in-depth analysis of market trends prior to, throughout, and following the peak of the pandemic. The Pre-COVID phase sets the baseline, depicting the market conditions and trends before the global health crisis. The COVID phase encapsulates the immediate and most intense impact of the pandemic on the market, characterized by heightened volatility and uncertainty. Finally, the Post-COVID phase aims to capture the market's adaptation and response to the evolving pandemic situation, including the gradual recovery and the lingering effects of the crisis.

By juxtaposing these periods, the study endeavors to trace the trajectory of market changes, discern patterns, and identify shifts in consumer behavior and global trade adaptations. The investigation into these aspects is crucial for several reasons. Firstly, it provides insights into the resilience and vulnerability of agricultural commodity markets in the face of global disruptions. Secondly, it aids in understanding how such crises can lead to systemic changes in market behavior, influencing investment strategies and policy-making. Finally, the study contributes to the broader discourse on managing and mitigating the impacts of global health crises on essential commodities.

II.3.1. Agricultural ccommodity markets overview

Past studies indicate the difficulty in identifying commodity market efficiency (Lyu et al., 2021), particularly due to sudden shifts in commodity futures during crisis events like the Global Financial Crisis and COVID-19 (Sifat et al., 2021).

The pandemic outbreak hitched the commodity returns via three sources: demand, offer and increased risk (Baldwin and Mauro, 2020). After the capital market crash in 2000, commodities became an important actives class of alternative investments (Zhang et al., 2017; Vivian & Wohar, 2012). This comes under the name of commodities financialisation (Huynh et al., 2020; Basak & Pavlova, 2016), was observed on the global markets on a large scale (Basak & Pavlova, 2016; Silvennoinen &Thorp, 2013, 2016; Cheng & Xiong, 2014). It is well-known that the commodity-financialisation increased volatility of the commodity markets and its spill-over effects constitute an integrated mechanism of destabilisation and uncertainty in the world economy (Gromb & Vayanos, 2010; Maizels, 1994). The pandemic has brought unprecedented and devastating effects on various economic sectors (Van Nguyen et al., 2022), with some authors suggesting that vaccination could offer a possibility for economic recovery. This is particularly relevant given that other government policies specific to the pandemic period, such as social distancing, may adversely impact economic outcomes (Alhassan et al., 2021). Other studies highlight the connection between the pandemic period and government bond yields, showing significant variations (Jareño et al., 2023).

A key factor driving the growing interest of investors in commodity markets is the portfolio diversification advantage gained from the low correlation between returns in the commodity market and those in other major asset classes, such as the stock market (Kang et al., 2023).

The cotton industry has an old tradition, yet it heads more and more towards the new technologies integration in the current activities (Paudel et al., 2021), including as regards accounting technology (Griffin, 2021). Besides the prices potential drops or growths on the commodity market, certain researchers mention the negative effect that the COVID 19 virus

contamination by the labour force from the cotton industry may have, which may lead to negative effects (Charlton & Castillo, 2021). For the last period, respectively the COVID 19 pandemic outbreak, there is very little data or research that analyses the US cotton evolution on the commodity market. The ante-pandemic period clearly shows that every transitioned commodity has a different efficacy concept of the price and the investors and traders had to know very well the commodities in order to cover the price risks (Baranidharan & Sutha, 2021). In the actual period, this risk is doubled by the market prices evolution unpredictability (Feng, et al., 2017). In the last years, the cotton price recorded a decline in the world market because of the subsidies granted to producers by the developed countries (especially United States) and the European Union (Laouan, 2021). Studies in the field mentioned a connection between the price of cotton and corn with the petroleum price (Harri et al., 2009). More than the pandemic crisis, the cotton industry seems to be strongly undermined by the difficult commercial relationship between the two big world economies, United States and China (Yuan et al., 2020).

In turbulent times, investors seek for solutions to protect their portfolios from inherent risks or devastating losses. Sugar existence as part of an investor's portfolio offers substantial financial and security advantages (Babirath et al., 2021), in the conditions that when markets drop, investors seek alternative secure refuge for money or portfolios' protection (Zhang et al., 2019). Sugar is a part of the important agricultural commodities with high consumption. The financial crisis cumulated with the pandemic lead to a substantial growth of stock exchange volatility (Uçak et al., 2022). The sugar demand and offer were modified during the pandemic, a fact that led to sugar stock modifications. According to certain already performed studies, the actual pandemic did not bring significant structural changes to the sugar market, the relation between the sugar prices and the market uncertainty being insignificant (Kotyza et al., 2021). The unforeseen phenomena, such as the COVID 19 pandemic, generate modification in different markets, among which we encounter the sugar market. Many types of research reflect the high incidence of sugar, salt or fat consumption on an emotional basis, also specific for this period (USDA Report, 2020). A study carried out in Italy (Anonymous. World Sugar Marker Report, 2020), a deeply affected country by the pandemic, outlined that the pandemic period, from the point of view of individual consumption, implied growth of dessert type foods quantity (ice-cream, chocolate). Domestic consumption, which abounds in products with sugar as raw material, is not similar to the consumption outside the household (USDA Report, 2020) in commercial locations, where it is not possible in this period. The consumption outside the domicile implies, generally, products with a high quantity of salt in their composition (salty snacks) or other specific elements (carbonated drinks), products for which the consumption dropped (Di Renzo et al., 2020). The measures imposed by the authorities as shut-down methods for the pandemic, among which we firstly mention the social distancing, had as effects the enacting of a negative tendency for sugar demand (Solomon et al., 2020; Anonymous. World Sugar Market Report, 2020; European Commission, 2020), a major impact negatively felt by the US market.

For the rough rice market, the last decade meant the start-up of certain investments and major research for rough rice yield improvement per hectare (Atungulu & Shafiekhani 2019). The global market of *Rough Rice* suffered multiple transformations caused by the rough rice consumption growth in Africa, where the actual local production capacities were exceeded for the moment, and during the COVID 19 pandemic, the rough rice is alleged to be reduced (Kathiresan et al., 2020).

The wheat market is one of the most efficient world markets, after the heating oil market and cotton markets (Kristoufek &Vosvrda, 2014). Wheat cultivation occupies the third-largest acreage in the United States, trailing behind corn and soybeans, and contributes approximately 7 percent to global production (Dohlman et al., 2022). From the pandemic outbreak up until now, the wheat price on the markets grows by 8% and rice price by 25%. Russia, the main world exporter of wheat, limited the exports for three months to ensure the local supply sufficiency (Torero, 2020).

Current reality illustrates a strong global demand for groceries. The supply predictions on the world market for US corn did not apprehend modifications in estimations on world agricultural demand and offer (Westcott et al., 1999). There is a direct link between cotton and corn: cotton crop rotation improves corn yields, benefiting developing countries (Martin et. al., 2002). The trade increased volume of US corn is expected to grow, and the corn exports projected by the United States do not reflect possible changes (USDA Report, 2020). In the actual context of the pandemic, the recording of record prices for corn is expected, the reason why corn cultivation activity is spurred in America (Singh, 2021; Singh, et.al., 2014).

In recent research, significant efforts have been directed towards understanding the complexities of coverage risks in financial markets, particularly in the context of portfolio management and investment strategies. Researchers like Shakatreh et al. (2023), Baur and Smales (2020), and Adekoya et al. (2021) have explored various methods to effectively manage these risks, focusing on the development of optimal coverage policies tailored to the specific characteristics of random portfolios (Murray et al., 2022). This line of inquiry includes examining the influence of coverage risks on market price fluctuations and the application of these insights in volatile market conditions (Pal Singh, 2017). The goal of these risk management strategies, particularly in scenarios affecting organizations, is to integrate coverage risk considerations into policy implementation. By doing so, they aim to mitigate the intensity of potential future risks and enhance the overall expected utility of investments, as highlighted by Primayudha et al. (2023) and Huang et al. (2023).

However, it is important to recognize that even well-considered risk coverage measures can encounter challenges, particularly in situations where risks are difficult to quantify and coverage strategies are complex to implement, as noted by Ciorciari (2019). Achieving optimal coverage risk assurance requires a balanced and fair determination of coverage prices, ensuring that all parties involved in a contract are exposed to comparable levels of risk. This necessitates a dynamic and adaptable approach, as proposed by Marzban et al. (2022). Furthermore, the status of financial coverage in relation to commodity price risks is significantly affected by the approach taken in financial decision-making processes, with an emphasis on strategic financial billing methods as discussed by Ahola (2023).

In environments characterized by economic and political instability, the ability of investors to effectively structure and manage their portfolios becomes crucial. The stability and development of financial markets during such turbulent periods hinge on this capability, as demonstrated by the work of Su et al. (2022) and Sikarwar (2022). These insights underline the importance of understanding market structures, especially in the context of unpredictable economic conditions, and highlight the need for informed and strategic decision-making in portfolio management.

Considering these, we can formulate the research question of this study:

RQ: What is the volatility transmission mechanism pertaining to agricultural futures returns during crisis periods, such as the COVID-19 pandemic?

Considering the variables of the S&P 500, US 10-year T-bill, Brent crude oil, and the US Dollar Index as determinants for the markets of cotton, sugar, rice, wheat, and corn is crucial due to their significant influence on economic conditions and investor behaviors that directly affect these commodity markets. These factors are influential because they reflect broader economic trends and conditions that can significantly impact the supply, demand, and pricing of these commodities. Understanding how these financial instruments behave provides insight into potential trends and shifts in commodity markets, enabling better prediction and strategic planning for stakeholders in these sectors.

The S&P 500 Index is a key indicator of economic health and serves as an indicator of the US stock market and general economic environment. A high index level signals a robust economy, impacting both consumer and corporate demand for commodities like cotton, wheat, and corn (He & Kwon, 2023). A vigorous S&P 500 typically denotes a healthy economy, potentially increasing the need for vital commodities such as wheat and corn (Zapata et al., 2023). In contrast, a weaker S&P 500 may suggest an economic downturn, potentially reducing the demand for these commodities (Wand et al., 2023).

US 10-year Treasury Bill (T-bill) reflects investor sentiment and the economic outlook. Lower yields signal economic uncertainty and cheaper borrowing, influencing agricultural investments and, consequently, commodity supplies. This government-issued security is a barometer of economic expectations. When investors expect economic turmoil, they may invest in T-bills, leading to lower yields (Hejazi, 2000). This shift can impact commodity markets by influencing the cost of borrowing and investment trends. Lower yields can make it cheaper for companies in the agriculture sector to borrow money, potentially increasing investment in commodity production. On the other hand, higher yields might tighten credit conditions, reducing investment and potentially impacting commodity supply.

As a key indicator of global oil prices, fluctuations in Brent crude oil can directly impact the costs of agricultural production; is a major cost factor in agriculture. Higher oil prices increase the expenses for items such as fuel and fertilizers, thereby raising the production costs for crops like corn and wheat (Iftikhar et al., 2023). Rising oil prices increase biofuel demand, boosting crop demand like corn for biofuel production, subsequently elevating commodity prices (Zubair et al., 2023; Lima et al., 2019).

US Dollar Index measures the dollar's strength against other currencies. Commodity prices are often dollar-denominated. US cotton output typically makes up around 15% of annual world production, and US exports represent around 35% of the value of international cotton trade (Ridley & Devadoss, 2023); USA is among the largest producers and exporters of corn in the world (Gao et al., 2023). A stronger dollar can make these commodities more expensive for international buyers, affecting global demand and prices (Nazlioglu, 2012). Commodities, often priced in dollars, can become costlier for those using other currencies with a stronger dollar, potentially decreasing their demand and leading to lower prices (Shobande & Shodipe, 2021; Rees, 2023). On the flip side, a weaker dollar can make these commodities cheaper for foreign buyers, spurring demand and possibly increasing prices (Awartani et al., 2016).

These financial indicators can impact the mentioned commodity markets through various mechanisms, such as altering production costs, modifying global demand, and influencing investment patterns. Understanding these interconnections is vital for assessing how economic shifts affect these commodity markets.

II.3.2. Data and Methodology

The dataset used in our research comprises daily future prices for five prominent agricultural commodities, namely, US Cotton 2, U.S Sugar 11, Rough Rice, US Wheat, and US Corn. Additionally, it encompasses the closing prices of significant macroeconomic determinants influencing agricultural financial markets. These determinants encompass the S&P 500, serving as a proxy for overall stock market growth; the US 10-year T-bill rate, employed to gauge anticipated inflation; the US dollar index, utilized as a proxy for measuring exchange rate fluctuations; and Brent oil prices, a well-established driver of agricultural commodity returns (Kang, et.al., 2017; Pal & Mitra, 2018; Silvennoinen & Thorp, 2016). The study period spans from June 1, 2006, to June 1, 2023, encompassing the pre-pandemic, COVID-19, and post-pandemic periods judiciously. This extensive time frame allows for a comprehensive examination of the pandemic's impact on the agricultural futures timeline. Furthermore, the selection of a 17-year sample period affords a meaningful basis for comparing the severity of impact induced by earlier financial crises, such as the Global Financial Crisis (GFC), with that of the COVID-19 pandemic. The database used in this research is sourced from Bloomberg and FRED. Daily continuous returns are computed using the formula Rt = log (Pt/Pt− 1), where Pt and Pt− 1 represent the closing prices at time t and t − 1, respectively.

II.3.2.1. Structural break test:

The innovational outlier approach suggests that the break occurs gradually and impact on mean is persistent compared to additive outlier approach. The break function λ is an endogenous variable. The null hypothesis assumes that daily returns $\{y_t\}_{t=1}^{T}$ is an integrated process with drift. The break point $\lambda = \frac{T_b}{T}$, where $T_b$represents each time point when the trend function is changed. The alternative hypothesis assumes that $\{y_t\}$ is a stationary process with a one time break in the trend occurring at unknown point in time. The objective is to find the break point which gives highest weight to the alternative hypothesis. According to Perron's Augmented Duckey Fuller (Dickey, D.A et al., 1981; Phillips and Perron, 1988) testing strategy, the regression equation (used to measure change in the level and slope of trend function) to test for a unit root is

$$y_t = \hat{\mu} + \hat{\theta}\, DU_t(\hat{\lambda}) + \hat{\beta} t + \hat{\gamma} DT_t^*(\hat{\lambda}) + \hat{\alpha} y_{t-1} + \sum_{j=1}^{k} \hat{c_j} \triangle y_{t-j} + \hat{e_t}$$

where $DU_t(\lambda) = 1$ if $t > [T\lambda]$, 0 otherwise; $DT_t^*(\lambda) = t - [T\lambda]$ if $t > [T\lambda]$, 0 otherwise.

Perron (1989) introduced the statistic about presence of unit root $(\alpha = 1)$ as $t_{\hat{\alpha}}(\lambda)$. The test statistic depends on the location of break point $\lambda = \frac{T_b}{T}$. The rejection rule of null hypothesis is given by

$$t_{\hat{\alpha}}(\lambda) < \kappa_{\alpha}(\lambda),$$

where $\kappa_{\alpha}(\lambda)$ denotes the critical value for a fixed λ. For innovational outlier approach, objective is to select the value of λ which provides minimum t-statistic value for rejection of null hypothesis. Hence, for each value of the statistic $(t_{\hat{\alpha}}(\lambda))$ is computed. The minimum t-statistic value over all

T-2 regressions is considered and the corresponding break year resulted in optimal structural break point.

First, we applied the structural break test; then we performed the econometric analysis which examines structural relationship and how the relationship is changed in relation to different behaviors of financial performance. We assume the presence of two different regimes during the sample period. This is justified since the structural break test identified only one break in all cases.

II.3.2.2. Model Selection:

Markov switching models are a type of dynamic regression model that describes how parameters change over time in relation to latent states managed by a Markov chain. When the spontaneous shift in the dynamic movement of financial markets is of interest, or in the case of event-study research, the model is considered a good representation. The latent state is unobservable and is defined by transition probability from one time period to the next.

The financial returns data in agricultural market between 2006 and 2023 is assumed to be governed by a combination of two distributions in three sub sample (Pre-Covid, Covid and Post-Covid) periods of the study. One discusses financial market behaviour in a low stress regime, and the other a high stress regime. The contagion phenomenon made its presence felt when firms were experiencing the effects generated by economic stress periods (Goodell & Corbet, 2023).

We look at three alternative model specifications. The first model assumes that state transition has no effect on the conditional mean and volatility, while the second model assumes that the conditional mean of a stochastic process varies in low and high stress regimes, and the third model examines whether conditional volatility varies in low and high stress regimes.Once the model selection is made, the following econometric approach is used to obtain parameter estimates.

II.3.2.3. Econometric Model:

The methodology is introduced by Weinbach, G. C. (1994), which assume that $\{s_t\}_{t=1}^{T}$ represents a two-state discrete time Markov chain with transition probabilities governed by a logistic function of $x'_{t-1}\beta_i$ for i=1,2, where x_{t-1} is a $(k \times 1)$ vector of independent variables which impact the stochastic process of daily returns and $\beta = (\beta'_1, \beta'_2)$ is a $(2k \times 1)$ vector representing the set of parameters in each state respectively. The transition matrix is provided as follows:

$$
\begin{array}{c}
\\
\text{State} = 1 \\
\\
\text{Time(t} - 1) \\
\\
\text{State} = 2
\end{array}
\begin{bmatrix}
\text{State} = 1 & & \text{State} = 2 \\
p_t^{11} & & p_t^{12} \\
= P(s_t = 1 | s_{t-1} = 1, x_{t-1}; \beta_1) & & = P(s_t = 2 | s_{t-1} = 1, x_{t-1}; \beta_1) \\
= \dfrac{\exp(x'_{t-1}\beta_1)}{1 + \exp(x'_{t-1}\beta_1)} & & = 1 - \dfrac{\exp(x'_{t-1}\beta_1)}{1 + \exp(x'_{t-1}\beta_1)} \\
p_t^{21} & & p_t^{22} \\
= P(s_t = 1 | s_{t-1} = 2, x_{t-1}; \beta_2) & & = P(s_t = 2 | s_{t-1} = 2, x_{t-1}; \beta_2) \\
= 1 - \dfrac{\exp(x'_{t-1}\beta_2)}{1 + \exp(x'_{t-1}\beta_2)} & & = \dfrac{\exp(x'_{t-1}\beta_2)}{1 + \exp(x'_{t-1}\beta_2)}
\end{bmatrix}
\begin{array}{c}
\\
\\
\text{Time(t)} \\
\\
\\
\end{array}
$$

Let $\{y_t\}_{t=1}^{T}$ represents the stationary discrete time stochastic process (daily returns) that depends on $\{s_t\}_{t=1}^{T}$ as follows:

$$(y_t|s_t = i\ ;\ \alpha_i) \sim^{iid} N(\mu_i, \sigma_i^2) \quad for \quad i = 1,2.$$

The density function of $\{y_t\}_{t=1}^{T}$ conditional on $\{s_t\}_{t=1}^{T}$ is provided by:

$$f(y_t|s_t) = \frac{1}{\sqrt{2\pi\sigma_i^2}}\ exp\left(\frac{-(y_i-\mu_i)^2}{\sigma_i^2}\right)$$

The set of parameters $\alpha_i = (\mu_i\ , \sigma_i^2)\ for\ i = 1,2$ stacked together in (4×1) vector $\alpha = (\alpha_1', \alpha_2')$.

Let $\theta = (\alpha, \beta)$ is a $(2k + 4 \times 1)$ vector of all model parameters. The complete likelihood function is given by

$$f\left(\underline{y_T}, \underline{s_T}\ \middle|\underline{x_T}; \theta\right) = f(y_1|s_1\ ; \alpha)P(s_1)\prod_{t=2}^{T} f(y_t|s_t\ ; \alpha)\ P(s_t|s_{t-1}, x_{t-1}\ ; \beta),$$

where underline represents the complete history of the stochastic process up to time point T.

Since the states are latent (unobserved), so the incomplete log- likelihood function can be obtained by summing over all possible state sequences.

$$\log f\left(\underline{y_T}\ \middle|\underline{x_T}; \theta\right) = \log\left(\sum_{s_1=1}^{2}\sum_{s_2=1}^{2} \ldots\ldots \sum_{s_T=1}^{2} f\left(\underline{y_T}, \underline{s_T}\ \middle|\underline{x_T}; \theta\right)\right)$$

and maximizing with respect to parameter θ. The numerical maximization is computationally impossible over all unobservable state sequences, so the expectation maximization (EM) principle suggested by Hamilton (1990) is followed. The EM algorithm is an iterative method to maximize the parameters of incomplete log likelihood function via maximization of expectation of complete likelihood function conditional on the observable data. The procedure involves following steps:

1. Initialize an algorithm with random parameter values of vector θ i.e. $\theta^{(0)}$
2. Obtain $P\left(s_t = 1\middle|\ \underline{y_T}, \underline{x_T}\ ; \theta^{(0)}\right)\ \forall\ t,$

$$P\left(s_t = 2\middle|\ \underline{y_T}, \underline{x_T}\ ; \theta^{(0)}\right)\ \forall\ t,$$

$$P\left(s_t = 1, s_{t-1} = 1\middle|\ \underline{y_T}, \underline{x_T}\ ; \theta^{(0)}\right)\ \forall\ t,$$

$$P\left(s_t = 2, s_{t-1} = 1\middle|\ \underline{y_T}, \underline{x_T}\ ; \theta^{(0)}\right)\ \forall\ t,$$

$$P\left(s_t = 1, s_{t-1} = 2\middle|\ \underline{y_T}, \underline{x_T}\ ; \theta^{(0)}\right)\ \forall\ t,$$

$$P\left(s_t = 2, s_{t-1} = 2\middle|\ \underline{y_T}, \underline{x_T}\ ; \theta^{(0)}\right)\ \forall\ t$$

3. Construct $E\left[\log\left(\ f\left(\underline{y_T}, \underline{s_T}\ \middle|\underline{x_T}; \theta^{(0)}\right)\right)\right]$ and obtain

$$\theta^{(1)} = \arg\max_{\theta} E\left[\log\left(\ f\left(\underline{y_T}, \underline{s_T}\ \middle|\underline{x_T}; \theta^{(0)}\right)\right)\right]$$

4. Iterate the procedure until convergence is reached.

The test is implemented in STATA 14.0, with preliminary assessments of model adequacy conducted through log-likelihood maximization. Subsequent to estimation, model checks encompass residual analysis. It is noteworthy to highlight that an analogous methodological approach is adhered to, as delineated in Iuga et al. (2023).

II.3.3. Results and Discussion

Table II.3.3-1 presents the descriptive statistics of future returns for agricultural commodities and the macroeconomic drivers influencing agricultural markets. The entire dataset is stratified into three distinct sub-sample periods: the pre-COVID era, denoted by future returns up to February 2020, prior to the public announcement of strict social distancing measures for COVID-19; the COVID-19 period spanning from March 2020 to March 2021; and the post-pandemic period extending from April 2021 to October 2023. With the exception of the post-COVID-19 period, the daily returns (Figure II.3.3.) of wheat exhibit the highest stability, while rice displays the least stability. This observation aligns with the justification derived from the lowest Jarque-Berra statistic value for wheat returns, signifying that although returns deviate from normal distribution, they closely approximate normality. Conversely, the high JB statistic for rice returns, particularly during the COVID-19 period, elucidates a significant departure of daily returns from normality. Corn manifests a robust early response to COVID-19 measures, as evidenced by the negative mean returns observed during both the COVID and post-COVID periods. Conversely, wheat and cotton prices exhibit greater resilience than corn throughout the pandemic period, although their average returns turn negative in the post-pandemic period, further confirmed by Schnitkey et al. (2021).

In the realm of macroeconomic determinants, the most pronounced volatility impact of COVID-19 is visible in crude oil prices. The co-movement of oil prices with agricultural commodities, specifically the spillover effects from oil to cotton returns during pandemic periods, is substantiated by Adhikari and Putnam (2020). Likewise, Serra (2011) provides evidence of a robust co-movement between sugar and oil. Furthermore, the US dollar index underscores a pronounced economic downturn commencing with the implementation of lockdowns in March 2020, as indicated by negative returns during the pandemic period. Nevertheless, the US and other major economies exhibited a swift recovery, as evidenced by higher positive returns in the post-pandemic period compared to the pre-pandemic period. Notably, Nazlioglu (2012) concludes that a weak dollar exerts a positive impact on twenty-four world agricultural commodity prices. In contrast, Rees (2023) posits that, in the aftermath of the Covid pandemic, rising commodity prices are associated with a strengthening US dollar. The pandemic-induced volatility extends to the S&P 500, and the relationship of stock market with commodity prices confirms with Minutolo et. al., (2018) demonstrating a transmission of volatility from the stock market to commodity prices. Despite the heightened volatility, the average returns for the S&P 500 remain positive across all three sub-sample periods. Additionally, Zapata et al. (2023) assert the existence of a cyclical relationship between stock markets and commodity markets, both for aggregate and tradeable indexes, with a duration of approximately 31 years from peak to peak. The impact of the pandemic on the average returns of Treasury Bill Rates is evident through the inverse coefficient observed during both the COVID and post-COVID periods. Yao et al. (2022) contribute to this understanding by finding that US unconventional monetary policy may lead to a more positive and

significant covariation between expected real interest rates and the real returns of agricultural commodities over short horizons.

Table II.3.3-1. Descriptive statistics of returns

	Pre-COVID			COVID			Post-COVID		
	Mean	SD	JB	Mean	SD	JB	Mean	SD	JB
Cotton	-0.00032	0.01576	1734.25***	0.0015	0.01597	7.7592*	-0.00013	0.0228	25273.44***
Sugar	-0.00019	0.02145	1578.85***	0.0005	0.0210	8.329*	0.00074	0.0157	18.7911***
Rice	0.0114	1.4831	1452.59***	-0.01399	3.0222	16450.61***	0.03099	1.5909	134586***
Wheat	0.00085	0.0210	393.50***	0.00089	0.0172	6.2448*	-0.00016	0.0258	1170.80***
Corn	0.00095	0.0183	1989.6***	-0.00028	0.0166	2702.97***	-0.00016	0.0217	10308.52***
S&P 500	0.02439	1.2018	18051.46***	0.1067	2.1665	866.335***	0.0136	1.1354	70.4456***
US-10 year T-bill	0.0070	0.3709	4452.96***	-0.0006	0.3067	680.19***	-0.0330	0.4298	61.3465***
Brent crude oil	-0.0117	2.1101	2202.26***	0.0341	7.2377	9974.06***	0.0740	2.4897	292.598***
US dollar index	0.0026	0.3438	3852.92***	-0.0177	0.4018	162.828***	0.0112	0.3287	22.715***

Note: JB = Jarque–Bera normality statistic, SD = standard deviation. * = rejection of null hypothesis at 10 percent, ** = at 5 percent, *** = at 1 percent

Table II.3.3-2. Unit root test with structural break

		Cotton	Sugar	Rice	Wheat	Corn
Pre-COVID	ADF statistic	-48.56720**	-60.24799**	-55.15095**	-59.36205**	-58.42335**
	Break date	6/23/2014	11/12/2010	7/15/2014	2/29/2008	5/15/2013
COVID	ADF statistic	-17.62697**	-16.89701**	-16.05732**	-18.07387**	-15.94600**
	Break date	3/23/2020	4/30/2020	7/15/2020	3/25/2020	3/18/2020
Post-COVID	ADF statistic	-27.58803**	-25.59747**	-26.98796**	-26.04695**	-28.07121**
	Break date	6/24/2022	3/01/2023	7/14/2023	3/03/2022	7/15/2021

Note: Pre-COVID period: 06/01/2006 to 02/28/2020 (except for cotton returns: 10/15/2009 to 02/28/2020), COVID period: 03/02/2020 to 03/02/2021, Post-COVID period: 03/03/2021 to 10/20/2023, ** denotes rejection of null hypothesis at a 1% significance level with a critical value of -5.72.

Subsequently, the outcomes of the structural break test for the three sample periods are presented in Table II.3.3-2. The findings indicate that two pivotal historical events, namely, the credit crunch in 2008 associated with global economic uncertainty and the collapse of oil prices since late 2014, exerted profound impacts on agricultural returns. Notably, the impact of the COVID-19 pandemic appear more substantial in comparison to the aforementioned crises. This is justified through the identification of structural breaks in the returns of each commodity not only during the COVID period but also in the post-pandemic period. It is imperative to underscore that during the post-pandemic period, various salient determinants such as crude oil pricing, inflation, extreme climate change, and increasing production costs etc contribute to justifying the observed shifts in market behavior. However, it is noteworthy that many of these factors are endogenous to

the COVID-19 context. The analysis reveals that future returns for wheat, corn, and cotton appear to rebound in 2022, whereas the structural instability of sugar and rice returns persists, as evidenced by the identified structural break dates. The findings of three distinct model specifications of the Markov switching model for the entire sample period are presented in Appendix 1a. It is observed that the Markov switching model, characterized by distinct volatility structures in two regimes, appears to be appropriate for analyzing returns across various commodities.

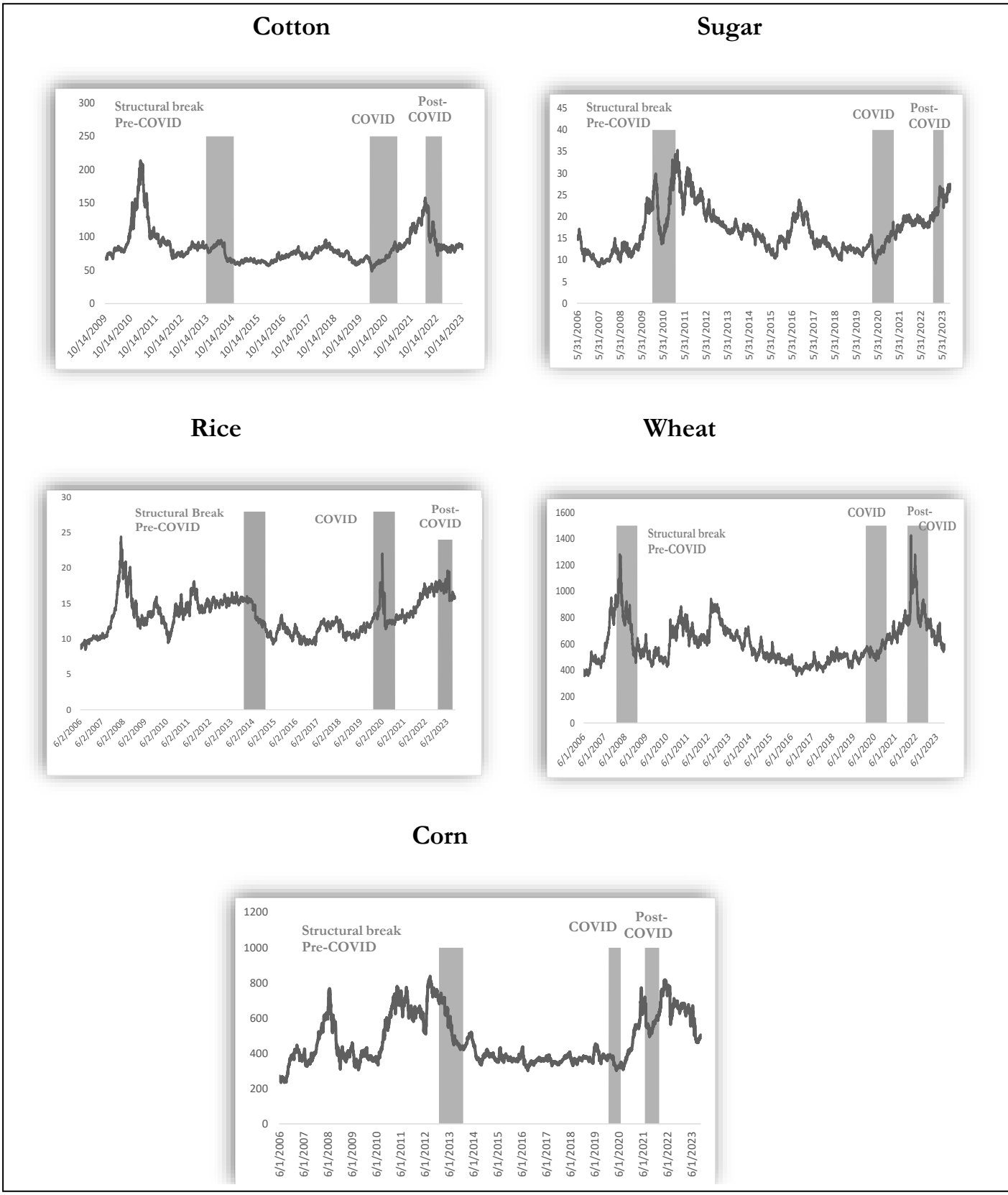


Figure II.3.3. Daily returns for selected series

Indeed COVID-19 impact all financial sectors of global economy, however the effect is highest for food commodities. The reason from demand side is job loss which decreases purchasing power whereas from supply side it is movement restrictions which creates factory closures, local shortages, delays and disruptions etc. The pandemic impact is not limited to "farm-to-fork "food supply chain, but it also enables the hoarding effect within and across countries. The analysts at Bank of America stated "Covid-19 has forced consumers to shift from just-in-time inventory management to a more conservative approach which was labeled just-in-case. The result is that consumers are holding more inventory as a precaution against future supply disruptions." Further, the export restrictions by 22 countries during (March 2020-May 2020) significantly impact food security and consequently food prices especially in least developing and developing countries. This creates a heterogeneous impact across various countries and regions and the uncooperative trade policy induces the multiplier effect on food prices in domestic and global markets.

Our empirical investigation, as detailed in Table II.3.3-3, supports the findings that the volatility of cotton future returns increase during both pandemic and post-pandemic subperiods. While agricultural markets conventionally exhibit low cross-correlation and are predominantly influenced by fundamental factors such as weather conditions, oil prices, and exchange rates, recent trends indicate an observable co-movement among certain commodity returns. In light of the ongoing research focus on comprehending financial integration across diverse markets amid the COVID-19 pandemic, we explore the impact of each agricultural return on all other selected returns during two distinct regimes identified by a Markov Switching Model for each subperiod within our sample. Initially, our analytical approach omitted macroeconomic determinants. However, in pursuit of a more comprehensive understanding of market dynamics, we subsequently incorporated four key market fundamentals into our analysis. This inclusion aims to enhance our ability to understand the intricate interplay of factors influencing agricultural returns and, by extension, contribute to a comprehensive analysis of broader market interactions during the specified subperiods.

Cotton has being growing in the world from 7000 years (Beckert, 2015) and cotton futures traded in New York since 1870. Although the cotton prices already showing a downward trend in last few years, but the impact of COVID-19 is observe severe when future returns drop more than 20 percent during February 2020- April 2020. However, the impact is short term and cotton returns rebound and start increasing May 2020 onwards. Our analysis discerns that within the high volatility regime of the COVID-19 period, the daily movement of cotton returns exhibits minimal sensitivity to other commodity returns, with the notable exception of a significant impact from oil returns (Mutuc, et al., 2011). Conversely, in the low volatility regime of COVID-19, the influence of sugar returns becomes pronounced, alongside market fundamentals related to overall growth, exchange rate movements, and oil returns. The noteworthy significance of sugar returns in the low volatility regime is particularly intriguing as it appears to act as a mediator between cotton and oil returns. This mediation is attributable to the established link between sugar and crude oil, primarily stemming from ethanol production (Lima et al., 2019). Beyond the physical interconnection through ethanol production, the behavioral dynamics of sugar and oil are intertwined, especially in light of the escalating trend of financialization in the market (Gromb & Vayanos, 2010). This behavioral association further underscores the intricate relationships among these commodities, shedding light on their interdependence during periods of varying market volatility. In the pre-COVID sample period, our analysis indicates a consistent impact of market fundamentals on cotton returns, albeit with a notable shift. Specifically, wheat emerges as a more substantial determinant of cotton returns when compared with sugar returns. This finding aligns with the economic benefits derived from the

successful implementation of the cotton-wheat system in various global regions, thereby reflecting the evolving dynamics within the agricultural markets (Feng, et al., 2017). The persistence of this relationship is underscored by a high likelihood of remaining in either the low or high volatility regime, amounting to 90% and 97%, respectively. During the post-pandemic period characterized by heightened global turmoil and increased volatility, our findings unveil a noteworthy transformation in the factors influencing cotton prices. Intriguingly, fluctuations in the S&P 500 now exert a more pronounced influence on cotton prices compared to periods of stable and predictable economic growth, as evidenced by the magnitude of the coefficient associated with the S&P 500.Notably, this heightened global uncertainty amplifies the impact of other agricultural commodities on cotton returns. However, the transition probability of remaining in a high volatility state is approximately 58%, indicating that over the long term, agricultural commodity prices, including cotton, are likely to revert to being predominantly influenced by fundamental factors such as supply and demand, as discussed by Smith (2020). This insight underscores the transient nature of external influences during periods of global crises, emphasizing the enduring significance of underlying market fundamentals in shaping price dynamics.

Sugar is one of the most traded agricultural commodity across the globe. As per the findings reported by the Observatory of Economic Complexity in 2017, raw sugar occupies the 119th position among the most traded commodities. Projections for the upcoming decade suggest a persistent concentration of sugar exports, wherein Brazil is anticipated to maintain its prominent role, constituting 38% of global trade, as elucidated by the OECD-Food and Agriculture Organization in 2019.The market is highly volatile with large ups and downs varies across different regions and countries according to governmental tariff barriers. During last few years, it is observed that sugar prices are linked with oil and corn due to ethanol production but in general the market functions independently and exhibit insignificant co-movement with other commodities. The Markov Switching model characterizes two latent states with different volatility structures in three sub sample periods. Our analysis in Table II.3.3-4 aligns with the findings drawn by Babirath et al. (2021), affirming that sugar can indeed function as a hedge amidst the onset of financial crises, as evidenced by consistently positive returns within high volatility regimes across all periods under consideration. Nevertheless, our analysis underscores that significant determinants influencing future returns in the U.S. sugar market are the U.S. dollar index and Brent oil, respectively. The conventional association with the U.S. dollar aligns with historical trends, wherein during commodity price upswings, the U.S. dollar typically depreciated, and conversely, during downturns in commodity prices, the value of the U.S. dollar tended to rise (Rees, 2023). Nonetheless, the analysis brings to light a robust linkage between oil and sugar prices during the Covid-19 period, as substantiated by Wang et al. (2023). Moreover, our extended sample analysis reveals the pronounced interconnectedness of cotton future returns with sugar returns in diverse regimes. The obtained result finds validation in the research conducted by Uçak et al. (2022), wherein it was demonstrated that volatility spillover and interconnectedness experience an increase during crisis periods. Notably, their findings underscored that agricultural products particularly vulnerable to the impact of external shocks include sugar, soybeans, and cotton. However, our analysis suggests that the market fundamentals with a significant impact on US sugar future returns are US dollar index and Brent oil respectively. The relationship with US dollar is traditional that in commodity price booms, the US dollar typically depreciated and, when commodity prices fell, the value of the US dollar tended to rise (Rees, 2023). However, analysis reveals that the relationship between oil and sugar prices have a strong linkage at the time of Covid-

19, supported by Wang, et. al., (2023). Further, our expanded sample analysis reveals the strong interconnectedness of cotton future returns with sugar returns in various regimes respectively. The result is justified based on the findings by Uçak, et.al.,(2022) who showed that volatility spillover and interconnectedness increased during crisis periods and the agricultural products most vulnerable to the effects of external shocks are sugar, soybeans and cotton. Likewise, the influence of wheat returns during both the low regime of the pre-Covid period and the post-Covid period emerges as noteworthy. We attribute this influence to the volatility spillover effect through the crude oil channel. This outcome is substantiated by the supporting evidence presented by Du et al. (2011) concerning volatility spillover dynamics among crude oil, corn, and wheat markets subsequent to the decline in 2006. This phenomenon is explicable by the heightened interdependence between crude oil and these commodity markets, induced by ethanol production. In the high volatility regime of the COVID-19 period, sugar future returns demonstrate resilience against the influence of returns from all other commodities. The transition probability of transitioning to another state is notably less than 10%, elucidating the sustained presence of a high volatility state. Remarkably, this persistence of high volatility regimes is observed both in the pre-Covid and post-Covid periods. Conversely, an inverse average impact of rice returns is discerned during the COVID and post-COVID periods, respectively. This outcome is rationalized by the significant decline in sugar future returns from February to May 2020, coinciding with a noteworthy increase in rice returns during the same period. Intriguingly, the impact of corn returns diminishes in the extended sample period analysis. We posit that in the presence of market fundamentals, the impacts of wheat and cotton appear more pronounced, thereby justifying the insignificant impact of corn returns (Babar et al., 2023).

Next, the agricultural commodity under consideration, rice, has exhibited a pronounced impact to the volatility induced by the COVID-19 pandemic, as explained by the calculated coefficient in Table II.3.3-5, which is fivefold higher compared to non-crisis periods. Analogous to other agricultural commodities, the determinants influencing the supply and demand dynamics of rice encompass climatic variations, unforeseen disruptions, profit margins, and governmental policies (Szczepańska-Przekota, 2022). Our analytical investigation delineates that two pivotal agricultural commodities, namely wheat and corn, exert noteworthy influences on the future returns of rough rice. This interconnectedness is rationalized by the fact that corn contributes to more than 85 percent of the overall U.S. feed grain production, with feed and residual utilization constituting a principal demand driver for corn (Westcott et al., 1999). Likewise, wheat cultivation occupies the third-largest acreage in the United States, trailing behind corn and soybeans, and contributes approximately 7 percent to global production (Dohlman et al., 2022). In parallel with other agricultural commodities, macroeconomic fundamentals such as Brent oil and the U.S. dollar emerge as pivotal factors influencing the dynamics of rice returns. Nevertheless, our analysis indicates that, amid the pandemic, the trajectory of rice prices remains impervious to the influence of other selected agricultural commodities or macroeconomic fundamentals. This phenomenon is attributed to the sustained elevation of futures prices in the U.S. rice market during this period, primarily stemming from constrained old crop rice supplies. The dynamics of the 2019 marketing year are characterized by a manageable carry-in, concurrent sales to Iraq, consistent export shipments to Latin America, and substantial early sales of rough rice in the 2019/20 marketing year. The identified pandemic-induced regimes demonstrate a persistent state, with a 96% probability of remaining in a high-volatility state and an 82% probability of staying in a low-volatility state. However, our analysis reveals that in the

post-pandemic period, there is an increased cross-correlation of rice returns with other agricultural commodities and market fundamentals, aligning with the observations made by Wang et al. (2023).

Wheat production ranked 3rd globally after corn and rice. The justification could be that crop adopts easily under different climate conditions, soil types and elevation of land. Due to favorable crop conditions in 2019, the production of wheat increased significantly by 4% compared to preceding year, whereas the wheat consumption remains stable at 747 millions metric tons which is 1.6% increase compared to previous year. This leads to the price fall of wheat in 2019. China and India remains responsible for majority share in production and consumption of wheat in the global market. In 2020-2021, COVID-19 pandemic and unfavorable weather conditions of U.S, E.U and U.K etc forecasted the reduction in wheat supply globally, but the crop production remains stable in terms of an increase of 1.4% compared to 2019. In terms of consumption, the domestic wheat usage increased by 3% whereas the highest jump is observed in domestic feed usage which is 6% more compare to previous year. This justifies the rebound in wheat returns after June 2020 when the prices started signify increasing pattern. Interestingly, the increased consumption of wheat mainly comes from residual wheat usage by China and the Industrial usage by India. The United States department of agriculture stated "China's 2020-21 feed and residual use is raised to a record 30 million tonnes, surpassing the previous 2012-13 record of 26 million tonnes. China's domestic corn prices continue to be at a premium to wheat, encouraging greater wheat feed use. Additionally, increased auction volumes of old-crop stocks in China have expanded the availability of feed-quality wheat." (https://www.foodbusinessnews.net/articles/17924-usda-sees-larger-2020-21-global-wheat-supply). Our examination of future wheat returns in Table II.3.3-6 employs a Markov switching model, revealing that during the pandemic period, identified regimes are characterized by shifts in mean rather than volatility. This outcome is noteworthy, as other agricultural commodity returns typically exhibit latent states defined in terms of volatility. In the context of wheat future returns, the analysis indicates that the volatility in high-stress regimes is comparatively lower than in low-stress regimes, with negative mean returns in low-stress regimes and positive mean returns in high-stress regimes. This finding is coherent with the understanding that high volatility is inherent in the wheat market (Haase and Huss, 2018), and so analysis reveals that pandemic crises impact its average returns more profoundly than variance. Among the selected commodities, corn returns exert the most substantial influence on wheat returns in sub-sample periods. Given that corn and wheat are primary cereal grains, serving as substitutes in the feed grain market, the interdependence observed in the movement of their returns is rationalized. This correlation is further justified by the cotton-wheat cropping system successfully implemented in numerous developing nations (Martin, et.al.,2002). Similarly, our analysis unveils a co-movement between sugar and wheat in various sample periods. Analogous to other commodities, exchange rates and Brent oil prove to be significant determinants of wheat returns. Intriguingly, the transition probability of moving from low stress regime to high stress regime is markedly more in pre-COVID periods compared to COVID and post-COVID periods. This suggests the persistent impact of the pandemic on future wheat returns.

Corn is the most important cereal grain with the highest global production of 1116.34 million metric tons in 2019-2020. One justification is its usage in producing ethanol, a semi-renewable energy source whose consumption is significantly increased during last few years. Another, the corn is successfully used in producing animal feedstock and sweeteners too (Singh, et.al., 2014). Hence, the corn market is well connected with other commodity markets like wheat, sugar, oil etc. However,

due to COVID-19 initially the corn prices drop significantly and the justified reasons are closure of meatpacking plants, reduced gasoline demand etc. But the high demand of US corn from China in 2020-2021 enables the grain to rebound and the returns stabilize quickly (Singh, 2021). Our analysis in Table II.3.3-7 reveals a parallel behavior in the returns of corn, mirroring the patterns observed in wheat returns (Ahumada et.al., 2016). During the low-stress regime, the returns of wheat, cotton, and sugar exhibit a notable impact on corn returns, with wheat exerting the most substantial influence in both regimes. This relationship is substantiated by the pivotal roles of both crops in the feed-grain market, as previously elucidated. The noteworthy impact of cotton returns on corn returns during the low-volatility regime can be rationalized by the cotton crop rotational strategy, which confers economic benefits in various developing nations (Martin, et.al.,2002). Lastly, the influence of sugar returns on corn returns can be attributed to the increasing utilization of corn in the production of artificial sweeteners and fructose corn syrup, among other factors(Singh, et.al., 2014). The structural relationships among commodity returns during the low-volatility regime appear consistently robust, as evidenced by a 94% probability of remaining in the current state during the pre-COVID period and a 98% probability during the post-COVID period. However, during the pandemic period, the probability of remaining in the low-volatility regime diminishes to 35%, while in the high-stress regime, it rises to 91%. The U.S. dollar emerges as a significant determinant in the high-stress regime of the pandemic period, whereas the impact of crude oil is notable only during the low-stress regime of the COVID period. These findings align seamlessly with the existing literature, as reviewed earlier.

Table II.3.3-3. Markov switching model for Cotton Futures

Dependent Variable	**Pre-COVID**		**COVID**		**Post-COVID**	
Frequency	Daily		Daily		Daily	
AR(1) term	Yes		Yes		Yes	
Stress Regime	LOW	HIGH	LOW	HIGH	LOW	HIGH
Constant	-0.0008	0.0002	-0.0098**	0.0036**	-0.00003	-0.0469**
Standard deviation	0.0242	0.0107	0.0090	0.0123	0.0173	0.0078
Sugar	0.1075**	0.0347**	0.1972**	-0.0273	0.2196***	-2.5134***
	(0.0459)	(0.0135)	(0.0883)	(0.0557)	(0.0467)	(0.1921)
Rice	0.0002	0.0001	0.0012	0.0001	0.0011**	-0.0019
	(0.0007)	(0.0002)	(0.0014)	(0.0003)	(0.0004)	(0.0024)
Wheat	0.1193*	0.0441**	-0.0523	0.0908	0.0683**	0.4037***
	(0.0664)	(0.0186)	(0.1279)	(0.0655)	(0.0309)	(0.1243)
Corn	0.1043	0.0544**	0.1857	0.0692	0.0145	-1.3896***
	(0.0710)	(0.0218)	(0.2910)	(0.0859)	(0.3523)	(0.3316)
S&P 500	0.0020	0.0016***	0.0045***	0.0005	0.0025***	-0.0559***
	(0.0013)	(0.0003)	(0.0011)	(0.0006)	(0.0006)	(0.0019)
US 10 Year T-bill	-0.0005	0.0005	0.0052	-0.0001	-0.0007	-0.0265***
	(0.0031)	(0.0009)	(0.0062)	(0.0040)	(0.0017)	(0.0446)
US dollar index	-0.0126***	-0.0038***	-0.0209***	-0.0030	-0.0067***	-0.0111
	(0.0039)	(0.0009)	(0.0059)	(0.0032)	(0.0024)	(0.0106)
Brent Oil	0.0005	0.0005***	-0.0005***	0.0009***	0.0014***	-0.0179***
	(0.0007)	(0.0002)	(0.0002)	(0.0002)	(0.0003)	(0.0019)
Transition probability						
P11	0.9031		0.3637		0.9852	
P22		0.9721		0.8215		0.4241
Expected duration	10.31	35.84	1.571	5.60	67.57	1.74
Log likelihood	7696.59		735.6136		1722.6113	
Nber of observations	2676		255		666	

Note:* p<0.10, ** p<0.05, *** p<0.01

Table II.3.3-4. Markov switching model for Sugar Futures

Dependent Variable	**Pre-COVID**		**COVID**		**Post-COVID**	
Frequency	Daily		Daily		Daily	
AR(1) term	Yes		Yes		Yes	
Stress Regime	LOW	HIGH	LOW	HIGH	LOW	HIGH
Constant	-0.0010***	0.0014*	-0.0178***	0.0028*	-0.0072***	0.0009
Standard deviation	0.0135	0.0274	0.0053	0.0184	0.0001	0.0147
Cotton	0.0479*	0.2334***	0.2647***	0.0636	0.2961***	0.0998***
	(0.060)	(0.0467)	(0.0716)	(0.1016)	(0.0010)	(0.0263)
Rice	0.0001	0.0006	-0.0016***	-0.0002	-0.0010***	0.0004
	(0.0003)	(0.0005)	(0.0003)	(0.0007)	(3.51e-06)	(0.0005)
Wheat	0.0888***	0.0396	0.0536	0.1228	0.0937***	0.0857***
	(0.0232)	(0.0439)	(0.0946)	(0.0969)	(0.0004)	(0.0272)
Corn	0.0389	0.2135	0.1837	0.1409	0.1109	0.0197
	(0.0249)	(0.0510)	(0.0905)	(0.1172)	(0.0004)	(0.0322)
S&P 500	0.0005	0.0010	-0.0003	-0.0018	0.0025	-0.0003
	(0.0004)	(0.0006)	(0.0005)	(0.0010)	(0.00002)	(0.0006)
US 10 Year T-bill	-0.0003	0.0002	-0.0069**	-0.0048	0.0072	-0.0020
	(0.0011)	(0.0020)	(0.003)	(0.0057)	(0.00005)	(0.141)
US dollar index	-0.0064***	-0.0054	-0.0162***	-0.0086**	-0.0002	-0.0059***
	(0.0013)	(0.0024)	(0.0031)	(0.0042)	(0.0001)	(0.0020)
Brent Oil	0.0007***	0.0006	0.00005	0.0011***	0.0010***	0.0010***
	(0.0002)	(0.0004)	(0.00008)	(0.0003)	(6.2e-06)	(0.0003)
Transition probability						
P11	0.9659		0.5500		0.3928	
P22		0.9485		0.9007		0.9816
Expected duration	29.326	19.417	2.222	10.071	1.6469	54.3478
Log likelihood	8971.576		660.603		1907.181	
Nber of observations	3524		253		666	

Note:* p<0.10, ** p<0.05, *** p<0.01

Table II.3.3-5. Markov switching model for Rice Futures

Dependent Variable	**Pre-COVID**		**COVID**		**Post-COVID**	
Frequency	Daily		Daily		Daily	
AR(1) term	Yes		Yes		Yes	
Stress Regime	LOW	HIGH	LOW	HIGH	LOW	HIGH
Constant	0.0051		0.0728		0.0830	
Standard deviation	0.9104	1.8287	1.0221	5.9691	1.0745	2.9967
Cotton	1.2719	2.2049	1.5348	16.0828	3.9714*	-528.684***
	(1.8788)	(2.9985)	(5.5689)	(56.4772)	(2.0289)	(135.907)
Sugar	-2.0318	4.7288**	0.8836	-69.5231	3.7172	23.7789
	(1.5187)	(2.1494)	(4.1025)	(42.9597)	(2.9917)	(62.4547)
Wheat	5.9175***	12.652***	11.016	-87.1885	10.5696***	96.7307***
	(2.008)	(2.8686)	(5.0239)	(59.4544)	(2.3509)	(30.4236)
Corn	10.1593***	7.4926**	1.7787	152.3173**	-0.3396	-135.365***
	(2.2101)	(3.4306)	(6.1898)	(66.9025)	(2.7772)	(47.0068)
S&P 500	-0.0008	0.0888**	-0.0182	-0.3344	-0.0225	8.5553***
	(0.033)	(0.0381)	(0.0456)	(0.5050)	(0.0428)	(1.3106)
US 10 Year T-bill	0.0005	0.0663	-0.0089	-3.0891	-0.0240	33.1712***
	(0.1017)	(0.1304)	(0.2999)	(3.0847)	(0.1075)	(5.7086)
US dollar index	-0.2796***	-0.3082**	-0.0408	-0.0043	-0.0736	24.6123***
	(0.1044)	(0.1501)	(0.2265)	(3.0939)	(0.1504)	(5.0471)
Brent Oil	-0.0166	0.0702***	0.0115	-0.0346	0.0570***	2.2338***
	(0.0145)	(0.024)	(0.0163)	(0.0842)	(0.0201)	(0.4732)
Transition probability						
P11	0.9417		0.9666		0.9876	
P22		0.9281		0.8239		0.5298
Expected duration	17.1527	13.9082	29.9401	5.6786	80.6452	2.1268
Log likelihood	-5908.683		-473.0591		-981.816	
Nber of observations	3464		253		619	

Note:* p<0.10, ** p<0.05, *** p<0.01

Table II.3.3-6. Markov switching model for Wheat Futures

Dependent Variable	**Pre-COVID**		**COVID**		**Post-COVID**	
Frequency	Daily		Daily		Daily	
AR(1) term	Yes		Yes		Yes	
Stress Regime	LOW	HIGH	LOW	HIGH	LOW	HIGH
Constant	-0.0013	0.0046	-0.0007	0.0271	-0.0024	0.0048
Standard deviation	0.0137	0.0339	0.0138	0.0126	0.0158	0.0431
Cotton	0.1232**	0.0101	0.0616	0.4801**	0.0519	0.5386
	(0.0290)	(0.0380)	(0.0424)	(0.1956)	(0.0354)	(0.3732)
Sugar	0.0199***	0.079***	0.088**	1.4707***	0.0316	1.2357**
	(0.0204)	(0.0279)	(0.0373)	(0.2230)	(0.0639)	(0.6216)
Rice	0.0014***	0.0006	0.0009**	0.0012**	0.0015**	0.0011
	(0.0003)	(0.0004)	(0.0003)	(0.0005)	(0.0007)	(0.0018)
Corn	0.4534***	1.0257***	0.5247***	0.0243	1.0349***	0.1090
	(0.0339)	(0.0490)	(0.0398)	(0.0678)	(0.0731)	(0.1640)
S&P 500	0.0003	-0.0003	-0.00001	-0.0030	6.2e-07	-0.0022
	(0.0004)	(0.0006)	(0.0005)	(0.0015)	(0.0008)	(0.0077)
US 10 Year T-bill	-0.0026	-0.0009	-0.0002	-0.0266***	0.0004	0.0106
	(0.0012)	(0.0018)	(0.0020)	(0.0062)	(0.0021)	(0.0186)
US dollar index	-0.0035**	-0.0017	-0.0030	0.0701***	0.0003	0.0123
	(0.0016)	(0.0022)	(0.0021)	(0.0080)	(0.0032)	(0.0287)
Brent Oil	-0.0003	0.00005	-0.0003**	0.0052***	0.0008*	-0.0033
	(0.0002)	(0.0003)	(0.0001)	(0.0009)	(0.0004)	(0.0029)
Transition probability						
P11	0.5074		0.9901		0.9702	
P22		0.321		0.813		0.7882
Expected duration	2.030	1.4728	101.01	5.3476	33.56	4.7214
Log likelihood	9549.3741		1420.272		1049.4874	
Nber of observations	3464		505		415	

Note:* p<0.10, ** p<0.05, *** p<0.01

Table II.3.3-7. Markov switching model for Corn Futures

Dependent Variable	**Pre-COVID**		**COVID**		**Post-COVID**	
Frequency	Daily		Daily		Daily	
AR(1) term	Yes		Yes		Yes	
Stress Regime	LOW	HIGH	LOW	HIGH	LOW	HIGH
Constant	-0.00007	0.0001	-0.0007	0.0271	0.0016	-0.0114
Standard deviation	0.01866	0.9580	0.0138	0.0126	0.0158	0.0431
Cotton	0.0485**	0.0844***	-0.0076	0.1211**	0.0170	-0.2002
	(0.0297)	(0.0161)	(0.0643)	(0.0525)	(0.0209)	(0.2560)
Sugar	0.0946***	0.0198	0.622**	0.0041	-0.0134	0.3607
	(0.0227)	(0.0123)	(0.0644)	(0.0377)	(0.0322)	(0.3217)
Rice	0.0011***	0.001***	0.0007**	-0.0002**	0.0011**	-0.0003
	(0.0003)	(0.0002)	(0.0003)	(0.0003)	(0.0004)	(0.0017)
Wheat	0.5381***	0.4523***	-0.6298***	0.4542***	0.4282***	0.1578
	(0.0229)	(0.0151)	(0.1120)	(0.0444)	(0.0209)	(0.1310)
S&P 500	0.0001	0.0002	-0.0006	0.0002	-0.0002	-0.0039
	(0.0004)	(0.0002)	(0.0004)	(0.0004)	(0.0004)	(0.0061)
US 10 Year T-bill	3.53e-06	0.0002	0.0079**	-0.006**	0.0002	-0.011
	(0.0016)	(0.0007)	(0.0032)	(0.0029)	(0.0011)	(0.0132)
US dollar index	-0.0046**	-0.0012	0.0038	-0.0040***	-0.0003	-0.0114
	(0.0016)	(0.0008)	(0.0034)	(0.0023)	(0.0016)	(0.0166)
Brent Oil	0.0006	0.0001	-0.0003*	0.0001	0.0003	0.0022
	(0.0005)	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0019)
Transition probability						
P11	0.9412		0.3515		0.9763	
P22		0.958		0.9075		0.8316
Expected duration	17.01	23.81	1.542	10.81	42.19	5.94
Log likelihood	10344.93		793.9069		1930.261	
Nber of observations	3500		259		672	

Note:* p<0.10, ** p<0.05, *** p<0.01

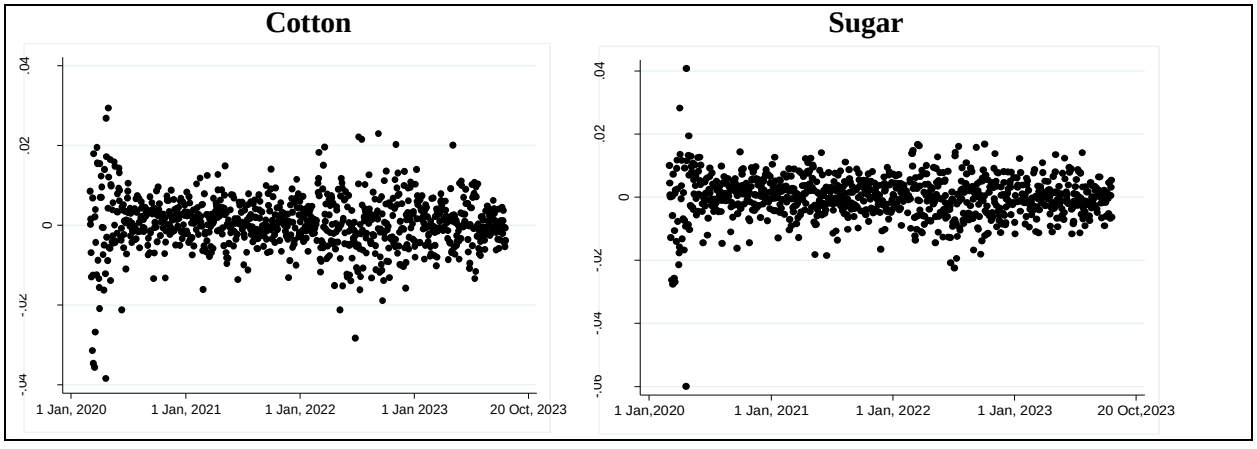
II.3.3.1. Model Adequacy

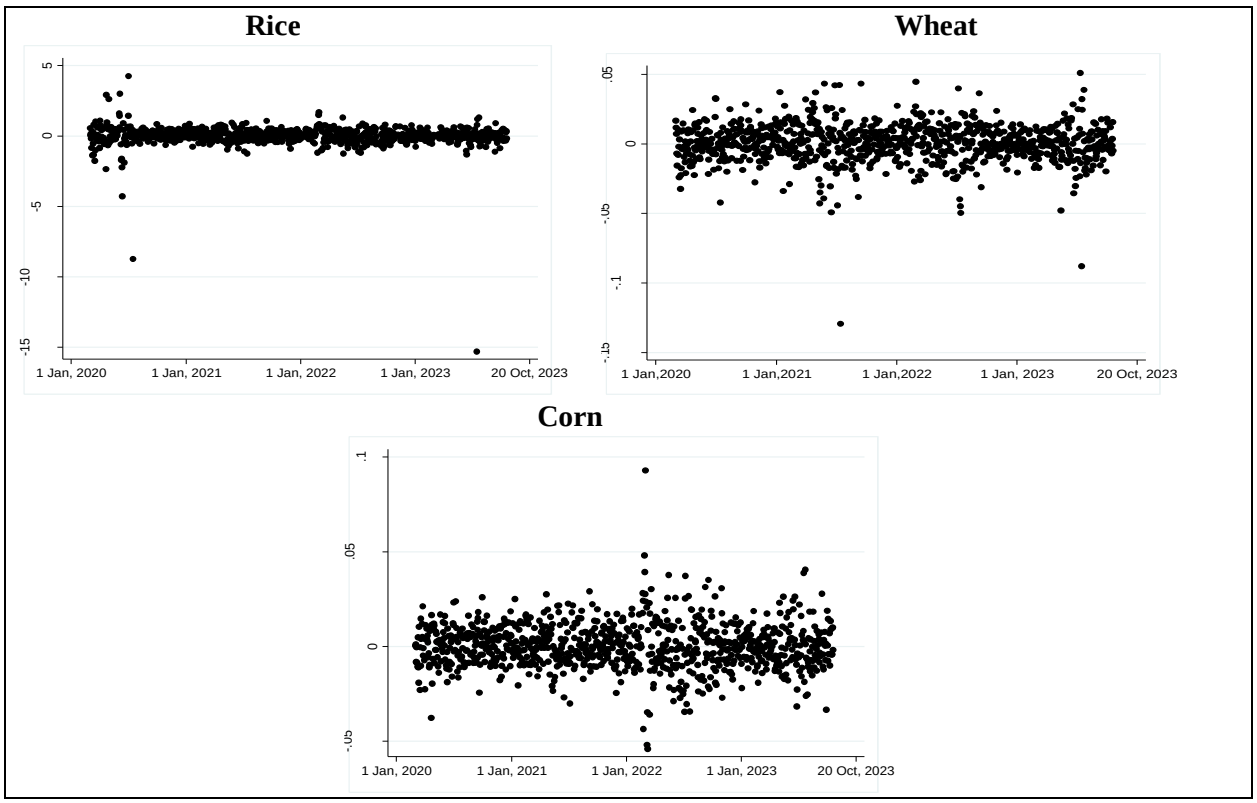
Following the estimation of an econometric model, we proceed to assess the applicability of recommended models for forecasting. We compare the model's fit to two criteria. The first is a residual scatter plot, while the second is the Bartlett Periodogram white noise test (Bartlett, 1955,1967; Nason & Savchev, 2014). The scatter plot of residuals is gaining popularity due to its ease of use in assessing possible issues such as heteroskedasticity, autocorrelation, and curvilinear trend of data points. The criterion is that residuals retrieved from the model be independent and identically distributed, or follow a "white-noise" approach. The scatterplot findings are shown in Figure II.3.3.1-1. The close proximity of data points suggests an issue with heteroskedasticity.

Although a scatter plot of residuals is a first option for any model diagnostics, it cannot provide a meaningful judgement regarding model adequacy. As a result, we analyze another well-known test based on spectrum analysis. For every given stochastic process, spectral density is the fourier transformation of the autocorrelation series. It is calculated using a periodogram, which depicts the frequencies on the horizontal axis and the signal strength on the y-axis. In the presence of periodicities, the signal exhibits peaks at specific frequencies. The Bartlett Periodogram white noise test presumes that the signal is white noise with a flat spectrum.

The periodogram is based on an asymptotically distributed series of independent and identically distributed exponential random variables, hence the cumulative periodogram is a straight line with a 45-degree angle. The largest deviation between the straight line and the normalised cummulative periodogram of residuals is used to calculate the Bartlett's test statistic. The null hypothesis assume that residuals follows a white-noise process and corresponding p-value is calculated. The results of Bartlett's test are presented in Figure II.3.3.1-2. The test provides an optimistic results, since 5 out of 5 financial assets from commodities markets prove that the residuals extracted from suggested models is just a white noise and hence models are appropriate for forecasting. The p-value of Bartlett's test statistic, on the other hand, is less than 1% significance level for residuals recovered from corn models. One justification could be the fluctuating nature of corn returns and residuals. Overall, the research demonstrates that the Markov switching econometric technique is effective at identifying different market conditions during moments of market turbulence.

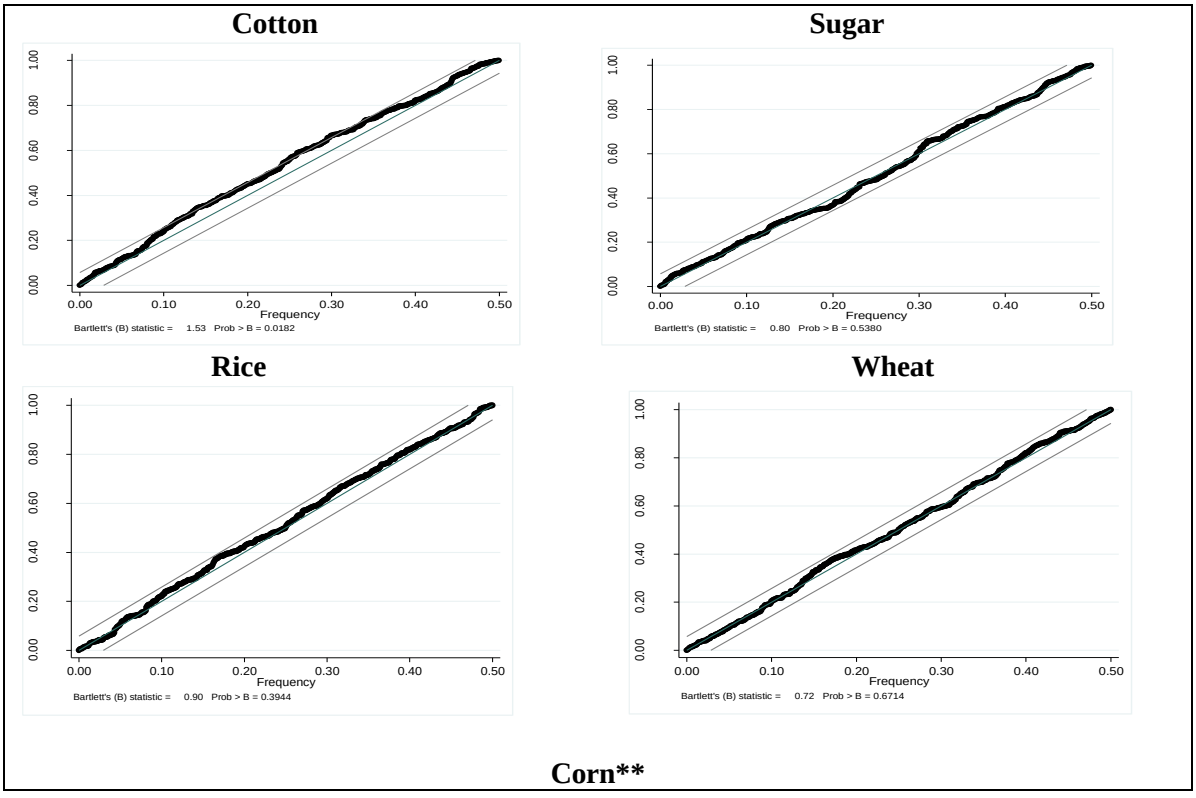
Figure II.3.3.1-1. Scatter plot of model standardized residuals

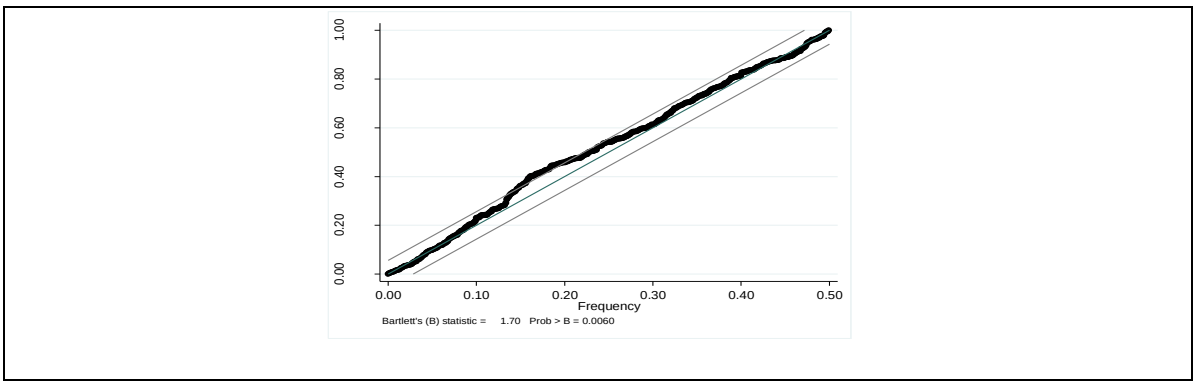




Note: For the readibility of plots, pre COVID-19 period is excluded. However, the similar behaviour is observe across all plots.

Figure II.3.3.1-2. Bartlett Periodogram white noise test results for selected series





Note: ** represents rejection of null hypothesis that residuals follows a white-noise process at 1% level of significance

II.3.4. Concluding remarks

The primary objective of this study is to elucidate the repercussions of abrupt perturbations in the structural stability of global commodities markets induced by the COVID-19 pandemic. Utilizing the Markov switching model, we endeavor to discern variations in the co-movement impact across diverse financial indices within each market during two distinct regimes. The selection of commodities for investigation is deliberate, considering the prevalence of these five categories among global investors. Criteria for selection are based on the trading volume exhibited in each market. Additionally, we identify and incorporate four salient macroeconomic determinants influencing commodity future returns. Through the application of the Markov Switching model, our findings reveals that the COVID-19 pandemic not only increased the volatility within financial markets but also imparted a discernible and enduring influence on the structural dynamics within commodities markets.

The principal findings of this study underscore noteworthy aspects within the realm of agricultural commodity markets amid the COVID-19 pandemic. Notably, except for wheat, the pandemic has instigated a sustained escalation in the volatility of selected agricultural commodity market returns. The wheat market, conversely, experiences a positive impact on returns attributed to the hoarding effect during the pandemic, albeit transient in nature. Furthermore, the volatility of rice returns surges five-fold during high-stress periods in contrast to normal market conditions.Exploring interrelationships among selected commodities, wheat and corn emerge with the highest cross-correlations in returns. Despite this, financial integration among agricultural commodities remains modest, both in regular market conditions and crisis scenarios. The study identifies the exchange rate of the dollar and Brent oil prices as influential macroeconomic determinants of agricultural commodity future returns. Significantly, the impact of these determinants intensifies during the pandemic and its aftermath. The temporal analysis reveals two structural breaks within a three-year timeframe, encompassing the COVID-19 period and the subsequent post-COVID era, alongside one break in the pre-COVID interval spanning 2006-2020. This temporal segmentation highlights the ongoing financial turbulence within agricultural commodity markets, with the impact of the crises surpassing that of preceding episodes such as the 2008 credit crunch and the 2014 collapse of oil prices. This underscores the enduring and heightened susceptibility of agricultural commodity markets to disruptive economic events.

Our study presents consequential implications for financial investors navigating the dynamics of agricultural commodity markets. The persistent escalation in the volatility of selected agricultural commodities suggests heightened uncertainty and risk, prompting a requisite adaptation of risk management strategies. Notably, the positive impact of the hoarding effect on wheat market returns during the COVID-19 period is discerned as transitory, emphasizing the need for investors to recognize short-term benefits while acknowledging the limited sustainability of these effects. Additionally, the substantial increase in the volatility of rice returns during high-stress periods underscores the imperative for investors in the rice sector to factor in this heightened volatility in their decision-making processes. Cross-correlations between wheat, corn, and other selected commodities indicate potential spillover effects within portfolios, urging investors to exercise vigilance and employ diversification strategies. The observed low financial integration among agricultural commodities in normal market conditions provides opportunities for diversification, while the identified macroeconomic determinants—exchange rates and Brent oil prices—require continuous monitoring due to their heightened impact during the pandemic and post-pandemic periods. The study underscores enduring concerns regarding the resilience of agricultural commodity markets, portraying the crises' impact as more substantial than preceding episodes, thereby necessitating ongoing scrutiny by investors and policymakers alike.

This study acknowledges potential limitations in its methodology, primarily associated with the utilization of the Markov switching model. Firstly, the sensitivity of this model to the initial conditions of the estimation process and its characterization as data-driven introduce a level of variability in results, particularly in response to changes in the sample period or the inclusion of variables. Although our incorporation of macroeconomic determinants and the segmentation of the dataset into three sub-sample periods has led to adjusted estimation results, revealing, for instance, the significance of sugar returns as a predictor in various agricultural commodity future returns, we recognize the need for caution in interpreting these relationships, attributing them to specific channels such as the oil-sugar nexus. Moreover, the computational intensity of estimating Markov switching models, especially in the context of large datasets, precludes a comprehensive sensitivity analysis. Additionally, the model's assumption of abrupt and instantaneous transitions between regimes may not fully capture the more gradual nature of real-world regime shifts. Despite achieving independent and identically distributed residuals in various instances, the persistent presence of heteroskedasticity prompts consideration of alternative models, such as GARCH or stochastic volatility models, which may offer more accurate and efficient representations of the underlying processes. These reflections underscore the importance of recognizing and addressing the methodological constraints inherent in this study.

Chapter II.4. GOVERNMENT ARTIFICIAL INTELLIGENCE READINESS AND BRAIN DRAIN: INFLUENCING FACTORS AND SPATIAL EFFECTS IN THE EUROPEAN UNION MEMBER STATES[7]

The concept of Artificial Intelligence (AI), often utilized in specialized studies and increasingly prevalent in recent language, encompasses technically complex and computer-oriented ideas that are difficult to succinctly express. From a governmental standpoint, AI represents a multifaceted blend of technology, policy, and social impact, necessitating a multidisciplinary approach for its successful integration and application.

In citizen services, AI's applications range from handling inquiries and processing documents to directing requests, aiding translations, and drafting documents (Mehr, 2017). Three primary AI applications in government stand out: Robotic and cognitive automation, enabling the reallocation of human labor to more value-added tasks through technologies like Robotic Process Automation; Cognitive insights generation, improving predictive capacities; and Cognitive engagement, addressing citizen queries (Eggers et al., 2017).

Government entities are increasingly adopting AI, expected to fundamentally transform their operations, from policy-making to the execution of daily public services. AI provides tools for predictive analytics, decision-making, and problem-solving, particularly valuable in contexts of significant uncertainty. Utilizing AI capabilities allows public sector organizations to enhance agility, anticipate citizen needs, optimize resource allocation, and improve service delivery quality (Mikhaylov et al., 2018).

AI presents countries with a vital opportunity to advance their economic landscapes, especially in public services. It enables enhanced, personalized service delivery (Robles & Mallinson, 2023). Its powerful data analytics capacity helps governments derive insights from large data sets, supporting evidence-based policymaking. AI equips governments with powerful tools for automating bureaucratic tasks, extracting insights from vast data, and customizing public services to meet individual needs, thus symbolizing a beacon for improved governance, informed policymaking, and heightened citizen engagement (Frățilă et al., 2023).

The European Union, a unique assembly of countries with varied economic and technological paths, offers a key study area for examining government AI readiness and brain drain within its unified political and economic structure. Understanding each member state's AI preparedness is crucial, as disparities could significantly impact the EU's collective policy and strategic direction.

The EU's principle of free movement (Article 45, Treaty on the Functioning of the EU) highlights its unique brain drain issues, with high-skilled workers easily relocating between states, differing from global patterns. Member states face similar problems like aging populations (Walker & Maltby, 2012) and upskilling needs (Jacobs, 2023). Examining AI readiness in this context reveals opportunities for collective strategies and cooperation.

Given the EU's acknowledgment of AI as an instrumental force shaping future socio-economic contours (European Parliament, 2023), gauging the AI readiness of its governments is indispensable. "The Government AI Readiness Index provides an overall estimate for how prepared

[7] This section is based on the article: **Iulia Cristina IUGA**, Adela SOCOL. 2024. Government Artificial Intelligence Readiness and Brain Drain: Influencing Factors and Spatial Effects in the European Union member states. *Journal of Business Economics and Management*, 25(2), p. 268-296. https://doi.org/10.3846/jbem.2024.21136. WOS: 001198020900001

each country's national government is for implementing AI in public service delivery" (Oxford Insights, 2022).

The EU's policy harmonization, alongside its member nations' varied economic and technological stages (Calderaro & Blumfelde, 2022), poses challenges and opportunities in tackling brain drain and enhancing AI readiness. The EU's Coordinated Plan on Artificial Intelligence (European Commission, 2018) encouraged nations to develop or integrate AI strategies. By 2023, all 27 EU countries had AI strategies (OECD, 2023; European Commission, 2020; Cath et al., 2017). Studying the EU offers a comprehensive view on AI readiness and brain drain dynamics, yielding relevant insights into AI integration and labor mobility trends in the EU.

Prior research reveals new emerging paradigms in public administration (post-New Public Management Paradigms) have been identified that focus on the importance of technological innovation and artificial intelligence to improve the delivery of services to citizens and the policies implemented by the government (Ojo et al., 2019). These new paradigms focus on tangible benefits and creating public value through investment in disruptive technologies.

Integrating AI into governance introduces innovation but also challenges. Studies indicate that governments struggle to keep pace with AI advancements, showing a noticeable gap in public sector AI governance (Wirtz et al., 2020). Challenges often arise from skill shortages (Dwivedi et al., 2021), evident in employees' limited AI and machine learning knowledge (Ojo et al., 2019) and a lack of local AI experts (Gupta, 2019). The scarcity of AI professionals (Al-Mushayt, 2019) and insufficient advanced technology education (Montoya & Rivas, 2019) add to these difficulties. Simultaneously, many countries, especially developing ones, face a significant "Brain drain" – skilled workers migrating to developed countries for better opportunities. The Fragile States Index highlights the economic and developmental impacts of such human displacement (Fund for Peace, 2022).

In the context of the European Union (EU), spatial interactions and spillovers between member states are crucial for understanding phenomena like brain drain and AI readiness. In the EU, countries are interdependent; developments in one can influence others. This interconnectedness, inherent to the EU's structure, necessitates a comprehensive view of these dynamics, considering the collective impact rather than isolated national trends.

The EU's principle of free movement for workers fosters a unified labor market, enabling professionals to pursue opportunities across borders with fewer migration barriers. This mobility carries significant consequences: professionals transfer their skills, experiences, and insights as they move (Frankowska & Pawlik, 2022), encouraging cross-border collaborations in research and innovation.

The interconnectedness of the EU means that member states are continually observing, learning from, and adapting policies from their neighbors (Altuzarra et al., 2019). A successful policy or initiative in one country can serve as a blueprint for others.

To our knowledge, there has been no research exploring within the EU member states how the national context influences government readiness to adopt AI in neighboring states.

The aim of the study is to analyze whether governments' readiness for artificial intelligence AI in the European Union countries depends on "brain drain", using Government Artificial Intelligence Readiness Index as dependent variable and the Human Flight and brain drain as the major independent proxy. Also, given the specifics of the EU labour market and the freedom of movement of workers, we were interested in discovering possible spatial interactions and spillover effects between countries.

The objective of the paper is threefold:

1. Examines the influence of brain drain on government AI readiness in EU countries;

2. Studies the existence of spatial effects and spillover effects between neighboring EU countries;

3. Highlight the policies that can be adopted to reduce the government AI discrepancy between the EU member states.

This study addresses the following research questions:

RQ1: Does the European Union experience a negative effect of brain drain on AI government readiness?

RQ2: Are there positive effects of EU-funded projects for R&D, economic freedom, and government spending on AI government readiness in the European Union countries?

RQ3: Does the brain drain (along with control variables) in a country influences the government's readiness to adopt AI in the neighboring states?

While there is indirect literature exploring the individual phenomena of brain drain and government AI readiness, there remains a paucity of research specifically examining the interplay between these two dimensions, especially within the unique context of the European Union. The existing body of work often treats brain drain and AI readiness as distinct entities, with limited exploration of how they might influence each other. Moreover, the spatial interactions and spillover effects within the EU, shaped by its singular policies such as the freedom of movement, present a nuanced backdrop that hasn't been adequately addressed in current studies. This lacuna in understanding becomes particularly significant given the rapid technological advancements and shifting labor dynamics within the EU. As such, there is a pressing need for an integrative analysis that holistically examines how brain drain might impact AI readiness across governments and vice versa, and how these dynamics manifest in the EU's interconnected landscape. This study endeavors to bridge this gap, offering insights that can inform both policy-making and future academic pursuits.

The present study bridges gaps in the prevailing literature on AI in government and the phenomenon of brain drain. Historically, AI's role in public sector augmentation has been discussed in isolation, with emphasis on its potential to streamline operations and elevate citizen engagement. This study illuminates the intricate interplay between brain drain and government AI readiness, a dimension underexplored in earlier works. Echoing findings from Oxford Insights (2019) we underscore the criticality of human capital in the AI realm. This aligns with Docquier and Rapoport (2012), who highlighted the repercussions of high-skilled labor emigration on a country's technical prowess. Our research deviates from merely acknowledging brain drain as a challenge, extending into its direct and indirect impacts on AI adoption, especially in the European context. Furthermore, while past literature like Brynjolfsson and McAfee (2014) touched upon potential delays in AI development due to expertise shortage, our findings delve deeper into the cascading effects of such delays on public service quality and national security. By juxtaposing economic freedom, EU-funded R&D projects, and government readiness for AI, we offer a comprehensive narrative that not only augments existing literature but also charts out potential trajectories for future research in the domain.

The innovation of this paper is that we incorporate five major groups of factors (human, macroeconomic, governance, education and research & development) into the model and study both panel effects for European Union states, as well as spatial effects and data clustering.

The research's originality lies in its unique combination of geographical focus, methodological robustness, emphasis on spatial interactions, exploration of the brain drain phenomenon, and its bridge between theoretical findings and policy implications.

II.4.1. Impact of Brain Drain and Governance on government AI Readiness: a literature review

II.4.1.1. Interaction between government AI and brain drain

Government AI signifies the use of AI technologies in the public sector, enhancing efficiency, effectiveness, and decision-making. It possesses the potential to transform government operations by improving citizen services, reducing costs, and optimizing resource use. AI involves computational techniques that enable machines to learn, reason, and solve problems, akin to human cognition. Worldwide, governments are increasingly interested in embedding AI into their operational fabric.

AI's application in government spans various domains: in *Public Services*, it could automate tasks like application processing and inquiry handling; in *Policy and Decision-making*, it could analyze extensive datasets for policy shaping; in *Law Enforcement and Public Safety*, technologies like facial recognition and predictive analytics could augment safety efforts; in *Infrastructure and Resource Management*, AI could assist in resource management and infrastructure planning (Wang & Cui, 2022); and in *Healthcare*, AI could improve public health outcomes by analyzing medical data for disease detection and treatment optimization (Gomes de Sousa et al., 2019).

Countries' readiness for AI technology varies, as revealed by an Oxford Insights (2019) review, which identified challenges in adopting AI for the common good, including policy, capacity, and resources, with human capital as a key resource. The Human flight and brain drain indicator focuses on the economic effects of skilled labor migration and its impact on a nation's advancement. Brain drain, a complex phenomenon, particularly affects developing countries, with skilled workers emigrating to more developed regions (Docquier & Rapoport, 2012). This migration impacts a nation's capacity to maintain and grow its expertise in critical areas like AI. In the context of globalization and international competition, brain drain affects a country's ability to maintain and develop its expertise in key areas such as AI and attract foreign direct investment (Czaika & de Haas, 2015; Siar, 2013).

In the European Union, there's a notable migration of experts from Central and South-Eastern Europe to Western countries (Bălan & Olteanu, 2017). This movement, driven by personal and socio-economic factors, began after the fall of communist regimes in the 1990s. The impact of brain drain on government AI is multi-dimensional: It restricts access to needed expertise for AI development (Brynjolfsson & McAfee, 2014), potentially causing delays in AI adoption and risks to data protection (Dignum, 2019). It also leads to a loss of AI talent to the private sector, slowing public sector innovation. Additionally, governments might become over-reliant on private AI solutions (Gesk & Leyer, 2022), posing national security risks and loss of control over data and algorithms (Offer, 2022). The public-private pay gap (Agrawal et al., 2019) and the lack of public sector investment in AI R&D (Johnson, 1965) further fuel brain drain.

Overall, while AI holds transformative potential for government operations, its effective integration faces hurdles due to brain drain, resource limitations, and evolving AI development and policy landscapes. This interplay requires a multifaceted approach to enhance AI readiness in the public sector, considering the dynamics of economic disparities and global talent mobility.

Considering these, we can formulate the main research hypothesis of this study:

H1: There is a negative effect of brain drain on AI government readiness in the European Union countries.

II.4.1.2. Interaction between macroeconomic, governance, education and research & development variables on AI government readiness

Brain drain, government spending, economic freedom and EU-funded research and development projects for artificial intelligence are fundamental themes for the contemporary debate on sustainable development and national or European competitiveness.

The introduction of artificial intelligence into government operations has the potential to transform the mode the public sector operates, optimizing efficiency, effectiveness and decision-making. Government spending can have a positive impact on government readiness for AI, ensuring that public institutions can reap the benefits of this innovative technology (Bredt, 2019).

Investing in infrastructure, health, education and research can help increase a country's competitiveness and improve citizens' quality of life (Bose et al., 2007), while the development of the telecommunication infrastructure has a significant positive impact on the efficiency of government (Doran et al., 2023). Thus, governments can also help prepare the workforce for the integration of AI in the public sector. By investing in training and reskilling programs, governments can ensure that public sector employees are prepared to work with AI technologies and manage the changes associated with the automation of certain tasks (Duan et al., 2019). This can lead to a better adaptation of the workforce to technological developments and to a smoother transition into the digital age. With the development of advanced language models using Artificial Intelligence (AI), the issue of AI readiness becomes critical, and the quality of the human factor involved in AI depends largely on the use of AI for purposes truly useful to humanity and without associated risks, especially those related to unpredictability and ethical concerns.

Another important aspect of government spending is investment in the infrastructure needed to support AI implementation (Wang & Cui, 2022). This may include the development of high-speed communication networks, data centers and other technological resources that enable the efficient use of AI in public services and decision-making processes. On the other hand, investments in infrastructure, education and research and development can help increase a country's AI competitiveness. Studies show that governments investing in AI can benefit from economic growth and improved quality of life for citizens (Arntz et al., 2019).

Government investment in AI can also foster international cooperation (Millard, 2017) and partnerships between different governments and organizations, promoting a global and harmonized approach to AI regulations and standards. This can lead to greater interoperability between AI systems used in different countries and to strengthen collaboration to address common challenges such as cybersecurity and data protection (Pan & Zhang, 2021).

Government spending on R&D in AI is another key issue for sustainable economic development. The European Commission has made significant investments in the projects of Artificial Intelligence (AI) research and development firms. This is done with the intention of enhancing the preparedness of governments to adopt AI technologies.

Given the premise that governmental expenditures are directed towards enhancing the capability of governments to deploy artificial intelligence, it is hypothesized that:

H2: There is a positive effect of government spending on AI government readiness in the European Union countries.

The Economic Freedom Index by The Heritage Foundation assesses economic liberty worldwide, often used to examine the economic conditions favorable for Artificial Intelligence (AI) growth. Nations scoring higher on this index typically present a conducive environment for AI adoption, characterized by lower taxes, fewer regulations, and better property rights protection.

Economic freedom is instrumental for governments in AI readiness, mainly by attracting investment and fostering innovation. Countries with high scores in the Index of Economic Freedom attract investors, thanks to stable economic conditions and growth potential. This environment helps governments gather necessary capital and expertise for AI development and implementation (World Economic Forum, 2023).

Moreover, countries with greater economic freedom usually have dynamic, competitive markets, sparking innovation and advanced AI technologies. In such markets, companies invest more in research and development, striving to create and market top-tier AI products (Ciftci & Durusu-Ciftci, 2022).

Another benefit of economic freedom for government AI readiness is the promotion of entrepreneurial spirit and risk-taking. High-scoring countries on the Index of Economic Freedom offer favorable conditions for entrepreneurship, like easier credit access and strong property rights. These factors encourage individuals and businesses to pursue innovative ideas, including AI-related ventures. As a result, governments in these countries have access to a continuous stream of innovative AI technologies and applications (Le & Kim, 2020).

Economic freedom also facilitates the integration of AI technologies within governments. High-ranking countries on the Index of Economic Freedom typically have efficient, streamlined bureaucratic systems that can easily adapt to AI-driven changes. These nations face fewer bureaucratic hurdles to innovation, allowing government entities to experiment with new AI applications and technologies more freely (Okulich-Kazarin et al., 2020).

In summary, economic freedom significantly influences government AI readiness. It draws investment, stimulates innovation, fosters entrepreneurship, and eases AI technology integration within government. Countries prioritizing economic liberty are better positioned to leverage AI's benefits, thus reaping the rewards of this transformative technology.

Considering these, we can estate:

H3: There is a positive effect of economic freedom on AI government readiness in the European Union countries.

EU-funded projects for R&D in AI are another key element in supporting technological development and innovation. The European Union has invested massively in programs such as Horizon 2020 and the new Horizon Europe program (2021–2027) to boost AI research and development (European Commission, 2021a). These initiatives offer financial support and collaborative prospects among researchers, universities, and companies across various European countries, thereby advancing the sharing of knowledge and the creation of innovative solutions (Spence, 2021). A pertinent example is the AI4EU project, funded by the EU under Horizon 2020. It strives to establish a European platform for the advancement and utilization of AI, contributing positively to both the economy and society (AIoD Platform, 2019).

The substantial investment by the European Commission in projects related to AI research and development firms has notably enhanced government readiness for AI. These initiatives have contributed to better government efficiency, increased citizen engagement and satisfaction, and augmented accountability and transparency. As AI technology continues to evolve, these advantages are expected to become even more distinctive, positioning AI as an increasingly vital instrument for governments globally. These projects have produced considerable positive effects, furnishing governments with the essential tools to leverage the potential of AI and revolutionize their operations.

A key advantage of the European Commission's funding in AI research and development firms' projects lies in the improvement of government operations' efficiency and efficacy. Utilizing AI-powered instruments, governments can automate mundane tasks and procedures, consequently cutting operational expenses, enhancing accuracy, and boosting speed. For example, AI can assist governments in swiftly and precisely processing enormous quantities of data, facilitating superior decision-making and more efficient resource allocation (European Parliament, 2021a).

Another significant benefit of these projects is improved citizen engagement and satisfaction. AI-driven chatbots and virtual assistants can facilitate citizens in accessing government services with greater speed and efficiency, leading to reduced waiting times and an enhanced overall experience. Additionally, AI-enabled tools can assist governments in more comprehensively comprehending the needs and preferences of their citizens (Ojo, 2019), thereby allowing for the delivery of more tailored services (European Parliament, 2021b).

The investments made by the European Commission in AI research and development firms' projects have additionally contributed to enhancing government accountability and transparency. AI-enabled tools can aid governments in overseeing and assessing their performance, simplifying the process of pinpointing areas that need improvement and tracking progress over time. Moreover, AI can assist governments in identifying and averting fraud and corruption, thereby guaranteeing that public funds are utilized properly (European Commission, 2021b).
Considering the abovementioned, we can formulate the last hypothesis:

H4: There is a positive effect of EU-funded projects for R&D on AI government readiness in the European Union countries.

II.4.2. Data and methodology

Our study analyzes whether governments' readiness for artificial intelligence AI in the European Union (EU) countries depends on "brain drain", using Government Artificial Intelligence Readiness Index as dependent variable and the Human flight and brain drain as the major independent proxy. Several economic, research and development and governance factors are considered control variables, based on the results identified in the previous studied literature. To control the macroeconomic conditions, the study use Government Expenditure, Gross Domestic Product and Economic Freedom, while to control governance and education in AI field, two proxies are employed: Government Pillar of AI Index and AI in University Bachelor's Programs (proportion of programs with AI content in the total number of programs). Also, the study considers the variable represented by AI R&D Firms' Projects founded by European Commission (percentage of the total number of AI R&D players financed) as a proxy to capture Research and Development activities in AI.

The panel comprises the European Union countries, except for Cyprus, Malta and Ireland, which are excluded from the studied sample, given their geographical status without EU neighboring countries (bases on spatial analysis methods that do not allow the analysis of those states that do not have common borders with the rest of the states in the chosen sample).

Table II.4.2.-1 presents the description of the variables and data sources from which the information was gathered.

Table II.4.2.-1. Variables and data sources

Category	Variable / Symbol / Source	Definition / Measurement
Explained – Governance	AI IN GOVERNMENT. Government Artificial Intelligence Readiness Index (Oxford Insights, 2022)	The measure of governments readiness to implement AI in the delivery of public services. Score: 0 (low) – 100 (high).
Core explanatory – Human	BRAIN DRAIN. Human Flight and Brain Drain Index (Fund for Peace, 2022)	The measure of the economic impact of human displacement (for economic or political reasons) and the consequences this may have on a country's development. Score: 0 (low) – 10 (high).
Control variable – Macroeconomic	GOVERNMENT EXPENDITURE. Government Expenditure (World Bank, 2022a)	General government final consumption expenditure includes all government current expenditures for purchases of goods and services (including compensation of employees). Billion current U.S. dollars
Control variable – Macroeconomic	ECONOMIC FREEDOM. Economic Freedom Index (Heritage Foundation, 2022)	The measure of fundamental right of every human to control own labor and property. The mix of 12 quantitative and qualitative factors, grouped into four broad categories: rule of law, government size, regulatory efficiency and open markets. Score: 0 (low) – 100 (high)
Control variable – R&D / Governance	AI R&D FIRMS EC FUNDED PROJECTS. AI R&D Firms' Projects founded by European Commission (European Commission, 2022)	Proportion of AI R&D Firms in the total number of AI R&D players financed by European Commission. Percentage
Instrumental (only in 2SLS and LIML instrumental-variables regressions)		
Macroeconomic	GDP. Gross Domestic Product (World Bank, 2022b)	Gross Domestic Product is a basic measure of the value added created through the production of goods and services in a country. Billion current U.S. dollars
Governance	GOVERNANCE Government Pillar of AI Index (Oxford Insights, 2022)	The assessment of vision, governance & ethics, digital capacity, and adaptability of governments in AI implementation. Score: 0 (low) – 100 (high)
Education / Governance	AI BACHELOR. AI in University Bachelor's Programs (European Commission, 2022)	Proportion of bachelor programs with AI content in the total number of bachelor programs. Percentage.

To best to our knowledge, at regional or global level, the scarcity of indicators to capture the preparation of governments in the implementation of artificial intelligence is obvious, because there are limited initiatives to develop such indicators. We are interested in capturing the situation of AI implementation in government in the period as close to the present as possible, so we use a year window which refers to the year 2022, and for the rest of the variables we rely on the most recent data collection available, published in 2022 and related to the previous year or years, depending on the collection criteria of those variables.

The issue of preparing governments for AI deployment is rarely studied in the literature, much less its connection to brain drain, given the novelty of the subject and the incipient concerns of scientific communities to analyze unconventional perspectives of AI implementation by

governments. As far as the author's knowledge is concerned, no study has explored such a topic from the perspective of the European Union and the variables chosen by us. The theoretical previous identified literature mentions demographic shift, namely brain drain, which is composed of well-educated masses as a challenge for implementing the AI strategy in Turkey's case (Can, 2023).

The motivation for choosing brain drain as core explanatory variable is based on the essential role that the highly qualified human factor plays both in creating AI tools, AI implementing and assisting AI users. International mobility and the exodus of highly skilled workforce generate labor market distortions and shortages of specific skills needed by governments in AI implementation. The migration of highly skilled labor force from the former communist countries of the European Union has been sizeable for last three decades, amid socio-economic difficulties, political instability, social insecurity, corruption, unemployment, inflation, low wage levels, inefficient health and education systems etc. Based on the analyzed data, in the traditional countries of the European Union there are lower levels of labor migration with high knowledge and skills and are usually preferred as destination countries for skilled emigrants, attracted by job quality and career prospects.

A particularity of our analysis is given by the incorporation of a wide range of control variables belonging to macroeconomics (GDP), governance (Government pillar of AI Index), R&D (AI R&D Firms' Projects founded by European Commission) and education in AI (AI in University Bachelor's Programs).

The choice of economic freedom as a control variable is based on the fact that it is directly related to the fundamental right of individuals to work and property, and that it characterizes an environment conducive to growth and innovation. Economic freedom is organically linked to government, whose decisions influence individual autonomy, as well as personal and national prosperity.

Another control variable used in modelling the effect of brain drain on AI government readiness is proportion of AI R&D Firms in the total number of AI R&D players financed by European Commission. Its choice was based on the major role of AI companies in developing the AI-specific technology and software ecosystem, based on research, innovation and entrepreneurship, given that a country's AI advancement depends on grants and patent applications in AI-related technologies (Thomas & Murdick, 2020).

Government expenditure is a major macroeconomic determinant considered the explanatory control variable in our study. Governments' ability to implement AI depends significantly on their willingness to incur government spending, both to provide AI infrastructure and software, as well as to provide the necessary trained and sufficient human resources to operate the technical facilities of government AI.

Endogeneity represents an essential aspect to be studied in econometric analysis of economic data, whose potential for endogeneity is considerable compared to other areas and which, if ignored, increases the risk of including not only very few explanatory variables, but also irrelevant ones in the model, leading to the so-called omitted variable bias (Ibrahim & Arundina, 2022). Endogeneity can result from the omission of unobserved factors from the model, which could affect the relationships between the studied variables and also endogeneity can be understood as a consequence of the past on the present, both on the model (dependent variable) and on independent variables, or as a causal relationship between regressors and the variable explained over time (Labra & Torrecillas, 2018).

Based on these considerations, and in line with prior research, our approach is to identify the risk of endogeneity initially through theoretical judgement, followed by statistical Durbin-Wu-Hausman

tests, which confirm endogeneity (Ullah et al., 2018). A detailed analysis of the significance of government spending shows that it is intrinsically linked to diverse specific factors, among which the following are relevant in the context of this analysis: economic growth, a composite indicator showing vision, governance & ethics, digital capacity, and adaptability of governments in AI implementation, and a specific factor related to the undergraduate degree program that addresses specific AI content.

We will detail in turn each of the three variables mentioned as influencing factors of government expenditure. First, the influence of government expenditure on economic growth is extensively studied in the literature, while the inverse relationship is less analyzed. The numerous competing theories that analyze the link between government spending and economic growth (Keynesian macroeconomic theory, Wagner's law, Peacock and Wiseman displacement effect hypothesis, etc.), although antagonistic, show consistent results of the determining role that economic growth has on government spending (Szarowska, 2022; Voda et al., 2022). From the perspective of our study, we want to find out to what extent economic growth influences government expenditure and we chose GDP as a reference, given its high degree of complexity, standardized methodology of determination and ability to reflect the fundamental aspects of the country's economic development (Trishch et al., 2023).

Second, governance is critical for government spending and institutional efficiency contributes to the efficacy of public expenditure (Thanh et al., 2020). We are interested in a particular form of governance (Government pillar of AI Index) aimed at openness, vision and digital capacity of states in implementing AI. Such a complex composite indicator of governance in AI implementation captures in a comprehensive manner the degree of governance of the analyzed state from the perspective of AI implementation: vision (by answering the question of whether governments have a vision for implementing AI and a specific strategy), governance and ethics (whether governments have set up specific legislation and an ethical framework for implementing AI in a manner that builds trust and legitimacy) digital capacity (whether governments have the digital capacity to implement AI – online services, IT infrastructure, government investment in emerging technologies) and adaptability (whether governments are indeed change and innovate effectively in AI field). A high degree of institutional governance contributes significantly to the digitalization of businesses and public services for citizens (Ionescu et al., 2022).

Third, although unconventional and previously unexplored by the literature studied to our knowledge, the link between government spending and AI content addressed in university studies represents an avant-garde approach that encompasses a specific education variable directly connected to the topic of AI. We believe that in studying the relationship between governments' AI readiness and brain drain and human flights, it is necessary to create an expanded perspective, by calling for an education variable, reflecting how much governments invest in education and familiarization of tertiary education graduates in AI. The AI contents of the undergraduate studies that have been considered refer to all types of studies, not only the technical ones, but also to AI-specific social, psychological, ethical, legislative, etc. contents. Countries in the European Union have integrated specific AI aspects into their university curricula, and as higher education systems in the European Union are mainly funded by the state (Lepori et al., 2018; European Tertiary Education Register, 2019), we consider that governments' motivation to invest in AI content is a strong marker of government spending. Government awareness of AI's staggering expansion has also led to the creation of educational mechanisms for AI to become part of university training. The generalized desideratum to recognize and learn about AI from various perspectives – technical, social,

psychological, legislative, etc. – is obvious and can contribute over time to obtaining expected positive effects in terms of managing AI within appropriate moral, social and economic parameters.

The paper gradually approaches three econometric methods. First, given the conceptual links presented between the analyzed variables and the presence of endogeneity, the model suitable to address endogeneity proves to be instrumental-variables regression with regressors endogenously determined, namely two-stage least-squares 2SLS, and for robustness testing the LIML model (limited-information maximum likelihood). The choice of these methods is based on the systems of simultaneous equations, whose premises are built on the use of instrumental variables, correlated with the identified endogenous variable and unrelated with the error term and which allow to predict the links between the investigated variables.

Second, to find the similarities between countries in the government's readiness for artificial intelligence, we apply cluster analysis as a descriptive and explanatory technique for data analysis, whose principle is to place countries in homogeneous groups.

Third, founded on the spatial data of the countries, we set out to discover patterns of spatial dependence, global spatial autocorrelation, and spatial relationship. Europe shapefile (.shp) that store geographical characteristics of countries is used in GeoDa software and then import into Stata, which allowed the spatial analysis of the mentioned states from the perspective of the determinants of the government's readiness in the implementation of AI.

Instrumental-variables 2SLS and LIML regressions are developed based on the following model (equations 1 and 2), in which the endogenous regressor is considered GOVERNMENT EXPENDITURE, while BRAIN DRAIN, ECONOMIC FREEDOM and AI R&D FIRMS EC FUNDED PROJECTS are included in the model as exogenous regressors. The excluded exogenous regressors are lnGDP, GOVERNANCE and AI BACHELOR, which are instruments for endogenous variable GOVERNMENT EXPENDITURE. Government spending is considered endogenous starting from the endogenous growth model valences, according to which the role of government expenditure in allocating resources in the economy is very important and the lever of government spending improves the quality of public services (Nguyen & Bui, 2022).

$$AI\ IN\ GOVERNMENT_{it} = \alpha_1 + BRAIN\ DRAIN_{it}\beta_1 + GOVERNMENT\ EXPENDITURE_{it}\beta_2 + ECONOMIC\ FREEDOM_{it}\beta_3 + AI\ R\&D\ FIRMS\ EC\ FUNDED\ PROJECTS_{it}\beta_4 + u_i, \quad (1)$$

$$GOVERNMENT\ EXPENDITURE_{it} = \alpha_2 + lnGDP_{it}\Pi_1 + GOVERNANCE_{it}\Pi_2 + AI\ BACHELOR_{it}\Pi_3 + BRAIN\ DRAIN_{it}\Pi_4 + ECONOMIC\ FREEDOM_{it}\Pi_5 + AI\ R\&D\ FIRMS\ EC\ FUNDED\ PROJECTS_{it}\Pi_6 + v_i, \quad (2)$$

where *i* represents country; *t* is time; α_1 and α_2 represent intercepts; u_i and v_i are zero-mean error terms, and the correlation between u_i and the elements of v_i are presumably nonzero.

Cluster analyses is performed through the hierarchical clustering methods, based on them main premise that the geographically close countries exhibit similar behaviors compared to the more distant states (Noja, 2018). The analyzed countries are grouped into clusters formed based on complete link method and Ward's method. In the hierarchical clustering methods, the distance or dissimilarity between a group *k* and a group (*ij*), which consists of the fusion between two groups (*i* and *j*), based on the Lance-Williams formula is the following (Everitt et al., 2011):

$$d_{k(ij)} = \alpha_i d_{ki} + \alpha_j d_{kj} + \beta d_{ij} + \gamma |d_{ki} - d_{kj}|, \quad (3)$$

where *i, j* and *k* represent group *i, j* or *k*; d_{ij} is the distance between groups *i* and *j*; d_{ki} is the distance between groups *k* and *i*; d_{kj} is the distance between groups *k* and *j;* α_i, α_j, β and γ are parameters; n_i, n_j and n_k are the number of observations in group *i, j* and *k*, respectively.

In the third phase of the study, spatial analysis is conducted to find out whether the data collected from the European Union countries are spatially correlated, specifically whether the observations of closer countries tend to be more similar than further ones and the spatial spillovers decrease as the distance between countries increases (Belotti et al., 2017).

In developing the spatial dependency model, we started from the general equation (Equation (4)) of the Spatial Error Model (Belotti et al., 2017; Pisati, 2001):

$$Y = X\beta + \lambda W\xi + \epsilon, \quad (4)$$

where *Y* denotes an *Nx1* vector of observations on the dependent variable; *X* denotes *Nxj* matrix of observations on the explanatory variables; β is a *jx1* vector of regressions coefficients; λ denotes the spatial autoregressive parameter; ξ is an *Nx1* vector of spatial errors; and ϵ represents an *Nx1* vector of normally distributed, homoscedastic, and uncorrelated errors. The testing of the spatial autocorrelation is performed using the Moran test. The expected values of the Moran coefficient could vary between –1 and +1 (perfect dispersion or perfect correlation) and show how much close countries are in comparison with other close countries (Noja, 2018).

$$\text{Moran's I} = \frac{n \sum_{i=1}^{n} \sum_{j=1}^{n} W_{ij}(Y_i - \bar{Y})(Y_j - \bar{Y})}{\sum_{i=1}^{n} \sum_{j=1}^{n} W_{ij} \sum_{i=1}^{n}(Y_i - \bar{Y})^2}, \quad (5)$$

where *i* and *j* are countries; *Y* represents the variable of interest; $\bar{Y}$ is the average value of *Y*; W_{ij} is an element of a matrix of spatial weights and is generally a binary value.

The preliminary statistic descriptive analysis of the variables is stated in Table II.4.2.-2. and Table II.4.2.-3.

Table II.4.2.-2. Descriptive statistics (part 1)

CHARACTERISTICS	AI IN GOVERNMENT	BRAIN DRAIN	GOVERNMENT EXPENDITURE	ECONOMIC FREEDOM
Mean	65.810	3.204	154.275	71.041
Std. Dev.	7.911	1.552	235.461	4.813
Minimum	48.590	0.700	7.360	61.000
Maximum	77.590	5.700	947.78	78.000

Table II.4.2.-3. Descriptive statistics (part 2)

CHARACTERISTICS	AI R&D FIRMS EC FUNDED PROJECTS	GDP	GOVERNANCE	AI BACHELOR
Mean	0.675	692.810	70.788	5.309
Std. Dev.	0.097	1041.030	10.378	4.307
Minimum	0.461	37.190	48.700	0.000
Maximum	0.809	4259.930	88.450	14.070

Regarding the dependent variable, AI IN GOVERNMENT, it varies between 48.590 and 77.590 values, with a mean of 65.810 and the standard deviation of 7.911, which suggests the significant differences between countries. Also, the interval in which BRAIN DRAIN varies between 0.700 and 5.700, as well as the other disclosed statistic values, outline for the human flight and brain drain a character of increased heterogeneity in the studied countries. The lowest degree of dispersion from the average is found for the variable ECONOMIC FREEDOM, whose mean is 71.041, with a standard deviation of 4.813 between the analyzed states. At the opposite pole, with the highest values of disparity from the mean, it stands out GOVERNMENT EXPENDITURE, GDP and AI

BACHELOR, which denotes a higher degree of diversity between countries, in terms of the evolution of indicators especially regarding macroeconomic conditions and AI implementation in curricula for bachelor's studies. The rest of the examined variables (AI R&D FIRMS EC FUNDED PROJECTS and GOVERNANCE) display medium significant values of the dispersions compared to the average.

II.4.3. Results and discussion

II.4.3.1. Instrumental-variables regressions

The influence of brain drain on AI in government is estimated for the analyzed EU countries through the instrumental-variables 2SLS and LIML regressions models, whose outcomes are presented in Table II.4.3.1.

Table II.4.3.1. Indicators' impact on AI IN GOVERNMENT: instrumental-variables 2SLS and LIML approaches

AI IN GOVERNMENT	2SLS	LIML
BRAIN DRAIN	–1.661** (0.821)	–1.520* (0.853)
GOVERNMENT EXPENDITURE	0.012*** (0.004)	0.013*** (0.004)
ECONOMIC FREEDOM	0.710*** (0.158)	0.728*** (0.163)
AI R&D FIRMS EC FUNDED PROJECTS	19.661* (11.502)	20.076* (16.575)
Constant	5.485 (16.020)	3.228 (16.575)
R-squared	0.816	0.807
Durbin test	2.753*	na
Sargan test	5.060*	na
Basman test	4.542	2.211
Anderson-Rubin test	na	6.243**
Instrumented: GOVERNMENT EXPENDITURE *Instruments*: BRAIN DRAIN, ECONOMIC FREEDOM, AI R&D FIRMS EC FUNDED PROJECTS, lnGDP, GOVERNANCE, AI BACHELOR		

Note: * Significant at 10%; ** Significant at 5%; *** Significant at 1%; na – not applicable. Standard errors are in round brackets.

To confirm the reliability of the results, several robustness checks are employed. First, we perform endogeneity test to determine whether GOVERNMENT EXPENDITURE as endogenous regressor are in fact exogenous and for that, the performed Durbin test shows that null hypothesis which considers variable as exogenous can be reject (at 10% significance level in the SLS model). Therefore, the variable GOVERNMENT EXPENDITURE considered initially endogenous based on the theory of economic growth models, it really proves in the econometric robustness test to be endogenous to the government's readiness for artificial intelligence. Second, in both models, we test whether the instruments are uncorrelated with the error term, through Sargan and Basman tests in 2 SLS approach, whose results show that the null hypothesis that instruments are valid cannot be rejected (not significant at 1% and 5% levels for Sargan test and not significant for the Basman test). In the case of the LIML model, the tests obtained, Anderson-Rubin and Basman, illustrate the validity of the instruments (not significant at the level of 1% for Anderson-Rubin and not significant for the Basman test). Also, in the 2SLS model, we perform tests to study the explanatory power of the instruments, whose outcomes confirm that additional instruments (lnGDP, GOVERNANCE and AI BACHELOR) have significant explanatory power for AI IN GOVERNANCE after control

for the effect of the rest of the independent variables of the model (F statistic significant at 1% level). The minimum eigenvalue statistic as a test of weak instruments compared with critical values of 2SLS relative bias denotes that our instruments are not weak (the F statistic exceeds the critical value if we were willing tolerate a 10% relative bias).

As far human proxy is concerned, BRAIN DRAIN has a significant negative influence on AI IN GOVERNMENT, which shows that the increase in the flows of human flight and brain drain from a country that is losing human capital we are witnessing a reduction in the government's ability to implement and manage artificial intelligence in public services for citizens. There are only circumstantial indications within the cited literature suggesting a negative effect of brain drain on government AI readiness. Our findings are consistent with this body of literature (Czaika & de Haas, 2015; Siar, 2013; Brynjolfsson & McAfee, 2014; Dignum, 2019) and validate the main research hypothesis H1 that brain drain negatively affects AI in government.

The brain drain phenomenon can have a negative impact on a country's government's AI readiness, for several reasons:

1. Shortage of AI-skilled human resources can slow down or even stop the development and implementation of AI-based solutions in the public sector (Vicsek, 2021);

2. Brain drain can negatively affect the level of innovation in a country (Spence, 2021) (when AI experts leave the country, they take their knowledge and experience with them, which can lead to a decrease in scientific and technological advances in AI);

3. Brain drain can lead to a loss of investment in education and training: governments invest in the education and training of AI specialists, with the hope that they will contribute to the country's economic development and growth. When these specialists choose to work abroad, the government loses the benefits of its investments, while the host countries benefit from these talents;

4. Brain drain can create major difficulties in international collaboration: experts who leave their home country may be less interested in working with the government and institutions in their country of origin, which can make it difficult to access international knowledge and resource networks;

5. Brain drain can weaken ability to compete globally: as other countries attract talent into AI, they can become more technologically and economically competitive. At the same time, the country of origin could be left behind in the global AI race.

Adopting strategies can help governments counter the negative effects of brain drain on government AI training and develop an environment conducive to growing AI expertise and skills in the country. From the multitude of strategies that can be applied by governments, we present the most important ones:

1. Enhancing education systems: Investing in academic and research institutions to deliver superior AI programs, developing AI training and research initiatives, and fostering partnerships between universities, businesses, and governmental entities. Promoting STEM education: Encouraging interest in AI from an early school level through emphasis on science, technology, engineering, and mathematics.

2. Providing financial incentives and support: Allocating government funds for AI research and development and establishing a tax-friendly environment for companies developing and applying AI technologies.

3. Creating a conducive environment for innovation: Encouraging collaboration between public and private sectors to tackle societal and governmental issues via AI, and facilitating access

to essential infrastructure and resources for AI solution development and implementation (Bredt, 2019).

4. Attracting and retaining of AI talent: implementing favorable migration policies to attract and retain foreign AI talent; providing competitive and advantageous career opportunities in the public sector for AI specialists. Even more, the policy of increasing wages and benefits can also be applied (governments can increase wages and benefits for public sector AI professionals to encourage retaining and attracting talent. This strategy could also include the development of bonus schemes and other benefits that would attract and retain AI professionals in the country) (Agrawal et al., 2019).

5. International cooperation and knowledge exchange: participation in international AI alliances, partnerships and projects to benefit from the expertise and resources of other countries; promoting academic and professional exchanges in the field of AI to facilitate the transfer of knowledge and good practice; supporting cooperation between research and innovation institutions in different countries to work together in the development of AI solutions.

6. AI infrastructure development: governments can develop the infrastructure needed to support AI development, such as data centers, communication networks, and cloud computing infrastructure (Duan et al., 2019). This strategy could also include investments in the country's digital infrastructure, including connectivity and the development of advanced digital technologies.

Regarding the control variables of the models, the contribution of GOVERNMENT EXPENDITURE in strengthening the capacity of governments to implement artificial intelligence is confirmed and demonstrates a positive relationship with dependent variable: the higher the volume of government spending, the higher the government's readiness in artificial intelligence. The results confirm the general assumptions from previous literature (Wang & Cui, 2022; Bredt, 2019; Duan et al., 2019; Bose et al., 2007) and the resorts of such an interdependence are related to the innovative and relatively expensive technical character of the state's investments in the artificial intelligence infrastructure and software for the public services. Also, the personnel needed to develop and manage informatic applications and infrastructure based on artificial intelligence leads to significant government spending. Given the premise that governmental expenditures are directed towards enhancing the capability of governments to deploy artificial intelligence, the outcomes of the study empirically validate and substantiate Research Hypothesis H2, which posits a positive effect of such spending on AI government readiness in the European Union countries.

ECONOMIC FREEDOM is positively significantly associated with the government's ability to implement artificial intelligence (Ciftci & Durusu-Ciftci, 2022; Le & Kim, 2020; Okulich-Kazarin et al., 2020). The more economic freedom is experienced in EU countries, the more it creates premises for governments to adopt artificial intelligence. Drawing from the empirical findings of the study, Research Hypothesis H3, which posits that there is a positive effect of economic freedom on AI government readiness in the European Union countries, has been validated.

The financing by the European Commission of research & development firms for artificial intelligence projects is also found to be a significant determinant of increasing artificial intelligence in public administration (Spence, 2021). The higher the percentage of research & development companies that benefit from financing artificial intelligence projects, the more national governments benefit from scientific research results in artificial intelligence, which can be developed and implemented at government level. Upon rigorous examination of the data, Research Hypothesis H4, which postulates a positive effect of EU-funded projects for R&D on AI government readiness in the European Union countries, has been validated.

In the instrumental-variables regressions, GOVERNMENT EXPENDITURE is considered the instrumented variable, whose configurated instruments are lnGDP, GOVERNANCE and AI BACHELOR. Employing GDP as an indicator to assess the influence of AI on the economy has been beneficial for gauging governmental AI readiness. GDP, a prevalent metric of economic activity, when used to measure AI's impact, underscores the technology's significance for economic expansion. By monitoring AI's contribution to GDP, governments can achieve a more profound comprehension of AI's economic benefits and identify the sectors where AI can make the most substantial impact (Piasecki et al., 2021).

The development of Government Pillar of AI Index has been a positive development for government AI readiness. The index is a tool for assessing the readiness of governments for AI adoption, and it includes a range of metrics related to AI policies, regulations, and infrastructure. It provides the assessment of vision, governance and ethics, digital capacity, and adaptability of governments in AI implementation.

By using the index to benchmark their AI readiness, governments can identify areas for improvement and develop strategies to support the growth of AI in their countries.

The Government Pillar of AI Index also provides a platform for international comparison, allowing governments to assess their AI readiness in relation to other countries. This can help to promote competition and encourage governments to adopt policies and strategies that support the growth of AI in their countries.

As AI's role in shaping the future of work expands, its integration into University Bachelor's Programmes has gained importance. Governments globally acknowledge the significance of AI readiness and developing AI strategies for sustainable economic growth. The use of GDP and AI in University Bachelor's Programmes, as well as the development of Government Pillar of AI Index, have both had a positive impact on government AI readiness.

The drive to integrate AI into University Bachelor's Programmes stems from the increasing demand for AI skills in the job market. The application of AI tools is quickly becoming an integral part of numerous industries, including finance, healthcare, and manufacturing. Universities, by incorporating AI in their programmes, equip students with vital skills for the future workplace (Vicsek, 2021).

Moreover, this integration fuels innovation and economic growth. AI is a potent innovation tool, and the emergence of new AI technologies could stimulate new industries and jobs. Universities, by teaching students the skills needed to create and apply AI solutions, spur economic growth and pave the way for new opportunities for graduates.

In summary, the use of GDP as an AI impact measure, the creation of the Government Pillar of the AI Index, and the integration of AI into University Bachelor's Programmes have positively influenced government AI readiness. By tracing AI's economic benefits, providing a gauge for government AI readiness, and preparing students with essential skills for the future workplace, these initiatives bolster global governments' capacity to leverage the opportunities AI offers.

II.4.3.2. Cluster analysis

To establish groups of EU countries and discover their mutual similarities based on the set of independent variables associated with the government artificial intelligence readiness, we carried out the cluster analysis for the year 2022. EU countries are characterized by disparities in socio-economic development and unequal national evolution, especially as the states that joined the European Union in 2004 and 2007 (Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania,

Poland, Romania, Slovakia and Slovenia) experienced centralized communist economies until the early 1990s, have since passed through difficult periods of transition to the market economy and have had to overcome structural differences and gaps in their economies compared to those of the developed countries of the European Union. In addition, traditionally, national inequalities also derive from the different size of states, discrepancies in equipment and public technological infrastructure. The determination of homogeneous clusters of states in terms of AI implementation in government is quite challenging given the obvious conditions of heterogeneity exposed.

The clusters associated with the government artificial intelligence readiness index were developed through two categories of hierarchical clustering algorithm (complete linkage that produces spatially compact clusters and Ward's linkage where groups were joined to maximize an error-sum-of-squares objective function), which were applied to establish the groups of homogeneous states and which creates a hierarchy of clusters, based on dissimilarity measure in comparing two observations. The suitable number of clusters was established based on cluster stopping rules (Duda-Hart pseudo-T-squared small values and Calinski-Harabasz pseudo-F large values, which both indicated four clusters), as well as from the study of the dendrogram and graphic representation.

By applying the complete linkage and Ward's methods for year 2022, four countries clusters based on their similarities are obtained (Table II.4.3.2.-1.). The synthetic description of the characteristics of the countries in each cluster, according to the studied variables, confirms that the degree of implementation of artificial intelligence in public services is inversely proportionally with the brain drain phenomenon. Also, the positive associations of the dependent variable with spending expenses, economic freedom and research and development projects funded by the European Commission for AI companies are confirmed.

Table II.4.3.2.-1. Clusters by AI IN GOVERNMENT – complete linkage and Ward's methods

Group of country	AI IN GOVERNMENT dimension	Number of cluster - complete linkage method	Number of cluster - Ward's method
Countries with the average highest degree of government artificial intelligence			
Czechia, Finland, Netherlands, Luxembourg, Austria, Denmark, Estonia, Sweeden	High to medium (in terms of AI IN GOVERNMENT) Medium to low (in terms of BRAIN DRAIN) High (in terms of ECONOMIC FREEDOM and AI R&D FIRMS EC FUNDED PROJECTS) High to medium and low (in terms of GOVERNMENT EXPENDITURES)	Cluster 1	Cluster 1
Countries with high level of government artificial intelligence			
France, Germany	High to medium (in terms of AI IN GOVERNMENT) Medium (in terms of BRAIN DRAIN, ECONOMIC FREEDOM and AI R&D FIRMS EC FUNDED PROJECTS) High (in terms of GOVERNMENT EXPENDITURES)	Cluster 2	Cluster 3
Countries with moderate level of government artificial intelligence			
Belgium, Hungary, Italy, Greece, Portugal, Slovenia, Spain	Medium (in terms of AI IN GOVERNMENT) Medium to low (in terms of BRAIN DRAIN) High to medium (in terms of AI R&D FIRMS EC FUNDED PROJECTS) High to medium and low (in terms of GOVERNMENT EXPENDITURES) Medium to low (in terms of ECONOMIC FREEDOM)	Cluster 3	Cluster 2
Countries with low degree of government artificial intelligence			
Romania, Slovakia, Croatia, Latvia, Poland, Bulgaria, Lithuania	High to medium (in terms of AI IN GOVERNMENT) High (in terms of BRAIN DRAIN) Medium to low (in terms of GOVERNMENT EXPENDITURES, ECONOMIC FREEDOM) Low (in terms of AI R&D FIRMS EC FUNDED PROJECTS)	Cluster 4	Cluster 4

The geographical representation of the countries based on the main proxy BRAIN DRAIN compared with the cluster's representation in complete linkage methods are illustrated in Figure II.4.3.2.-1.1.

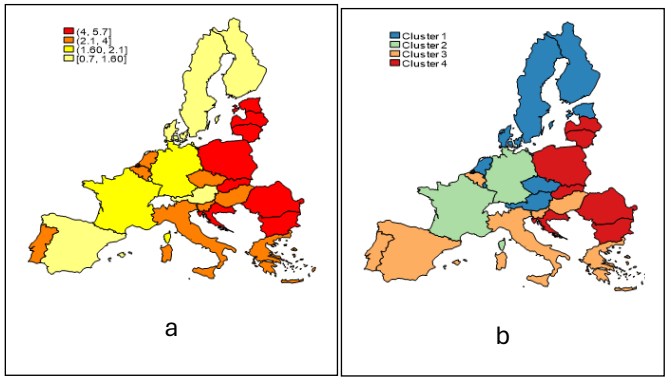


Figure II.4.3.2.-1. Geographical representation of the EU (24) countries based on: a – brain drain; b – Clusters in complete linkage method

The lowest values of core explanatory variable (BRAIN DRAIN) are in Romania, Bulgaria, Croatia, Slovakia, Poland, Latvia, Lithuania and Estonia. This group of states overlaps (with the exception of Estonia) with the last cluster obtained, cluster 4, determined on the basis of cluster analysis and containing states with low degree of government artificial intelligence. The similar type of correspondence between the two maps (Figure II.4.3.2.-1.) is found for the first three clusters, in the sense that the countries in categories 2, 3 and 4 after the decreasing volume of the brain drain are in distinct clusters and for the entire set of data analysis by the cluster method, in which all variables were considered in the AI government estimation (Figure II.4.3.2.-1.b and Table II.4.3.2.-2. For example, the countries with the lowest brain drain values (Finland, Netherlands, Luxembourg, Denmark, and Sweden) are included in cluster 1 with the average highest degree of government artificial intelligence. States such as Czechia and Austria, placed in cluster 1 and having medium brain drain values are in the first part of the states studied from the perspective of adopting AI in government. Estonia's case is a special one, in the sense that although it presents high values of brain drain migration flows, it has developed and consolidated AI in government, through targeted and successful national measures. Germany and France (cluster 2 in complete linkage method) present medium values in terms of brain drain and high level of government artificial intelligence, while the rest of countries (cluster 3 – Belgium, Hungary, Italy, Greece, Portugal, Slovenia, Spain) shows average to low brain drain values, as well as average values of AI in government. The analyzed geographical distribution reveals situations in which immediately neighboring states have the same type of behavior from the perspective of the clusters of belonging and the variation of the variables studied by the cluster analysis, which adds preliminary signals of influences between states, as we will study in the following through spatial analysis.

To determine if the selected independent variables have the potential to explain the evolution of the degree of implementation of the government artificial intelligence, we estimate a cluster multivariate regression model (Table II.4.3.2.-2.). The results display high rates of explanation of the chosen model for each independent variable (R-squared), as well as statistically significant outcomes of the F statistic, which indicates that the model has predictive capability.

Table II.4.3.2.-2. Clusters analysis for AI IN GOVERNMENT

AI IN GOVERNMENT	F	R-squared
BRAIN DRAIN	13.596***	0.671
GOVERNMENT EXPENDITURE	29.465***	0.815
ECONOMIC FREEDOM	10.468***	0.610
AI R&D FIRMS EC FUNDED PROJECTS	21.356***	0.762

Note: * Significant at 10%; ** Significant at 5%; *** Significant at 1%. Source: Authors' calculations using STATA.

II.4.3.3. Spatial analysis

After identifying the relationship between the variables studied by the instrumental-variables regression method and cluster countries analysis, another aim of the study is to find the spatial pattern of the data, more precisely whether AI IN GOVERNMENT and its determinants display agglomeration of high values with high values between countries, low values with low values or high values is grouped next to low values.

To perform the spatial analysis, we initially design a spatial weight matrix in the GeoDa software (Anselin et al., 2006), which defines the neighborhoods between states, in a binary format, in which if there is a common border between countries the value is 1 and otherwise 0. As the weight matrix cannot reflect the specific relationships between countries (human, economic or governance in our case), we develop the nested spatial weight matrix obtained by multiplying the adjacent matrix with the weight matrix for human, economic or governance distance from our data. We use the nested standardized matrix, which can reflect the spatial characteristics of neighboring countries, as well as the degree of interdependence between countries (Elhorst, 2017; Wang et al., 2023).

Based on nested matrix, we estimate the global Moran index *I* and obtain positive values of it and quite close to 1 for the explained and core explanatory variables (AI IN GOVERNMENT and BRAIN DRAIN) which indicates that these variables have a substantial positive spatial autocorrelation, and the data is grouped on the principle high-high or low-low (Table II.4.3.3.-1.). Values are also positive, but closer to 0 are obtained for control variables and show a lower degree of spatial grouping of observations. Overall, data presents significant spatial correlation and is suitable for their use in spatial models.

Table II.4.3.3.-1. Global Moran's I spatial correlation for the selected variable, year 2022

Variable(s)	Moran's I	p-value	z-value
AI IN GOVERNMENT	0.479	0.002	2.818
BRAIN DRAIN	0.699	0.000	3.930
GOVERNMENT EXPENDITURE	0.193	0.071	1.469
ECONOMIC FREEDOM	0.258	0.054	1.612
AI R&D FIRMS EC FUNDED PROJECTS	0.267	0.048	1.666

Note: * Significant at 10%; ** Significant at 5%; *** Significant at 1%. Standard errors are in round brackets.

Following the confirmation of the existence of spatial correlations, the spatial error regression model is examined. The robustness check of the model shows that the lambda parameter is significant (as are the Wald and Lagrange multiplier tests), and the values of variance ratio and squared correlation ensure a considerable predict of dependent variable through explanatory indicators.

From the empirical results (Table II.4.3.3.-2.) we can find that both core explanatory variable and control variables present statistically significant values of spatial correlation coefficients and explain government AI from spatial perspective between countries. The increasing BRAIN DRAIN

in neighboring countries has a spatial spillover effects or negative externality on the home country's AI IN GOVERNMENT. Also, the improvement of macroeconomic conditions (GOVERNMENT EXPENDITURE and ECONOMIC FREEDOM), as well as those for financing AI R&D (AI R&D FIRMS EC FUNDED PROJECTS) in neighboring countries are responsible for increasing the capacity of governments to manage AI adoption.

Table II.4.3.3.-2. Spatial Error Model regression results (source: authors' calculations using STATA)

AI IN GOVERNMENT	SEM
BRAIN DRAIN	–1.826*** (0.633)
GOVERNMENT EXPENDITURE	0.008** (0.003)
ECONOMIC FREEDOM	0.703*** (0.108)
AI R&D FIRMS EC FUNDED PROJECTS	22.039* (11.850)
Constant	5.595 (14.669)
Variance ratio	0.843
Squared correlation	0.825
Lambda	–0.466*** (0.127)
Wald test	13.378***
Lagrange multiplier LM test	4.594**

Note: * Significant at 10%; ** Significant at 5%; *** Significant at 1%. Robust standard errors are in round brackets.

Spatial analysis of the influence of brain drain on AI in government highlights regional and global inequalities in the development and deployment of AI technologies in the public sector. Addressing these inequalities requires concerted efforts by governments, academia and the private sector to develop a strong talent base in AI, encourage international collaboration and support the development of local AI solutions tailored to the specific needs of different governments.

Spatial analysis of the influence of the brain drain on AI in government highlights regional and global disparities in the development and implementation of artificial intelligence in the public sector. Brain drain refers to the migration of highly qualified specialists, including AI experts, from countries of origin to destinations with better opportunities, such as developed countries (Kapur & McHale, 2005). This talent migration can have a negative impact on governments' ability to develop and deploy AI solutions.

Regional imbalances in AI development can critically affect government efficiency in public service delivery and policy formation (Wirtz et al., 2020). Governments with AI talent access and the resources to realize AI solutions are better equipped to tackle complex social and economic problems, meeting citizen needs (Mikhaylov et al., 2018). Conversely, governments failing to attract and retain AI specialists could see their public service and policy management efficiency decline (Zajko, 2022).

The brain drain can exacerbate inequalities between countries in access to innovations and advanced technologies in AI. Countries that manage to attract and retain talent in AI can benefit from investment in R&D and accelerated economic growth (Singh & Krishna, 2018). The concentration of talent in AI in certain regions or countries can amplify differences in AI development and adoption in governments around the world. Developed countries, especially

Western European countries, have managed to attract many AI specialists, strengthening their AI positions. In contrast, developing countries and local governments may face difficulties in attracting and retaining AI talent (Banerjee & Duflo, 2019).

At the same time, countries affected by the brain drain may lag behind in the technological race, which may limit their ability to address social and economic problems and respond to citizens' needs (Sabry, 2021).

To address these spatial inequalities and encourage a more equitable development of AI in the public sector, governments need to consider several strategies. First, investment in education and research in AI should be encouraged and supported at local and regional level (Basri & Box, 2010). This can help develop a solid talent base in AI and create employment opportunities in the public sector (Yamashita et al., 2021). Second, international AI collaboration can be crucial to combat the brain drain and ensure that former communist EU countries have access to cutting-edge knowledge and technologies (Berger, 2022). Partnerships between countries and institutions can facilitate the transfer of technology and knowledge and contribute to the development of AI solutions tailored to the specific needs of different governments (Qin et al., 2023). Third, governments can encourage the development of local AI solutions and support small and medium-sized enterprises (SMEs) specializing in AI. Creating an innovative AI ecosystem can attract local and international talent and help build governments' capacities to implement AI in the public sector (Djeffal et al., 2022).

The findings lead to various inferences and recommendations. For public administrations, AI extends beyond being merely instrumental; it's a transformative catalyst with potential to reshape governance, policy formation, and public service provision. AI can help governments generate accurate predictions and simulate complex systems to experiment with different policy options (Margetts & Dorobantu, 2019). Hence, it's crucial for public servants to keep pace with AI advancements and comprehend its applicability for societal welfare (Reis et al., 2019).

Moreover, AI's role in government underscores the necessity for robust collaborations amongst public institutions, private enterprises, academic bodies, and civil society organizations. Such partnerships encourage knowledge exchange, resource sharing, and expertise pooling, which are vital for crafting AI systems tailored to governmental needs and goals.

It is important to note that brain drain impedes government AI development, as the emigration of AI professionals slows AI progress in public services, reducing expertise and innovation. This results in economic losses for governments, especially in resource-limited nations, and hampers international AI collaboration due to less cooperation from relocated experts. Such nations risk falling behind in the global AI race, while those retaining talent could advance technologically and economically. Government spending is key to AI readiness, and stable economic policies favor AI adoption. The European Commission's AI R&D investment underscores the need for ongoing financial support in this field.

Finally, addressing brain drain is vital for a nation's AI future, economic growth, and innovation. Governments must tackle these challenges with proactive strategies, fostering an environment conducive to AI progress for the benefit of all citizens.

II.4.4. Conclusions and policy implications

Given the intersection between Artificial Intelligence (AI) and brain drain, this study garners broad public interest by providing valuable insights, enhancing understanding of AI's impact on

society, economy, and environment and highlighting the need for governments to regulate and implement AI across various sectors.

This study offers nuanced understandings of the factors influencing AI government readiness within the European Union. Specifically, it delves into the potential negative repercussions of Brain Drain (RQ1) and the potential positive implications of EU-funded projects for R&D, economic freedom, and government spending (RQ2) on AI preparedness. Moreover, the research provides crucial insights into the interplay between brain drain and a country's influence on its neighboring states' AI adoption readiness (RQ3). These findings elucidate the significance of understanding both internal and external dynamics to enhance AI readiness and integration at the governmental level in the European region.

Our findings unequivocally indicate a negative correlation between brain drain and AI readiness in EU governments in 2022. This suggests that as brain drain intensifies, governments' preparedness to integrate AI diminishes. This correlation, coupled with the insights garnered from the spillover effects and the potential policy interventions, offers a comprehensive roadmap for EU nations to strategically address the challenges posed by brain drain in the realm of AI readiness.

Several implications arise from our findings:

Detrimental Effects of Brain Drain: Brain drain significantly undermines government AI readiness. Skilled AI professionals migrating abroad impede the progress and application of advanced AI in public services, confirming Hypothesis H1 and supporting existing research findings.

Innovation Lag: The migration of AI talent leads not only to a loss of expertise but also diminishes the potential for technological innovation within their home countries.

Economic Implications: When AI experts leave, their home countries lose the investments made in their education and training. This exacerbates economic difficulties, especially in resource-constrained nations.

Challenges in International Collaboration: The brain drain phenomenon can adversely affect international AI collaborations. Experts relocating abroad might become less willing to engage with their home countries, resulting in lost opportunities in international AI projects.

Global AI Race: Countries severely affected by brain drain risk falling behind in the international competition for AI advancement. In contrast, those retaining or attracting AI talent could see significant technological and economic growth.

Prominence of Government Expenditure: There is a notable correlation between government investment and AI readiness. Adequate government funding can substantially improve the public sector's AI capabilities.

The Role of Economic Freedom: An enabling economic environment is crucial for the adoption of AI in government. Countries with greater economic freedom typically have an easier path to AI integration, emphasizing the importance of stable and supportive economic policies.

European Commission's AI R&D Investment: The European Commission's funding in AI research and development has been pivotal. This investment is essential for advancing AI readiness, highlighting the importance of ongoing financial support in this field.

Chapter II.5. DOES CLIMATE CHANGE DRIVE UP GOVERNMENT HEALTHCARE COSTS IN THE EUROPEAN UNION?[8]

Environmental degradation is a pressing global issue today, negatively influencing the economy, human health, and environmental aspects such as air quality and ozone levels. A primary contributor to this degradation is the escalating trend of carbon dioxide emissions (Weimin et al., 2022). The release of greenhouse gases due to human activities has led to a discernible surge in global temperatures, and this has been linked to an escalation in the occurrence and intensity of heatwaves and hot summers (IPCC. Climate Change, 2021). Recent years are the hottest on record (European Commission, 2022). Europe faces irreversible climate effects, including biodiversity loss and more forest fires. Concurrently, heatwaves significantly impact human health, causing illnesses and deaths (European Parliament, 2018). Between 2030 and 2050, an additional 250.000 deaths per year could result from malnutrition, malaria, diarrhea, and heat stress, attributable to climate change (WHO, 2021).

Climate change contributes to the decline in human health, with most studies primarily emphasizing the negative physical health effects (Rocque et al., 2021). Upon entering the European Union, many nations, notably former communist states, underwent significant industrialization (Wawrzyniak, 2020). This surge in industry escalated carbon emissions until 2010, elevating temperatures. Anticipating this, the EU initiated climate strategies by 2008, introducing the Climate and Energy package. A key 2020 target was reducing emissions by 20% from 1990 benchmarks (European Parliament, 2023a). While emissions dipped post-2010, environmental and health impacts lingered. Spending on healthcare is pivotal for individual health and a country's economic progress (Lopreite & Zhu, 2020; Lopreite et al, 2023). The industrial boom and rising CO2 levels aggravated health issues, especially respiratory and heart conditions (Beatty & Shimshack, 2014). Medical expenses for treatment and preventive measures have surged, driving up healthcare costs and putting a strain on healthcare systems. Concurrently, the rise in average temperatures, resulting from higher emissions, affects human health in different ways. It leads to heat-related illnesses and tropical diseases in areas previously unaffected. Healthcare spending in this area has risen sharply. For example, heat-related hospital admissions have increased by 15% in the past decade in some EU countries, according to certain statistics (European Environment Agency, 2022). In 2022 alone, over 60.000 individuals in Europe died because of extreme heat, a figure three times higher than previous estimates. With the ongoing warming of the planet, this number is anticipated to increase annually (WHO, 2023). In 2019, the European Parliament declared a climate emergency, leading to the Commission's European Green Deal for a climate-neutral 2050. On 24th June 2021, the European Parliament adopted the climate law, mandating a 55% emissions reduction by 2030 and climate neutrality by 2050. This strengthens the EU's global leadership in combating climate change and led to a 2021 legislative package called "Fit for 55" (European Parliament, 2023b).

The environmental changes described earlier led to specific health issues that, in turn, increased healthcare costs. This chain of events paints a tangible picture of how industrialization and climate change have had economic impacts on public health. Europe stands out as a significant climatic focal point (van Daalen, et al, 2022), experiencing a warming rate almost 1°C above the global increase,

[8] This section is based on the article: Socol A, Iuga H, Socol D and **Iuga IC.** 2023. Does climate change drive up government healthcare costs in the European Union? *Frontiers in Environmental Science*, 11. https://doi.org/10.3389/fenvs.2023.1286099. WOS: 001129233700001

and surpassing any other continent (European Commission. Climate Indicators: Temperature, 2022). In 2019 the EU was the fourth largest greenhouse gas emitter after China, the United States and India (European Parliament, 2023c). Furthermore, projections regarding Europe's climate warn that unless robust measures are taken to mitigate and adapt, temperatures and their subsequent effects on health will escalate at an expedited pace (Ballester et al., 2023). In future projections (period 2021–2050 vs. 1981–2010), around 0.4% of the yearly number of respiratory hospital admissions (RHAs) in Europe are estimated to result from heat, based on the average predictions across climate change forecasts. In absolute numbers, represents approximately 26,000 cases annually in Europe (Åström et al., 2013).

The research question is positioned at the critical intersection between environmental conditions and healthcare economics and is based on the findings of previous literature in the actual context of climate change affecting human health: *Does climate change impact government healthcare spending in the European Union countries?*

This paper tackles a relatively novel subject, extending existing academic discourse on health and medical spending by analyzing various factors that influence healthcare expenditures. However, there are relatively few empirical studies on the impact of climate change on health spending, especially for EU member countries, but no study combines these factors with governance variables, human development variables and macroeconomic variables, simultaneously.

The aim of the study is to explore the relationship between healthcare expenditure (dependent variable) and specific climate change factors such as temperature and CO2. We add several control variables: governance, macroeconomic and human development variables. The study includes all 27 European Union member countries during the period 2000-2020. The main findings of this work can be summarized as follows: Increases in temperature and CO2 levels lead to higher healthcare spending. Enhancements in governance, increased GDP growth, inflation, and a rise in the human development index all contribute to growth in governmental healthcare expenditure. These findings weave together the themes and evidence presented, offering a comprehensive view of the subject matter.

The central objective of this study is to explore the impact of climate change using two specific climate change variables (temperature and CO2 emissions) on government health spending for all EU member states, based on data from 2000-2020. We also introduced several control variables, namely: governance, two macroeconomic variables (GDP and inflation) and a human development variable (Human development index). Human development index (HDI) is considered suitable for our analysis because represents essential aspects of human capabilities, while we employ the life expectancy indicator (LIFE) instead of the human development index only for robustness tests, evaluating the stability of their main outcomes. The rationale for this decision arises from HDI's structure and their study's emphasis: HDI combines three facets - health (quantified by life expectancy at birth), education (quantified by average adult schooling years and projected schooling for new students) and living standards (represented by Gross National Income per head). By using life expectancy as an alternative for HDI, we are isolating the health dimension (life expectancy) from the overall human development measure. In essence, they are aiming to assess how the results might differ when focusing solely on the health dimension rather than a more comprehensive development index that also encompasses education and income levels. The study primarily examines climate change's impact on health spending. Life expectancy is a pertinent gauge of health outcomes in a population and using LIFE allows us to delve deeper into how climate variations potentially affect health results and, in turn, health expenditures.

To the best of the authors' knowledge, this is a pioneering study on the subject, considering all relevant variables. The results will help decision makers gauge how climate change affects health care spending and how GDP, governance, inflation and the human development index affect government health care spending in selected countries. Moreover, to ensure the robustness of the model, we additionally used other indicators from the above-mentioned groups (e.g. GDP per capita growth, used interchangeably with GDP per capita, life expectancy used instead of Human Development or individual variables from Worldwide Governance Indicators studied alternately instead of the Governance variable, determined by the method of Principal Component Analysis from Worldwide Governance Indicators).

The innovation of this paper lies in its comprehensive, pioneering approach to examining the effects of climate change variables (specifically temperature and CO2 emissions) on governmental health expenditures in all EU member states from 2000-2020, while also incorporating additional control variables like governance, macroeconomic factors, and human development indices.

While there is vast literature exploring the climate change or healthcare government challenges, there remains a scarcity of research specifically examining the interplay between the specific two dimensions – climate change expressed by average temperature and CO2 emissions on the one hand and government spending on health on the other - especially within the unique context of the European Union. This gap in understanding becomes particularly significant given the current manifestations of global warming and requires an integrative analysis that holistically examines how climate change might affect government spending on health and how these dynamics manifest themselves in the EU's interconnected landscape and how the relationship between climate change and health spending is affected by governance variables, macroeconomic or human development. This study endeavors to bridge this gap, offering insights that can inform both policy-making and future academic pursuits.

This study enhances the current literature in four significant ways. Firstly, it contemporaneously addresses both temperature and CO2 emissions concerning climate. Secondly, it incorporates control variables such as governance, macroeconomic elements, and human development indicators. Thirdly, all empirical models are validated by robust tests that show strong evidence of long-term relationships between variables and produce effective empirical results that are indeed plausible for policy engagement. Fourthly, the paper presents a set of political implications that state governments can consider.

Political Implications: Healthcare spending should consider the increased burden on health units during periods of extreme temperatures. The findings of this research underline a crucial connection between climate change and a rise in healthcare spending within the European Union, holding substantial implications for policymakers. The data emphasizes an immediate need to focus on both environmental conservation and public health. By showcasing the financial consequences of health problems associated with climate change, the results advocate for the incorporation of climate change prevention methods and adaptation into healthcare strategies. Using improved governance, economic growth, and an emphasis on human development, a comprehensive strategy can be developed to lessen healthcare expenditure and enhance the overall well-being of society.

II.5.1. Climate Change and Healthcare Spending: A Literature Overview

The nexus between climate change and healthcare expenditure is becoming increasingly visible. Stern (2007) notes a 0.7°C rise in global average temperature over the past century, raising global concerns. The World Health Organization confirms this, stating that heatwave exposure impacted 125

million people from 2000-2016, increasing health risks (WHO. Heat and Health, 2018). Complementing this, Zammit et al. (2021) argue that even a single-degree uptick in temperature due to global warming activates an acclimatization process that, if sustained, triggers pathways leading to neurodegeneration, like oxidative stress and excitotoxicity. Meanwhile, Tong et al. (2021) caution that such heatwaves lead to a surge in heat-related ailments - heat exhaustion, heatstroke, dehydration - requiring medical intervention and straining healthcare budgets. These interconnected findings heighten the urgency for addressing climate change's multifaceted impact on health. Such conditions often necessitate urgent medical care and hospital admissions, resulting in elevated healthcare costs. For example, during extreme heat events, hospitals may see a surge in admissions, putting strain on healthcare systems and requiring additional resources to treat affected individuals (Boz and Ozsari, 2020).

Increasing temperatures can change the habitats of disease-bearing vectors such as mosquitoes, facilitating the spread of illnesses like malaria and dengue fever into previously unaffected regions (Chowdhury et al., 2018). The public health measures required to address this expansion, including prevention, diagnosis, treatment, and containment, collectively contribute to increased healthcare costs and implicitly on government health expenditures. Increased temperatures can raise ground-level ozone levels, leading to respiratory issues (WHO. Heat and Health, 2018), particularly in urban locations. Addressing and treating these health concerns necessitates financial investments in healthcare services as well as measures to control environmental conditions.

Climate change and the associated increase in extreme weather events can impact healthcare infrastructure. For example, heatwaves may require hospitals to upgrade cooling systems, while rising sea levels and storms can damage healthcare facilities, necessitating repairs and improvements (Sasmaz et al., 2021).

Governments must anticipate these climate-related health risks and integrate them into healthcare planning. This involves investing in preventive measures such as early warning systems for heatwaves, improving healthcare infrastructure to withstand extreme weather events, and developing public health campaigns to educate the population about the risks associated with temperature extremes (Schneider, and Breitner, 2016).

The link between temperature and health spending is not isolated from broader economic factors. For example, the increased need for healthcare services during extreme temperature events may strain existing healthcare resources (Wondmagegn et al., 2019), leading to potential cost increases across the system (Fotourehchi & Çalışkan, 2018).

The impact of temperature on health spending also has social dimensions. Vulnerable populations may be disproportionately affected by temperature-related health issues, requiring targeted interventions. Addressing these disparities may necessitate additional spending on social support programs and tailored healthcare services.

Considering these, we can formulate the research hypothesis of this study:

Hypothesis 1 (H1): Rising temperatures lead to increased government health spending.

CO2 and government health spending nexus

Several theories in the literature elucidate the relationship between CO2 emissions and government health expenditure (Sohail et al. 2023): 1. Nightingale's Environmental Theory: Florence Nightingale emphasized the significance of a pristine environment, including clean air, for optimal health. CO2 emissions, a contributor to air pollution, when unchecked, can escalate healthcare

expenses due to pollution-induced ailments. 2. Life Course Health Development (LCHD) Framework: This framework accentuates health as an evolving process influenced by various determinants like biology, environment, and social context. Within this, CO2 emissions, an environmental determinant, can profoundly influence health. Resultantly, governments might escalate health budgets to tackle and preempt related health issues. 3. Carbon Dioxide Theory: This theory posits that surging CO2 levels elevate global temperatures, leading to heat-driven health issues and the spread of diseases. These health challenges can amplify governmental health costs. 4. Systematic Linkage Model: The Systematic Linkage Model connects health spending and carbon emissions, advocating for energy-efficient medical gear. This approach mutually benefits environmental sustainability and reduces operational costs. 5. Environmental Kuznets Curve (EKC): This theory suggests an inverse U-shaped connection between per capita income and environmental degradation. Initially, economic growth intensifies pollution, but after reaching a specific income threshold, the environment starts benefiting from continued economic progress. Wang et al. (2023) found that in the long term, social globalization, energy, and economic growth influence CO2 emissions. Sohail et al. (2023) indicate that specific economic stages may necessitate more healthcare investment to address health issues caused by CO2 emissions.

Global greenhouse emission concerns urge decision-makers worldwide to prioritize the environment, assess their ecological footprint, and find methods to enhance environmental quality (Nuţă et al., 2015). The desired climate neutrality that has been on the agenda of governments in recent years is, however, profoundly influenced after 2022 by manifestations of the energy crisis, against the background of the geo-political conflict of Ukraine, which negatively influences energy markets, studied between February and October 2022 (Chishti et al., 2023c).

Researchers globally, using varied methods, concur that rising CO2 emissions adversely impact public health and consequently inflate healthcare spending. The consensus underscores the urgency to address CO2 emissions for both health and economic reasons. They have concentrated their research on different regions and countries: Malaysia (Samah et al., 2020), USA (Gündüz, 2020), West Africa (Oyelade et al., 2020), Southeast Asia (Taghizadeh-Hesary & Taghizadeh-Hesary, 2020), 33 OECD countries (Akbar et al., 2021), BRICS countries (Li et al., 2022), Brazil (Travassos et al., 2020), Canada (Jerrett et al., 2003), China (Jia et al., 2021), Iran (Raeissi et al., 2018), Latin America (Koengkan et al., 2021), MENA countries (Khoshnevis & Khanalizadeh, 2017).

Kim et al. (2017) discovered that the 1997 wildfires' effects on individuals persisted for over a decade. Isen et al. (2017) demonstrated the impact of clean air legislation on increased earnings in adulthood due to reduced exposure to pollutants in childhood. Chaabouni et al. (2016) found unidirectional causality between CO2 emissions and health spending in 51 countries between 1995 and 2013. Usman et al. (2019) observed that climate change factors, i.e., air pollution, had two indicators; namely, CO2 and temperature, and showed a significantly positive relationship with government spending on health in 13 emerging economies from 1994-2017.

Developing on a highlighted literature gap, Zhang et al. (2023) innovatively construct a health quality index, which is used as a dependent variable for China's case from 1980 to 2020 and demonstrates by applying the VECM method that CO2 emissions negatively impact health quality.

This circumscribes the second hypothesis of the research:

Hypothesis 2 (H2): Increasing CO2 emissions lead to increased government health spending.

The connection between control variables and government health spending

Rising neglect and unawareness in areas like CO2 emissions and healthcare spending jeopardize global health (Sohail et al., 2023). There are numerous studies that argue that *GDP* influences health spending (Azam & Awan, 2022; Samudram et al., 2009; Wang et al., 2019; Zaidi & Saidi, 2018). They all claim that GDP positively and strongly influences health spending. In their 2019 study, Wang and colleagues utilized yearly time series data spanning from 1975 to 2017 to investigate the long-term interconnection between health spending, CO2 emissions, and GDP per capita. They employed the bootstrap ARDL cointegration model for this analysis, focusing on 18 countries listed by the World Health Organization and the Organization for Economic Cooperation and Development (OECD). Their primary findings indicate a positive correlation among the three studied variables. Kutlu and Örün's (2022) study reveals that in 21 OECD countries from 1992-2018, CO2 emissions and GDP per capita have a positive impact on health spending. The results of their study conclude that the effect of carbon dioxide (CO2) emissions, urban population and GDP per capita are significant and positive on health expenditure. OECD countries' recent rapid economic growth and environmental pollution have increased long-term health spending. Other researchers, for example, Javaid et al. (2023) found through regression analysis that GDP significantly impacts CO2 emissions both in the short and long term, indicating that GDP compromises environmental sustainability by elevating CO2 emissions. Environmental performance proves to be essential in establishing integrated sustainable development profiles of companies (Ma et al., 2022). Precursors of economic growth, foreign direct investment is a catalyst for pollution and significantly potentiates the export of highly polluting goods, as resulted from the study developed for five ASEAN countries between 1990 and 2019 (Salam & Chishti, 2022). Environmental policies simultaneously with circular economy and energy transitions contribute to global sustainable electricity generation and implicitly to sustainable development (Chishti et al., 2023b).

GDP, a crucial economic indicator, significantly influences healthcare expenditure (Efthalitsidou et al., 2021). A robust GDP often leads to higher public and private healthcare allocations, enabling more advanced treatments and facilities (Onisanwa, 2014). Affluent countries typically invest a larger portion of their budget in healthcare, improving its quality and availability (Barati & Hadiseh, 2020). Furthermore, GDP growth enhances individual purchasing power, rendering healthcare services more accessible. Higher incomes also encourage investment in preventative care and expensive treatments, thus elevating health expenditure (Chaabouni & Saidi, 2017). A strong GDP creates a stable economic environment, attracting investment in healthcare infrastructure such as hospitals and research centers (Rodríguez & Nieves Valdés, 2019). These developments necessitate sustained spending for upkeep and staffing. Additionally, a high GDP often leads to increased government revenue through taxation (Ullah et al., 2023), which may be channeled into public health initiatives, vaccination programs, and subsidized healthcare, thereby boosting overall healthcare spending. Moreover, a high GDP can lead to the implementation of various solutions, for example artificial intelligence, to combat climate change by analyzing data and predicting the results. Artificial intelligence helps develop sustainable solutions, optimize resources and minimize carbon emissions for a sustainable future (Firdaus et al., 2022). The ideal of future development of economies is mandatorily linked to green innovations, which contribute decisively to green economic growth, as recent study has shown based on innovative econometric methods (Wavelet Quantile Correlation and Wavelet Transform Causality), for the case of G-7 economies (Zaman et al., 2023). Climate mitigation technologies is impacted by GDP, as well as natural

resources, monetary policy, environmental taxes and economic globalization, as evidenced by a study developed for G-7 economies (Chishti & Patel, 2023).

Economic studies highlight multiple factors elevating health spending, with economic growth being the most scrutinized demand driver. To a lesser extent, another macroeconomic factor, *inflation*, was also investigated. The existing studies find that the relationship between health expenditure and inflation to be positive: inflation significantly increases health spending (Siami-Namini, 2018; Dunn et al., 2018; Yip et al., 2017; Cheng & Nopphol, 2019; De la Maisonneuve et al. 2017; Jakovljevic et al. 2017). For example, the results of the study by Azam and Awan (2022) conclude that inflation significantly increases health spending in sample economies (15 Asian countries from 2000Q1-2017Q4). Siami-Namini (2018), in his study found that inflation rate positively and significantly affected health expenditure in G7 countries during 1995-2015.

Inflation, the overall increase in prices and decrease in the purchasing value of money, can substantially influence health spending. When inflation rates rise, the cost of goods and services typically follows suit. Inflation can increase healthcare costs, including medical supplies, medications, and labor. This rise in operational expenses often results in increased out-of-pocket costs for patients, reducing healthcare affordability (Dunn et al., 2018). Additionally, public healthcare funding can also be affected. If a government's budget allocation for healthcare remains static while inflation is increasing, the real value of that funding diminishes. This reduction can lead to a lower quality of healthcare services, as resources become scarcer. It may necessitate cutbacks in services, a decline in staff-to-patient ratios, or limits on the availability of new, potentially more effective, but more expensive treatments (Yip et al., 2017). Moreover, inflation affects income levels. Nominal wage increases may not keep pace with inflation, impacting real income and healthcare affordability. This is especially tough for fixed-income groups, such as retirees, as rising healthcare costs consume a greater share of their unchanging income (Cheng & Nopphol, 2019). Lastly, high inflation rates can deter investment in healthcare infrastructure. Uncertain economic conditions make it risky for both public and private sectors (Koijen et al., 2016) to invest in long-term projects like hospitals or medical research facilities, thereby affecting the quality and accessibility of healthcare in the long run (De la Maisonneuve et al. 2017; Jakovljevic et al. 2017).

Little is known about the link between governance and health expenditures. Rahman et al., 2018 argue in their paper that spending should be managed through proper *governance*. It is acknowledged that research reveals positive outcomes between governmental health expenditures and governance (Jakovljevic et al., 2016; Ray & Linden, 2020; Kaur, 2020). Effective governance is crucial for directing health spending and ensuring quality healthcare. Strong governance structures aid in the strategic allocation of resources and the formulation of well-funded, comprehensive healthcare policies in both developed and developing countries (Nakatani et al., 2023). Such policies not only aim to improve the infrastructure but also address systemic issues like healthcare inequality. Conversely, poor governance often results in ineffective policies, plagued by corruption or bureaucracy, that may lead to misallocation of funds (Kim et al., 2017). On the other hand, governance is key in revenue collection and allocation. A transparent and efficient tax system can generate more public revenue, a portion of which can be allocated to healthcare. In countries where governance is poor, revenue often leaks through corruption, reducing the funds available for public health (Maugeri et al., 2023). Governance impacts the regulatory environment and effective governance can ensure the regulation of healthcare prices, quality of medical services, and even the conduct of healthcare professionals. This, in turn, can help in controlling expenditures and increasing the efficacy of healthcare services. Poor regulatory frameworks can result in inefficiencies that

balloon healthcare costs (Raeesi et al., 2018). Governance can also influence healthcare spending through international partnerships. A government with strong international relations can secure funding or expertise from international organizations or more developed nations. Such partnerships can lead to an increase in healthcare spending that is both efficient and effective (Kochuvilayil et al., 2023). The role of governance extends to crisis management, which was particularly evident during the COVID-19 pandemic. Well-governed countries have been more effective in securing necessary funding for healthcare services in times of crisis, ensuring the continuity and quality of care (Makin & Layton, 2021).

The rise in health expenditures is intricately linked to improvements in the *Human Development Index*, yet it is also influenced by the escalating challenges posed by climate change on public health. In fact, in an extended approach, human capital has favorable effects on the efficiency of sustainable development, as evidenced by the instrumented study of the provinces of China between 1998 and 2017 (Chishti et al., 2023a). Human development, measured through indicators like education, income, and life expectancy, significantly influences health spending. For example, a more educated population tends to be more aware of the importance of healthcare and preventive measures, leading to higher healthcare consumption (Biadgilign et al., 2019). Human development influences health spending in interconnected ways. Longer life expectancy results in an older population requiring more healthcare, thereby increasing expenditure (Brooks et al., 2005). Simultaneously, societal progress brings advanced, albeit expensive, medical technologies into common use. Higher incomes and increased awareness further fuel this demand. As social infrastructure improves, governments in developed nations expand public healthcare benefits, raising national health budgets (Miranda-Lescano et al., 2023). Urbanization, another byproduct of development, brings unique healthcare needs (Lin & Guo, 2023) like stress management and pollution control, necessitating specialized services and escalating costs (Shao et al., 2022). Development also means greater integration into the global economy, leading to increased risks like pandemics that require substantial health expenditure to manage (Pervaiz et al., 2021). These factors create a cycle where development and health spending are intrinsically linked, each reinforcing the other.

II.5.2. Methodology and data

To analyse the influence of climate change on health expenditure, we use data from 27 European Union (EU) countries over the period 2000-2020, considering the average temperature and CO2 emissions as proxies for climate change. The motivation for choosing these countries and the analysis interval is based on the common post-2000 history of most EU countries, given that 13 of the 27 component countries joined after 2000 (10 in 2004, 2 in 2007 and one in 2013). Thus, the analysis interval captures new EU states at about a decade of experimentation with free democratic regimes, after about four decades of totalitarian regimes.

To determine the impact of climate change on health expenditure, this study performs the dynamic panel system GMM method (Generalized Method of Moments) and the panel VAR Granger causality method technique. Compared to previous literature explaining the impact of climate change on health spending by exploring its direct effects, our study also looked at the moderating effects of various factors, such as economic, governance or human development.

Table II.5.2 presents the variables and data sources. The dependent variable refers to health expenditure and the core explanatory variables that reflect climate change are average temperature and CO2 emissions. Climate change is a major concern for public health, and experts consider temperature increase the biggest threat to climate change, which makes the target of limiting the

increase in global average temperature to a maximum of 1.5°C by the end of the twenty-first century to be set by the Intergovernmental Panel on Climate Change (Hayashi et al., 2022). In line with previous literature (Karahasan & Pinar, 2023), this study considers the average temperature as a proxy for climate change, especially due to the direct mechanisms by which the Earth's surface temperature reflects its specific energy balance (atmospheric air temperature rises or falls, under the influence of a combination of factors - solar radiation, heat inside the Earth, greenhouse gases, etc.). CO2 emissions is considered indicator of climate change in our study, as similar research considered them (Cengiz & Manga, 2022), starting from their significant percentage in greenhouse gas emissions and their defining role in heat capture and global warming. The climate future of the planet depends on the effectiveness of CO2 mitigation policies, which makes the main drivers of CO2 emissions - human activity, economic development or carbon intensity - the subject of national and inter-state analyses, in the fight against global warming.

Table II.5.2. Variables and data sources

Variables / Symbol	Description / Unit	Data source
Dependent		
Health expenditure / HEALTHEXP	Domestic general government health expenditure (% of general government expenditure)	The World Bank, World Development Indicators database, https://databank.worldbank.org/source/world-development-indicators
Core explanatory – Climate change		
Average temperature / TEMP	Average of air temperature recordings from weather stations on land and sea as well as some satellite measurements (°C)	Climate Change Knowledge Portal, https://climateknowledgeportal.worldbank.org/download-data
CO2 emissions / CO2	CO2 emissions (metric tons per capita). Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring.	The World Bank, World Development Indicators database, https://databank.worldbank.org/source/world-development-indicators
Control variables		
Governance		
Governance / GOV	Indicator obtained by Principal Component Analysis from Worldwide Governance Indicators: Voice and accountability, Political stability and absence of violence / terrorism, Government effectiveness, Regulatory quality, Rule of law and Control of corruption	The World Bank, World Development Indicators database, https://databank.worldbank.org/source/world-development-indicators
Macroeconomic determinants		
GDP per capita growth / GDPPPG	Gross Domestic Product per capita growth (annual %). Annual percentage growth rate of GDP per capita is based on constant local currency.	The World Bank, World Development Indicators database, https://databank.worldbank.org/source/world-development-indicators
Inflation / INFLA	Inflation, consumer prices (annual %)	The World Bank, World Development Indicators database, https://databank.worldbank.org/source/world-development-indicators
Human development		
Human Development Index / HDI	Human Development Index	The United Nations Development Programme, https://hdr.undp.org/data-center/documentation-and-downloads

To control the macroeconomic level, this study uses Gross Domestic Product per capita growth rates and annual inflation rates, while to control the institutional country's factors, the Worldwide Governance Indicators are employed. These Worldwide Governance Indicators capture six

dimensions of governance: Voice and accountability, Political stability and absence of violence / terrorism, Government effectiveness, Regulatory quality, Rule of law and Control of corruption. We use Principal Component Analysis to create a single comprehensive variable of governance, based on the mentioned Worldwide Governance Indicators. To estimate the effects of human development, we utilize Human Development Index, that measures the main dimensions of a long and healthy life, education and decent standard of living.

To study the influence of climate change impact on health expenditure in the European Union (2000-2020), we employ the following dynamic panel data model:

$$\mathrm{HEALTHEXP_{i,t}} = \propto_0 + \propto_1 \mathrm{HEALTHEXP_{i,t-1}} + \propto_2 \mathrm{TEMP_{i,t}} + \propto_3 \mathrm{CO2_{i,t}} + \propto_j \mathrm{Control_{i,t}} + \mathrm{u_{i,t}} \quad (1)$$

$$\mathrm{HEALTHEXP_{i,t}} = \propto_0 + \propto_1 \mathrm{HEALTHEXP_{i,t-1}} + \propto_2 \mathrm{TEMP_{i,t}} + \propto_3 \mathrm{CO2_{i,t}} + \propto_4 \mathrm{GOV_{i,t}} + \propto_5 \mathrm{GDPPPG_{i,t}} + \propto_6 \mathrm{INFLA_{i,t}} + \propto_7 \mathrm{HDI_{i,t}} + \mathrm{u_{i,t}} \quad (2)$$

where *i* represents the country, *t* is the period (years), $HEALTHEXP_{i,t-1}$ represents 1-year lag of HEALTHEXP, *Control* denotes control variables, *TEMP* is average temperature, *CO2* represents CO2 emissions, *GOV* is governance, *GPPPPG* is GDP per capita growth, *INFLA* reflects inflation, HDI is Human Development Index (as they are set in Table II.5.2.), α_0 is constant (intercept), $\alpha_{1,2,3,4,5,6,7}$ are the coefficients of the estimated parameters and $u_{i,t}$ is the error term. The variables TEMP and CO2 are considered in modelling in their form of first difference, temperature variation and CO2 emissions variation respectively.

System GMM (Roodman, 2009; Blundell & Bond, 1998; Arellano & Bond, 1991) was selected as the appropriate dynamic panel technique method for this study because it has the ability to address types of data such as those collected by us, in terms of panel size (21 years and 27 states) and adequately manages heteroscedasticity, serial correlation, cross-sectional dependence and endogeneity, respectively reverse causality problems between variables (Asteriou et al., 2023; Gerged et al., 2023; Kumar et al., 2022; Sarafidis & Wansbeek, 2012). We opted for the Generalized Method of Moments (GMM) over other methods for several key reasons:

1. GMM is well-suited to handle potential endogeneity issues, which arise when one or more explanatory variables are correlated with the error term. This is particularly relevant when studying dynamic relationships over time, as with the impact of climate change on healthcare expenditure. The VAR Granger panel analysis proven that there is causality between the analyzed variables, so the endogeneity is present, because the simultaneity is considered a marker of endogeneity (when two variables simultaneously influence each other) (Chatterjee & Nag, 2023; Labras & Torrecillas, 2018; Wintoki et al., 2012).

2. The study spans two decades (2000-2020), making the data both cross-sectional (across the European Union member states) and time-series. GMM is designed for such dynamic panel data, efficiently accounting for both within (across time for the same country) and between (across different countries) variations.

3. GMM can effectively use lagged values of variables as instruments, allowing the model to account for previous periods' influence on current outcomes. This is especially valuable when studying cumulative effects, such as the long-term impact of CO2 emissions on healthcare spending.

The choice of GMM and panel VAR Granger causality methods for this study is motivated by the need to provide reliable and efficient estimates that consider potential endogeneity, capture the dynamic interrelations between variables, and ascertain the direction of causality, all while addressing the specific challenges and complexities posed by the study's focus on the EU countries' diverse landscape. One of the main advantages of the GMM method is its ability to manage endogeneity concerns. Given the potential for certain factors, like health expenditure, to be influenced by past values or other endogenous variables in the model, GMM is apt for such estimations. Moreover, the GMM estimator uses lagged values of the variables as instruments, which helps in achieving consistent and efficient estimates, especially when the panel has a short time dimension and a larger cross-sectional dimension, as in the case of 27 EU countries over 20 years. For heterogeneity point of view, GMM considers unobserved country-specific effects, which are crucial when analyzing diverse EU countries with varying histories, economies, and health systems. Regarding the Granger causality technique, it allows to establish the direction of causality between variables. In the context of climate change and health expenditure, it's imperative to discover if changes in climate indicators lead to variations in health spending, or vice versa. Also, panel VAR model is suitable to examine the dynamic interdependencies between multiple variables over time. Given that the study isn't just about the direct impact of climate change but also about the moderating effects of economic, governance, or human development factors, a panel VAR can capture these complex interrelations.

To check the robustness and sensitivity of our findings, we have alternatively used instead of explanatory variables other indicators that capture similar facets of the same types of phenomena (e.g. GDP per capita growth, used interchangeably with GDP per capita, life expectancy used instead of Human Development or individual variables from Worldwide Governance Indicators studied alternately instead of the Governance variable, determined by the method of Principal Component Analysis from Worldwide Governance Indicators).

The data were preliminarily tested by analyzing the classical assumptions of regression models studied for the chosen variables: multicollinearity, stationarity, cross-sectional dependence, heteroskedasticity, cointegration, serial correlation and normality (Maladjian & Khoury, 2014). Attention has been paid to the phenomenon of endogeneity, which is not as often analyzed as would be required in econometric analyzes, because ignoring it can lead to inconsistent results (Ibrahim and Arundina, 2022; Ullah et al., 2018). Three major sources of endogeneity are presented in the literature: unobserved heterogeneity (when the relationship between two or more variables is influenced by an unobservable factor), simultaneity (when two variables simultaneously influence each other), and dynamic endogeneity (when the present value of a variable is influenced by itself, or other variables' past values) (Chatterjee & Nag, 2023; Labras & Torrecillas, 2018; Wintoki et al., 2012). We applied PVAR Granger causation tests (Granger, 1969; Lopez & Weber, 2017), to study whether there is reverse causality between variables and we used the system GMM method, which takes into account the effect of lag of the dependent variable on it and has the potential to effectively manage endogeneity. Econometric data were processed using STATA.

II.5.3. Results and discussions

The descriptive statistics of the variables are presented in Table II.5.3-1, which provides an overview of inhomogeneous developments between states and the period under review. The average HEALTHEXP value is 12.816%, ranges from 5.741% to 20.578%, with a standard deviation of 2.730, which denotes a medium dispersion from the mean. The analysis of the evolution of government health expenditures shows an increasing trend of their level in the analyzed period from year to year,

less in 2020 compared to the previous year, behavior that proves to be atypical in this general pattern of growth of about 20 years and which must be understood amid the manifestations of the COVID-19 pandemic and related population mobility restrictions and which led to fewer cases of presentation of those who needed medical care in the medical system and thus generated lower costs. The year 2020 is also atypical in terms of average temperature values, which decreased compared to the previous year, amid the reduction of pollution attributable to mobility restrictions. As for climate change variables, they show significant differences between states. In the case of the annual average temperature, it presents a minimum value of 0.910°C and a maximum value of 20.350°C, explained by the geographical extent of the analyzed states and the existing climate types. CO2 emissions record values within a wide range, between 2.972 mt per capita and 25.610 mt per capita, significant differences between states and the analyzed period, with an average of 7.512 and a standard deviation of 3.509. The GOV variable, obtained through the Principal Component Analysis process (out of the six dimensions of Worldwide Governance Indicators), is between the minimum of -5.509 and the maximum of 4.157, with a standard deviation of 2.259, compared to the average of 0.000 and characterizes a group of nations differently governed and institutionally developed during the analyzed period. The macroeconomic variables, GDPPPG and INFLA, also characterize a conglomerate of heterogeneous states that have gone through different periods of developments. GDP per capita growth varies between negative values of -14,464% and maximum positive values of 23.201%, which illustrate a high degree of inequality in the evolution of the economies. Regarding the levels of economic development of the analyzed states, the chosen analysis horizon captures the 27 EU states in different stages of economic growth or recession, different levels of economic evolution, as well as recovery rates from various difficult situations. Inflation is between a minimum value of -4.478% and a maximum of 45.667% and given an average of 2.477. HDI presents smaller fluctuations in relation to the rest of the indicators, has an average of 0.866 and a standard deviation of 0.048.

Table II.5.3-1 Descriptive statistics

Variables	Obs.	Mean	Std. Dev.	Minimum	Maximum
HEALTHEXP	567	12.816	2.730	5.741	20.578
TEMP	567	10.629	3.896	0.910	20.350
CO2	567	7.512	3.509	2.927	25.610
GOV	567	0.000	2.259	-5.509	4.157
GDPPPG	567	2.018	3.957	-14.464	23.201
INFLA	567	2.477	3.320	-4.478	45.667
HDI	567	0.866	0.048	0.715	0.948

Source: Authors' processing.

The preliminary investigation of the variables starts with the analysis of multicollinearity between variables (Table II.5.3-2), whose results denote that the variables are not correlated, the value of the correlation coefficients obtained being below the critical threshold (considered to be approximately 0.8) (Vatcheva et al., 2016). VIF (Variance Inflation Factor) was also studied, whose average value for the entire panel is 1.68 and with unit values of maximum 2.9, which indicates the absence of multicollinearity (Koengkan et al., 2019).

Table II.5.3-2. Correlation matrix of the variables (multicollinearity)

VARIABLES	HEALTHEXP	D.TEMP	D.CO2	GOV	GDPPPG	INFLA	HDI
HEALTHEXP	1.000						
D.TEMP	0.026	1.000					
D.CO2	-0.091	-0.215	1.000				
GOV	0.538	0.008	-0.095	1.000			
GDPPPG	-0.155	0.083	0.327	-0.159	1.000		
INFLA	-0.221	-0.014	0.107	-0.282	0.201	1.000	
HDI	0.615	0.073	-0.197	0.729	-0.327	-0.486	1.000

Source: Authors' processing.

The study of the stationarity of data (Table II.5.3-3) was performed through the Levin-Lin-Chu (LLC) and the Phillips-Perron (PP) tests (with demean option for managing cross-sectional dependence) (Levin et al., 2002; Perron & Vogelsang, 1992). The null hypothesis that all panels contain unit roots is rejected for all variables and the stationarity is demonstrated. Cross-sectional dependence analysis (Table II.5.3-3) was obtained with the Pesaran test (Pesaran, 2004), whose results indicate that the null hypothesis of cross-section independence is rejected, so the data are cross-sectionally dependent.

Table II.5.3-3. Results of stationarity and cross-sectional dependence

VARIABLES	STATIONARITY		CROSS-SECTIONAL DEPENDENCE
	LLC test	PP test	Pesaran CD test
HEALTHEXP	-1.508* (0.065)	-1.853** (0.031)	25.16*** (0.000)
D.TEMP	-15.262*** (0.000)	-31.312*** (0.000)	32.31*** (0.000)
D.CO2	-9.747*** (0.000)	-17.706*** (0.000)	32.38*** (0.000)
GOV	-3.552*** (0.000)	-3.489*** (0.000)	4.86*** (0.000)
GDPPPG	-5.571*** (0.000)	-8.864*** (0.000)	55.94*** (0.000)
INFLA	-7.219*** (0.000)	-10.174*** (0.000)	54.04*** (0.000)
HDI	-5.199*** (0.000)	-3.061*** (0.001)	82.02*** (0.000)

Source: Authors' processing. Notes: P-values in parentheses; ***, ** and * denote significance at 1, 5 and 10 percent level respectively. LLC test is Levin-Lin-Chu test, PP is Phillips-Perron test and Pesaran CD test is Pesaran cross-sectional dependence test.

To test the heteroskedasticity, we used the White, Cameron & Trivedi (Cameron &Trivedi, 1990) and the Breusch-Pagan (Breusch & Pagan, 1979) tests, whose outcomes reveal that no heteroscedasticity in the residuals (Table II.5.3-4). To study the premise of existence of a long-term equilibrium among variables, we performed the co-integration Pedroni (Pedroni, 2004) and Westerlund (Westerlund, 2005) tests, whose results (Table II.5.3-5) prove the presence of a long-term co-integration relationship between variables. The serial correlation is studied through the Wooldridge test (Wooldridge, 2002; Drukker, 2003), which proves that the null hypothesis of no serial correlation is rejected and that there is serial correlation in our data (Table II.5.3-6). The normality based on skewness and kurtosis was performed and denotes that all variables are normally distributed, except for HEALTHEXP is not normally distributed (Table II.5.3-7).

Table II.5.3-4. Results of heteroskedasticity

HETEROSKEDASTICITY	Stat.	p-value
Breusch-Pagan test	1.54	0.214
White test	32.03	0.231
Cameron & Trivedi test	32.03	0.231

Source: Authors' processing.

Table II.5.3-5 Results of cointegration tests

COINTEGRATION	Stat.	COINTEGRATION	Stat.
Pedroni test (Mod. Phillips-Perron t)	7.578***	Westerlund test	6.050***
Pedroni test (Phillips-Perron t)	3.406***		
Pedroni test (Augmented Dickey-Fuller t)	3.592***		

Source: Authors' processing.

Table II.5.3-6 Results of serial correlation test

SERIAL CORRELATION	Stat.	p-value
Wooldridge test	54.963	0.000

Source: Authors' processing.

Table II.5.3-7 Results of normality test

VARIABLES	NORMALITY		
	Skewness	Kurtosis	p-value
HEALTHEXP	0.327	0.183	0.255
D.TEMP	0.000	0.001	0.000
D.CO2	0.000	0.000	0.000
GOV	0.313	0.000	0.000
GDPPPG	0.021	0.000	0.000
INFLA	0.000	0.000	0.000
HDI	0.000	0.213	0.000

Source: Authors' processing.

Reverse causality between variables (Table II.5.3-8), based on Granger PVAR tests (Lopez & Weber, 2017), illustrates important two-way causality between TEMP and GDPPPG, which are mutually affected. Also, bidirectional causalities were obtained for variables CO2 – INFLA and INFLA-HDI. The outputs reveal that HEALTHEXP is influenced by GDPPPG, while HEALTHEXP influences HDI, which in turn causes CO2. An important relationship was obtained for CO2 influencing TEMP. The results also show that INFLA and HDI cause GDPPG.

Table II.5.3-8. PVAR Granger causality between variables

Null hypothesis of no causality		F-stat	Null hypothesis of no causality		F-stat
HEALTHEXP	L.TEMP	0.135	CO2	L.GOV	0.004
TEMP	L.HEALTHEXP	0.037	GOV	L.CO2	0.032
HEALTHEXP	L.CO2	0.002	CO2	L.GDPPPG	0.267
CO2	L.HEALTHEXP	0.635	GDPPPG	L.CO2	0.924
HEALTHEXP	L.GOV	0.682	CO2	L.INFLA	5.700**
GOV	L.HEALTHEXP	0.101	INFLA	L.CO2	5.432**
HEALTHEXP	L.GDPPPG	3.223*	CO2	L.HDI	3.630*
GDPPPG	L.HEALTHEXP	0.675	HDI	L.CO2	1.396
HEALTHEXP	L.INFLA	0.000	GOV	L.GDPPPG	0.006
INFLA	L.HEALTHEXP	0.001	GDPPPG	L.GOV	1.378
HEALTHEXP	L.HDI	0.136	GOV	L.INFLA	0.437
HDI	L.HEALTHEXP	3.586**	INFLA	L.GOV	0.495
TEMP	L.CO2	10.495***	GOV	L.HDI	0.097
CO2	L.TEMP	0.312	HDI	L.GOV	0.005
TEMP	L.GOV	0.331	GDPPPG	L.INFLA	15.179***

Null hypothesis of no causality		F-stat	Null hypothesis of no causality		F-stat
GOV	L.TEMP	0.100	INFLA	L.GDPPPG	1.984
TEMP	L.GDPPPG	5.038**	GDPPPG	L.HDI	28.457***
GDPPPG	L.TEMP	3.820*	HDI	L.GDPPPG	1.736
TEMP	L.INFLA	1.122	INFLA	L.HDI	6.593**
INFLA	L.TEMP	1.668	HDI	L.INFLA	15.329***
TEMP	L.HDI	0.044			
HDI	L.TEMP	0.071			

Source: Authors' processing. Notes: Standard errors in parentheses; ***, ** and * denote significance at 1, 5 and 10 percent level respectively. The key to interpreting causality tests is that previous values at lag 1 influence actual values.

Several important findings arise from our reverse causality analysis. First, it follows that CO2 emissions influence temperature. Global warming is an essential topic of current environmental policies and underlines the importance of shaping economic and sustainable development policies that contribute to lowering CO2 emissions. Such a demonstrated link between CO2 and temperature proves the importance of studying climate change variables as comprehensively as possible. The analysis also found that GDP per capita growth and temperature influence each other, confirming the results of previous climate-change economic literature and showing the interdependencies between economic growth and temperature. Human development influences CO2 emissions, but also GDP per capita growth. In turn, GDP per capita growth influences health expenditure, which causes human development. The interdependencies between the analyzed variables are numerous and represent arguments of the combined analysis of climate change, economic, governance and human development variables.

Once the causality between the mentioned variables was established, the two-step system GMM analysis was put into practice by successively testing several models that analyze the impact of climate change on health expenditure, based on dynamic panel models (Table II.5.3-9). The post-estimation analysis of the two-step system GMM models proves that the p-values of the Hansen tests accept the null hypothesis of overidentifying restrictions (Labras & Torrecillas, 2018). The value of the Wald tests sustains the goodness of fit models, and the second-order no-autocorrelation hypothesis is not rejected by the Arellano and Bond tests for autocorrelation AR(2), whereas AR(1) is significant, confirming the serial autocorrelation in the errors.

Table II.5.3-9. The effect of climate change on health expenditure (system GMM models)

HEALTHEXP	System GMM (model 1)	System GMM (model 2)	System GMM (model 3)
L.HEALTHEXP	0.951***	0.948***	0.902***
	(0.040)	(0.039)	(0.053)
D.TEMP	0.102**	0.086*	0.084**
	(0.051)	(0.048)	(0.041)
D.CO2	0.098***	0.065*	0.064**
	(0.017)	(0.034)	(0.026)
GOV	0.054*	0.059**	0.059**
	(0.031)	(0.028)	(0.024)
GDPPPG	-	0.017***	0.015**
		(0.006)	(0.006)
INFLA	-	-	0.031**
			(0.013)
HDI	-	-	2.620**
			(1.241)
Constant	0.730	0.730	-1.010
	(0.513)	(0.506)	(0.604)
Observations	540	540	540
No. of countries	27	27	27

AR(1) test (p-value)	0.001	0.002	0.002
AR(2) test (p-value)	0.593	0.668	0.612
Hansen test (p-value)	0.825	0.793	0.927
Chi2 test (p-value)	0.000	0.000	0.000

Source: Authors' processing. Notes: Standard errors in parentheses; ***, ** and * denote significance at 1, 5 and 10 percent level respectively. This table reports results of two-step system GMM (each column represents a separate regression model), based on xtabond2 Stata command, with orthogonal (to use the forward orthogonal deviations transform instead of first differencing), collapse (to create one instrument for each variable and lag distance, rather than one for each period, variable and lag distance) and robust (with Windmeijer's finite-sample correction for two-step covariance matrix) options.

The importance and influence of climate change on health expenditures are significant in all estimated models. The results obtained for each of the analyzed independent variables are detailed below. We obtain the dynamic persistence of health expenditure and confirm the dynamic specification of the models with statistically significant lag1 for health expenditure, which provides a positive correlation between $HEALTHEXP_{it-1}$ and HEALTHEXP itself.

Temperature and health expenditure. The results based on system GMM models reveal that increasing the average temperature has a positive and significant impact on health expenditure in the sample countries. These results confirm that **H1 hypothesis** can be accepted. Hypothesis H1 implied that rising temperatures lead to increased government health spending.

The surge in global temperatures activates biological mechanisms like oxidative stress, contributing to neurodegenerative conditions (Zammit et al., 2021). Concurrently, heatwaves increase the incidence of heat-related ailments, such as heat exhaustion, requiring urgent medical care and straining healthcare finances (Tong et al., 2021). Hospitals often see a spike in admissions during such events, adding financial burden to healthcare systems (Boz & Ozsarı, 2020). Warmer climates also expand the habitats of disease vectors like mosquitoes, facilitating the spread of maladies like malaria into new areas (Chowdhury et al., 2018). This necessitates additional public health measures, thereby escalating healthcare costs. Furthermore, climate change poses infrastructural challenges; hospitals may need to enhance cooling systems for heatwaves, and storms can cause facility damage, necessitating costly repairs (Sasmaz et al., 2021). Therefore, it's crucial for governments to integrate these climate-related health risks into healthcare planning, including preventive measures and infrastructure upgrades, to manage the increasing financial strain on healthcare systems (Schneider and Breitner, 2016).

CO2 and health expenditure. In the GMM models, we find that the growth of CO2 emissions contribute to higher health spending, thus validating the **H2 hypothesis**. Hypothesis H2 referred to the fact that increasing CO2 emissions lead to increased government health spending.

Our study reveals a direct correlation between the growth in CO2 emissions and a subsequent escalation in healthcare expenditures incurred by the government. This relationship underscores the economic implications of environmental factors on public health budgets. This result is consistent with previous studies: Samah et al., 2020), Gündüz (2020), Oyelade et al. (2020), Taghizadeh-Hesary and Taghizadeh-Hesary (2020), Akbar et al. (2021), Li et al. (2022), Travassos et al. (2020), Jerrett et al. (2003), Jia et al. (2021), Khoshnevis and Khanalizadeh (2017).

Rising CO2 emissions boost healthcare costs by aggravating air quality, increasing respiratory issues, and causing more extreme weather events that result in injuries and worsen chronic conditions. These factors together amplify the financial burden on healthcare systems. These elements collectively burden healthcare systems and escalate spending (González et al., 2014). Moreover, climate change-driven migration can lead to population surges in less-affected regions, adding further

strain on healthcare infrastructure and increasing expenditures (Li et al., 2022). Climate change worsens air quality and elevates ground-level ozone, intensifying urban respiratory issues. Addressing these health challenges requires both medical treatments and environmental control measures, leading to increased health care costs (Ballester et al., 2022).

Governance and health expenditure. The results of our study reveal positive results between government spending on health and governance, results that coincide with previous studies (Jakovljevic et al., 2016; Ray & Linden, 2020; Kaur, 2020).

Strong governance plays a pivotal role in healthcare, influencing everything from resource allocation to policy formulation in both developed and developing countries (Nakatani et al., 2023). Effective governance structures contribute to creating comprehensive, well-financed healthcare policies that aim to improve not just infrastructure but also address systemic issues like health inequality. A transparent and efficient tax system under good governance can generate increased public revenue, a portion of which can be channeled into healthcare. Moreover, governance significantly impacts the regulatory landscape, setting the stage for effective control of healthcare prices, service quality, and professional conduct (Raeesi et al., 2018). This regulatory oversight helps manage costs while enhancing the effectiveness of healthcare services. In the international arena, good governance can facilitate partnerships with other nations or global organizations, securing additional funding or expertise that leads to more effective and efficient healthcare spending (Kochuvilayil et al., 2023). Lastly, the role of governance becomes particularly critical during crises, as evidenced during the COVID-19 pandemic. Well-governed countries were more effective in securing necessary healthcare funding in times of crisis, ensuring the continuity and quality of care (Makin & Layton, 2021).

GDP and health expenditure. A robust GDP often serves as a catalyst for enhanced healthcare spending in multiple ways. First, it allows for greater allocations in both public and private healthcare sectors, enabling the adoption of more advanced treatments and facilities (Onisanwa, 2014). This is especially true in wealthier countries, which typically dedicate a larger portion of their budget to improve the quality and availability of healthcare (Barati & Hadiseh, 2020). As GDP growth enhances individual purchasing power, it renders healthcare services more accessible to the general population. This increased financial capability not only allows people to seek medical care more readily but also encourages investment in preventative care (Chaabouni & Saidi, 2017) and more expensive treatment options. In a stable economic environment fostered by a strong GDP, there's an attraction for investment in healthcare infrastructure such as hospitals and research centers (Rodríguez & Nieves Valdés, 2019). These facilities require sustained spending for their upkeep and staffing. Additionally, a high GDP typically boosts government revenue through taxation. This additional revenue can be channeled into public health initiatives, vaccination programs, and subsidized healthcare, thereby elevating overall healthcare expenditure across the board.

Inflation and health expenditure. Existing studies find that the relationship between health spending and inflation is positive: inflation significantly increases health spending. The results of our study are identical to Azam et al. (2022); Siami-Namini (2018); Dunn et al. (2018); Yip et al. (2017); Cheng and Nopphol (2019); Koijen et al. (2016); De la Maisonneuve et al. (2017) and Jakovljevic et al. (2017).

Rising inflation boosts costs in goods, services, and healthcare alike. This rise inflates the operational costs for healthcare providers, impacting everything from medical supplies to medications and labor costs. Consequently, patients often face higher out-of-pocket expenses, making healthcare less affordable (Dunn et al., 2018). On the public funding side, if governmental healthcare budgets

remain stagnant amid rising inflation, the real value of that funding diminishes, potentially leading to a decline in the quality of healthcare services due to resource scarcity (Yip et al., 2017). Such a scenario could necessitate cuts in services, reduced staffing levels, or limitations on the availability of new, more effective but costlier treatments (Cheng & Nopphol, 2019).

Inflation also has an impact on income levels, as nominal wage growth may not keep up, affecting the affordability of healthcare, especially for fixed-income groups like retirees. The rising costs of healthcare can consume an increasingly large portion of their limited incomes (De la Maisonneuve et al. 2017; Jakovljevic et al. 2017).

Human development and health expenditure. The progression of human development significantly impacts healthcare expenditures in various ways. An aging population due to increased life expectancy necessitates more medical care, thereby elevating costs (Brooks et al., 2005). With societal advancement, the adoption of costly medical technologies becomes more widespread. Government initiatives to expand public healthcare in developed countries also contribute to rising health budgets (Miranda-Lescano et al., 2023). Urbanization, a development byproduct, poses unique health challenges like stress and pollution, requiring specialized and often expensive services (Lin & Guo, 2023; Shao et al., 2022). Furthermore, increased global interconnectedness exposes countries to risks like pandemics, requiring substantial healthcare spending (Pervaiz et al., 2021).

To check the robustness and sensitivity of our baseline results, we use several alternative explanatory variables and perform two-step system GMM models (Table II.5.3-10). Three of the Worldwide Governance Indicators variables (Voice and accountability VOICE, Political stability and absence of violence / terrorism POLSTAB, Government effectiveness GOVEF) were used separately instead of the GOV variable (obtained by the Principal Component Analysis method from the six Worldwide Governance Indicators). For macroeconomic factors, Gross Domestic Product growth (GDPG, annual%) was used as a substitute of Gross Domestic Product per capita growth. For the HDI variable, robustness tests were performed using the Life expectancy indicator (lnLIFE, its logarithm form). The results obtained through robustness tests and based on alternative variables indicate the same meanings of climate change impact on health expenditure, but also of control variables on the dependent variable that render health spending.

Table II.5.3-10. The results of robustness tests (system GMM models)

HEALTHEXP	**System GMM (model 4)**	**System GMM (model 5)**	**System GMM (model 6)**	**System GMM (model 7)**	**System GMM (model 8)**	**System GMM (model 9)**
L.HEALTHEXP	0.943*** (0.033)	0.968*** (0.035)	0.941*** (0.037)	0.949*** (0.040)	0.902*** (0.052)	0.914*** (0.056)
D.TEMP	0.099** (0.050)	0.093* (0.050)	0.104** (0.049)	0.086* (0.047)	0.085** (0.042)	0.084** (0.041)
D.CO2	0.090*** (0.017)	0.081*** (0.018)	0.092*** (0.017)	0.065* (0.036)	0.066** (0.029)	0.059* (0.030)
GOV	-	-	-	0.055* (0.029)	0.059** (0.024)	0.068** (0.030)
VOICE	0.336* (0.184)	-	-	-	-	-
POLSTAB	-	0.208*** (0.066)	-	-	-	-
GOVEF	-	-	0.233** (0.097)	-	-	-
GDPPPG	-	-	-	-	-	0.017*** (0.006)
GDPG	-	-	-	0.017** (0.006)	0.015** (0.006)	-

HEALTHEXP	System GMM (model 4)	System GMM (model 5)	System GMM (model 6)	System GMM (model 7)	System GMM (model 8)	System GMM (model 9)
INFLA	-	-	-	-	0.029** (0.013)	0.032** (0.016)
HDI	-	-	-	-	2.356* (1.219)	-
lnLIFE	-	-	-	-	-	2.467* (1.478)
Constant	0.466* (0.245)	0.351 (0.437)	0.593 (0.382)	0.722 (0.524)	-0.780 (0.560)	-9.660* (5.808)
Observations	540	540	540	540	540	540
No. of countries	27	27	27	27	27	27
AR(1) test (p-value)	0.001	0.001	0.001	0.001	0.002	0.002
AR(2) test (p-value)	0.580	0.592	0.594	0.671	0.615	0.617
Hansen test (p-value)	0.850	0.815	0.872	0.783	0.915	0.889
Chi2 test (p-value)	0.000	0.000	0.000	0.000	0.000	0.000

Source: Authors' processing. Notes: Standard errors in parentheses; ***, ** and * denote significance at 1, 5 and 10 percent level respectively. This table reports results of two-step system GMM (each column represents a separate regression model), based on xtabond2 Stata command, with orthogonal (to use the forward orthogonal deviations transform instead of first differencing), collapse (to create one instrument for each variable and lag distance, rather than one for each period, variable and lag distance) and robust (with Windmeijer's finite-sample correction for two-step covariance matrix) options.

The connection between temperature fluctuations and government health spending is multifaceted and shaped by a mix of direct and indirect elements. The effects stretch beyond immediate health consequences, encompassing wider environmental, social, and economic considerations. Recognizing this link is vital for policymakers since it emphasizes the urgent need to intertwine climate-related issues within healthcare strategies and policies. By comprehending the diverse impacts of temperature on health, governments can devise comprehensive solutions that simultaneously tend to urgent health requirements and contribute to overall societal prosperity. The escalation in both the frequency and severity of temperature extremes requires a prompt, all-encompassing response. Necessary measures include significant investment in healthcare facilities, the execution of public health drives, the creation of early warning systems, and dedicated strategies for at-risk groups. These initiatives form a vital part of a strategy to alleviate the health effects of temperature variations and the ensuing costs. With growing evidence of the ties between temperature changes and healthcare expenditure, this subject is set to remain a paramount concern for governments, healthcare entities, and policymakers alike. It illustrates compellingly how climatic shifts can create tangible fiscal impacts on public health and serves as a clarion call for a unified, forward-thinking approach.

Patz et al. (2014) noted that by 2050 the earth's temperature will increase to an average of 32Cº. The human population will face more health problems, the health sector will be severely affected by the temperature. Regarding the relationship between CO2 and health expenditure, if CO2 emissions are not effectively reduced, increased medical spending can improve people's health. Thus, we can suggest that the governments of EU Member States increase health spending because only in this way can citizens' health improve and increase the stock of healthy human capital. While economic growth is crucial for EU countries, it should not compromise environmental integrity or the well-being of future generations. Improved public health is integral to this equation, as it correlates with economic efficiency and growth. Policymakers are increasingly recognizing the need for robust public health strategies. Evidence shows that nations with better economic and environmental conditions also enjoy

superior health outcomes (Barati & Hadiseh, 2020; Rodríguez & Nieves Valdés, 2019). Additionally, cutting greenhouse gas emissions yields significant health benefits, including lower costs for environmental mitigation, thereby offering a compelling reason for immediate action. The overarching implication is that sustainable development should be the focal point for policymakers, ensuring a balanced approach that doesn't jeopardize future generations. Governments should avoid supporting economic activities that pollute the environment, as this not only negatively impacts human health but also leads to increased expenditures on both pollution control and healthcare.

Policy recommendations. By implementing some recommendations, policymakers can better prepare for and mitigate the impacts of climate change on health expenditures, ultimately leading to more sustainable and resilient healthcare systems and societies.

The policy recommendations derived from the findings of this study can be summarized into several key areas, each addressing the interplay between climate change, economic factors, and health expenditures. The focus of these recommendations is to guide policymakers in mitigating the impacts of climate change on healthcare systems and economies:

1.*Strengthen Environmental Regulations*: Given the direct correlation between CO2 emissions and rising health costs, policies should target reducing emissions through stricter environmental regulations (Ballester et al., 2022). This includes promoting renewable energy sources, enhancing energy efficiency, and encouraging sustainable practices across industries.

2.*Healthcare System Resilience and Adaptation*: Governments need to invest in making healthcare systems more resilient to climate change impacts. The governments must upgrade infrastructure for extreme weather (Sasmaz et al., 2021), expand capacity for higher patient numbers during heatwaves or pollution crises, and ensure sufficient medical supplies.

3.*Public Health Initiatives*: Launching public health initiatives aimed at prevention and education to lessen climate change's health effects, including heatwave warnings, campaigns on risks of extreme temperatures, and efforts to curb vector-borne diseases.

4.*Climate-Integrated Healthcare Planning*: The governments should integrate climate change considerations into healthcare planning and policy formulation, assessing its potential health impacts and incorporating these into national and local healthcare strategies.

5.*Economic Policies for Sustainable Growth*: Formulating and enacting economic policies for sustainable growth, mindful of climate impact, by investing in green technology, backing sustainable agriculture, and favoring low-footprint industries.

6.*Governance and Policy Enforcement*: Strengthen governance structures to ensure effective implementation and enforcement of policies related to climate change and healthcare. This also involves ensuring transparency and accountability in the use of funds allocated for climate change adaptation and health expenditure.

7.*Addressing Inflation and Healthcare Costs*: Creating strategies to handle inflation's effect on healthcare costs (Azam et al., 2022), including price regulation for medical essentials and boosting public healthcare funding to counteract escalating expenses.

8.*Focus on Human Development*: Focusing on policies enhancing human development like education, healthcare access, and poverty alleviation, directly improving health outcomes and reducing climate change-related healthcare costs.

Our study provides important insights in line with previous literature and contribute in several ways to the actual stage of knowledge by examining the critical relationship between climate change, specifically temperature and CO2 levels, and governmental healthcare spending across EU countries. First, we use an empirical framework that simultaneously examines the effects of climate change,

economic, governance and human proxies on health governmental spending. These problems have sometimes been analyzed individually and at other times in different combinations; however, to our knowledge, no study has included these variables as factors of influence. Moreover, it is essential to simultaneously analyze the impact of these factors on health expenditure to avoid identifying false associations. Second, by focusing on the time frame of 2000-2020, the study uncovers new insights and sheds light on how environmental factors directly influence healthcare economics. Third, the study considers relevant control variables like governance, macroeconomic factors, and human development, that adds further depth to the understanding of the dynamics between climate change and health governmental spending. This study contributes to a better understanding of the role of climate change, macroeconomic, governance institutional and human factors in health spending and it can be valuable for policymakers in shaping legislative frameworks and public policies that compete with both increasing the quality of healthcare, mitigating environmental issues, economic growth, strengthening institutional governance of states, and increasing human development.

II.5.4. Concluding remarks

This study investigates the impact of climate change on health expenditure in the European Union countries, between 2000 to 2020, and examines the moderating roles of several control variables, respectively countries' governance indicators, macroeconomic determinants (GDP per capita growth and inflation) and human development. To capture climate change, two indicators were used, which are intensely considered as markers of global warming and whose valences are recognized in the previous literature: temperature and CO2 emissions. The results were obtained through dynamic system GMM and PVAR Granger causality methods.

We find that climate change, quantified by the increase in average temperature and CO2 emissions, burdens the health systems of the European Union countries. The results that prove the positive correlation between climate change and health spending are in line with the previous literature which emphasized the importance of climate change mitigation. Elevated global temperatures and CO2 levels not only exacerbate existing health issues but also create new challenges, such as heat-related illnesses and the spread of diseases like malaria. These lead to additional healthcare costs. There is a direct correlation between rising levels of CO2 emissions and increased governmental healthcare spending. This emphasizes the need for environmental considerations in public health budget planning.

Our comprehensive approach addresses the multifaceted relationship between various factors and healthcare expenditures, through the estimating impact of several variables (governance, macroeconomic indicators and human development) on health expenditure. Effective governance contributes to efficient healthcare spending and is crucial for the formulation of policies that address not just immediate healthcare needs but also systemic issues like health inequality. A robust GDP generally leads to increased healthcare spending, while rising inflation makes healthcare less affordable for the general population and may lead to reduced quality in healthcare services if public funding doesn't keep pace. With societal progress, healthcare expenditures often increase, driven by factors like an older population, advancements in medical technology, and health issues related to urban living.

This study has theoretical and practical implications. Each government is responsible for ensuring healthy air quality for its population. Viewing climate change solely as an environmental or developmental issue overlooks its considerable impact on both public health and national healthcare

budgets, impacts that are expected to increase in the near term. A deeper grasp of how climate change influences healthcare costs can improve both policy direction and decision-making. We consider that holistic planning needed, given the complexity and interconnectedness of these factors, there is an urgent need for integrated, multi-dimensional planning that considers all these variables in healthcare budgeting and policy formulation.

This study's findings are instrumental for policymakers, providing a nuanced understanding of the various factors that contribute to rising healthcare expenditures. Understanding the relationship between healthcare spending and climate change is crucial for policymakers and regulators to create a legislative environment that helps reduce global warming and does not put pressure on government health spending. Against the background of global warming and results demonstrating the increasing pressure on health systems, generated by climate change and pollution, the role of regulators is to urgently configure, implement and monitor a regulatory framework that contributes both to environmental conservation and increasing the capacity of health systems to manage patients' problems. Other extensive categories directly interested in the studied issues are citizens of the entire planet, whose interests converge health preservation and favorable environmental conditions, that do not contribute to diseases or medical problems.

A first limit of research refers to the study of a single conglomerate of countries (the European Union) and expanding the research area could contribute to obtaining relevant results for other groupings of states. The availability of data on health expenditure in the European Union has not allowed the research period to be extended. Future research directions involve both the extension of the researched area, the analysis period, as well as the study of other typologies of relationships between health variables and those that characterize climate change. The range of both categories of indicators mentioned is wide and refers to: medical infrastructure, health policies, seasonal temperature, high and low temperatures, greenhouse gases, ocean heat, sea level, glaciers etc.

Chapter II.6. DEFENDING THE NATION, SECURING THE ECONOMY[9]

Gross domestic product (GDP) is considered an indicator of a country's economic well-being. Military spending and states' welfare, represented by GDP, has been widely discussed in recent decades, since the 1970s and has increased in recent years (Benoit, 1978; Norkus et al., 2021; Topal et al., 2022). Conflict and insecurity are significant obstacles to economic growth (Dunne et al., 2005) and can be partially alleviated by increasing military spending. NATO's immediate response capability can only be achieved and maintained by ensuring adequate human, material, and logistical resources. Therefore, in NATO (North Atlantic Treaty Organisation), the defence and security expenses of the member states are very well established. All these resources, in turn, depend on the existing financial resources at the level of each member state. Given that the field of defence is part of the public sector, at the level of each state, military expenses are allocated as a certain percentage of GDP. In the wake of the Cold War, many NATO countries' governments reduced their investments in their security. This trend was evident both in the developed European countries, NATO members, and in the new NATO member states experiencing fundamental transformation processes in the 1990s (Odehnal & Neubauer, 2020).

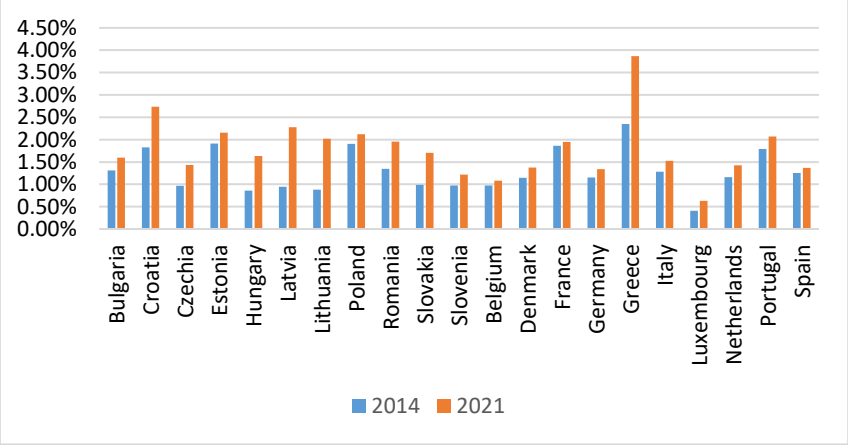
[9] This section is based on the article: **Iuga, IC**, Socol, A. 2023. Defending the nation, securing the economy. E&M EKONOMIE A MANAGEMENT, 26(4), 17–37. https://doi.org/10.15240/tul/001/2023-4-002. WOS:001153374100002

The NATO Summit of 2014 declared that NATO allies must aim to allocate 2% of their GDP towards their defence spending by the year 2024. With the complicated security situation in Europe from 2022, NATO has boosted its capability to defend its member countries against direct military threats.

In recent times, several NATO countries in Europe have started to boost their defence expenditure. However, only a limited number of NATO members have followed through on their long-standing political promise to dedicate 2% of their GDP to defence. Additionally, variations in the factors that influence military spending across NATO countries have resulted in an unequal distribution of the financial burden of defence spending among the member economies.

Of the 27 European Union (EU) member states, only 21 are NATO members. In all of these 21 states, the share of GDP allocated to military spending increased from 2014 to 2021 (Figure II.6-1). Consequently, in 2021, only 7 states (Croatia, Estonia, Latvia, Lithuania, Poland, Greece, and Portugal) out of 2021 fulfilled the political obligation to allocate 2% of their GDP to military expenditure. Greece ranked first, with a military expenditure value of 3.87% of its GDP. Most of the remaining 14 countries allocated between 1.5% and 1.95% of their GDP to military expenditure. However, some allies have indicated that their military spending will not rise to the recommended threshold by the 2024 deadline.

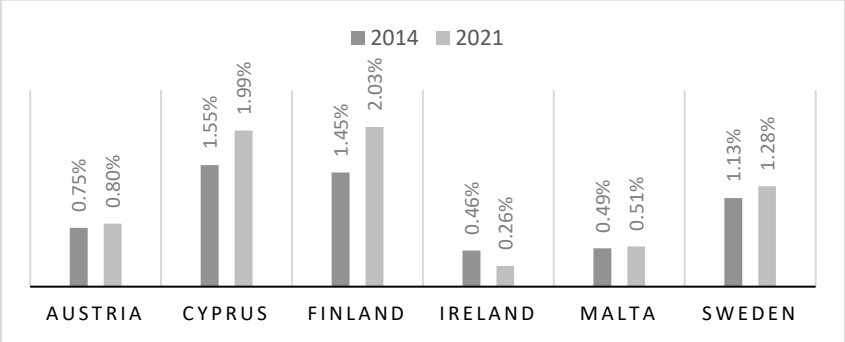
Figure II.6-1. Military expenditure percent of GDP – EU and NATO member countries



Source: SIPRI databases

Six EU member states are not part of the NATO alliance: Austria, Cyprus, Finland, Ireland, Malta, and Sweden; five of these countries increased their share of military spending in GDP in 2021 compared to 2014 (see Figure II.6-2). It should be noted that of the 6 countries that are not NATO members, only Finland committed more than 2% of its GDP to military expenditure in 2021. Among the other 5, Ireland was a typical case, with its percentage of military expenditure in GDP decreasing from 0.46 % in 2014 to 0.26% in 2021.

Figure II.6-2. Military expenditure percent of GDP – EU and non-NATO members.



Source: SIPRI databases

Most governments worldwide spend a large portion of their annual budgets on military expenditures because of the importance of national security. As a result, many studies have focused on the link between defence and economic growth. Moreover, theoretical literature has long recognised the fundamental importance of public security for economic activity (Bernauer et al., 2009). Consequently, the military sector tends to receive a large share of budgetary resources in most countries, but states vary considerably in the proportion of the resources they allocate to defence spending (Tao et al., 2020; Tiwari & Shahbaz, 2013; Topal et al., 2022; Topcu & Aras, 2015).

The relationship between military spending and GDP is an important and controversial issue. Some political leaders support the notion of increasing defence spending, while others stand for the opposite. Considering the central importance of this issue, scholars have devoted considerable attention to the complex relationship between defence spending and economic growth. Studying the influence of military spending on GDP is essential because it provides insights into the economic impact of defence budgets. It indicates how the allocation of significant public resources to the military sector can drive economic growth or, inversely, potentially divert resources from other productive areas. This research has important geopolitical implications, such as for the balance between security and economic development and the orientation of fiscal policy towards a more optimal distribution of resources.

Assessing the 2% foreseen in the 2014 Declaration at the NATO Summit in Wales, as well as the emergence of political and security events in Eastern Europe in 2022 (e.g. the geopolitical conflict between Russia and Ukraine), this paper attempts to determine the dynamic causality between military spending and GDP in all 27 EU member states. As it stands, there is no consensus on this topic, and relatively little attention has been paid to non-NATO EU member states. Moreover, no studies have looked at the military expenditure-GDP relationship while taking into account the criterion of NATO membership or compared the two groups of states (NATO states versus non-NATO states). However, examining the impact of military spending on GDP specifically for NATO and non-NATO countries can yield unique insights. The different security obligations, defence strategies, and external pressures faced by these two groups could significantly affect their defence expenditure and the economic impact of such spending. For NATO members, higher defence spending might be driven by collective defence obligations. By contrast, non-NATO states might have different motivations and constraints. Thus, such a study could help us to understand the broader geopolitical, economic, and fiscal implications of NATO membership, particularly in the context of EU states.

This paper focuses on the influence of military spending on GDP in conjunction with the influence on GDP of two other extremely important macroeconomic indicators: the inflation rate and the unemployment rate. The unemployment rate is closely linked to labour freedom (one of the four freedoms of the common market), meaning it is directly linked to labour migration within the EU. Meanwhile, the inflation rate indicates whether the member states' monetary, fiscal, and legislative government policies are effective. Inflation and unemployment rates are key macroeconomic indicators that directly impact GDP. For NATO and non-NATO countries, military spending can influence these rates (Nikolaidou, 2008; Odehnal & Neubauer, 2020). High defence spending may stimulate economic activity (Hung-Pin & Wang, 2022; Lin et al., 2015), thereby reducing unemployment (González-Astudillo & Roberts, 2022) but potentially causing inflation (Durguti et al., 2020; Stanić & Račić, 2019). Alternatively, resources allocated to the military sector could displace other productive investment, thus affecting job creation (Gricar et al., 2022; Malizard, 2014). The comparison between NATO and non-NATO countries allows us to observe differences in these dynamics potentially driven by defence obligations, adding a deeper layer to our understanding of how defence speding interacts with broader economic conditions.

The objectives of this research are as follows: to investigate whether NATO membership strengthens the correlation between military spending and GDP for both NATO and non-NATO EU member states; to emphasise the constraints on the development of the military expenditures of NATO allies in the EU; to analyse the impact of two critical macroeconomic indicators, namely unemployment and inflation, on GDP in both NATO EU member states and non-NATO EU member states; to provide reliable estimates of the relationship between military spending and GDP in the EU over the period 1998–2021; to understand how defence budget allocation impacts broader economic conditions in these countries, which could guide fiscal policy decisions and illuminate their geopolitical implications.

The analysis of the correlation between military expenditure and GDP and the quantification of the impact of military expenditure on GDP, corroborated by the analysis of the impact of inflation and the unemployment rate on GDP, is a key prerequisite for understanding the behaviour of EU member countries. Although the 27 states are members of the EU, representing a political and economic union, the differences in their development are evident and the allocation funds for defence purposes varies between states, according the development of the economic, security, and political factors that influence the military expenditures.

This paper attempt to answer two research questions:

Q1. Does NATO membership impose a stronger correlation between military spending and GDP for each of the two groups of countries (NATO and non-NATO)?

Q2. How significant is the influence of the two macroeconomic indicators (unemployment and inflation) on GDP in the case of the 21 NATO allies in the European Union from 1998–2021? Moreover, how significant is it in the case of the 6 states in the European Union that are not NATO members?

This study makes a major contribution to the existing literature by examining the nuanced relationship between military spending, GDP, inflation, and unemployment rates in both NATO and non-NATO EU member states. It uniquely considers the influence of NATO membership on these dynamics, an aspect that until now has been left unexplored. The study also provides insights into how military expenditure allocation can impact broader economic conditions in these varying geopolitical contexts. Hence, it enriches our understanding of defence economics, fiscal policy decisions, and their geopolitical implications.

II.6.1. The effect of military spending on GDP: a brief literature review

The effect of military spending on GDP has long been a subject of intense debate. Several empirical studies on the relationship between military spending and GDP have been conducted, but their empirical findings remain inconclusive (Bayrak, 2019; Carter et al., 2021; Chowdhury, 1991; Churchill & Yew, 2018; d'Agostino et al., 2011; Heo & Ye, 2016; ; Hung-Pin & Wang, 2022; Khalid & Habimana, 2019; Norkus et al., 2021; Odehnal & Neubauer, 2020; Topal et al., 2022; Topcu & Aras, 2015; Yilgör et al., 2014). What these studies do demonstrate, however, is that military spending is a complicated concept, with economic capabilities, political processes, and military linkages playing an interdependent role at the national, regional, and global levels.

Over time, military spending has been regarded as a crucial component of government budgets. As such, it has had a significant impact on macroeconomics. Many studies have attempted to explore the connection between military spending and GDP, which typically involves a country allocating a portion of its GDP for defence purposes (Bayrak, 2019; Bernauer et al., 2009; d'Agostino et al., 2011; Dunne & Nikolaidou, 2001). This is to ensure the state's internal and external security, as an increasing function for the threats against the nation's integrity (Bayrak, 2019). In this sense, it can be argued that defence spending can impact GDP directly or otherwise.

Various strands of the theoretical literature indicate different and conceptually ambiguous results regarding the military spending-GDP relationship, and empirical analysis has yet to resolve the issue decisively. Benoit (1978) was the first to study the relationship between military spending and economic growth, with many subsequent studies following suit.

The theoretical analysis of military expenditures is not a solely economic problem and therefore should not be analysed solely from an economic perspective. The analysis of military spending in the literature identifies four approaches – Keynesian, neoclassical, liberal, and Marxist – which analyse military spending from various angles. Keynesians focus on supply-side issues (excluding investment); according to the Keynesian perspective, military spending crowds out private investment, heightens inflationary pressures, and diverts resources from more productive public investments in infrastructure, healthcare, and education (Dunne et al., 2001). Neoclassicists view defence spending as a state-provided public good that safeguards the nation's well-defined interests. Studies using neoclassical models focus on the ways in which defence spending affects economic growth (modernisation, infrastructure, and secondary technological benefits). Most studies based on neoclassical models have found there to be a positive relationship between military spending and economic growth. Liberals prioritise the interests of the whole of humanity over the interests of individual nation-states. Lastly, the Marxist approach views military spending only from a socio-political and strategic perspective.

Although there are in the previous literature a multitude of theories that explain economic growth (Classical Growth Theory, Neoclassical growth theory, Endogenous Growth Theory, Harrod-Domar Growth Model, Keynesian Theory, Schumpeterian Growth Theory, Rostow's Stages of Growth Model, Solow-Swan growth model, Kaldor's Laws of Growth, Institutional Theories of Growth), in our study, only two prominent theoretical constructs are considered – theoretical constructs that we believe optimally encapsulate the relationship between economic growth and military spending (Neoclassical growth theory and Endogenous growth theory).

Neoclassical growth theory, primarily based on Solow's model (1956), suggests that long-term economic growth is influenced by capital, labour, and technology. While labour and capital are subject to diminishing returns, technological growth drives steady economic expansion. Thus, continuous growth can only be maintained through technological progress, which is considered

exogenous (external) and not explained within the model itself. The theory assumes market equilibrium and that economies naturally move towards a steady-state growth rate, dictated by population growth, savings, and technological progress. Military spending and other macroeconomic indicators interact with these factors, impacting GDP growth.

In the context of neoclassical growth theory, military spending is considered a part of capital investment. However, its impact on economic growth can be complex. Initially, higher military spending may stimulate economic demand and create jobs (Bayrak, 2019). However, in the long term, military spending is viewed as unproductive because it does not directly contribute to technological progress – a key driver of sustained economic growth in this model. Indeed, overemphasis on military expenditure could divert resources away from productive investments, potentially leading to slower economic growth (Carter et al., 2021). Therefore, achieving the optimal balance of military spending is crucial for economic development under this theoretical framework.

Contrary to the Neoclassical Growth Theory, the Endogenous Growth Theory (Romer, 1990) posits that economic growth is primarily a result of internal factors rather than external ones. Introduced by Paul Romer (1990) and Robert Lucas (1988), amongst others, this theory emphasises the importance of investment in human capital, innovation, and knowledge, which are all endogenous or internal to the economic system. The theory asserts that policy measures can have an impact on the long-term growth rate of an economy by influencing these factors. In other words, unlike the Neoclassical model, growth in the Endogenous model does not inevitably tend towards a steady state, and there are no diminishing returns to capital.

Endogenous growth theory emphasises the internal factors of an economy, such as innovation, human capital, and knowledge, in driving economic growth. In this theory, military spending can have diverse impacts. On the one hand, it can lead to technological advancements and human capital development, especially when it involves research and development, education (Lai et al., 2002), and training, thereby positively affecting growth (Churchill & Yew, 2018). On the other hand, excessive military spending may channel resources away from other vital sectors that directly contribute to endogenous growth factors, potentially slowing down economic growth (Heo & Ye, 2016). Thus, the net effect of military spending on economic growth under endogenous growth theory could be context-dependent.

Regarding the vast literature on the relationship between military spending and economic growth, some studies have shown contradictory effects (either positive effects or negative effects). Among the studies demonstrating the positive effects of defence spending on economic growth (Tiwari & Shahbaz, 2013; Wijeweera & Webb, 2011), a 2018 study by Churchill and Yew shows that the influence of military spending on economic growth, as measured by GDP, is more prominent in developed nations than in less developed nations. Moreover, in 2014, Yilgör et al. (2014) conducted research examining the connection between defence expenditure and economic growth in 11 countries that are members of NATO – USA, Germany, Belgium, Denmark, France, Netherlands, United Kingdom, Italy, Canada, Norway, and Portugal – for the period 1980–2007. The authors consider the correlation and causation of defence and economic growth and conclude that, in the long run, there is a correlation between defence spending and GDP. Furthermore, their use of a Granger causality test indicates that the proportion of defence spending in developed countries in GDP has led to GDP growth.

The positive relationship between military spending and GDP can be explained as follows:
(1) Defence spending leads to security, which enables private economic agents to carry out productive economic activities without fear of external appropriation.

(2) In many countries, a percentage of defence spending is allocated to research and development activities. Military research and development lead to innovations that subsequently lead to applications in the civilian sector, increasing productivity and revenue (Bernauer et al., 2009). For example, the civilian sector has adopted technologies initially developed in the military sector, such as air transport, nuclear power generation, and radar and space technology. These technological spillovers improved the productive private sector.
(3) Military spending, directly and indirectly, facilitates economic growth by increasing purchasing power, increasing aggregate demand, and financing heavy industry, especially armaments (Looney, 1991).

In opposition to the arguments above, however, some studies claim that military spending can negatively influence social welfare because it causes less public spending to accumulate human capital, thus hindering economic growth and indirectly bringing losses to social welfare (d'Agostino et al., 2011; Khalid & Habimana, 2019). The main argument in this category is that military spending diverts civilian resources from more productive uses (Heo & Ye, 2016). Another argument is that, with the increase in military spending, there is a decrease in research and development in the civilian sector, which has significant implications for GDP because it diverts non-military research and development spending.

In contrast to these two sets of studies, a third set makes the following claims: (1) there is no statistically significant relationship between these two variables (Gerace, 2002; Sekmen & Saribas, 2007), and this relationship cannot be generalised (Chowdhury, 1991; Lai et al., 2002; Mintz & Stevenson, 1995;); (2) the impact of military spending on economic growth is limited (Chang et al., 2011; Wijeweera & Webb, 2011); and (3) the impact of defence spending on economic growth is neither universal nor constant over time (Dakurah et al., 2001; Tao et al., 2020; Topcu & Aras, 2015; Saba & Ngepah, 2019;). Moreover, some studies observe all three types of effects (positive effect, negative effect, and no effect) (Carter et al., 2021).

These contradictory findings of the empirical literature may stem from the fact that some of the theoretical effects highlighted above are conditioned by the local and sometimes even regional political, economic, and security context. Analytical results may vary 'depending on such things as the extent of use, how military spending is financed, externalities from military spending, and the effectiveness of military spending in countering the threat' (Dunne et al., 2005). Moreover, existing empirical studies fail to consider the different time horizons over which the effects described above would occur.

The above discussion prompts us to propose the hypothesis of the study:
***Hypothesis H_1**: There is a positive effect of military spending on GDP.*

Military expenditure might induce immediate stimulative effects, yet it may also inadvertently lead to diminished private sector investment, curtailed spending in productive sectors, or an escalation of public debt to unsustainable levels.

Regarding the crowding-out effect on private investment, military spending often requires a significant budget allocation. This potentially large allocation could reduce the availability of resources for private sector investment (Fatehi-Sedeh & Safizadeh, 1989). Furthermore, if financed by rising interest rates, it can lead to 'crowding out' whereby government borrowing makes borrowing more expensive for the private sector, which in turn discourages private investment.

In addition, an increase in military spending can lead to a reduction in government spending in productive sectors such as education, infrastructure, and healthcare (Dunne et al., 2001). These sectors often provide a greater multiplier effect for economic growth and overall societal well-being.

Furthermore, financing increased military spending can also lead to an increase in public debt if the government borrows money to finance it. This can also cause a diversion of resources from sectors with higher potential for economic growth, such as technology or manufacturing (Heo & Ye, 2016), and such a redirection, in turn, can harm the overall health of the economy by reducing efficiency and long-term growth potential. Consequently, these factors could have detrimental implications for long-term economic growth.

Military spending is considered to be conducive to social welfare in that it accumulates well-trained human capital, technological innovation, and spin-offs in the defence sector. However, several empirical studies reveal that increasing military spending impacts indirect channels, such as income inequality, economic growth, and unemployment (Malizard, 2014). Moreover, there is a close relationship between the unemployment rate, military spending, and economic growth (González-Astudillo & Roberts, 2022). Okun (1962) formulated the well-known rule of thumb that assigns roughly a 3% drop in GDP to a point increase in the unemployment rate of 1%. There are numerous studies that confirm that the unemployment rate is one of the essential factors of GDP growth (Gricar et al., 2022; Malizard, 2014; Stanić & Račić, 2019; Vyrostková & Mirdala, 2022). Unemployment rate negatively affects GDP growth (Gricar et al., 2022; Stanić & Račić, 2019,).

Understanding the link between inflation and GDP growth is vital to improving any country's monetary policy because inflation is a monetary phenomenon (Burger & Šlampiaková, 2021). By contrast, GDP growth is a real phenomenon. Moreover, the characteristics of this link may be different in different countries, as well as in different periods of the same country. Several studies have investigated the link between inflation and GDP on a global scale, finding a negative relationship between the two variables (Barro, 1995; Denbel et al., 2016; Ghosh & Phillips, 1998; Ljupco et al., 2018; Stanić & Račić, 2019;), while others argue that this relationship is non-linear (Eggoh & Khan, 2014; Fischer, 1993; Ghosh & Phillips, 1998).

II.6.2. Research Methodology

Previous studies on the relationship between defence spending and economic growth are very diverse due to the variety of countries in the same region, different time periods in the same country, and various methodologies being used in manifold regions.

This study was divided into three panels to further develop the estimates and to test the robustness of the results. First, the EU countries were selected to explore the way in which military expenditure affects GDP, based on the annual data between 1998 and 2021. The decision to choose these states and this particular period lies in their common recent history, the elements of homogeneity generated especially by the common regulations specific to the EU, which justifies the study of the general trends of the EU states. In addition to the analysis of all EU countries (EU 27), they were approached separately in two different clusters: on the one hand, the 21 countries of the EU and which are also the NATO countries (EU-NATO 21) – second cluster, and the other 6 countries that are not part of NATO were studied in the third cluster (EU NON-NATO 6). The chosen analysis period starts at the end of the 1990s (especially given the availability of data for the ex-communist EU countries and which only in this period switched to democratic regimes) and extends until 2021, inclusive, which is of particular importance in terms of economics given that it marks the onset of the COVID-19 pandemic, which led to higher levels of inflation and unemployment than in previous years. As far as national defence systems are concerned, closely linked to public budgets, military spending proves to be in the contemporary period a vital element in shaping the premises of freedom and the

democratic status of nations, which are concerned with the binomial defence of the nation and securing the economy.

To unearth the causal nexus between military expenditure and GDP, a panel data model was developed as follows:

$$GDP_{i,t} = \propto_0 + \propto_1 Military\ expenditure_{i,t} + u_{i,t} \quad (1)$$

The unemployment and the inflation were considered control variables, based on the results identified in the previous studied literature.

$$GDP_{i,t} = \propto_0 + \propto_1 Military\ expenditure_{i,t} + \propto_2 Unemployment_{i,t} + \propto_3 Inflation_{i,t} + u_{i,t} \quad (2)$$

In Equations (1) and (2), *i* represents the country, *t* is the period, and $u_{i,t}$ is the error term.

Econometric data were processed using STATA 17 (Stata/SE Prof +Plan (dl) 17).

Table II.6.2-1 presents the description of the variables and data sources from which the information was gathered. To measure economic growth, the paper employs GDP, while to capture the essence of the governments' motivations for investing in defence, the military expenditure proxy was used. The other two major macroeconomic variables are monetary (inflation) and labour market (unemployment) phenomena, which are attributed to major economic imbalances or, on the contrary, contributions to economic growth.

Table II.6.2-1. Variables and data sources

Variables	**Symbol / Unit**	**Data source**
Gross Domestic Product	GDP / billions of current U.S. dollars	The World Bank, (https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?view=chart)
Military expenditure	Mex / billions of current U.S. dollars	The World Bank via Stockholm International Peace Research Institute (SIPRI), Yearbook: Armaments, Disarmament and International Security (https://data.worldbank.org/indicator/MS.MIL.XPND.CD?locations=US via https://milex.sipri.org/sipri)
Unemployment	Unemployment / % of total labor force	The World Bank via International Labour Organization, ILOSTAT database (https://data.worldbank.org/indicator/SL.UEM.TOTL.ZS)
Inflation (annual consumer prices)	Inflation / %	The World Bank via International Monetary Fund, International Financial Statistics and data files (https://data.worldbank.org/indicator/FP.CPI.TOTL.ZG)

Source: Authors' processing.

The paper gradually approaches several static and dynamic panel methods, with the aim of identifying the most appropriate and robust methodologies for determining the causal links between the analysed variables. After conducting an analysis of the variables based on the classical linear regression method (e.g. stationarity of the data, multicollinearity between variables, homoscedasticity, serial correlation, or cross-sectional dependence), some models were progressively tested, starting with Pooled Ordinary Least Squares (OLS) to establish an initial basis for comparison.

We continued with the Poisson Pseudomaximum Likelihood Regression (PPLM) method, suitable for log dependent variable (Correia et al., 2020). This method represents a cutting-edge methodology for estimation of (pseudo-)Poisson regression models with multiple high-dimensional fixed effects, based on a reweighted least-squares algorithm.

The specific problems of unfulfillment of some classical regression assumptions (homoscedasticity, serial correlation, or cross-sectional dependence) lead to further use of Fixed and Random Effect models, which unlike Pooled OLS have the potential to better control for unobservable heterogeneities across countries over time that could affect the relationship between the variables (Gerged et al., 2023).

In the next stage of the research two types of panel models were applied (Feasible Generalized Least Squares FGLS and Panels Corrected Standard Errors PCSE), chosen according to their potential to generate robust estimates under the conditions of unfulfilled mentioned assumptions of classical linear regression in the studied data.

Because static panel models do not take into consideration the dynamics of time-varying and the endogeneity of the variables, we applied a dynamic panel method – System Generalised Method of Moments (GMM), that is capable to address the reverse causality problems as well as the serial correlation and unobserved heterogeneity (Forgione & Migliardo, 2020). In economic terms, endogeneity can be interpreted as the effect of the past on the present, both on the model (dependent variable) and on the independent variables, or as the causal relationship between regressors and explained variables along the time (Labra & Torrecillas, 2018).

We aim to identify the unidirectional or bidirectional links between the studied variables and for the analysis of the influence of the past values of the independent variables on GDP we computed a novelty Granger causality test and HPJ (Half-Panel Jackknife) bias-corrected pooled estimator (Juodis et al., 2021; Xiao et al., 2022). In addition to this type of causality testing between the variables, the results obtained by applying the first two generations of causality tests were also analysed (Abrigo & Love, 2016; Dumitrescu & Hurlin, 2012; Holtz-Eakin et al., 1988; Lopez & Weber, 2017).

Table II.6.2-2. Descriptive statistics

Variables	**Obs.**	**Mean**	**Std. Dev.**	**Minimum**	**Maximum**
GDP (billions), EU (27)	648	482.644	798.511	3.958	4259.935
Mex (billions), EU (27)	648	7.048	12.031	0.025	56.647
Unemployment (%), EU (27)	648	8.607	4.296	1.81	27.47
Inflation (%), EU (27)	648	2.749	4.339	-4.478	59.096
GDP (billions), EU-NATO (21)	504	557.836	886.171	5.674	4259.935
Mex (billions), EU-NATO (21)	504	8.423	13.284	0.042	56.647
Unemployment (%), EU-NATO (21)	504	9.056	4.542	1.81	27.47
Inflation (%), EU-NATO (21)	504	3.068	4.813	-1.735	59.096
GDP (billions), EU NON-NATO (6)	144	219.473	181.516	3.958	635.663
Mex (billions), EU NON-NATO (6)	144	2.235	2.048	0.025	7.887
Unemployment (%), EU NON-NATO (6)	144	7.036	2.781	3.3	16.09
Inflation (%), EU NON-NATO (6)	144	1.633	1.445	-4.478	5.590

Source: Authors' processing.

The basic summary statistics of the dependent and independent variables are presented in Table II.6.2-2. The maximum and the minimum GDP indicate a high degree of dispersion of the GDP in the studied countries, which is justified given the different size of the countries in the EU, as well as the different speeds of economic development of the states, taking into account that new countries (including post-communist) joined after the 2000s and brought with them economic structural problems (11 new post-communist countries, of which 8 joined in 2004, 2 in 2007, and one in 2013). Moreover, the disparity between maximum and minimum military expenditure indicates a high degree of variety between the member states. The average GDP value is 482.644, ranging from 3.958 to 4259.935, with a standard deviation of 798.511, which denotes a medium dispersion from the

mean. The core explanatory variable, military expenses, has a mean of 7.048, ranging between 0.025 and 56.647, denoting a high degree of heterogeneity among the studied countries. Meanwhile, the control variables (unemployment and inflation) also exhibit large fluctuations between the minimum and maximum values for the countries and the analysed period, especially in 2020-2021. Two of these variables – GDP and military expenditure – are used in models in their logarithmic form because of the skewed distribution and the small and large values of the proxy across countries.

II.6.3. Empirical Results

To study the data characteristics, we test the basic classical linear regression model assumptions – stationarity of the data, multicollinearity between variables, homoscedasticity, serial correlation, and cross-sectional dependence – in order to be able to apply the most appropriate models (Maladjian & Khoury, 2014). The preliminary investigation of the variables involves the study of the stationarity of data through a LLC Levin-Lin-Chu unit-root test, which demonstrates that the variables are stationary (the null hypothesis of LLC test for stationarity is rejected for all variables in level, except for lnMex in EU NON-NATO PANEL, which is stationary in first-difference). Our investigation of the correlation between variables through the bivariate correlation matrix suggests that the dependent and explanatory variables are not correlated (except Mex and GDP). Also, by examining the VIF (Variance Inflation Factor – another important tool that verifies multicollinearity), we prove the absence of multicollinearity, thus eliminating the risk of spurious correlations. The mean of VIF is under 1.5 for all three panels, which is below the threshold level, approximately 5, according to the main approach in the area (Koengkan et al., 2019). Homoscedasticity analysis, based on the Breusch-Pagan test and the White test, emphasises heteroscedasticity in the residuals. Furthermore, for all three panels (EU, EU-NATO, and EU NON-NATO), data analysis indicates serial correlation in the idiosyncratic error term and the cross-sectional dependence. The strategy of applying certain types of models was established based on these preliminary tests of the data from the three panels.

To explore the relationship between the variables, in order to establish an initial basis for comparison for the results obtained, we initially develop the Pooled OLS model (Table II.6.3-1). Except for two variables (Unemployment and Inflation) for the EU NON-NATO model, all the remaining results are statistically significant, but in the conditions where some of the classical assumptions of the regression models are violated, the Pooled OLS model can generate spurious results, which involves testing the data with models that consider the properties of the analysed panels.

Table II.6.3-1. Pooled Ordinary Least Squares (OLS) and Poisson Pseudomaximum Likelihood Regression (PPML) models (1998–2021)

lnGDP	**Pooled Ordinary Least Squares (OLS)**			**Poisson Pseudomaximum Llikelihood Regression (PPML)**		
	EU (27)	**EU-NATO (21)**	**EU NON-NATO (6)**	**EU (27)**	**EU-NATO (21)**	**EU NON-NATO (6)**
lnMex	0.897*** (0.005)	0.914*** (0.008)	0.902*** (0.005)	0.034*** (0.0003)	0.035*** (0.0003)	0.036*** (0.0003)
Unemployment	-0.027*** (0.003)	-0.023*** (0.002)	-0.021 (0.029)	-0.001*** (0.0001)	-0.001*** (0.0001)	-0.0007 (0.0008)
Inflation	-0.027*** (0.005)	-0.023*** (0.003)	-0.035 (0.033)	-0.0008*** (0.0001)	-0.0007*** (0.00009)	-0.001 (0.001)
const	6.832*** (0.127)	6.371*** (0.204)	6.870*** (0.348)	2.513*** (0.007)	2.502*** (0.008)	2.483*** (0.017)
Obs	648	504	144	648	504	144
R^2 / pseudo R^2	0.938	0.954	0.889	0.018	0.018	0.016

Note: Standard errors in parentheses; ***denote significance at the 1percent level. PPML is based on ppmlhdfe Stata command, with robust and year fixed-effect option. Source: Authors' processing.

The parameters of log-linearised models established by OLS are inconsistent in the presence of heteroskedasticity, which requires one to test the data using an appropriate method, such as PPML (Correia et al., 2020). The outcomes of the PPML technique are in line with the results obtained using the primary Pooled OLS model, but with proper management of heteroskedasticity, PPML, proves to be more adequate.

Fixed-effects models are suitable for addressing unobserved heterogeneity (unexplained variation) among cross-sectional units (Duxbury, 2021), while the three data panels can continue to be analysed using the Fixed Effects (FE) and Random Effects (RE) models, which are presented in Table II.6.3-2. Here the results of the Hausman tests can also be found, according to which the FE model is suitable for the EU (27) and EU-NATO (21) panels, while the RE model proves to be adequate for the EU NON-NATO (6) panel. Fixed effects models have been studied alternatively by including (or not including) time-fixed effects, with the latter variant producing statistically significant results for all variables for the EU (27) and EU-NATO (21) panels. In the EU NON-NATO PANEL (6) the Random Effects model proves to be adequate, with the results being statistically significant only for the core explanatory variable, military expenditures.

Table II.6.3-2. Fixed Effects (FE) and Random Effects (RE) models (1998–2021)

	Fixed Effects (FE)						**Random Effects (RE)**		
lnGDP	**EU (27)**		**EU-NATO (21)**		**EU NON-NATO (6)**		**EU (27)**	**EU-NATO (21)**	**EU NON-NATO (6)**
lnMex	0.899*** (0.051)	0.346*** (0.052)	0.863*** (0.050)	0.392*** (0.050)	1.126*** (0.134)	-0.046 (0.270)	0.896*** (0.037)	0.875*** (0.035)	1.089*** (0.109)
Unempl.	0.004 (0.004)	-0.014*** (0.004)	0.001 (0.004)	-0.015*** (0.004)	0.005 (0.022)	-0.029** (0.008)	0.003 (0.004)	0.001 (0.004)	0.004 (0.021)
Inflation	-0.018*** (0.003)	-0.013*** (0.001)	-0.018*** (0.003)	-0.013*** (0.001)	-0.035 (0.027)	-0.049** (0.013)	-0.018*** (0.003)	-0.018*** (0.002)	-0.037 (0.027)
const	6.503*** (1.127)	18.051*** (1.093)	7.233*** (1.100)	17.176*** (1.075)	2.028 (2.769)	25.979*** (5.555)	6.572*** (0.789)	6.975*** (0.748)	2.816 (2.263)
Time-fixed effects	No	Yes	No	Yes	No	Yes	No	No	No
R^2 within	0.798	0.939	0.829	0.953	0.692	0.927	0.798	0.829	0.692
R^2 between	0.939	0.955	0.958	0.971	0.900	0.735	0.939	0.959	0.900
R^2 overall	0.930	0.843	0.949	0.881	0.887	0.001	0.930	0.949	0.887
Hausman test (p>chi2)	0.021	0.000	0.016	0.000	-	-	-	-	0.323

Note: Standard errors in parentheses; *** denote significance at the 1 percent level. The FE and RE models are estimated with the option robust and the time-fixed effects are included in FE model (based on F-test testparm i.year we obtain that time-fixed effects are needed). Source: Authors' processing.

The Fixed Effects (FE) and Random Effects (RE) models are based on the study of temporal effects, but without being configured to respond to potential data endogeneity problems, for which dynamic models are more suitable. Intermediate, up to the dynamic models, two panel-type methods were studied in order to manage heteroscedasticity, cross-sectional dependence, respectively serial correlation: Feasible Generalized Least Squares (FGLS) and Panel Corrected Standard Errors (PCSE). The outcomes of these methods, which are presented in Table II.6.3-3, show that the signs and significance of the results were consistent with the results provided by the Fixed Effects (FE) technique, especially in regard to the EU (27) and EU-NATO (21) panels. For the EU NON-NATO (6) panel, the results are not as robust (except when using the FGLS method), which confirms the structural differences between the NATO and NON-NATO countries.

Table II.6.3-3. Feasible Generalized Least Squares (FGLS) and Panels Corrected Standard Errors (PCSE) models (1998–2021)

	Feasible Generalized Least Squares (FGLS)			**Panels Corrected Standard Errors (PCSE)**		
lnGDP	**EU (27)**	**EU-NATO (21)**	**EU NON-NATO (6)**	**EU (27)**	**EU-NATO (21)**	**EU NON-NATO (6)**
lnMex	0.897*** (0.0001)	0.914*** (0.0007)	0.903*** (0.003)	0.897*** (0.008)	0.914*** (0.010)	0.902*** (0.017)
Unemployment	-0.027*** (0.0001)	-0.023*** (0.0001)	-0.023*** (0.003)	-0.027*** (0.004)	-0.023*** (0.003)	-0.021 (0.022)
Inflation	-0.027*** (0.00008)	-0.023*** (0.0001)	-0.023*** (0.007)	-0.027*** (0.002)	-0.023*** (0.002)	-0.035 (0.042)
const	6.832*** (0.004)	6.379*** (0.020)	6.847*** (0.077)	6.832*** (0.208)	6.371*** (0.252)	6.870*** (0.408)
Obs	648	504	144	648	504	144
R^2	-	-	-	0.938	0.954	0.889

Note: Standard errors in parentheses; *** denote significance at the 1 percent level. The FGLS method is applied with the option panels (correlated), which uses heteroskedastic and correlated error structure. The PCSE model is computed with the option hetonly, which specifies that the disturbances are assumed to be panel-level heteroskedastic. Source: Authors' processing.

To estimate the dynamic effects of Military expenditure on GDP, we applied a two-step GMM technique, using lagged values of the dependent variables as regressors (Arellano & Bond, 1991; Roodman, 2009). Both the Arrelano-Bond (AR) and the Hansen test results prove the robustness of the estimates (Table II.6.3-4) for the sample of EU countries as a whole and for the 21 NATO countries, with the same evolutionary meanings for the current values of independent variables as were obtained for the previous static panel methods (we thus record and prove positive relationships between the current values of military spending and GDP, while the current levels of unemployment and inflation negatively affect GDP). For the sample of non-NATO countries, the results are not as robust under the conditions of 1.0 values of the Sargan test, which could indicate the use of too many instruments and a small sample size (only 6 countries). Important contributions to the literature of the field (Labra & Torrecillas, 2018; Roodman, 2009) state that the estimators are developed for panels with short time dimensions, implying that they generate instrument sets whose number grows quadratically and that the instruments can overadapt endogenous variables by failing to expunge their endogenous components and biasing coefficient estimates. In the opinion of the aforementioned author, the possible vitiation of the Hansen test values should be accompanied by the report of the instrument count in order to disclose credible results.

Table II.6.3-4. System GMM models (1998–2021)

lnGDP	**EU (27)**	**EU-NATO (21)**	**EU NON-NATO (6)**
L1.lnGDP	0.624***; (0.070)	0.668***; (0.079)	1.583***; (0.446)
lnMex	0.402***; (0.062)	0.380***; (0.071)	0.379*; (0.205)
Unemployment	-0.011***; (0.004)	-0.008**; (0.004)	-0.036***; (0.012)
Inflation	-0.009*; (0.003)	-0.005**; (0.002)	-0.026*; (0.014)
const	3.333**; (0.545)	2.759***; (0.434)	-
Hansen test of overidentifying restrictions	26.53; p=0.088	20.65; p=0.297	0.00; p=1.000
Arellano-Bond test for AR (1)	-3.70; p=0.000	-3.42; p=0.001	-2.32; p=0.020
Arellano-Bond test for AR (2)	-2.22; p=0.026	-2.32; p=0.020	-0.94; p=0.348
Obs	567	441	126
Number of instruments	25	25	24

Note: Standard errors in parentheses; ***, **, and * denote significance at the 1, 5, and 10 percent level, respectively. This table reports the results of the two-step system GMM, based on xtabond2 Stata command, with orthogonal, collapse, robust and split (only for first two models) options. Additional independent variables are L2.lnGDP and L3.lnGDP (significant in all models and with negative results for second lag and positive for third). The instruments are the independent variables and unemployment variation (first two models) / variations of the independent variables (the last model).

Next, we studied the causality between the analysed variables by using the first-generation Panel Granger causality tests (Lopez & Weber, 2017) and the second-generation Granger tests (Abrigo & Love, 2016; Dumitrescu & Hurlin, 2012). The most important outputs of the causality techniques (Table II.6.3-5) refer to a two-way (bidirectional) causality between Military expenditure and GDP, which are mutually influenced (the key to interpreting causality tests is that previous values at lag 1 influence actual values). Considering the EU (27) and EU-NATO(21) panels, bidirectional causal links were also obtained for the remaining analysed variables (especially based on the second-generation tests), with an exception without statistical significance: lag of Military expenditure does not cause Inflation (year 2021 was included in the analysis, with almost double the levels of inflation in the studied countries compared to 2020, suggesting that high contemporary inflation is definitely linked to other determinants besides previous military expense). The third panel, the EU NON-NATO (6), is characterised by fewer two-dimensional relationships than the first two panels, but, interestingly, by including in the analysis the year 2021, we obtain statistical significance for the two-dimensional link between Military expenses and GDP, which may lead to the preliminary assumption that previous values of Military expenses contribute to the modification of current GDP values.

Table II.6.3-5. Granger causality between the variables, first-generation and second-generation tests (1998–2021)

		EU (27)		**EU-NATO (21)**		**EU NON-NATO(6)**	
Null hypothesis of no causality		F-stat	Z-bar	F-stat	Z-bar	F-stat	Z-bar
lnGDP	L1.lnMex	1.289	4.543***	0.935	3.859***	0.062	2.418**
lnMex	L1.lnGDP	6.266**	4.663***	3.046*	1.422	0.681	7.232***
lnGDP	L1.Unemployment	0.038	2.493**	0.003	2.534**	1.428	0.547
Unemployment	L1.lnGDP	0.573	9.107***	0.954	8.258***	0.048	3.869***
lnGDP	L1.Inflation	0.883	3.209***	1.541	3.836***	0.058	-0.370
Inflation	L1.lnGDP	0.162	3.751***	0.211	3.424***	0.167	1.552
lnMex	L1.Unemployment	5.005**	10.692***	2.450	10.964***	0.344	2.168**
Unemployment	L1.lnMex	0.684	14.873***	0.987	12.379***	0.004	8.391***
lnMex	L1.Inflation	0.931	2.644***	0.276	3.034***	0.068	-0.067
Inflation	L1.lnMex	0.016	0.659	0.000	0.103	0.251	1.205
Unemployment	L1.Inflation	3.677*	14.838***	2.001	14.113***	2.106	5.074***
Inflation	L1.Unemployment	0.164	7.144***	0.025	5.235***	0.866	5.362***

Note: ***, **, and * denote significance at the 1, 5, and 10 percent level, respectively. Source: Authors' processing.

To ensure greater accuracy of the results, we analysed whether past values of independent variables cause GDP by computing the third generation of Granger-type causality tests (Juodis et al., 2021; Xiao et al., 2022), whose specificity is that, in addition to enabling us to assess causality, it helps us to obtain the results of an HPJ (Half-Panel Jackknife) bias-corrected pooled estimator regression (Table II.6.3-6).

Table II.6.3-6. Granger causality between the variables, third-generation tests HPJ (Half-Panel Jackknife), and regression models (1998–2021)

lnGDP	**EU(27)**	**EU-NATO(21)**	**EU NON-NATO(6)**
L1.lnMex	0.044*; (0.026)	0.093***; (0.029)	-0.303***; (0.063)
L1.Unemployment	-0.007***; (0.001)	-0.006***; (0.001)	0.008**; (0.003)
L1.Inflation	-0.017***; (0.001)	-0.019***; (0.001)	0.002; (0.006)
HPJ Wald-stat	119.407***	133.507***	28.664***

Note: Standard errors in parentheses; ***, **, and * denote significance at the 1, 5, and 10 percent level, respectively. Source: Authors' processing.

Several important findings arise from our analysis. The influence of the past values of the Military expenditure on GDP is statistically significant and positive only for the group of EU and NATO member countries, which confirms that, as past values of Military expenditures increase, current GDP

also increases. These results can be explained as follows: (1) the higher the level of Military expenditure, the more the country in question maintains a stable level of security for a very long period of time, thus establishing investor confidence (Fatehi-Sedeh & Safizadeh, 1989); this means that defence spending produces security, which enables private economic agents to set up and carry out productive economic activities without fear of external appropriation (through investments it will increase GDP). (2) In numerous countries, a percentage of the defence expenditure is allocated to research and development activities. Military research and development leads to innovations, which in turn lead to applications in the civilian sector, thus increasing productivity and revenues (Bernauer et al., 2009). For example, the civilian sector has adopted technologies that were originally developed in the military, such as air transport, nuclear power generation, and the use of radar and space technology, each of which have boosted the productive private sector. (3) Military spending helps both directly and indirectly to facilitate economic growth by increasing purchasing power, raising aggregate demand, and financing heavy industry, especially armaments (Looney, 1991).

In the literature, there are arguments to support the positive impact of defence expenditures on economic growth. For instance, Benoit (1978) observed that defence programmes in many countries have a significant effect on the civilian economy by providing food, housing, and clothing to individuals who would otherwise have to be supported by the civilian economy. Additionally, military programmes provide education, medical care, and technical training that has high civilian value. The military also engages in various public works projects and scientific and technical specialties that benefit the civilian population and conducts research and development activities that might not be carried out solely for civilian demand.

In contrast to the above results, for the group of non-NATO EU member countries, the influence of the past values of the Military expenditure coefficient on GDP is statistically significant and negative, which implies that, as the level of Military expenditure rises, GDP decreases. First, we document that it is possible for the effects of Military expenditure on GDP to be negative; indeed, as in the first argument, military spending can have a negative influence on social welfare as it leads to less public expenditure on the accumulation of human capital hampering economic growth and indirectly bringing losses to social well-being; plus, if governments prefer to cut other important public investments, such as education, public health, and infrastructure, in favour of increasing military spending, defence spending may decrease long-term economic growth (Topal et al., 2022). A second argument would be that the most negative effects of military spending on economic growth come from the aggregate part of supply, which deals with ‘opportunity costs’. These costs are associated with certain economic problems, such as inflation, imbalances in the international financial structure, and excessive public debt. The main argument in this category is that military spending diverts civilian resources from more productive uses (Heo & Ye, 2016). Another argument is that with the increase in military spending, there is a decrease in research and development spending in the civilian sector, leading to major implications for GDP because non-military research and development spending are diverted.

The differences in the findings obtained for the two groups of countries in our study may stem from the fact that some of the recorded effects are conditioned by the national and sometimes even regional political, economic, and security context. However, there are some reasons why the causal relationship between military spending and economic growth yields different results from one group of countries to another, such as different preferences applied in countries' defence policies and growth policies (Topal et al., 2022). Additionally, analytical results may vary ‘depending on things like

usability, how military spending is financed, externalities in military spending, and the effectiveness of military spending in countering the threat' (Dunne et al., 2005).

Regarding the relationship between military spending and economic growth, it is advisable to consider the factors that could have negative implications for economic growth in the long run. Military spending can initially stimulate economic growth through job creation and increased demand. However, larger defence budgets may also reduce private investment (Fatehi-Sedeh & Safizadeh, 1989) due to the crowding-out effect. Furthermore, diminished government spending in productive sectors like education or infrastructure (Dunne et al., 2001), coupled with rising public debt (Heo & Ye, 2016), could curtail long-term economic growth. Additionally, diverting resources from high-growth sectors may limit economic efficiency. These factors could have detrimental implications for long-term economic growth.

Based on the previous models for the three panels – EU (27), EU-NATO (21), and EU NON-NATO (6) – the testing of our hypothesis led to the following considerations:

Regarding the military spending and GDP nexus, for the **H_1** hypothesis, the results of most models indicate a positive correlation between current military expenditure and economic growth (GDP), with robust and reliable results both in the static and dynamic panel models. The results are consistent with relevant results from past literature (Churchill & Yew, 2018; Tiwari & Shahbaz, 2013; Wijeweera & Webb, 2011; Yilgör et al., 2014), meaning the **H_1** hypothesis can be accepted for the current level of military expenditures. Based on the new Granger causality method and Half-Panel Jackknife bias-corrected pooled estimator regression (Juodis et al., 2021; Xiao et al., 2022), we found that past values of military expenditures positively influence GDP in the groups of EU and NATO-EU countries, while in the panel of non-NATO EU countries past values of military expenditure exert a negative influence on GDP. This invalidates the **H_1** hypothesis for this group of countries (EU non-NATO), thus supporting previous research that emphasises the potential of military spending to inhibit economic growth (Topal et al., 2022).

Based on the negative coefficients in the predominant computed static and dynamic panel models, the results suggest evidence of a relationship between unemployment and economic growth, in line with previous research (Gricar et al., 2022; Hashmi et al., 2021). In both NATO and non-NATO EU countries, high unemployment rates negatively influence GDP because fewer people are contributing to the economy's productivity, leading to lower overall output. Additionally, prolonged unemployment can lead to a degradation of skills, further affecting productivity. This cycle of reduced productivity and economic output confirms the negative correlation between unemployment and economic growth. In the context of military spending, high unemployment may limit a country's ability to allocate resources to defence. For NATO members, who have agreed to spend a certain percentage of their GDP on defence, high unemployment and its consequent impact on GDP could hinder their ability to meet this obligation. The same negative sense of the unemployment GDP relationship is obtained for the non-NATO panel, but the results are statistically significant only in FGLS model.

Inflation, meanwhile, also has a negative relationship with economic growth, as was shown to be the case in previous studies (Denbel et al., 2016; Stanić & Račić, 2019). This is because high inflation erodes purchasing power, discourages savings and investment, and introduces uncertainty into the economy, thus negatively impacting GDP in both NATO and non-NATO EU countries (the latter panel shows less statistically significant results and only the FGLS model is robust). In relation to military spending, high inflation could devalue the real impact of defence budgets. Moreover, for

NATO countries with specific defence spending commitments, high inflation could necessitate even greater nominal spending to maintain the agreed real value of defence contributions.

Finally, we emphasise that the main achievement regarding the core explanatory variable, military expenditures, is that NATO membership imposes a stronger correlation between military spending and GDP.

II.6.4. Concluding remarks

The role of military expenditure in ensuring the security and defence of European nations has become increasingly salient in light of the war in Ukraine, which broke out in February 2022. More than ever, protecting freedom and democracy is a central theme for the EU states, national governments, and EU authorities. As a result, they have had to address security and defence challenges that have consumed significant public funds, while also dealing with the effects of economic recession, including unemployment and rising inflation. Thus, many governments have been presented with the dilemma of choosing between security and welfare.

This study discussed the role of military expenditure, unemployment, and inflation in the GDP evolution of the EU countries, both in regard to NATO member states and non-NATO states. The current research was motivated by the need to resolve a vast antagonistic literature in which numerous macroeconomists, political economists, and scientists have laid out multiple mechanisms by which the interaction between defence budget growth and GDP can be theorised yet still fail to arrive at a consensus, with both positive and/or negative influences being found between different variables.

Our research analysis and findings are in line with the previous literature and conclude that the current and past values (first lag) military expenditure level positively influenced GDP between 1998 and 2021 in the EU and NATO EU countries. Regarding the group of non-NATO countries, given the small size of the studied sample, the statistical results differ in certain cases from the results obtained for NATO EU states. Moreover, the non-NATO countries are characterised by geopolitical features, historical particularities, and structural characteristics in the field of defence policies that differentiate them from NATO countries. These six studied non-NATO states did not adhere to the long-term political commitment to allocate 2% of their GDP to their defence budgets until 2024. Even more strikingly, one of the non-NATO states has reduced its share of military spending in GDP in 2021 compared to 2014 (Ireland). In such a context, the results obtained denote notable peculiarities of non-NATO states, for which we have proven that the current values of military expenditures contribute to the growth of GDP, while the past values of military expenditures have the potential to inhibit GDP.

For all NATO and non-NATO EU countries, the robust results obtained in most of the studied static and dynamic panels models for two analysed proxies as control variables (unemployment and inflation) reveal the negative correlation of current and past values of unemployment and inflation with GDP. Also, a positive influence of GDP's past evolution (first lag) on its current values has been documented, based on a GMM approach.

These findings suggest two significant political implications: (1) these results could be helpful to policymakers in the sense that governments can use military spending as a driver of GDP growth, but they must ensure that resources are appropriately managed and efficiently allocated to ensure such accelerated growth; (2) it is unwise for states to use defence spending to create jobs to stimulate their economies.

To conclude, there are key differences between NATO EU members and non-NATO EU members. The primary difference revolves around security commitments and defence spending. NATO

members are part of a mutual defence pact binding them to the principle of collective defence. This means that an attack against one NATO member is considered an attack against all members. As part of their NATO membership, these countries have agreed to aim to spend at least 2% of their GDP on defence, although this target is not always met. This commitment can influence national budgeting decisions, as countries need to allocate significant resources towards defence. For NATO EU members, their obligation to aim for a specific defence spending target (2% of GDP) can lead to a more substantial immediate economic stimulus through job creation and increased demand in defence-related industries. This commitment can also lead to technological advancements driven by military research and development.

Non-NATO EU members, on the other hand, do not have this specific commitment. While they participate in collective security and defence policy frameworks within the EU, such as the Common Security and Defence Policy (CSDP), these commitments are generally not as binding as NATO's. Therefore, these countries might enjoy greater flexibility in their defence budgets and overall economic planning – a difference that could potentially influence the dynamics of economic growth, inflation, and unemployment between NATO EU members and non-NATO EU members, especially considering the significant resource allocation required for defence among NATO countries.

However, the potential drawbacks related to the crowding-out effect, public debt, and resource diversion could also be more pronounced in NATO EU countries due to their higher defence spending commitments. Thus, their economies may experience more significant trade-offs between military expenditure and investment in other productive sectors.

By contrast, non-NATO EU countries, with potentially lower military spending, may have more resources available for private investment and other public sector initiatives. The potential for crowding out, higher public debt, and resource diversion might therefore be less pronounced in these economies. However, these countries might also experience less of the immediate economic stimulus and technological development benefits associated with high levels of defence spending.

For NATO EU countries, the results confirm the Neoclassical growth theory view that military expenditure, as a form of capital investment can stimulate growth through enhanced security, technological spillover, and demand increase. In non-NATO EU nations, though, the negative correlation supports the Endogenous growth theory, highlighting the potential adverse effects of military spending crowding out essential investments in human capital and productive sectors, thus hampering long-term economic growth.

(B-ii) The evolution and development plans for career development

The development of my academic career represents a natural continuation of a journey begun 25 years ago, when I first entered a lecture theatre as a lecturer in the autumn of 1999. The 25 years dedicated to teaching and research activities trace their origins back to 1997, when I completed my undergraduate studies at the Academy of Economic Studies in Bucharest, Faculty of Commerce, specialising in Marketing.

In 1999, I commenced my teaching activities at the AISTEDA University Foundation (Academy for Technical, Economic, Legal, and Administrative Sciences) as an associate doctoral teaching assistant, since my primary position was at S.C. BANC POST S.A. – Alba Branch, Alba Iulia. After passing the competition in 2000, from the 1st of October, I became a full doctoral teaching assistant at the "1 December 1918" University of Alba Iulia. In 2003, I was promoted to the position of Lecturer, and since 2005, I have been an Associate Professor.

During the period 1998-2002, I pursued doctoral studies in Economics, specializing in Finance, at Babes-Bolyai University, Faculty of Economics and Business Administration (FSEGA), obtaining a PhD in 2002.

Currently, the candidate works as an Associate Professor, PhD., within the Department of Finance-Accounting, Faculty of Economic Sciences, at the "1 Decembrie 1918" University of Alba Iulia. Throughout the academic career (1999-2024), the candidate has engaged in teaching and research activities.

The perspectives of my career have two very important dimensions, namely: *teaching and scientific research*.

Perspectives for teaching activity

My teaching responsibilities, as Associate Professor, PhD, within the Department of Finance-Accounting, include activities for the following disciplines: “Monetary Economy” and „International finance” (Bachelor studies, Banking and Finance specialization); “Banking techniques and operations” (Bachelor studies, Business Administration specialization and Economics of trade, tourism and services specialization); “ Evaluation and financing of investments“ (Bachelor studies, Business Administration specialization); „Financial-banking management” (Master studies, “Business Administration in Trade, Tourism, Services“ specialization); „Funding of entities and investment management” (Master studies, “ Taxation and Financial Management“ specialization).

An important component of the didactic activity is represented by the scientific research carried out by the students. In this regard, I have been mentoring students to partake in sessions of scientific presentations organized by universities in the country and the Republic of Moldova. Starting from 2018, I have served as a coordinator for students in the research component, specifically for those who have been awarded scientific achievement scholarships.

Also, my involvement in the research carried out by the students is demonstrated by the publication with them of several books (*Iuga Iulia, Mihalciuc Anastasia, *Economic Crises. Effects On Banking Systems And Investment Decision*, LAP Lambert Academic Publishing, 2020, ISBN: 978-620-2-92090-2; *Iuga Iulia Cristina, Neamţu Anisia, *Small and medium-sized enterprises marketing during digital transformation*, LAP Lambert Academic Publishing, 2022, ISBN:978-620-4-74737-8)

and one ISI article (*Iuga IC, Mihalciuc A. 2020. Major Crises of the XXIst Century and Impact on Economic Growth. Sustainability, 12(22):9373. DOI: 10.3390/su12229373. WOS: 000594570900001).

As a teacher, I will continuously improve my professional training, the teaching methods and communication with students so that I can provide easy explanation and transmission of specialized knowledge.

From an educational point of view, my primary objective is to make my contribution to the high quality professional training of students, their personal development, to support them in the development of research projects, bachelor and dissertation papers of high academic standing.

In order to develop my teaching activity, I propose the following objectives:

- increasing the quality of the teaching activity by permanently updating the course and seminar support based on the researches carried out and on the feedback received from financial and banking specialists;
- using students feedback and the results of the assessment of my teaching activity by students in order to improve my teaching activity;
- continuous improvement of teaching methods and techniques, as well as the development of communication relations with students through participation in training and professional development courses;
- participating in internships at prestigious universities abroad with the purpose of improving and diversifying teaching and communication methods and techniques;
- active involvement in the organization of student circles and scientific manifestations;
- stimulating students to participate with research papers at various scientific conferences and student competitions.

Research directions

With regard to the scientific research activity, I will focus on identifying new research, current and interest directions on the issues of banking, but also in the field of corporate performance and sustainable economic growth. I also propose:

- publishing books at nationally and internationally recognized publishing houses;
- dissemination of research results through participation in prestigious international conferences in the field of banks;
- the publication of scientific papers in journals indexed in international databases, particularly in the Social Sciences Citation Index (Clarivate Analytics);
- initiating collaborations with academics and researchers to develop scientific papers and develop joint projects on topics of interest.

I also aim that my entire research activity to be correlated with the didactic work, and the research results to be of interest to students, the academic community and practitioners.

The main research directions that I am focusing on in the following period are:

1. **Does banking concentration affect the stability and profitability degree of the banking system? Evidence among post-communist European countries.**

The variance in financial intermediation levels across post-communist countries during the first decade post-1989, despite strong concentration, is a well-documented phenomenon in the literature.

Yet, the impact of a competitive banking market on the financial robustness of these countries' banking systems remains an unresolved question.

Our research intends to conduct a thorough comparative analysis of banking performance in 11 post-communist countries, examining both the pre-EU accession and post-EU accession phases. Additionally, this study aims to elucidate how prevailing theories on market concentration's impact on banking performance adapt within the milieu of changing political and economic regimes.

From a policy-making perspective, our findings highlight the critical need for flexible regulations capable of bolstering the banking sector's resilience and adaptability amidst fluctuating economic conditions. The identification of an inverted U-shaped correlation between competition and banking performance further emphasizes the imperative for a balanced competitive environment, essential for fostering a robust and prosperous banking industry in post-communist European nations.

2. The Impact of Governance on Internet Banking in the European Union, with Technological Progress as the Moderator

This study aims to dissect the effects of governance, human development indices, and technological advancements on the uptake of internet banking services across the 27 European Union member states. It endeavors to offer a holistic view on the contributions of these elements to the development and preference shifts towards digital banking services within the EU framework.

The uniqueness of this study lies in its targeted examination of how governance, human development, and technological progress collectively influence internet banking adoption in a context that is both diverse and unified under the European Union. By considering a broad spectrum of variables within a comparative lens, the study introduces a novel, in-depth perspective on the evolving trends and disparities among EU countries. An exhaustive literature review revealed no existing studies that simultaneously tackle the interaction between internet banking usage and a comprehensive set of factors encompassing governance, human development, and technological progress within the EU, highlighting the originality and importance of our investigative approach. This research bridges this gap by amalgamating these critical factors, thereby furnishing a thorough comprehension of internet banking adoption trends across the EU member states.

Spanning over two decades, our study delivers insights into the evolution of internet banking against a backdrop of significant shifts in governance and technology. Concentrating on the EU 27, it scrutinizes the influence of European policies and regional integration on the adoption of financial technologies, weaving together the often separately considered strands of governance and technological evolution to explore their collective impact on the adoption of internet banking. It assesses how pivotal occurrences, such as the EU enlargement (2004, 2007, and 2013), the global financial crisis (2008), and notable technological breakthroughs (2004, 2014, 2019), have molded digital financial behaviors.

3. Government investment in health and macroeconomic factors

This study will explore the impact of healthcare system quality and economic indicators, including GDP, unemployment, inflation, availability of hospital beds, and healthcare investment, on the percentage of the elderly population in EU countries. Employing System GMM and wavelet

coherence analysis on 21 years of data from 27 EU nations, the methodology will offer a comprehensive examination of the ongoing interactions among critical variables and their influence on the elderly population's proportion. These analytical techniques are expected to shed light on the dynamic interactions within the time-series data.

The anticipated findings are to establish clear connections between the economic conditions and healthcare resources with the size of the elderly population. Positive correlations with economic prosperity, efficient healthcare expenditure, and accessibility to hospital beds, which are projected to contribute to an increase in the elderly demographic, will likely be observed. Wavelet coherence analysis will further reveal the joint effects of economic and healthcare variations on aging trends across different time spans and frequencies.

By underscoring the crucial need for economic stability and a robust healthcare system, the research will advocate for the implementation of integrated policies aimed at improving the welfare of the elderly in the EU. These findings will be instrumental in highlighting the importance of a concerted effort to enhance elderly care through strategic investment in healthcare and the management of macroeconomic factors, thus ensuring a better quality of life for the aging population across the European Union.

4. The Impact of Digitalization on the Volume and Quality of the Money Supply

The aim of our research is to meticulously assess the impact of digitalization on the volume and quality of the money supply. We intend to explore how advancements in digital technologies are reshaping the landscape of monetary economics, particularly focusing on the changes in the money supply metrics and their implications for economic policy and financial stability.

The analysis of literature on monetary economics and digitalization reveals a burgeoning interest in understanding how technological progress influences financial systems, including the mechanisms of money creation, distribution, and control. Despite this growing interest, there remains a significant gap in comprehensive studies that directly link digitalization with the qualitative and quantitative aspects of the money supply.

The review of empirical studies within the fields of digital finance and monetary policy highlights the emergent need to delineate the effects of digitalization on the money supply. However, a detailed examination of how digital banking, cryptocurrencies, and fintech innovations are altering the traditional concepts and measures of the money supply remains scarce, particularly in the context of its quality and aggregate volume.

Our study brings at least two contributions to the current literature on digitalization's impact on monetary economics. Firstly, it provides empirical evidence on how digitalization is transforming the mechanisms of money creation, potentially altering the velocity of money and its effectiveness in economic stimulation. Secondly, it evaluates the implications of digital financial innovations for monetary policy efficacy and financial stability, offering insights into the challenges and opportunities faced by central banks in the digital age.

According to our knowledge, there is a small number of researches focused on the intersection of digitalization and the money supply, especially research that critically evaluates both the qualitative and quantitative dimensions. Our study seeks to fill this gap by offering a comprehensive analysis of

digitalization's effects on the volume and quality of the money supply, thus contributing valuable insights for policymakers, economists, and the broader financial community.

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