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As we do every quarter, in this issue we also focus on the new challenges spawned by the (geo)political malaise that erupted in Serbia during Q4 2024. We begin with a contribution from a duo of authors, *D. Đuričin* and *A. Kovačević*, in the *Sustainability and Climate Risks* section. Their paper puts the spotlight on the green energy transition, with a key idea centred on developing an energy hub based on biomass-powered heat and power units. This initiative also includes establishing a lithium refinery at the site of the current lignite-based power plant, whose phase-out the authors suggest.

In the *Finance* section, Governor *J. Tabaković* sheds light on the external and internal factors shaping bank performance during different phases of economic cycles influenced by major geopolitical and global economic shocks, notably the global polycrisis. The paper highlights the delicate interplay between external destabilizing trends and internal anti-inflationary policy measures, and their combined impact on the banking sector performance, macroeconomic outcomes, and growth potential.

The paper in the *Economic Growth and Development* section, authored by *I. Todorović* and *M. Nedeljković*, deals with the spillover effects of U.S. monetary contraction. The authors particularly emphasize the prolonged and non-immediate effects, such as a decline in the real sector.

Measuring tax morale is an ambitious goal of the paper in the *Tax and Law* section. According to *S. Ranđelović*, 78 percent of people in Serbia report a high level of tax morale, placing the country in a below-average group among European nations. This reflects below-average trust in government effectiveness and the quality of public goods.

In the *Accounting, Auditing and Forensics* section, *N. Džudović* and *D. Malinić* analyze the mechanisms parent companies use in the pursuit of desirable financial results. The authors measure the impact of the commercial and financial aspects of transfer pricing on the performance of complex economic entities operating in Serbia.

An interesting discussion in the *Technology Change and Innovation* section starts with *D. Vujović's* paper, which deconstructs GenAI as a true general-purpose technology of the new industrial revolution. The objective is to highlight its potential and the scope of its impact on economic growth and policymaking. The second paper, authored by a team including *N. Savić*, *J. Lazarević*, *F. Grujić*, and *V. Čolić Mihajlović*, compares Gen Z with Gen Alpha, aiming to provide a sneak peek into their potential to "live" the new technology and harness its capabilities more extensively.

Finally, in the *International Economics and Business* section, *R. Kastratović* and *D. Lončar* examine the impact of FDI on energy efficiency. Based on empirical tests, the authors find firm evidence within the examined sample that foreign ownership contributes to improved energy consumption through the adoption of new technologies, thus leading to higher productivity.

Prof. Dragan Đuričin, Editor-in-Chief

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NAVIGATING THE POLYCRISIS: A RESPONSIBLE ROADMAP FOR SERBIA'S GREEN ENERGY TRANSITION

Kroz izazove polikrize – odgovorna mapa puta za zelenu energetsku tranziciju u Srbiji

Abstract

The global economy is in an age of astonishing change driven by a polycrisis, full of conflicting signals and contradictions. The post-COVID recovery in Serbia in the period 2022-2024 was characterized by slow-to-moderate growth. However, the country's future growth faces significant challenges from deeply rooted external and internal disruptors. One of them certainly is the 30% energy output gap. The structure of energy output is the related challenge. Defining a solution for energy security, in terms of the volume and structure of energy production, as a key limitation to sustainable growth, has been influenced by the green energy transition. Persistent issues, such as a widening energy output gap, a high carbon footprint, the dominance of energy-intensive and hard-to-abate industries in economic structure (mining, steel, copper, cement, construction, transportation, ICT, etc.), as well as the low efficiency of end-use sectors, pose serious macroeconomic risks. The policy mix implemented in 2024 successfully curbed inflation, bringing it within the target tolerance band of 3% ± 1.5%, and reduced simultaneously the share of the fiscal deficit and public debt relative to GDP. Consequently, Standard & Poor's has classified Serbia as an economy with an investment-grade credit rating (BBB-). In parallel, the dangerous nexus of key disruptors continues to fuel inflationary pressures and challenge the country's macroeconomic fundamentals. To make matters worse, (geo) political malaise erupted in Q4 2024. The escalating costs of concerted mediation efforts to counteract these negative consequences have further squeezed the fiscal space available for investment. In this deteriorating context, the current energy output gap could soar to an uncontrollable level, exacerbating the energy security issue. In the meantime, a new external asymmetric shock has emerged, the US sanctions to NIS (Naftna industrija Srbije), a Russian-Serbian joint venture and a leader from the energy sector. The sanctions on NIS could exacerbate an already severe energy output crunch. An additional factor of concern is the structure of Serbia's energy production, which is heavily reliant on lignite, accounting for 68% of electricity generation. There is a growing urgency to address this issue, not only to ensure energy security in Serbia but also to align with global climate change mitigation goals. To achieve and sustain energy security in Serbia, three critical goals provide the solution: energy output expansion, supply diversification, and the shift from fossil fuels to renewable energy sources. The Green Energy Transition Action Plan serves as the framework for achieving these goals. In the energy sector, the EU tends to be more explicit, elevated, and sophisticated in its requirements regarding compatibility with candidate countries. By meeting a net-zero future, Serbia will increase its chances of joining the EU. We want Serbia to be integrated into the EU as sustainably and inclusively as possible. A responsible roadmap should be not only feasible and effective but also based on local renewable energy sources, fiscal space, and the credit potential of relevant stakeholders, making it affordable for the capital blending needed for green finance. Our view is that biomass will be a key renewable energy source in the medium term. Other elements of the plan include the regulatory framework for the carbon marks, the issuance of thematic securities (green bonds, green credits, etc.), and green fiscal subsidies, along with measures to prevent non-complying behavior. Following the previous line of reasoning, the paper is organized around four fundamental issues. Part 1 is dedicated to explaining the polycrisis as the context that demands a polytransition, colloquially referred to as the green transition. In Part 2, we focus on a strategic audit of Serbia's macroeconomic fundamentals as a zero step in defining feasible solutions. Part 3 discusses two growth scenarios: the "as-is" scenario and the "to-be" scenario. Part 4, the most important section, provides the key explanatory details regarding the deployment

of biomass technology as the center of Serbia's green energy transition in the medium term, along with aggregate financial projections. The paper concludes with a *Nota Bene*.

Keywords: *Serbia, market fundamentalism, structural imbalances, polycrisis, climate change, energy security, green energy transition, macroeconomic fundamentals, biomass, green financing, carbon tax*

Sažetak

Globalna ekonomija prolazi kroz period spektakularnih promena na koje utiče polikriza obeležena konfliktnim signalima i kontradiktornostima. Oporavak u Srbiji u post-Covid periodu 2022-24 obeležen je sporim do umerenim rastom. Ipak, budući rast izložen je brojnim izazovima pod dejstvom duboko ukorenjenih eksternih i internih uzroka problema. Jedan od takvih faktora svakako je energetski autput gep od 30%. Povezani izazov je struktura energetskog autputa. Rešenje za pitanje energetske sigurnosti, definisane preko količine i strukture proizvodnje energije kao ključnog ograničenja za održiv ekonomski razvoj, pod uticajem je zelene energetske tranzicije. Uvreženi problemi kao što su povećanje energetskog autput gepa, visok ugljenični otisak, dominacija energetski intenzivnih sektora čija se potrošnja energije teško smanjuje u strukturi industrije (rudarenje, proizvodnja čelika, bakra i cementa, građevinarstvo, transport, IKT), kao i niska efikasnost u potrošnji energije, utiču na ozbiljan makroekonomski rizik. Kombinacija ekonomskih politika primenjena u 2024. godini uspešno je smanjila inflaciju uvodeći je u ciljani koridor 3% ± 1.5%, a simultano smanjujući učešće fiskalnog deficita i duga u BDP. Posledično, Standard & Poor's klasifikovao je Srbiju među ekonomije sa investicionim kreditnim rejtingom (BBB-). Paralelno, opasna grupa faktora rizika povećava inflatorni pritisak i kvari makroekonomske fundamente sistema. (Geo)politička kriza koja je eruptirala u četvrtom kvartalu 2024. godine značajno je pogoršala situaciju. Rastući troškovi sveobuhvatnih napora za medijacijom, kako bi se suzbile negativne posledice, smanjuju fiskalni prostor za investicije. U kontekstu koji je izložen pogoršanju postojeći energetski autput gep mogao bi se povećati do nekontrolisanih granica, još više zaoštravajući problem energetske sigurnosti. U međuvremenu, pojavio se novi eksterni asimetrični šok, sankcije SAD uvedene NIS (Naftna industrija Srbije) rusko-srpskom zajedničkom ulaganju i lideru energetskog sektora. Sankcije mogu pojačati problem nedovoljne energetske proizvodnje. Faktor koji zahteva dopunsku pažnju je struktura energetske proizvodnje koja je visoko zavisna od lignita koji učestvuje sa oko 68% u proizvodnji električne energije. Postoji visoka urgentnost rešavanja tog problema, ne samo u svetlu energetske sigurnosti Srbije, već i poštovanja globalnih ciljeva koji doprinose rešavanju problema klimatskih promena. Rešenje pitanja postizanja i održavanja energetske sigurnosti u Srbiji zavisi od tri cilja: povećanje proizvodnje, diversifikacija snabdevanja i prelaska sa fosilnih na obnovljive izvore energije. Akcioni plan zelene energetske tranzicije predstavlja okvir za ostvarivanje ovih ciljeva. Kada je reč o usklađivanju zemalja kandidata u energetskom sektoru, EU nastoji da bude potpuno eksplicitna i sofisticirana u svojim zahtevima. Ostvarivanjem nulte emisije u budućnosti, Srbija se približava integraciji u EU. Želimo da Srbija bude integrisana u EU na što održiviji i inkluzivniji način. Odgovarajuća mapa puta nije samo izvodljiva i efektivna, već i zasnovana na lokalnim obnovljivim izvorima, fiskalnom prostoru i kreditnom potencijalu relevantnih interesnih grupa sposobnih da stvore kombinaciju izvora kapitala potrebnu za zeleno finansiranje. Naša ideja je da će biomasa biti ključni obnovljivi izvor energije u srednjem roku. Drugi elementi plana uključuju regulatorni okvir karbonskog tržišta, kao i emisiju tematskih hartija od vrednosti (zelene obveznice, zeleni krediti) kao i zelenih subvencija, zajedno sa merama prevencije njihove zloupotrebe. Sledeći prethodni način razmišljanja, rad je organizovan oko četiri bitna pitanja. Prvi deo je posvećen objašnjenju polikrize kao konteksta koji zahteva politranziciju, poznatu po kolokvijalnom nazivu „zelena tranzicija". U drugom delu fokusiraćemo se na strategijsku reviziju makroekonomskih fundamenata u Srbiji kao nultom koraku u definisanju izvodljivog rešenja. Treći deo razmatra dva scenarija rasta: „as-is" scenario i „to-be" scenario. U četvrtom delu, kao najvažnijem segmentu rada, navodimo ključne činjenice u vezi sa uvođenjem tehnologije zasnovane na biomasi kao centralne tehnologije u sprovođenju zelene tranzicije u Srbiji u srednjem roku, uz agregirane finansijske projekcijei. Članak završava sa završnim napomenama.

Ključne reči: *Srbija, tržišni fundamentalizam, strukturne neravnoteže, polikriza, klimatske promene, energetska sigurnost, zelena energetska tranzicija, makroekonomski fundamenti, biomasa, zeleno finansiranje, karbonske takse*

A Growing Need for the Green Transition

For nearly two and a half centuries, the economy and society have prospered within the liberal capitalism framework, fueled primarily by the cumulative impact of four industrial revolutions. The related socio-economic context was shaped by three key vectors: private property, market economy, and democracy (both political and economic). By the end of the last millennium, the same mix of forces redirected evolution toward the most extreme variant of capitalism, the neoliberal capitalism. Such a radical change brought capitalism into a long and deep crisis. This crisis is the consequence of inbuilt fault lines, such as financialization, deindustrialization, soft budget constraints, etc. Climate change stands as the most severe physical structural imbalance in the system, while income (and wealth) inequality serves as the most impactful social structural imbalance of neoliberal capitalism.

In the Anthropocene age[1], climate change and its multiple negative effects on the socio-economic system are

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1 The period of humankind evolution with a dominant impact of humans on nature, physical system and biosphere.

evident to all, along with their detrimental impact on the physical subsystem and the biosphere as components of the planet, or the so-called "system dynamics," as defined by J. Forrester [15]. Anomalies within system dynamics interact with one another, disrupting the "sustained sustainability" across the planet's subsystems. Additionally, the physical system and biosphere upon which humankind critically depends have been deeply reconfigured, indeed destroyed. The planet does not need the economy and society (or people). In contrast, people, society, and the economy depend on the planet.

These days, the prevailing economic narrative has changed, as facts have dictated this change. Neoliberalism, rooted in the ideology of market fundamentalism, has exacerbated the inbuilt imbalances of the economic system. A nexus of rules, such as liberalization, deregulation, privatization, and globalization, forms the ideological foundation of neoliberalism. The problem with this nexus is its disregard for the limits of nature, the laws of nature, and the negative externalities of economic transactions on the planet. First and foremost, these propositions are not in line with common sense, simply because the planet has finite natural resources. Moreover, since the rise of neoliberalism, the situation that existed at the beginning of capitalism has fundamentally changed. The overuse of resources driven by egoism and profit maximization, along with the uncontrolled expansion of industrial production (and consumption), urbanization, and massive transport, has pushed the planet to the brink of upheaval. On the other hand, the globalization rule has been exclusive, benefiting some while discriminating against others. Namely, it has created opportunities for some but has not been inclusive of all.

Moreover, neoliberal policies (monetary and fiscal, primarily) are in direct conflict with planetary boundaries and the laws of nature, particularly the reversibility of the physical system and the evolution of the biosphere. Despite systemic overconsumption and the depletion of natural resources, supply has become a much more serious problem than demand. Furthermore, trade and investment in rare earth metals/minerals, energy resources, and food are becoming casualties of the geopolitical game. As investment expectations decline under such

circumstances, the economy is heading toward low or even negative growth. In the end, after the socio-economic system becomes trapped in a polycrisis, the planet shifts from a "Green Planet" to a "Ponzi Planet."

In this new context, non-linear systems dominate over linear ones. Non-linear systems are filled with unknowns, whether they are labeled as "risk" or simply as "uncertainty." Planetary (or strictly external) unknowns, e.g., climate change or microbe pandemic, dominate other types of unknowns (those related to individuals, companies, financial institutions, national economies, etc.). Planetary unknowns, often referred to as "external asymmetric shocks," have a universal but asymmetric impact, which is impossible to mitigate through individual reactions because they consist of interlinked, non-linear components.

At tipping points, unknown factors, characterized by multiple correlations, holistic by nature, can trigger external asymmetric shocks. The "black swan"[2] phenomenon belongs to this class of system anomalies. Multiple interactions of unknowns further cement existing imbalances, deepening them and creating new mega-imbalances. In such a context, the number of asymmetric external shocks and black swan events grows exponentially, generating global headwinds that obscure the prospects of addressing the root causes of crises and navigating through them.

After experiencing unconventional, experimental, and mostly ineffective policy responses based on neoliberal theory, in the prevailing economic narrative mega imbalances have been institutionalized as the "new normal" (or "non-normality"). Without corrective mechanisms in place, the economy is destined to be crisis-prone, which is also part of a new narrative.

The current conjuncture could be described as a "permacrisis"[3], a "rolling crisis," a "crisis in a system of crises" or a "crisis of crisis." However, the construct of "polycrisis" may be the best way to depict the explanatory element of the new crisis, in which separate crises (climate,

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2   The correlation of multiple non-linear feedback loops, which have a low probability but extremely high impact.

3   After the word "permacrisis" was announced as the Word of the Year by Webster's Dictionary in 2023, three economic luminaries wrote a book with the same title [6].

economic, biotic, etc.) have emerged, interacted, and amplified one another.

Climate change is the most significant disruptors of the modern socio-economic context, maybe. For a long time, business and political elites around the world have not taken climate change seriously enough, or at most, viewed it as a non-normality. The scientific understanding, however, has been much stronger. At the beginning of the last century, Nobel Prize laureate S. Arrhenius [1] used principles of physical chemistry to explain how an increase in carbon dioxide (CO_2) in the atmosphere impacts the so-called "greenhouse effect" and contributes to temperature increases on the planet's surface. In the 1960s, Ch. Keeling [23] further elaborated on the impact of CO_2 on global warming and climate change. Later, the Kyoto Protocol [44], by defining seven greenhouse gases (GHGs), including CO_2, recognized this phenomenon as a root cause of global warming.

The impact of GHG emissions on global warming and related climate change is scientifically verified through thousands of research papers across various fields of science. Since the start of industrialization in the late 1800s, the world economy has emitted more than 30 trillion metric tonnes of CO_2 equivalent. There is no doubt that the top ten hottest years on record, including 2024, have occurred, driving real-time climate breakdown. The planet is heating up rapidly, approaching the "boiling point." Glaciers are melting at an alarming rate, triggering a negative chain reaction, with a variety of extreme weather events. Agriculture, transport and casualty insurance have been hit hardest by extreme weather events, such as wildfires, droughts, flooding, and water shortages, particularly affecting crop and livestock production. All these events are becoming more intense and frequent.

Climate change is predominantly driven by human behavior. Energy production based on fossil fuels is a key negative externality of industrialization, urbanization, and transportation expansion. Even today, fossil fuels account for majority of primary energy production. The second major contributor to global GHG emissions is agriculture. The third is the indirect effect of deforestation, as the biosphere is incapable of offsetting GHG emissions.

Focusing on maximizing GDP (macro level) and shareholder value (micro level) is highly unhygienic and contradicts the sustainability proposition. In a world with physical limits and competition for scarce resources, development that ignores the natural boundaries is unsustainable. To simplify to the extreme, the planet is not enough for the development ambitions of all economic agents (supranational institutions, fast-growing national economies, incumbent companies, startups, or anyone else). Moreover, humanity's ecological and, particularly, carbon footprint exceeds the planet's biogeochemical capacity to regenerate used natural resources and absorb and reuse the related waste. Plastic is a prime example. When we factor in ultimate but rare earth materials such as fossil fuels and precious metals, resources that are not only limited but also non-recoverable on one hand, and contribute significantly to various forms of pollution on the other, it becomes clear that "maximization" is a fundamental fault line in neoliberal economic reasoning.

Let us illustrate the problem of resource regeneration and waste management by using "Earth Overshoot Day"[4] According to Global Footprint Network [17], the overconsumption of natural resources is causing earth overshoot day to arrive sooner and sooner each year, leading to the conclusion that the economy, society and the planet are on an unsustainable path. Specifically, the planet's biogeochemical capacity to regenerate already used natural resources and absorb the waste resulting from anthropogenic activities has been significantly diminished. On Earth Overshoot Day, humanity will have already consumed all the renewable resources the planet can replenish in a given year. For example, in 2024, earth overshoot day was marked on August 1. By applying some formula, it means that after August 1, humanity would require 1.75 planets to meet the demands of the global population.

Figure 1 illustrates how quickly selected countries were depleting natural resources in 2024, alongside their relationship with the global average of earth overshoot day. In the same year, Serbia entered its overshoot day on May 23. The United States experienced its overshoot

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4   It marks the date when the demand for resources in a given year exceeds what the planet can regenerate during that year.

day on March 14, meaning that the U.S. has an ecological footprint roughly five times higher than the global average. Also, it means that if the entire world lived like the average American, we would need about five Earths to sustain that level of consumption.

One of the key consequences of overshooting is pollution. Global warming is the most dangerous form of pollution. Global warming will continue to escalate in a non-linear manner because there is no Planet B. Recent reports from the Intergovernmental Panel on Climate Change (IPCC) highlight an alarming reality [19], [20], [21]. At the beginning of 2025, the planet is 1.55°C warmer than it was in the late 1800s, and it is warmer than at any point in the past two thousand years. In other words, the planet is already facing a climate emergency.

Climate scientists from the IPCC, UNESCO and other relevant institutions are concerned that, before 2050, the average global temperature will rise by more than 2.0°C above pre-industrial levels. Despite efforts of the Paris Agreement [45] to mitigate climate change, the planet is not on track to avoid surpassing the 1.5°C red flag by 2050.

Moreover, uncontrolled global warming increases the likelihood of more frequent biotic feedback loops, a higher emergence of microbial pandemics, and the rapid extinction of living organisms. The extinction rate of living organisms in the Anthropocene, with the exception of the human race, is accelerating faster than in any previous period of the planet's geological history. Over the past 50 years, biodiversity loss has amounted to around 50%.

Paradoxically, the current socio-economic context does not allow for the massive diffusion of groundbreaking innovations, such as converging and super-intelligent technologies that combine innovations from various fields enhanced by AI solutions. In fact, the commercialization of these breakthroughs is neither as frequent as expected, nor does it possess the capacity to significantly boost productivity and/or living standard. Although new technologies have the potential to propel the economy and society from crisis to prosperity, socio-economic frictions can prevent them from fulfilling this potential.

In the latest crisis, the dominance habit, deeply rooted in human nature, is amplified. When humanity wages war on both nature and human nature itself, the interactions within the nexus of conflicts lead to the emergence of new dimensions of conflicting interests. To navigate the road ahead with less risk, economic challenges will likely require a more intensive approach to geopolitics. As a result, geo-economic policy measures become significant macroeconomic variables.

The treatment of geopolitics as a part of macroeconomic equation represents the final push toward the degradation of neoliberal capitalism. Under the influence of geopolitics, certain resources such as oil, gas, uranium, rare metals, even food are being weaponized. As these resources move out of the market, their trade incurs higher transaction costs. Consequently, geopolitics leads to massive supply shocks in the global economy and asymmetric inflationary pressures at the local economic level. As imported inflation

Figure 1: Global average of earth overshoot day and overshoot days for selected countries in 2024
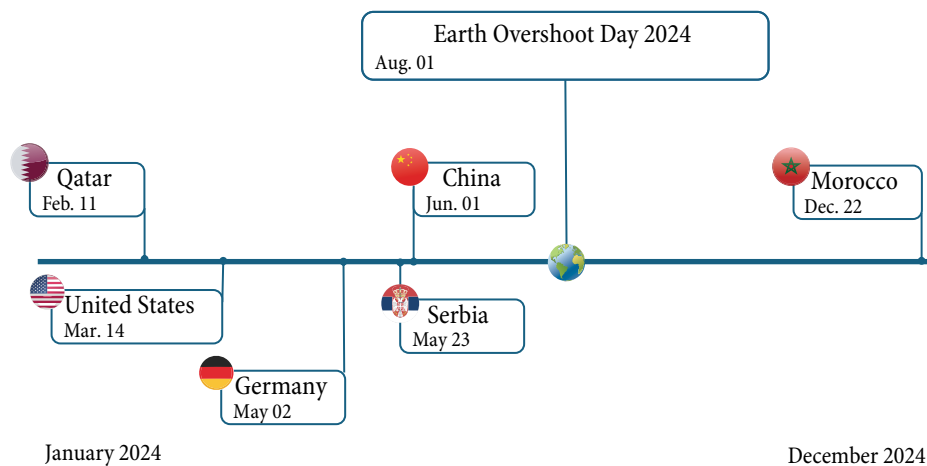
Source: Earth Overshoot Day, 2024

expectations become unanchored from economic logic, this external asymmetric shock not only exacerbates inflation but also diminishes the growth potential of the local economy.

Geo-economic policy measures are expanding in various forms, including economic sanctions, trade wars (import and export tariffs), currency wars, FX wars, hybrid wars, and even world war. Geopolitics poses a major threat to deglobalization. After deglobalization, the next stage is re-globalization. However, since re-globalization is based on geopolitical criteria, it will likely lead to the fragmentation of the global market.

Import tariffs (trade levies and sliding scale fees) are the most frequently used tools in the geopolitical game. Within the biggest economies, import tariffs exacerbate existing structural imbalances and create new ones. When sanctions are imposed, the benefits of outsourcing, such as cheap labor, and the effects of diversification are undermined. Also, import sanctions on energy, critical commodities, and essential food accelerate the inflation spiral. In doing so, the biggest economies, formerly leaders of the free market economy, further exacerbate protectionism, de-globalization, and global market fragmentation. In this process, counter tariffs also have the role to play. The side effects of import tariffs include export counter tariffs from smaller, open, and landlocked economies, which act as self-defeating measures.

Such a game, based on geo-economic measures, is a zero-sum game. The planet operates as a closed system rather than an open one. In a closed system, a zero-sum game is possible but inherently unsustainable. In this game, toxic stressors interact and amplify one another, creating a downward spiral. These dynamics trap the planet, along with the economy and society, in a conundrum, a lose-lose game. The lose-lose game makes the freefall of the global economy very real. Consequently, all subsystems of the system dynamics and the planet as a whole are dying slowly but surely.

The dominance of geopolitics over economics signals that the socio-economic system is heading toward the final stage of crisis, militarization. When "soft power" fails to function effectively, "hard power" takes over. Any activism in this regard becomes counterproductive,

as militarization serves to entrench inbuilt imbalances while exacerbating or creating new ones. Furthermore, geo-economic measures and countermeasures contribute to the further militarization of both the economy and society, emphasizing the unlimited use of cutting-edge technological solutions to develop so-called "weapons of mass destruction" (WMD).

Militarization misuses leading edge technologies and consumes valuable fiscal space that could otherwise be allocated to productive investments, making them counterproductive in addressing profound climate, economic, financial, and ecological imbalances. As a result, going green ambitions could fade, transforming the current climate situation from bad to worse. Namely, from climate change to a full-blown climate emergency.

Without significant investment in decarbonization, the average global temperature could rise by more than 2 degrees Celsius, potentially even before 2050. This trajectory would transform conventional weather patterns into what can be described as "weather of mass destruction" (WMD).

Weapons of mass destruction and weather of mass destruction, intertwined in "2WMD," potentially lead to apocalyptic consequences. Echoing the spirit of the appeal by I. Šlaus and J. Zidanšek [37], the Doomsday Clock[5] inches ever closer to midnight.

From an economic perspective, the epilogue of the inability to resolve the current polycrisis would be the entry of the global economy into a technical "stagflationary recession," as predicted by N. Roubini [34].

It is uncertain how long the current 2WMD and related stagflationary recession will last. Finding systemic solutions, namely a way to escape from the "new normal" toward a "better normal" in all economies, whether developed or developing, small or large, fast-growing or stagnant, is the imperative of our time. Confronting the reality of the "new normal," alongside the potential of the "better normal," calls for a radical change in the structure and functioning of the economic system through polytransitions (climate, economic, biotic, and geopolitical). This non-evolutionary

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5 The Doomsday Clock measures how close the planet is to annihilation. If the clock strikes midnight, it signals catastrophic consequences, such as the irreversible effects of climate change or the exchange of weapons of mass destruction, which would devastate the economy, society, and the planet itself.

shift is often referred to as the "green transition," with the intention to remind how the planet was before the era of market fundamentalism. The green transition is a gateway to a new model of growth, which should be circular and regenerative. This growth model should be based on the decarbonization of current industries and the deployment of climate-neutral technologies, primarily in the power sector. Following the Paris Agreement [45] and the UN's 17 SDGs, by 2050, the economy, society, and planet could reach a climate-neutral inflection point, known as "net-zero," which serves as the linchpin of the green transition.

Serbia can explore different views on how to meet its climate-neutral commitments. One group of climate thinkers argues that carbon pricing[6] and the marketization of thematic securities are key drivers in advancing the green transition, primarily contributing to "going green" approach. Another group advocates for state impact investments in high-capacity power generation and green energy infrastructure, along with related financing models. The solar boom is particularly evident in China, while both wind and solar are hallmarks of the EU's energy strategy. Energy experts agree that nuclear energy[7], especially nuclear fusion, as well as green hydrogen and biomass-based technologies, represent the most potent and sustainable solutions.

Both sides of the argument present strong points, and everyone has their own individual preferences. However, whether one likes it or not, the momentum for a new economy based on climate-neutral reindustrialization is steadily increasing worldwide. The specific choice depends on local circumstances, including the nexus and critical mass of renewable resources, fiscal capacity, and the credit potential for capital blending to finance green initiatives. High-potential decarbonization technologies are unlikely to be financeable in the visible future without a significant combination of funding sources, including multilateral development credit institutions as anchor investor, and additional sources of financing based on carbon taxes, public incentives for thematic securities (green bonds and green credits), and green surcharges.

Many empirical studies, e.g. [10], [28], have confirmed that there is still a limited shift in the attitudes of Serbia's private capital towards the green transition and sustainability-based disclosures (SDGs/ESG metrics). Therefore, it is essential to understand what the green transition is and what it is not. The catalytic role of the state in impact investments and industrial policies for tradable sectors is crucial.

To survive, recover, and prosper, Serbia's economy in 2025 and beyond must be powered by, and extremely agile in, the green energy transition. In the first stage, coal-based electricity production and heating systems should be significantly reduced. Other fossil fuels must follow. In the medium term, many sectors dependent on oil and gas will need to implement net-zero targets. Serbia should outcompete fossil fuels primarily by using its hydro potential and implementing nature-based solutions, such as planting trees for biomass production. Simultaneously, Serbia should begin serious preparations for the deployment of nuclear energy.

Serbia has biomass as a significant local renewable energy resource. Also, the country possesses substantial deposits of lithium and copper. The demand for precious metals and minerals essential for green technologies, such as lithium, cobalt, and copper, has surged dramatically. As a result, mining, metallurgy, and new materials management are poised to benefit from the green transition.

Before delving into the specifics of implementing biomass technology as a key renewable energy source for a quantum leap in the energy sector in the middle run, we will first analyze the macroeconomic fundamentals that are essential prerequisites for financing related investment.

Serbia's Macroeconomics: The Scale and Nature of Challenges

Growth, fiscal balance, debt, investments, (un)employment, payrolls, pensions, and participation rates are always in the spotlight for policymakers, particularly during the recovery stage of the business cycle. Relevant data indicates that the policy mix in Serbia during the post-Covid period (2022-2024) has been working well. Favorable

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6   Current carbon tax of USD 53 per ton is too low to avoid Paris 2C limit. More than USD 90 is required.

7   COP28 advises a threefold increase in nuclear energy capacity by 2050.

developments over the past two years suggest that Serbia's economy has strengthened significantly.

After the successful fiscal consolidation 2015-2018, Serbia's economy made a U-turn, driven by state impact investment in infrastructure and a strategic restructuring of its portfolio of industries. Unfortunately, the COVID-19 lockdown 2020-2022 slowed down this recovery. The state's support for companies facing liquidity problems and its solidarity with people in credit distress during the pandemic placed a significant financial burden on the country's economy. Interestingly, during the post-COVID period, the economic contraction was less severe than in the EU and less than initially expected. The growth rate of 3.9% in 2024 vividly illustrates the previous point.

As for inflation, the data is encouraging, confirming that the NBS is on track to meet its target tolerance band of 3.0% ± 1.5%. Headline inflation has been slowing since April 2023 and has continued to decline thereafter. By May 2024, headline inflation returned to the target tolerance band. In November 2024, headline inflation stood at 4.6% YoY. Unfortunately, core inflation remained above headline inflation, amounting to 5.3% YoY in December 2024 [32].

Debt as a share of GDP is on a declining path, dropping from 51.0% in 2023 to 47.1% at the end of November 2024. The share of fixed investments in GDP has been consistently increasing, hitting a historic high of 24.3% at the end of 2024. In Q3 2024, employment reached a historic maximum of 51.9%, while unemployment fell to a historic low of 8.1%. Employment growth was driven by a participation rate of 73.1% and an activity rate of 56.4%. The growth in formal employment was accompanied by double-digit real growth in wages and pensions throughout the year.

The current account deficit in the analyzed period amounted to around 5% of GDP, which does not comply with fiscal rules, but it is within the bounds of external sustainability. The current account deficit is fully covered by FDIs. By the end of 2024, the budget slipped into a deficit of around 2.7%, which remains within the Maastricht criteria. The budget deficit is stable despite an increase in expenses, largely due to the expansion of FDIs by 7.9%, reaching roughly EUR 5.1 billion, and an export growth of 4.5% YoY. General government debt at the end of 2024 was below 50% of GDP.

During the last year, the stability of the financial sector has been preserved. The NPL ratio was at a historical minimum of 2.7% at the end of 2024. The benchmark interest rate has remained steady at 575 bps, after a 75 bps cut in June 2024.

Macroeconomic indicators at the beginning of 2025 fuel cautious optimism, despite the global polycrisis and evident local weaknesses, such as core inflation being higher than headline inflation, signaling inflationary pressures and a negative impact of (geo)politics. Low-to-moderate growth, which could, under certain circumstances, be transformed into moderate-to-strong growth, is a predominant factor impacting the overall viability of the economy. The NBS's headline inflation expectations, as well as those of the financial sector, remain within the target tolerance band. Based on state impact investments and industrial policies for tradable sectors, the government anticipates an acceleration of the growth rate over the next two years, in the range of 4.0% to 5.0%.

The aforementioned macroeconomic fundamentals have been aligned with an improvement in credit ratings. Specifically, in October 2024, Standard & Poor's upgraded Serbia's rating to BBB-, placing it in the investment-grade category. Serbia received this credit rating because the economic conditions are expected to remain favorable, in line with capital market expectations.

Unfortunately, risk stressors remain strong and active. The industrial malaise in the EU, Serbia's main export market, is taking hold, particularly affecting the tradable sector in Serbia, most notably manufacturing and ICT. For instance, Germany accounts for approximately 15% of Serbia's total exports, making it Serbia's largest single export destination. However, in November 2024, German industrial orders dropped by 5.4% MoM, fueling fears of an impending recession [14].

Why is this so important? Because the EU, and Germany particularly, as Serbia's immediate environment, are experiencing a long-term stagflationary recession. The combination of inflation, economic slowdown, and a "fear of fear" mindset in the investment community are the consequences of deeply rooted structural imbalances of economic neoliberalism and impact of geopolitics. The

fractures of the socio-economic context have been further deepened and exacerbated by reaction policies (often unconventional, inconsistent, and experimental) as well as external asymmetric shocks, such as climate change, microbe pandemics, geopolitical disputes, etc.

In addressing the negative effects of the stagflationary recession from its key export markets, Serbia, as a small, open, and developing economy on the path to catching up with the mainstream EU, faces two policy choices. The first option is to rely on market forces following a currency adjustment to purchasing power parity (PPP), which would initially involve a depreciation of the national currency and maintaining a flexible FX rate after that. The second option is to keep FX rate stable while hiking key policy rates in line with the global shift from hawkish to dovish monetary policies. Simultaneously, Serbia could leverage FDI inflow to compensate for insufficient money supply (M2) through fiscal stimulus. Supporters of the first option overlooked the elephant in the room, the output gap. Policymakers in the recent period have chosen and consistently applied the second option for years. A key weakness of this policy mix is high inflationary pressures, which continuously undermine price stability, increase the cost of capital, and exacerbate recession fears. So, to make this policy mix effective, the NBS must focus on controlling inflation, while the Treasury Department should prioritize controlling the budget deficit and providing sufficient liquidity by attracting FDI.

In recent history, Serbia has had a respectable track record in combating inflation. In the period 2014-2020, headline inflation in Serbia averaged around 2%, which was one of the key factors contributing to the country's attractiveness for investors. However, the COVID-19 lockdown and subsequent geopolitical headwinds have slowed this trend. Inflation surged dramatically in the post-COVID period, particularly during 2022-2023.

In the past two years, the NBS has been relatively successful in its fight against inflation. After peaking at 15.1% YoY in March 2023, headline inflation reached an inflection point in July 2023, declining to 13.6% YoY. Inflation cooling gained momentum in the second half of 2023. Specifically, in October 2023, headline inflation had dropped to 9.5% YoY, continuing to decline at an accelerated pace in the following months, plateauing within the target tolerance band by the end of the first half of 2024.

To bring inflation down, the NBS has consistently avoided FX interventions, maintaining an almost fixed FX as a pivot of its monetary policy. The appreciation of RSD is a side effect of this policy. In October 2023, the RSD surged against reserve currencies, reaching its highest level since January 2016. This policy has had a detrimental impact on a significant portion of the domestic tradable sector. The overvalued RSD makes imports cheaper while making exports less attractive. However, FDI exporters have been more resilient, benefiting from transfer pricing mechanisms.

What does the NBS aim to achieve in the fight against inflation? The NBS was among the first monetary authorities to shift from a hawkish to a dovish policy stance. Benchmark lending rates have been increasing, including rates for the 1-year and 5-year LPR, as well as inverse repo rates (for 7, 14, and 21 days). The key policy rate of 575 bps at the end of 2024 remained unchanged for more than six months. As inflation risks persist, the NBS is prepared to either maintain the interest rate at this level or consider another rate hike. To stay on track toward a neutral interest rate in relation to growth, while maintaining a vigilant stance on inflation by keeping the policy rate at a relatively high 575 bps, the NBS has capped the interest rate spread at 400 bps.

Despite the evident cooling of inflation, inflationary pressures have not dissipated, as inflation is not just transitional but a structural phenomenon. Inflationary pressures are growing due to various external and internal factors. Much of Serbia's inflationary pressure has been imported via geopolitics. In a time when geopolitics is driving up energy, food, and commodity prices globally, national economies are quickly sliding into unintended macroeconomic chaos. Thus, keeping inflation within the target tolerance band in the long run remains a challenging task. Theoretically, the NBS may need to maintain high policy rates if inflation persists, but this strategy heightens recession fears. Anyway, the polycrisis presents a nightmare for any monetary power, as it is damned if it reacts and damned if it does not.

In an economy with an output gap like Serbia's, the NBS should care not only about inflation but also about growth, aiming to either delay benchmark interest rate hikes as long as possible or implement them more slowly. The NBS generally prefers not to resort to aggressive monetary tightening. However, in the current context, where inflation is rising due to geopolitical factors, slower tightening of the policy rate could prove counterproductive because it might contribute to the acceleration of de-anchoring of inflation expectations, thereby exacerbating recession fears.

Monetary tightening has its monetary rationale, but it faces fiscal and political constraints. The Treasury Department is much more sensitive to policy rate hikes than the central monetary authority. This explains the divergence between the NBS and the Treasury Department regarding monetary easing (both in terms of level and timing), particularly after Q4 2024, a period burdened by increased political polarization and rising mediation costs[8].

Despite many risk stressors, core banking has remained stable and even prospered. Despite monetary tightening, the NPL ratio remains at a historic low of 2.7%, signaling the viability of monetary policy. However, the real issue lies in the capital market, which is thin and underdeveloped. To be honest, some of the problems in the capital markets are unsolvable. Serbia's monetary power lacks the necessary tools to address challenges imported from global financial markets. A typical example is the trend of an inverted yield curve on fixed-yield assets, where short-term yields are elevated relative to long-term yields on government bonds. The NBS tries to keep the yield curve under control using conventional monetary measures, but in a thin market, an inverted yield curve is nearly uncontrollable. Another challenge is the turmoil in the global bond market and the ongoing recalibration. To maintain confidence in the local capital market and create a positive correlation between bonds and stocks, the NBS has been buying bonds of state-owned companies. However, this is not only insufficient but also risky. On the other hand, the Treasury Department has been active in issuing bonds. In mid-2024, a 10-year ESG Eurobonds

denominated in USD, amounting to USD 1.5 billion, were successfully issued. The final borrowing cost of 4.75% is favorable compared to neighboring countries that already hold an investment-grade credit rating [32].

An ongoing challenge for the architects of the economic system is managing both the transitional and current output gaps, the latter emerging intermittently. The prolonged output gap, coupled with significant pressure on state and household income, requires mitigation. In response, the government has opted to implement structural policies, focusing on impact investments in infrastructure (both physical and digital), as well as industrial policies targeting tradable sectors. In an economy grappling with an output gap, structural policies can boost economic growth. Among the tradable sectors, investments in ICT, construction, power, and manufacturing have been particularly growth-enhancing. This policy aims to increase GDP and improve its structure, creating space for income (and pensions) growth. However, a key challenge of this strategy is the rise in corruption associated with large-scale projects, which may trigger a series of negative consequences, including political instability.

Anyhow, Serbia's development strategy has increasingly pivoted around FDI, given its significant positive impact on macroeconomic liquidity and growth. The primary effect of FDI is on FX stability through an expanded monetary base (M2). The second effect involves the positive impact of increased employment and export expansion on growth. The third effect is improved competitiveness, driven by a more favorable output structure and productivity growth, resulting from capital infusion in leading edge technologies. In addition to its role in financing the current account deficit and increasing liquidity in the short term, the most significant long-term contribution of FDI is the growth total factor productivity.

Unfortunately, while public and foreign investments have experienced growth (both absolute and relative), private investments have declined relatively. This trade-off is evident, because a relatively high tax burden negatively affects private investments. While tax income having a positive effect on public investments, reduction of retained earnings having negative impact on private sector. Reducing profit tax and other fiscal instruments

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8 Aiming to avert a general strike, the government has reached a tentative deal with various groups, including universities, unions of elementary and high schools, Serbian electricity distribution company, etc., thereby breaking budget proportions.

could create room for new private sector investments. A potentially more effective alternative could be fostering public-private partnerships, particularly those focused on the green transition.

The new economic context has created a favorable climate for savings. In 2024, household gross national savings reached historical highs, amounting to 23%. The savings-investment balance stands at a tolerable level of 4.7%. In December 2024, FX reserves reached a record EUR 29.3 billion, sufficient to cover seven months of imports of goods and services. During the same month, monetary gold holdings rose to nearly 48.15 tonnes, valued at around EUR 4.0 billion, sufficient to cover more than one month of the trade deficit. In contrast to previous data, both categories of liquid assets, state savings and household saving, contribute significantly to expanding fiscal space for future state impact investments

By adhering to strengthened macroeconomic fundamentals, an approved and strictly monitored policy mix by the IMF[9], and an investment-grade credit rating, policymakers are able to create a countercyclical buffer in the first stage and build fiscal space in the next stage by attracting various sources of capital. By doing this, they make capital blending necessary for green investment feasible. With these achievements, Serbia is on track to attract financing for green investments through EU special-purpose funds, IMF/WB credit lines, and/or other multilateral financial institutions, making green investments financeable. The WB/IMF estimates suggest that developing countries require approximately USD 1 trillion annually by 2030 to effectively address climate change and transition to sustainable energy systems [47]. This dynamic is expected to relax private sector risk aversion and encourage private investment in the green energy transition.

Despite the echo of respectable macroeconomic fundamentals from the last two years, Serbia entered a (geo)political crisis in Q4 2024, with postponed and unpredictable economic consequences. The momentum for a sustainable growth trajectory has weakened. Students

and professors, supported by opposition parties and the NGO sector, have consistently challenged the potential positive impact of key government infrastructure projects (primarily lithium and EXPO 2027), while ignoring the impact of the so-called "Kosovo issue" on the country's geopolitical positioning vis-à-vis the EU. The opposition has focused on direct confrontation with the government, the ruling party, and the President of the Republic, accusing them of using heavy-handed tactics in critical aspects of economic life and, consequently, being laden with fraud, abuse, and waste. (Geo)political malaise may significantly reduce Serbia's attractiveness to investors, particularly foreign direct investors. This adversarial trend raises a pressing question: should the related investment portfolios, particularly for strategic projects, continue to be financed amid political uncertainty? As general risk aversion grows, the economy shifts quickly from a path of transition to one of confusion.

Following the onset of political malaise in Q4 2024, due to the growing costs of mediation, the Treasury Department shifted focus to phasing out the previously established countercyclical buffer to prepare the economy for potential "black swan" events. The political distress has slowed both foreign direct and domestic investments, creating an investment crunch that could be a headwind for the stability of RSD and the financial system as a whole. This environment will make it exceedingly difficult for the NBS to stabilize inflation within its target tolerance band while keeping FX rate unchanged.

From the perspective of the Treasury Department, during a political crisis where confidence becomes a fundamental sentiment, many fiscal measures are likely to deviate from established fiscal rules. Moreover, such measures may not be in line with the available fiscal space. This paves the way for a policy of soft budget constraints to enter through the back door, undermining adherence to fiscal discipline and eroding respect for fiscal rules. Over time, this could jeopardize Serbia's hard-earned investment-grade credit rating.

The latest external asymmetric shock stems from recently imposed U.S. economic sanctions on NIS, a joint venture between Serbia's state-owned company and Russian equity partners (Gazprom Neft and Gazprom),

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9   The IMF's ultimate goal is to slow the outflows of state money from the Treasury Department. To achieve this, the IMF insisted on a 3% of GDP red flag, targeted an optimal government size of 15% of GDP, and urged restructuring of the energy sector.

both holding the majority stake. The potential closure of NIS, Serbia's largest provider of oil and oil derivatives, has heightened supply risks, significantly accelerating concerns over energy security. The potential closure of NIS, Serbia's largest provider of oil and oil derivatives, has heightened supply risks, significantly increasing concerns over energy security. In addition to disrupting the oil market, sanctions are expected to raise the prices of oil derivatives, contributing to the inflationary spiral. Meanwhile, global oil prices have reached a 5-month high due to U.S.-imposed trade levies on some oil producers (such as Canada), with the targeted countries responding with counter-tariffs against the U.S.

Implications of Two Development Scenarios for the Energy Sector

In today's world, no nation's economy can afford to be overly independent when it comes to combating climate change with zero-tolerance attitude. These characteristics are neither mere side effects of shifting political focus, nor simply the result of changing mindsets among policymakers. Instead, they stem from the deep roots of an economy and society: what they are and what they stand for if they intend to survive and prosper? This is a universal truth that no nation can escape.

Bracing for a better normal in the case of Serbia is not easy. From the early 1990s until now, Serbia has, explicitly or implicitly, been an excommunicated country. As a result, it has lost touch with the EU mainstream. Being an "exotic" country, isolated from EU trends, is far from an ideal starting point for sustainable and inclusive development, particularly in the context of network technologies in general, and in the energy sector specifically. The installed energy production capacity of 4,300 MW exceeds the actual capacity of 2,800 MW. Moreover, the current energy output gap, which is roughly 30% of production, makes progress in the energy transition and EU integration even more difficult.

If Serbia intends to become part of the EU, it must undergo rapid and radical transformation across all sectors, particularly in the energy sector. For every EU member state, transitioning by mid-century to net-zero, or at least

to a significantly lower-carbon development trajectory, is a key priority. The expectation that private investors from the EU or other parts of the global economy will leapfrog Serbia's economy on the path to mitigating the negative consequences of climate change and, by doing this, closing the energy output gap is unrealistic. Moreover, achieving energy security with an adequate structure of energy mix requires convergence in both economic performance and alignment with EU regulatory frameworks[10], energy strategies, and targets. These are hygienic prerequisites for addressing climate challenges and ensuring Serbia's energy sector becomes as competitive and sustainable as possible.

Serbia has already started to align its regulatory settings with EU framework, particularly in areas such as the regional energy market and the assessment of energy-related hazards, including mitigation and opportunity costs. Without an expansion in energy production, Serbia risks a potential reduction in GDP that could reach double-digit figures by 2050. Also, without significant investment in green energy transition, this aspect of energy security will remain a major barrier to further economic growth.

Mitigation costs for identified obstacles are indeed high, but the benefits, both direct and indirect, can be even greater. According to [48, p. 2], Serbia would need to invest roughly USD 9.5 billion over the next decade, or about 0.4-0.6% of GDP per year, to mitigate climate-related hazards.

Convergence in the level of development is a critical performance indicator for countries in the EU accession process. Serbia faces a significant development gap compared to the EU. From 2011 to 2024, Serbia's GDP PPP per capita accounted for only 55% of the EU-27 average. Investments (level, speed, and effectiveness) are key drivers for catching up. In 2024, the investment level in Serbia amounted to slightly over 24% of GDP, which is fair enough. The share of investment in GDP formation is increasing. Despite this, the average growth rate for the period 2014-2023 was 3.12%, which is not enough. To bridge the gap with the EU, Serbia would need CAGR = 7% over a 10-year period, assuming the EU grows at a CAGR = 2.5%. If we factor in investments needed to offset the costs of the COVID-19

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10 Recently, the EU carbon border tax has come into play.

pandemic, the required timeframe for convergence may need to be extended by at least 5 more years [9].

The bottom-line assumption for any development scenario in Serbia is that there will be no significant investments in the energy sector. Given that the government predicts a growth rate of 4-5% for 2025 and 2026, we have decided to calculate a moderate growth scenario, or "as-is" scenario, with a CAGR = 4.5 (Table 1A). Given the energy output gap of 30% at the start of the projection, in this scenario the energy output gap would increase to 54.93% of energy production by the end of the projection period.

In a robust growth scenario, or "to-be" scenario, Serbia would experience a 7% annual growth rate over a 10-year period (Table 1B). This scenario would lead to the energy output gap expanding from 30% to 64.42% of energy production by the end of the 10-year projection (Table 1B).

The general conclusion is clear. Without significant investments in the energy sector, the energy output gap will remain a major barrier to further economic growth in both scenarios.

Another problem lies in the structure of energy output. To meet the net-zero emissions target by the middle of the century, Serbia must completely phase out fossil fuel-based energy production and replace it with a diverse range of renewable energy sources.

Achieving economy-wide net-zero emissions by 2050, along with a significant increase in energy production, requires even higher investments in the deployment of climate-neutral technologies enabling strong growth. This calls for a decisive action plan, such as the Integrated National Energy and Climate Plan (INECP) [31], which outlines strategies for the energy sector along sectoral decarbonization pathways. While the plan is in place, it is still too early to say that the green energy transition has truly begun.

The action plan includes incremental investments to scale up renewable energy sources with moderate power capacity, such as solar, wind, geothermal, and hydro capacities. Alongside significant penetration of these renewable sources, the phase out of lignite-based electricity production must primarily rely on investments

in the most potent renewable energy sources, such as biomass (in the medium term), and nuclear energy (in the long term). The transport, construction, and agriculture sectors, along with hard-to-abate sectors like cement, steel, and ICT, will also require substantial investments in the green transition, with a focus on green hydrogen-based fuels, energy efficiency improvements, electrical grid optimization, and the adoption of electric vehicles. Also, the industrial sector will need to undergo a significant transformation, shifting from fossil fuels to renewable

Table 1: Energy output gap for two development scenarios

A. As-Is scenario (CAGR = 4.5 %)

Year	Growth [%]	GDP	Energy Investment YoY	Energy Output Gap [%]
0				**30.00**
1	4.5	1.045	1.000	33.01
2	4.5	1.092	1.000	35.90
3	4.5	1.141	1.000	38.66
4	4.5	1.193	1.000	41.30
5	4.5	1.246	1.000	43.83
6	4.5	1.302	1.000	46.25
7	4.5	1.361	1.000	48.56
8	4.5	1.422	1.000	50.78
9	4.5	1.486	1.000	52.90
10	4.5	1.553	1.000	**54.93**

B. To-Be scenario (CAGR = 7.0 %)

Year	Growth [%]	GDP	Energy Investment YoY	Energy Output Gap [%]
0				30.00
1	7.0	1.070	1.000	34.58
2	7.0	1.145	1.000	38.86
3	7.0	1.225	1.000	42.86
4	7.0	1.311	1.000	46.60
5	7.0	1.403	1.000	50.09
6	7.0	1.501	1.000	53.36
7	7.0	1.606	1.000	56.41
8	7.0	1.718	1.000	59.26
9	7.0	1.838	1.000	61.92
10	7.0	1.967	1.000	**64.42**

Note:

Eprod = X(1 + INV)(1 + INV)…

Econsump = Y(1 + GDP)(1 + GDP)…

Energy Output Gap = 1 – Eprod/Econsump = X/Y(1 + INV1)(1 + INV2)…/(1 + GDP1)(1 + GDP2)…

Present value (Year 0) X/Y = 0.3

Energy consumption assumed as: Econsump = Y(1 + GDP1)(1 + GDP2)…

GDP1- first year, GDP2 - second year

Production assumed as: Eprod = X(1 + INV1)(1 + INV2)…

Energy Output Gap [%] = 1 – Eprod/Econsump = X/Y(1 + INV1)(1 + INV2)…/(1 + GDP1)(1 + GDP2)…

energy sources, including the installation of energy and/or carbon capture/storage/utilization capacities.

Substantial green investments require, in terms of quantum, equally substantial green finance, as well as robust regulatory and policy efforts enabling capital blending from different sources to create the critical mass needed to finance climate change-induced investments. For example, to deploy biomass technology with high power capacity and large-scale electricity production potential, Serbia would need to invest at least an additional EUR 10 billion over a period of 3-4 years.

Investments in green technologies, being capital-intensive, high-risk, and low-yield, are often non-financeable. On one hand, there is widespread consensus that public capital alone cannot counteract climate change. On the other hand, private capital is either short-term, expensive, and insufficiently flowing, or lacks the critical mass needed for large-scale green projects ("big shots"). The EU pre-accession financing and special-purpose funding from international financial institutions, such as the IMF and the WB, aimed at extending fiscal space to support state impact investments in decarbonization, will be the primary sources of financing for major energy infrastructure projects (production capacities, grid, storage). Also, the catalytic role of the government in developing innovative capital-blending strategies, along with the development of capital markets for the issuance and trading of thematic securities (green bonds, for example), as well as leveraging guarantees for green credits and public-private partnerships, are essential to counteracting climate change.

Anyway, the major source of financing for all types of investments will come from institutional investors, with an estimated total investment potential of USD 100-200 trillion per year. However, green financing accounts for a smaller portion of that potential. According to [5, p. 4], approximately USD 50 trillion in incremental investments will be required by 2050 to counteract climate change. One of the problems is the internal limit due to the mismatch between risk appetite and inadequate de-risking strategies within credit institutions. Moreover, institutional investors are very selective when it comes to either the projected stream of free cash flows or the macroeconomic stability of the national economy.

Therefore, for adequate capital blending to finance green energy transition projects, both the bankability of proposed green projects and sustained macroeconomic stability are necessary. This "double bottom line" is a hygienic precondition for green financing.

A Big Idea for a Homegrown Renewable Energy System

In this part of the paper, we are going to talk about energy security from relevant perspectives, including energy market specifics, risks to energy supply, the unsustainable nature of the "as-is" development scenario aiming for a CAGR = 4.5% over a 10-year period, and the necessity of the "to-be" development scenario aiming for a CAGR = 7% over the same projection period.

Also, we are going to consider the feasibility and affordability of the proposed energy strategy. The main goals of this strategy should include the core business rightsizing (assets, capital, and the number/structure of employees), as well as an expansion into a diversified portfolio of climate-neutral technologies based on homegrown renewable energy sources (biomass, hydro, waste, geothermal, solar, wind). The role of EPS in this energy transition is crucial. As a utility company, EPS has an obligation to supply the local market with an adequate amount of electricity and heat. As a joint-stock company, EPS is also responsible for delivering a satisfactory return on investment to its shareholders during the proposed investment cycle.

Serbia consumes more primary energy per unit of GDP (PPP) than the world average. Moreover, Serbia energy supply portfolio and GDP formation are more carbon-intensive compared to the world average, and significantly beyond the EU27 average, as indicated in Figure 2.

Serbia's carbon intensity of 6t CO_2 per capita is only somewhat smaller than the EU27's per capita carbon intensity (6.2t CO_2 per capita)[11], while its GDP per capita is considerably below the EU27 average. The use of lignite dominates Serbia's carbon intensity (2/3), followed by transport fuels (1/5), and natural gas (>1/10) that makes

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11 Ember estimates a further reduction in the EU27 carbon intensity during 2025 following further closures of coal-fired power plants.

Figure 2: Comparative Final Energy Consumption (TFC) intensity of GDP (PPP) versus carbon intensity of GDP (PPP)
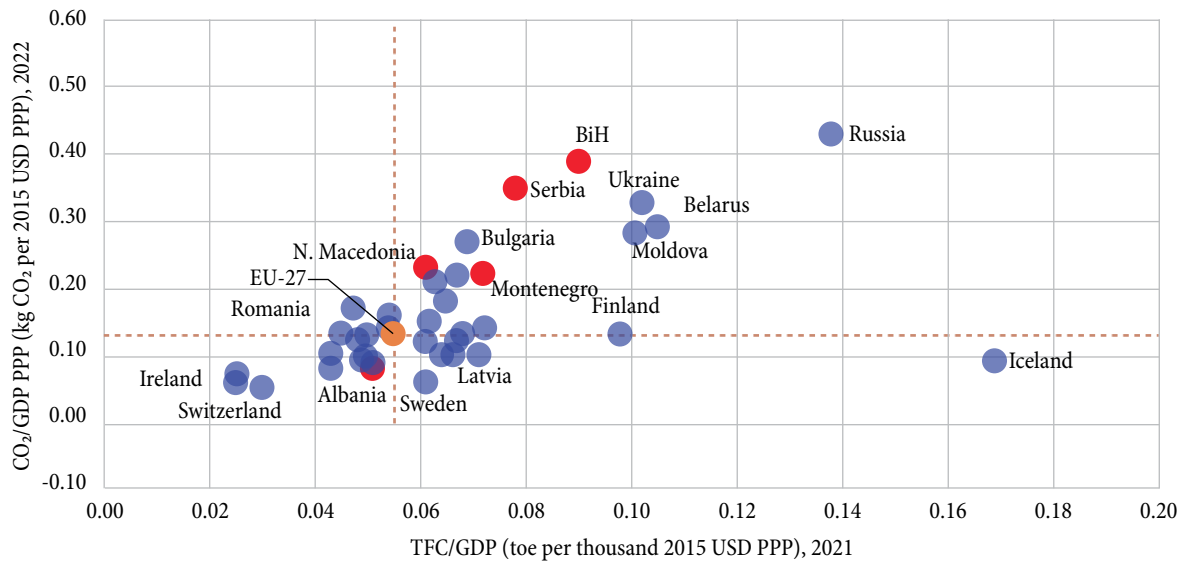
Source: World Bank [49, p. 20]

about 98% of carbon emissions from the energy sector[12]. While international climate change policies dictate considerable uncertainty related to carbon intensity, it is safe to assume that a carbon intensity of this magnitude is a political and financial hazard that Serbia cannot easily afford in case of a climate emergency.

It must be considered that Serbia has a stake in the eventual success of global climate change policies. The country's territory is exposed to a variety of external asymmetric climate risks, flooding in particular. The massive floods in 2014 highlighted the critical nature of this issue. Major energy infrastructure (lignite mines and power plants) is located in lowland areas and exposed to most significant risks of flooding. Therefore, interventions to reduce climate impacts across its territory (forestation, flood protection, and the prevention of erosion and landslides) have to be combined with active engagement in international climate change policies.

Extreme weather and the decreasing predictability of its consequences are affecting the demand for natural gas and electricity. This dictates the maintenance of (costly) fuel reserves (natural gas in underground storage, water in hydropower accumulation lakes, coal stocks), with both

formation costs[13] and opportunity costs[14]. These costs are further magnified as access to international waterborne energy markets is constrained, and the procurement of energy commodities from international markets with different price formation patterns than those in Europe is more costly. Therefore, Serbia is forced to acquire commodities at additional cost and hold stocks for longer periods, with further cost of capital. Alternatively, the country may subcontract its security of supply to third parties, with additional security and political risks [2].

As a landlocked country, Serbia's economy is heavily dependent on trade and transit through neighboring countries [46]. Unfortunately, Serbia is surrounded by economies with fairly poor Logistical Performance Indexes (LPI), well below European comparisons. Furthermore, Serbia itself performs below European standards. That creates considerable cost and supply risks when it comes to trading energy and fuels in international markets.

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12 Authors have conducted analyses using extensive "Our World in Data" comparative data sets.

13 The compression of natural gas into underground storage implies expenditure of gas for compression while the quality of lignite deteriorates during storage and exposure to elements. Fuel storage implies the engagement of turnover capital and lesser utilization of available infrastructure that needs to be oversized to respond to volatility and peak demand. Returns on investments into infrastructure are reduced by lower utilization rates.

14 When hydro accumulation is held back to meet domestic demand volatility, it cannot be used to trade in European electricity markets where flexibility is on high demand and commands premium price.

Figure 3: LPI for selected countries (lower rank indicates better performance)
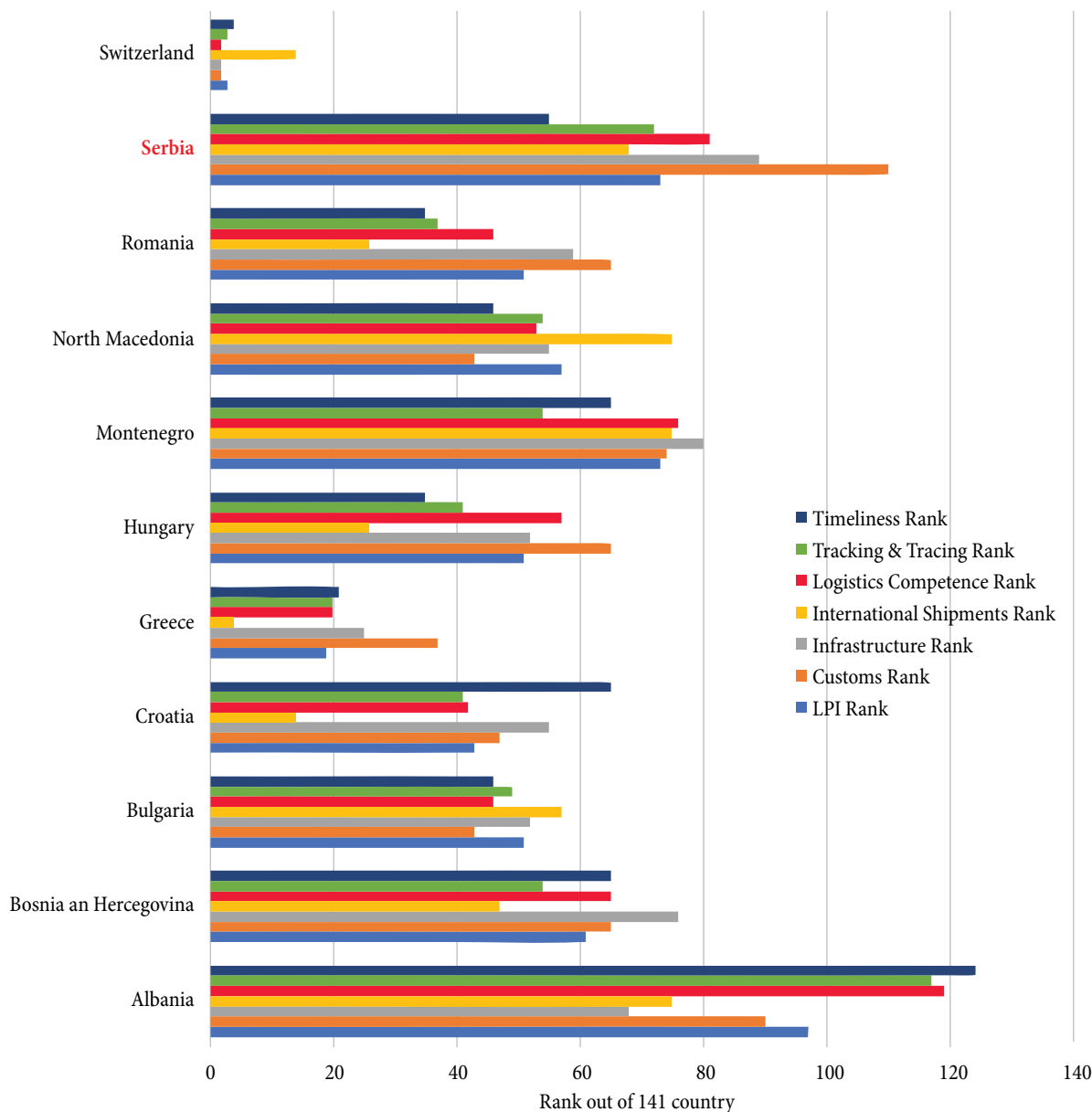

Source: LPI Database, assembled by authors

Figure 3 is developed using the World Bank LPI database. The data for Switzerland indicate benchmark performance of landlocked country.

As for major fossil fuels like crude oil, petroleum products, natural gas and coal, Serbia encounters serious limitations, risks and costs of supply. The navigation regime on the Danube River, the only international navigable waterway with direct unobstructed access for Serbia, is undergoing major changes following the conflict in Ukraine [7]. It remains to be seen whether political and regulatory limitations on navigation will be lifted. If they are, it will be a major challenge for Serbia's economy to capitalize on trading opportunities by adjusting ports, shipbuilding, and the river-sea-going fleet.

The challenges to the security of supply for natural gas, crude oil and coal are growing and getting more complex as time goes by. Access to seaports is to be considered as a major obstacle to direct access to international seaborne energy markets. The utilization rates of major transport infrastructure are limited below the minimum economies of scale, which turns up transit costs per unit of volume. As a consequence, trade in petroleum products is limited to the regional market, with further limitations and costs penalties.

Figure 4: Domestic material consumption by main material category in 2023 (tonnes per capita)

Legend: ■ Non-metallic minerals ■ Biomass ■ Fossil energy materials ■ Metal ores
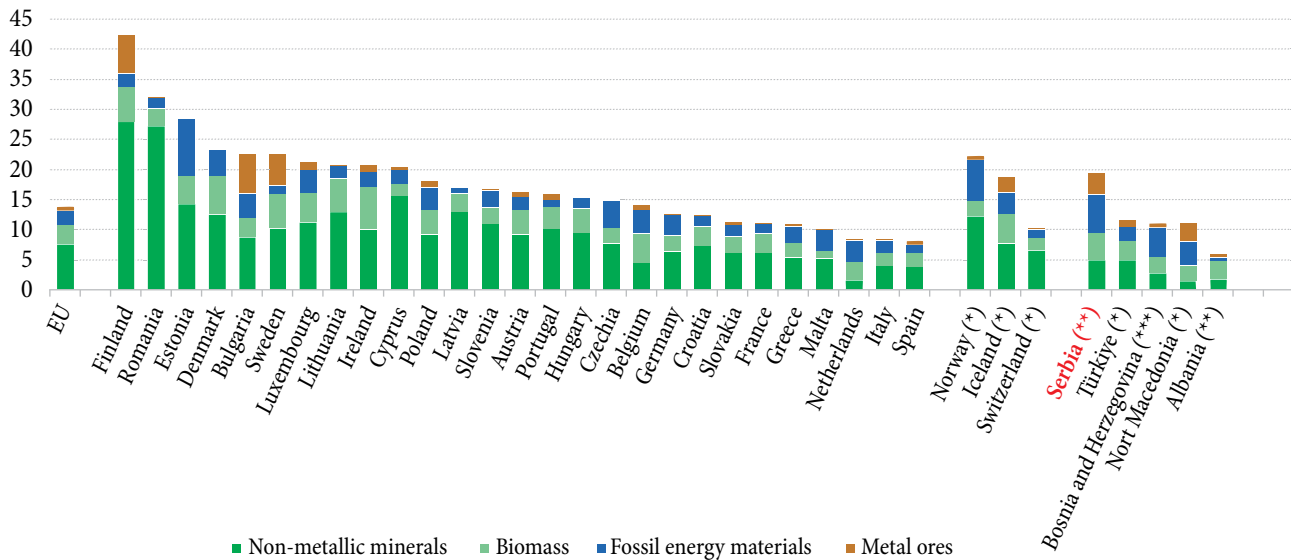
(*) 2022 instead of 2023, (**) 2021 instead of 2023, (***) 2019 instead of 2023
Source: Eurostat
Note: The 'Other products' and 'Waste for final treatment and disposal' categories are included in the 'Non-metallic minerals' category

Following the major failure in Serbia's power generation system from December 12, 2021 [3], fuel wood prices increase by over 150% in 2022 [39]. As a consequence, fuel wood prices per unit of useful energy, taking into account the low efficiency of heating stoves, exceed electricity prices.

During 2023, grid losses accounted for over 14% of the electricity delivered to customers [11]. Another 3% was consumed within lignite mines for extraction, handling and delivery of lignite and overburden. In fact, fuel wood (biomass) and lignite (fossil energy materials) are the bulk of material intensity in Serbia's economy. This includes about 7 million m³ of fuel wood [16, p. 14] and 31-39 million tonnes of lignite [11], combined by several million tonnes of agriculture products. Figure 4 demonstrates Serbia's material intensity in comparison with other countries in Europe. This volume of material consumption is well beyond the EU27 average.

The economic value of these materials is limited, leading to very low resource productivity in Serbia. As a consequence, Serbia's resource productivity, measured by GDP (PPs) per unit of domestic material consumption (DMC), is only 27% of the EU average [13] and remains the lowest in Europe.

To make things worse, the extraction productivity of fuel wood (where high-productivity forest machinery

is not available) and lignite remains well below European comparisons (see Figure 5).
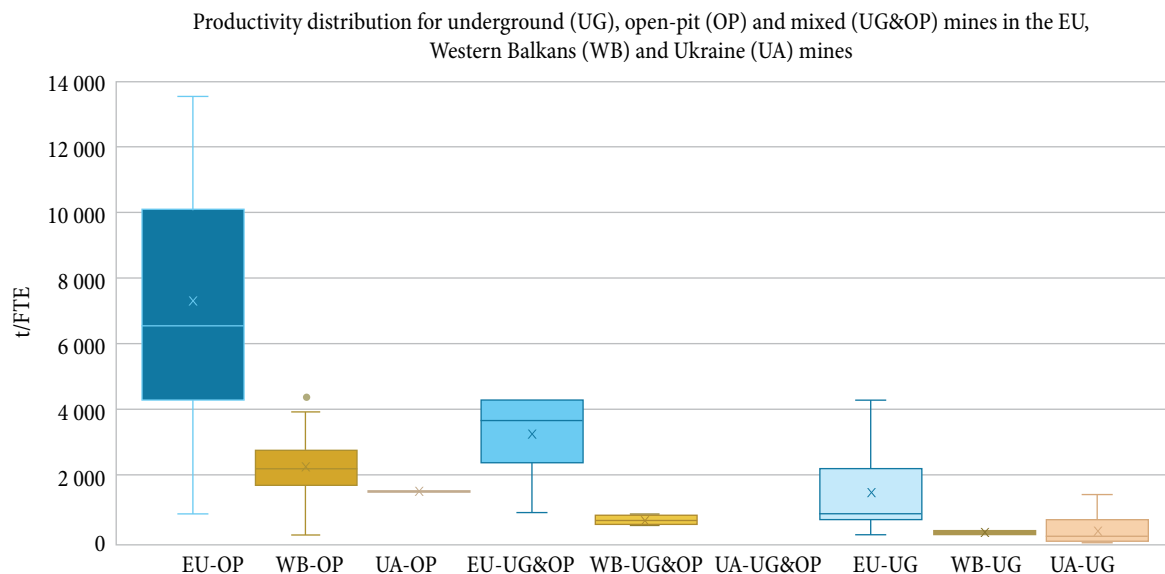
Fuel wood is used in light heating stoves, which are on average over 15 years old and are 3-4 times less efficient than standard stoves (including masonry stoves) found elsewhere in Europe. Lignite provides half the fuel energy per tonne compared to average lignite elsewhere in Europe. It takes 4-5 times more labor to produce that lignite in Serbia than elsewhere in Europe, and this fuel produce only 2/3 of the electricity per unit of fuel energy due to the low combustion efficiency of existing power plants.

However, it produces more harmful emissions, leading to health impacts and soil acidification, which further accelerates erosion, landslides, and the degradation of forest cover, while also disposing further 6-10 million tonnes of ash to landfills.

Full-time employees (FTE) in lignite mines and power plants operate massive amounts of machinery, handling such big amounts of material, and command disproportionally high wage-adjusted labor productivity in 2022[15] versus other sectors of Serbia's economy [40, p. 206].

While the security of supply with imported fuels (crude oil [41], natural gas [12], [38], imported coal) is

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15 That equates to a 2.45-times higher wage-adjusted labor productivity than the Serbian average. This suggests that any transition strategy relying on low-capital-intensity jobs with inferior remuneration is unlikely to gain acceptance within miners' communities.

Figure 5: Lignite mines productivity comparisons in volume per full-time employee (FTE)

Productivity distribution for underground (UG), open-pit (OP) and mixed (UG&OP) mines in the EU,
Western Balkans (WB) and Ukraine (UA) mines

Source: Ruiz Castello et al. [35, p. 27]

at risk due to exposure to logistical, infrastructure and geopolitical risks, the extraction of lignite in domestic open-pit mines is reduced from about 40 million tonnes to about 31 million tonnes. As a result, Serbia's power sector has become a net importer of electricity, natural gas, and coal.

While there are no data in the public domain, it is plausible to assume that the probability of technical failures in existing lignite-fired thermal power plants has now increased to 15-20% for units that started operating in the 1980s, and even more for older units. The average full-capacity operation equivalent for these power generation units is about 270,000 hours during more than 40 years of service. Major units are equipped with complex and large-volume flue gas desulfurization plants, which increase the probability of failures and divert scarce maintenance resources. The quality of lignite has deteriorated and is now mixed with imported coal from a variety of origins and with variable quality. This exposes power plants to additional operation challenges, further increasing maintenance requirements.

Serbia has recently acquired a new lignite-fired power plant unit, Kostolac B3. This additional power generation capacity increases production by 8.5% or 350 MWe. However, it may not provide that much service as the company is looking for. Paradoxically, the operational performance of similar plants in China (with more

consistent coal quality) is somewhere between 4,300h – 6,000h [26], so the new unit may have a lower utilization rate than aging units in Serbia.

In very short, domestic power generation is not secure and may be exposed to major risks of technical failures as well as an increasingly ruthless electricity market. To make matters worse, the security of electricity supply in the Western Balkans region is exposed to similar risks, augmented by the actual depletion of some lignite mines.

Key policy documents (the National Energy Strategy [33] and the National Energy and Climate Plan (NECP) [31] do not fully address the inadequate quantity and structure of supply. The NECP calls for a gradual increase in energy import dependency from about 30% to about 45% and a maximum GDP growth rate somewhat over 2% per annum, which is well below to the less ambitious "as-is" scenario of 4.5% presented here. We are going to make assumption that the available policy framework does not provide sufficient tools for EPS to preserve (or improve) its market share and meet shareholder expectations. However, the policy framework does not prevent an ambitions development scenario that the company may pursue. Taking into account that the company's strategy comprises more ambitions decarbonization goals than those outlined in these policy documents, the analyzed documents provide ground for taking an active position

in international carbon markets, following the principle of additionality.

The corporate EPS strategy is to comprise the following objectives. First and foremost, the rapid replacement of the current lignite-fired thermal power generation portfolio with more suitable alternatives. The existing power generation portfolio (excluding the new Kostolac B3 unit) is likely to accumulate an average of 3 million operational hours by 2030. At that point, the probability of failures is likely to increase beyond a manageable level, causing an irrevocable loss of market share. Kostolac B3 is likely to reach 30-40 thousand operational hours, resulting in the depletion of its technical resources.

Second, the new power generation portfolio should be capable of providing superb energy security, flexibility and reliability of energy services to commercial, industrial, public and residential customers across the country. It is to offer energy service right to the customer's doorstep, competitive to any alternative supply that customer may have.

Third, EPS needs to reduce material intensity, enhance production productivity and power generation efficiency to levels competitive with its European peers.

Taking into account the need to facilitate GDP growth at a CAGR = 7% over the period of ten years, the aim of the strategy is to double the volume of electricity available for commercial and industrial use.

Fourth, to eliminate (or considerably reduce) the weather sensitivity of power demand, EPS needs to offer heat supply with adequate heat storage capacity.

We are hereby taking an assumption that wind and solar power resources in Serbia provide medium competitiveness in Europe circumstances. Better solar energy yields are available south from Serbia and along Mediterranean coasts. These resources are likely to deliver over 20% more electricity per year compared to the same investment in Serbia. In similar fashion, wind farms installed in the Black Sea region or even north of Europe are likely to deliver over 30% more electricity for the same investment.

Therefore, investments into wind and solar energy in Serbia are more capital-intensive per unit of production and exposed to a higher Weighted Average Cost of Capital (WACC) than identical investments elsewhere in Europe.

Serbia's territory comprises outstanding hydropower potential that has already been captured by lead-edge, large-scale hydropower plants. However, the full commercial potential of these technologies is constrained by the need to reserve these capacities for responding to technical failures in thermal power plants and weather-induced demand spikes. Furthermore, changes in water inflow regime toward more frequent flooding, caused by the loss of forest cover and water conservation over the territory, constrain the optimal commercial validation of these assets. There is a minimal, yet strategically important, addition to the hydropower production portfolio. Beyond that, Serbia's territory is one of the most interesting places in Europe for developing pumped storage hydropower plants that may, in the future, deliver strategic flexibility services to the European market. Some projects that were considered in the past are currently being reconsidered, but we believe a much more comprehensive re-examination is needed in the context of: new physical realities across the territory, the availability of new advanced hydropower technologies, new opportunities in the European power markets, and the potential establishment of a more appropriate electricity trading regime with the EU27.

Lignite production at the major Kolubara lignite basin is declining in both quality and quantity. The deterioration of lignite quality creates an additional layer of operational risk for existing power plants. Starting with 30 million tonnes in 2020, production declined to 27 (2021), 25 (2022) and 22 (2023) million tonnes. There are ongoing efforts to restore somewhat better production outcomes, but these efforts may gain only temporary relief as inadequate productivity is unlikely to change and lignite quality is not expected to significantly improve in the long term. The optimal strategic decisions will be: to focus on the best-quality local resource that is available in the mid-term and extract the most economic value out of it, while shifting power generation to a new paradigm.

Geothermal resources in Serbia provide interesting development opportunities, provided that the country is able to resolve legal issues and bring in investors with access to advanced technologies.

Moreover, Serbia is one of the best places in Europe to grow short-rotation softwood plantations: there is

considerable unused land, well-supplied with shallow water resources, suitable quality soils, at low and medium altitudes, all covered by massive transport infrastructure: navigable waterways and electrified railways, both of which are heavily underutilized [24]. The actual production of disposable agricultural waste is sufficient to produce more than 800 thousand tonnes of methane per year. Furthermore, conventional forest resources from managed private and state-owned forests provide the equivalent of 7 million m³ of fuel wood per year for low-efficiency heat-only applications. More than 100 thousand tonnes of valuable mineral fertilizer ash are thrown away per year, rather than being used to maintain soil quality.

Loss of forest cover (including softwood plantations) causes erosion, landslides, wind erosion, and further problems with water conservation across the territory. Consequently, a large-scale reforestation plan provides further production potential.

One ton of biomass delivers about 2-3 times more fuel energy than one ton of average-quality lignite in Serbia without the need to remove another 3.5 tonnes of overburden and devastate the land to any extent. Quite the contrary, sustainable biomass production that takes into account biodiversity and sustainability criteria improves the land's value.

From an efficiency perspective, biomass combustion has the potential to deliver over 1/3 more electricity per unit of fuel energy than actual lignite fired-power plants. In other words, 1t of biomass delivered to a modern power plant is going to produce about 3.45 times more electricity than 1t of lignite delivered to existing power plants. In same fashion, tonne of biomass in a modern power plant may produce well over ten times more useful energy equivalent than burning that biomass in a light burning stove.

Finally, industrial-scale power generation ensures the sustainability of biomass resources. It allows for the application advanced growing technologies that are well-known in Serbia's agriculture sector.

In a very short period (3-4 years), it is possible to establish an efficient value chain for biomass energy supply, encompassing production, transportation, combustion, and re-growing of biomass, all of which would be entirely clean (green) and carbon neutral. By combining the efficiency of energy conversion with the physical properties of biomass, it is sufficient to produce about 12 million tonnes of biomass to replace the electricity currently produced from 40 million tonnes of lignite (which also delivers over 6 million tonnes of dangerous ash waste). This shift would reduce the material intensity of Serbia's economy by ¾ of the actual lignite handling, as well as eliminate the need to remove 100 million tonnes of overburden, which is not accounted for in material intensity reporting.

Production and labor productivity, as well as transport efficiency, which could be achieved in Serbia are probably unattainable in other parts of Europe, except for the former Soviet Union.

The more efficient conversion of primary energy into electricity, which is more proficient, sustainable and effective, is a key driver of economic growth. Developed countries are steadily improving electricity-to-TPES (total primary energy supply) ratio. The EU27 improved its electricity-to-TPES ratio from 15% in 1990 to about 21% in 2022, while the world average followed suit, by improving from about 13% to about 18% in 2022. China saw its electricity-to-TPES ratio grow from 8.5% in 1990 to about 22% in 2022, overtaking the EU27 between 2017 and 2020. In this context, Switzerland and Norway are great performers: landlocked Switzerland with about 31% and Norway approaching 50%.

Sweden managed to increase the share of electricity in its total primary energy supply (TPES) portfolio from 39.8% in 2010 to 48.6% in 2020. Finland increased the share of electricity in its total primary energy supply (TPES) portfolio from 28% in 2013 to 38.6% in 2023. The 10% increase over 10 years was possible as both countries[16] applied ambitious expansion of renewable energy production, considerable use of biomass in power generation and significant provision of district heating from cogeneration (Combined Heat and Power, CHP) plants. Both countries are leaders in modern combustion technologies. They, however, failed to apply a sufficiently high level of standardization to CHP installations, which made developments somewhat more expensive.

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16 The authors' research uses extensive comparative data sets from "Our World in Data".

Figure 6: Electricity-to-TPES ratio in Serbia, 1990-2022 with projection to 2035[17]
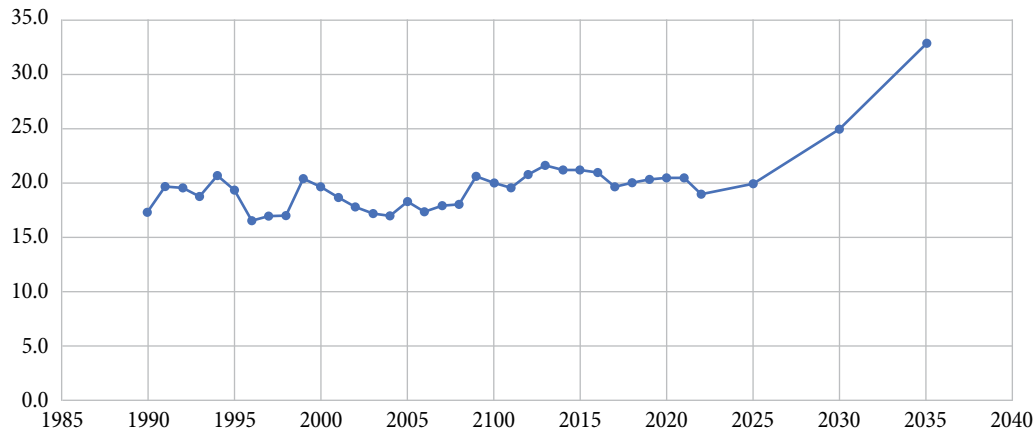
Source: Authors calculations' using the IEA/OECD database

Serbia inherited a fairly high electricity-to-TPES ratio of over 17% in 1990 and was bouncing between 18-21% during the 2000s. To achieve an electricity-to-TPES ratio of >32% (see Figure 6), Serbia needs to replicate the rapid growth demonstrated by Sweden and Finland. This would bring its economic growth opportunities to a level comparable to that of Switzerland.

During the period 1976-1987, EPS was able to install and commission 3,747 MWe of lignite and natural gas power plants, mostly through greenfield projects that required associated infrastructure, roads, railways, lignite mines and grid connections. These undertakings were part of massive international framework investment arrangements [25].

Convergence to the EU27 average in the power sector requires achieving a long list of ambitious goals: 1) a one-third reduction in material intensity; 2) a reduction of carbon intensity by half; 3) a reduction in import dependency, including the elimination of politically and socially sensitive imports; 4) improvements in overall energy efficiency through structural changes in primary energy use; 5) alignment with the EU Industrial Emissions Directive standards and clean air regulations; 6) an increase in domestic renewable energy use in transport to 10% or more; 7) an overall increase in total final energy available for consumption; 8) a doubling of electricity available for industrial and commercial use; 9) making the system's final

energy supply-to-GDP formation more resilient to external shocks; 10) a higher utilization rate of new power generation systems with low capital intensity; and 11) better returns on capital, while offering customers more competitive and affordable tariffs to support economic growth. By doing so, Serbia will delay its overshoot day in the mid-term.

Finaly, the transition is to be achieved by people with well above-average renumeration, due to the opportunity to operate high-capital-intensity economic processes (rather than exceptionally high productivity). To make it more interesting, as the probability of technical failures increases, utilization rates decrease, but the relative capital intensity of output actually increases, tempting operators to request further wage growth. It is therefore critical to offer outstanding renumeration within the new energy paradigm in exchange for outstanding performance, to prevent the status quo from prevailing.

Based on previous assumptions, the green energy transition plan[18] includes the following steps. The first step involves providing waste heat from existing lignite-fired power plants to existing district heating systems, aiming to replace the source of waste heat with biomass or methane of waste power plants once these plants are built. It is to be considered that envisaged plant locations should be able to cover 92% [42] of actual district heating services in the country. Once low-cost and entirely renewable heat sources are available, local district heating companies should be able to expand district heating coverage and cover twice

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17 Data for Total Primary Energy Supply for the period 1992-2020 have been adjusted upward to reflect fuel wood volumes that were actually consumed but not reflected in public statistics.

18 A similar investment scenario has been considered in the past with far less developed technologies [50].

Table 2: Power generation estimates in GWh

Year	Lignite[19]	Oil	Natural gas[20]	Hydro[21]	Biofuels[22]	Waste	Solar PV[23]	Wind[24]	Total
2022	23546	15	1449	9274	252	6	15	949	35506
2035 (estimate 1)	2450	0	3096	10895	20480	1440	2625	5200	46186
2035 (estimate 2)	525	0	3096	11440	22405	1440	3675	7280	49861

Source: Authors' estimates based on IEA data for 2022

as many customers. This is going to reduce domestic fuel wood use by about half and clean air in the urban areas. At the same time, these installations are going to resolve balancing problems with actual wind farms and open up further installation opportunities. This is likely to increase the value of real estate in various cities and municipalities. The following step includes the deployment of methane-fired power plants with biomass-to-methane conversion facilities to further enhance grid flexibility, reduce grid losses, and provide district heating services. Methane could also be used as a fuel for large-scale biomass cultivation and transportation. The third step includes increasing the assets of EPS with state-owned unused land and moving a considerable portion of the workforce from lignite mines to earthmoving tasks, as well as preparing land areas for biomass cultivation, infrastructure construction, and training. A gradual introduction of efficient transport systems is also planned. EPS will be immediately relieved of a portion of its wage bill, as the required investments will need to be financed separately. The fourth step is the development of a master plan for municipal waste management, assuming a single waste-to-energy and recycling hub with efficient and clean transport. This will relieve almost the entire country of waste disposal issues and landfills, offering a modern, modular solution. EPS needs to identify a partner for waste management and recycling and retain power generation. The fifth step focuses on deploying biomass-to-heat/power plants, with the subsequent decommissioning of lignite-fired power plants in an appropriate order.

As a result of the aforementioned 5-step restructuring plan, the power generation portfolio from 2022 will undergo radical changes by 2035, as described in Table 2:

There is going to be a reduction of 1,000 GWh in grid losses and another 1,000 GWh in electricity consumption in lignite mines. This energy will become available for commercial and industrial use.

Generation portfolio based on all relevant climate-neutral technologies supporting the restructuring plan, with exception of geothermal, intended to facilitate robust growth (CAGR=7%). It maintains energy security, reduces import dependency, increases efficiency in energy production, while preserving current headcount in EPS.

In the final year of projection (2035), the generation portfolio is going to provide about 14,000 GWh for residential and institutional use, about 30,000 GWh for industrial and commercial use, 4,000 GWh in network losses, and about 1,200 GWh for hydro pump storage. This provides twice the amount of electricity for industrial and commercial use compared to 2022.

Also, this generation portfolio provides ground (both in terms of grid flexibility and stability, as well as the robustness of governance and biogenic CO_2 management, to enhance the economics of nuclear power) and establishes the infrastructure prerequisites for the installation of at least 2,000-2,400 MWe of nuclear power plants from 2035 onward. Once installed, this capacity will serve commercial demand and further support economic development beyond 2035. Comprehensive standardization and adequate strategic partnerships are prerequisites for delivering this investment portfolio according to the agreed timeline, taking into account the supply chain issues currently

19 Actually, available resource. Immediate improvement in performance due to focusing on the best portions for a limited period of time.

20 Domestic natural gas production followed by the production of bio-methane from available agri residues.

21 Existing production assets, average production during 1990-2022 period.

22 Biomass resources. Requires 350,000-400,000 hectares for new softwood plantations.

23 Already agreed-upon utility-scale projects, plus residential domestic hot water production, are intended to relieve the load on the distribution grid and power generation system in the short term.

24 Existing plus new wind farms. The introduction of modern biomass and methane plants, combined with district heating models, resolves balancing issues and significantly increases grid connection capacity. This unlocks EUR 6-7 billion in private commercial investments.

Table 3: Investment portfolio for homegrown renewable energy system, period: 2025-2035

#	Project class	Power & Heat capacity (MWe; MWt)	Fuel	Investment (million €)	Investor	Carbon capture ready?	Carbon negative option?
1	Biomass Heat & Power plants	Power: 2800 MWe Heat: 4560 MWt	Biomass	7840	EPS	Yes	Yes
2	Methane power plants	Power: 800 MWe Heat: 1200 MWt	Natural gas, methane, bio-methane, e-methane	800	EPS	Yes	Depending on fuel
3	Waste-to-energy plants with recycling facilities	Power: 180 MWe Heat: 480 MWt	Combustible waste, more than 50% biogenic	900	EPS	Yes	Yes, >50%
4	Wind power	Power: 4000 MWe – 6000 MWe	Wind energy	5-6000	Private	N.A.	No
5	Solar power	Power: 2000 MWe – 3000 MWe	Solar energy	2000	Private	N.A.	No
6	Geothermal	To be considered	Geothermal heat	Unknown	Private	Yes	Possible
	Total dispatchable	Power: 3780 MWe Heat: 6240 MWt	98% Biogenic renewable	9540	EPS	Yes	Yes
	Total variable	6000-9000 MWe	Renewable	>7000	Private	N.A.	No

Source: Authors' estimates

experienced by key equipment vendors. Therefore, upfront planning is a key factor for success.

The summary long-term plan of generation portfolio is presented in Table 3. Of the total investment of EUR 9.5 billion, EUR 7.8 billion is to be allocated to biomass technology. This will involve eight units, each with a capacity of 200-500 MW, located in accordance with the electricity grid configuration, heat and power demand density, and the logistics of fuel supply. Four of these units will be located near the Kolubara thermal power plant. The minimal required volume of biomass per unit of energy makes this scenario feasible within the boundaries of available land, biomass production, and fuel wood use. Consequently, emissions of particulates, nitrogen oxides, or sulfur dioxide are nearly zero, making the flue gas suitable for carbon capture at an exceptionally low cost. This provides further opportunities to produce fertilizers needed for local agriculture and biomass growth.

The envisaged portfolio reduces waste in landfills across the country, air pollution in key urban areas, and the acidification of soils, erosion, floods, and landslides in the most productive regions. It requires the same level of employment as the current lignite portfolio, while offering somewhat higher remuneration to employees as a result of massive improvements in productivity and efficiency.

Biomass-to-heat/power plants and methane plants are suitable for non-recourse funding based on carbon credits and a commitment to close coal-fired power plants, as the scenario is more ambitious than the current National Energy and Climate Plan (NECP) [31] as required

by existing EU regulations. No sovereign guarantees are needed. The dispatchable portfolio provides a foundation for long-term power offtake agreements, facilitating a portion of private wind power investments.

With such a portfolio, EPS could produce and sell approximately 40% more electricity and 12 times more heat with the same number of employees and lower maintenance costs, all while eliminating harmful emissions and achieving roughly 11 times lower material intensity. It may also generate higher revenues while providing more affordable electricity and heat to consumers.

Thanks to this energy platform, total primary energy supply could be reduced from 671,255 TJ to about 485,000 TJ, representing a reduction of 28%.[25] This is a consequence of structural change in energy supply. Further growth will be stimulated by competitive prices of electricity for industrial and commercial customers, as well as increased domestic spending due to reduced residential heating costs. Reduced dependence on natural gas imports will mostly contribute to a decrease in the current account deficit.

Last but not least, the electricity surplus could be used to simultaneously electrify new forms of transport and phase out conventional transport solutions. This can be achieved through the introduction of an effective urban rail system in Belgrade and the rollout of electrified rail services along the Subotica – Novi Sad – Belgrade – Niš axis, as well as a car-by-rail service Čačak – Kolašin in Montenegro. Furthermore, the electrification of public bus and taxi services could accelerate this transition.

25 For macroeconomic effects of this structural change, please consider [8].

Nota Bene

At the beginning of 2025, the global economy finds itself at a crossroads. During the polycrisis, structural imbalances, social fractures, and cultural tensions have deepened, expanded and exacerbated to intolerable levels. Efforts to mitigate such a complex, fast-moving and radical changes are increasingly influenced by geopolitics. Geopolitics promotes a mercantilist approach and leads initially to deglobalization and, subsequently, to re-globalization. Re-globalization, driven by geopolitical criteria, is fostering further fragmentation of the global trade and investments.

The scarcity of natural resources has become in spotlight. If there was ever an illusion of abundant natural resources, it has completely vanished with the measurement of World Overshoot Day. The disregard for natural boundaries and laws of nature, entrenched in the nexus of rules of market fundamentalism, has led to overconsumption. Socio-economic system in rules-based disorder without built-in corrective mechanisms and effective policy responses, is becoming increasingly self-destructive. As geopolitics increasingly serves as a macroeconomic variable, economic rational is losing its power. Given that the threat of so-called "2WMD" is intensifying, the key question remains: how long can the global economic powers sustain their dominance based on the neoliberal model, and which path will ultimately prevail, economic or non-economic?

The green transition is striving for a better normal, as crisis mitigation and the subsequent revival pave the way toward a net-zero point by 2050. Estimates suggest that achieving this goal will cost between USD 5 and 10 trillion per year globally [22], [29]. While projections are not destiny, this remains a substantial amount of money. Therefore, a reality check on the scale and profitability of green investment, and related financing model are necessary.

As Serbia faces a significant 30% energy output gap, it needs more energy to overcome its energy security challenges. At the same time, Serbia needs a quite different energy structure, a shift from fossil fuels to renewable energy sources. It is crucial to recognize that the phased-in of climate-neutral technologies, alongside the phase-out of lignite-based technologies, will ensure

a reliable and adequately structured energy mix. We believe that biomass-based technology should be at the very center of Serbia's green energy transition in its initial stage, with nuclear energy taking on a central role in later phases. Nuclear energy will be pivotal for "to-be" scenario of economic development (CAGR = 7%), and beyond. A responsible roadmap for the green energy transition also requires regulatory measures such as carbon pricing, climate finance, and the issuance and trading of thematic securities.

Geopolitics is an important element in this endeavor. Serbia seeks EU accession but has not yet been fully integrated. Socio-economic movements within the EU are further energizing Serbia to commit fully to the green energy transition. The collective actions taken by the EU in the green energy transition could serve as a replicable blueprint for Serbia. The key goal of EU energy policy is to deploy a homegrown renewable energy system that is more powerful, diversified, and resilient.[26] In Serbia, much of the GHG emissions abatement before 2030 will be driven by the phase-in of existing technologies based on renewable sources (biomass, solar, wind, hydro, geothermal) with low-to-medium power potential. Beyond 2030, emissions abatement will rely on new technological solutions with medium-to-high power potential (green hydrogen, nuclear fusion, advanced nuclear fission, green ammonia, etc.), as well as energy and/or carbon capture/storage/utilization solutions. In addition to the imperative of compatibility with the EU, access to financing from the EU Green Deal and complementary initiatives from multilateral financial institutions also matter.

For such massive investments, macroeconomics has a role to play. In today's complex and ever-changing global context, the distinction between probability and predictability is widening, especially for a small, developing, landlocked economy on the EU accession path. Everything is relative, as significant achievements are tentative. Inflation, particularly core inflation, is a typical example. In economic theory, the question of how long headline inflation persists during a polycrisis remains largely unanswered, with tentative answers varying. For

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26 For example, in 2024, solar energy overtakes coal in the EU energy mix for electricity generation.

developed and highly financialized economies, such as the US and the EU, the most reliable forecasts tend to show a downward trend with cyclical ups and downs. In contrast, developing and highly industrialized economies, such as China, are facing deflation due to overcapacity and lack of demand, both domestic and global. Deflation can often distress an economy even more than inflation. For Serbia, the lack of domestic supply, due to the energy output gap and dependence on global commodity markets, will likely increase inflationary pressures and exacerbate the energy security problem.

Also, reaction policies, primarily core policies like monetary and fiscal, are ineffective in addressing mainly imported inflationary pressures, as supply shocks and inflationary pressures are influenced by geopolitics, making them disconnected from economic logic. The combination of power shortages and rising inflationary pressures reduces growth potential of the real economy, negatively affecting all public sectors (healthcare, education, science, and public services).

In such a challenging and unpredictable global context, the big picture visionaries must recognize the necessity of "sustained sustainability" by carefully navigating global macroeconomic and geopolitical headwinds. In this strategic game, central monetary authority and treasury have distinct but complementary roles. Both are inspired by the same idea, a sustainable and inclusive economy, both toward people and toward planet. The proposed energy hub will consist of biomass technology and a lithium carbonate refinery on the same site where the phase-out of lignite-based technology will proceed gradually.

In this complex endeavor macroeconomic stability has role to play. Sticky prices have fueled expectations of further interest rate cuts in Serbia, which, in turn, encourage more investments. The legacy of the NBS's monetary easing policy in 2024 could lead to a slightly expansive monetary policy in 2025, which is a prerequisite for energizing investments in the green transition. The Treasury Department pursued an expansive fiscal policy, too. Building on last year's achievements, it is expected that a stronger stance will be taken on this policy platform, signaling an even more investment-friendly or expansive approach to monetary and fiscal policies in 2025. In this

context, state-backed investments in energy infrastructure and solar energy could serve as an anchor in supporting this strategy.

Last not least, technology change is enabler of economic development. These days, the trends in cutting-edge technologies are profound. A dramatic leap in converging technologies across three key fields (information and communication technologies, industrial engineering, and biotechnology) has been accelerated by the evolution of specialized artificial intelligence toward general-purpose technology (GenAI – Generative Artificial Intelligence). With GenAI enhancing these converging technologies, they become "intelligent." The impact of such technology change on incumbents is profoundly disruptive, but it is chance for newcomers. These advancements and, in some cases, setbacks, have pushed socio-economic systems into a new era, known as the "Intelligent Age," as conceptualized by K. Schwab [36].

GenAI in Intelligent Age is the biggest technological game changer, with potential to reshape the economy, industries within it, and even the way people live and perceive themselves and society. Moreover, GenAI has ability to empower human cognition beyond biological limits, which, at the end of the day, can improve interpersonal relationships by shifting the focus from dominance to cooperation. Human superintelligence, emerging from the symbiosis of the biological brain and the silicon brain, could open up new avenues of development that go beyond technology alone. In this evolving context, collaboration is not only critical but also increasingly challenging. It requires redirecting human motivation from egoism toward collective well-being, A circular model of growth and a heterodox economic policy platform should make technology change implementable.

The ICT sector is Serbia's largest exporter, with exports amounting to roughly EUR 4 billion. This highlights the country's critical mass of talent and skill sets essential for the development of GenAI. To avoid the risk of creating a cascading effect of uneven distribution of new technological opportunities, Serbia has joined the Global Partnership on Artificial Intelligence (GPAI), an international initiative established to promote the responsible development and application of GenAI [18]. Serbia is excited about the

potential of GenAI to support the green energy transition. As a small country, Serbia should focus on small number of critical issues. The key challenge will be how quickly GenAI can be integrated into solutions that bring an entirely new level of efficiency and effectiveness in areas such as climate modeling for a net-zero future, green investment selection, capital blending, risk management, electrical grid optimization, energy and carbon capture and use, and other related issues. Increasing energy production to revitalize growth is crucial, as GenAI and data centers, as key infrastructure, will require substantial power. An additional challenge is the massive re-skilling, upskilling, retraining and relocation of workforce to match the emerging labor demand patterns [43, p. 133].

In recent times, the (geo)political context in Serbia has strongly undermined macroeconomic stability, as well as squeezed current fiscal space and build-up of funds for investments. Geopolitics (Kosovo issue and sanctions to Russi) and internal political polarization, intertwined together, are hindering the economy's ability to meet growth prospects. The costs of mediating internal political tensions (primarily, wage increases in the public sector and utilities, CAPEX/OPEX increases in local communities, funds refraction, etc.) are growing rapidly. The investment community is in a wait-and-see mode due to concerns over a potential breach of fiscal rules, particularly the 3% budget deficit target. A key explanatory detail of Serbia's strategy consistently implemented by policymakers for years, along with a fixed FX rate policy, a mix of prudential monetary measures, expansionary fiscal policies, and industrial policies for tradable sectors, is the sufficient quantum of FDIs. Is it realistic to expect a sufficient level of FDIs to maintain macroeconomic stability when (geo) political malaise is intensifying? Is it possible to keep the FX rate stable when current monetary reserves cover only 7+1 months of the trade deficit? Is it feasible to invest the huge amount of money required for the green energy transition when the current fiscal space has already been used as a counter-cyclical buffer? The simple answer to these questions is likely both "Yes" and "No," with "Yes" probably contingent on a (geo)political settlement.

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PROFITABILITY DETERMINANTS OF THE BANKING SECTOR OF THE REPUBLIC OF SERBIA

Faktori profitabilnosti bankarskog sektora Republike Srbije

Abstract

The paper analyses the key factors that influenced the profitability of the banking sector of the Republic of Serbia during the period from 2009 to 2023. The focus is on net interest income, credit risk management, operational efficiency, banking market concentration, and the impact of regulation. Through an examination of macroeconomic and microeconomic conditions, the paper examines how various external and internal factors shaped the performance of banks during different phases of economic cycles, including the global financial crisis, the euro area crisis, and the COVID-19 pandemic. Particular attention is devoted to the analysis of the net interest margin, credit losses, and operational efficiency, as well as their relationship with macroeconomic indicators such as GDP and the exchange rate. The findings highlight the complexity of the interaction between external factors and internal management practices, which is critical for maintaining the stability of the banking sector. The general conclusion is that the stabilisation of the country's macroeconomic conditions since 2013, particularly the tackling of inflation and the relatively stable exchange rate of the dinar against the euro, along with employment and wage growth, fully contributed to the expansion and quality improvement of credit activity. Enhancements in risk management processes also had a positive effect on results. Thanks to the stabilisation of macroeconomic conditions, banks were able to significantly reduce credit losses. Although net interest income increased in 2023 amid the fastest and most aggressive tightening of monetary policies, the net interest margin in 2023 remained lower than in the run-up to 2012.

Keywords: *bank profitability, net interest margin, credit loss, regulation*

Sažetak

Ovaj rad analizira ključne faktore koji su uticali na profitabilnost bankarskog sektora Republike Srbije u periodu od 2009. do 2023. godine. U fokusu su neto prihodi od kamata, upravljanje kreditnim rizikom, efikasnost poslovanja, koncentracija bankarskog tržišta, kao i uticaj regulative. Kroz analizu makroekonomskih i mikroekonomskih uslova, u radu se ispituje i kako su različiti spoljašnji i unutrašnji faktori oblikovali rezultate poslovanja banaka u različitim fazama ekonomskih ciklusa, uključujući globalnu finansijsku krizu, krizu evrozone i pandemiju COVID-19. Posebna pažnja posvećena je analizi neto kamatne marže, kreditnih gubitaka i operativne efikasnosti, kao i njihovom odnosu sa makroekonomskim indikatorima kao što su BDP i devizni kurs. Zaključci rada ukazuju na složenost interakcije između eksternih faktora i internih upravljačkih praksi, što je presudno za održavanje stabilnosti i bankarskog sektora. Generalni zaključak je da su se stabilizacija makroekonomskih uslova u zemlji od 2013. godine, posebno rešavanje inflacije i relativno stabilan kurs dinara prema evru, uz rast zaposlenosti i zarada u punom obimu, odrazili na rast obima i kvaliteta kreditne aktivnosti, a pozitivno je na rezultat delovalo i unapređenje procesa upravljanja rizicima. Zahvaljujući stabilizaciji makroekonomskih uslova, banke su uspele da značajno smanje kreditne gubitke. Iako su neto prihodi od kamata povećani u 2023. godini u uslovima nikada bržeg i agresivnijeg zatezanja monetarnih politika, neto kamatna marža je i 2023. godine bila niža u odnosu na period do 2012. godine.

Ključne reči: *profitabilnost banaka, neto kamatna marža, kreditni gubitak, regulativa*

Introduction

The history of Serbia in the first two and a half decades of the 21st century is inextricably tied to significant changes that occurred in the banking sector during that period, reflecting broader social and economic transformations in the country. The Serbian banking sector underwent numerous changes in the early 2000s, beginning with the abrupt delicensing of four major domestic banks. With a single stroke of the pen, these four large banks were eliminated, without any evaluation of the justification or lack thereof for such actions.

Initial assessments by the National Bank of Yugoslavia regarding the general state of the banking sector at the beginning of 2001 indicated the following [19, p. 28]:

1. A high level of contaminated non-performing loans (NPLs) and a low proportion of genuinely interest-bearing assets, directly contributing to low profitability;
2. Inadequate provisioning to cover potential losses;
3. Undercapitalisation in real terms and the inability of capital and reserves to absorb assumed risks;
4. The insolvency of the largest banks, which accounted for more than 57% of the banking sector's total assets;
5. High illiquidity;
6. The absence of, or inadequacies in, internal control and internal audit systems;
7. An inadequate risk management system;
8. Low professionalism among external auditors.

This was followed by a period of regulatory liberalisation, market openness, privatisation of domestic banks, and the entry of foreign banking groups into the domestic market. Through the new banks, globalisation, with its advantages and disadvantages, entered Serbia's banking system. Market liberalisation led to credit activity growth, often excessive, and predominantly in foreign currencies (mainly euros and euro-indexed loans, with a brief episode involving Swiss franc-denominated housing loans). This increased credit and currency risks amid pronounced domestic currency instability. During this period, the National Bank of Serbia (NBS) implemented macroprudential policy measures to curb excessive credit growth in the household sector. Domestic vulnerabilities were compounded by global

risks, including the US subprime mortgage crisis, which escalated into a global economic crisis in 2009.

Only with the macroeconomic stabilisation of the country and the adoption of a strategy to resolve the banking sector's legacy of poor-quality assets were conditions created for a healthy banking system. The traditional banking model, which is still prevalent today and focuses on credit and deposit operations, was strengthened. Alongside the growth of the deposit base and the base of quality clients, credit activity also expanded, increasing the banking sector's assets. This business model resulted in banking sector profits being primarily derived from the difference between interest income and interest expenses – i.e. the net interest margin – which serves to cover operating costs and expenses associated with credit risk, as the primary risk in banking operations. These key sources of operating results and sustainability, combined with business decisions and global factors, ultimately determined the financial performance of banks (Figure 1).

Thus, anyone wishing to contribute to the growth and development of the national economy, even by way of a quality analysis, must approach this task responsibly and professionally. This includes analysing financial statements and the performance of all business entities. To draw reliable conclusions about business success and extract lessons for the future, the analysis must be comprehensive and objective, and it is only such analysis that can ensure proper understanding and interpreting of the performance of any industry, including the banking sector.

For this reason, a key part of this paper focuses on analysing the factors driving banking sector profitability. These factors are not only crucial for assessing business performance but also for identifying operational risks in the future. Given the traditional banking model in Serbia and the region, the following key factors influence the banking sector's performance:

- Lending and deposit interest rates and interest margins;
- The volume of credit activity, which reflects the phase of the business and financial cycle;
- The willingness to assume a certain level of risk;
- The level of credit losses, reflecting the effectiveness of risk management;

- Sector concentration;
- Banking regulation.

In parallel, and naturally connected to these factors, this paper also analyses the macroeconomic conditions under which banks in Serbia operated from 2009 to 2023. This period was not only relatively long but also rather turbulent, encompassing the global financial and economic crisis, and the sovereign debt crisis in several euro area member states, whose banks, through local subsidiaries, held significant market shares in Serbia. However, one of the most impactful events on society as a whole, including the banking sector, was the outbreak of the COVID-19 pandemic, which threatened to halt economic and financial flows. Without a coordinated global policy response, this would have been inevitable. Adding to this was the energy crisis amid escalating geopolitical tensions that had simmered for decades, driving global inflation and necessitating responses

from monetary policymakers. Such movements in the global goods and capital markets require an analysis of business performance within this period, marked both by significant easing of monetary policies and their synchronised and unprecedently fast tightening, to be conducted in line with the relevant sub-periods. That is where I shall begin.

Banking Sector Performance in Serbia in 2009-2023

An analysis of the macroeconomic conditions under which banks operated from 2009 to 2023 confirms that banks achieved results under markedly different macroeconomic circumstances, i.e. bank profitability was influenced by numerous domestic and external factors, the characteristics of which led to the identification of four sub-periods (Figures 1, 2, and 3).

Figure 1: Elements of pre-tax net result for the banking sector in 2009-2023, in RSD bn
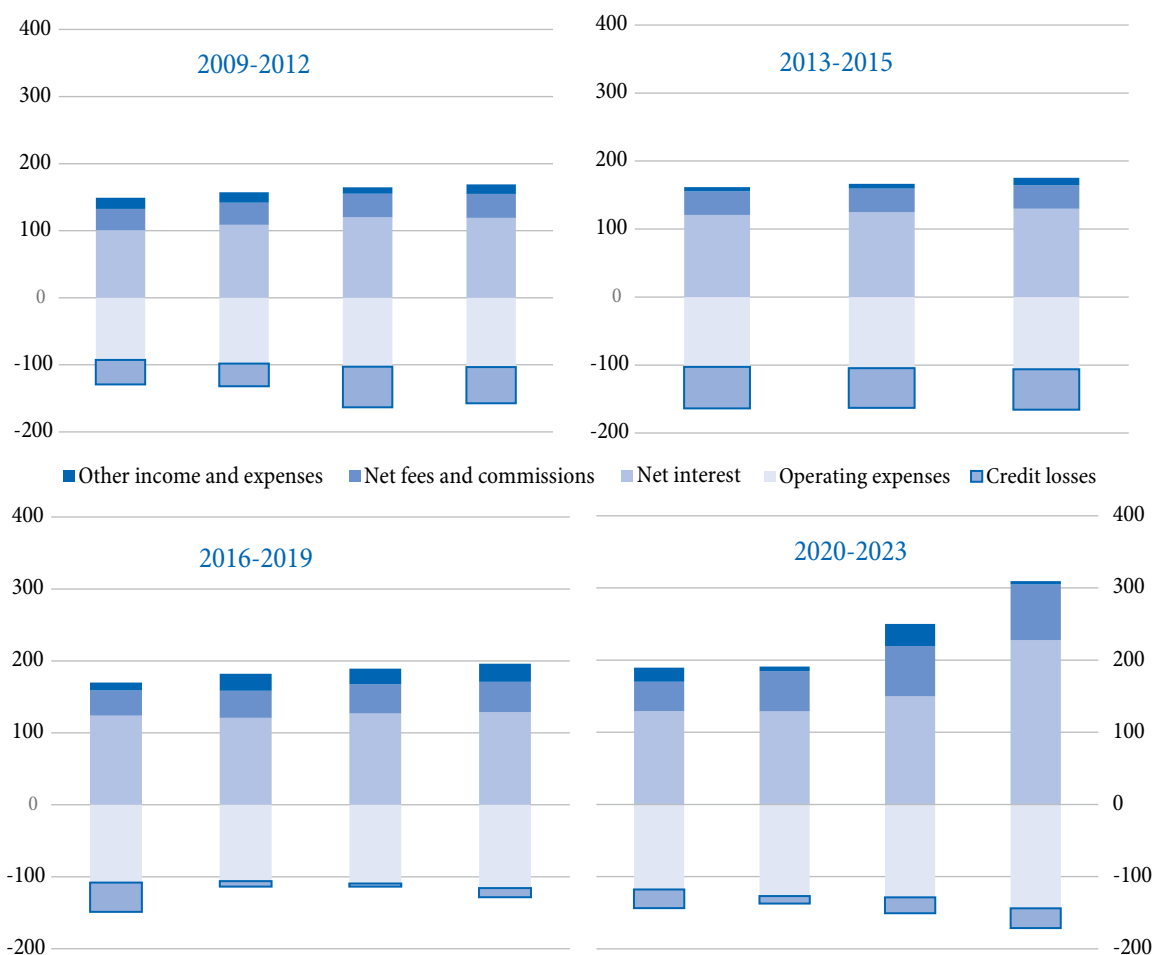
Source: NBS and the author's calculation

1. From 2009 to 2012, the banking sector in Serbia operated in the context of the global economic crisis and the debt crisis in the home countries of some local banks, as well as the pronounced depreciation of the dinar, rising domestic inflation, and consequently increased credit risks. Specifically, in the macroeconomic sphere, this period was marked by significant instability of the local currency, with the dinar losing a third of its value over four and a half years (from 2008 to August 2012), although FX reserves worth almost EUR 6 bn were spent to defend its value. Along with the depreciation of the dinar, and largely as a result of it, the period was also characterised by high and volatile inflation. This combination of macroeconomic pressures, coupled with heightened uncertainty in the global and particularly the domestic market, led to a decline in credit activity and a sharp increase in NPLs, further complicating the operations of banks already facing a deteriorated management system. The unstable and discouraging macroeconomic environment and inadequate risk management by banks meant that the key factors influencing financial results during this period were credit losses. Due to high interest rates on domestic loans as a response to domestic inflationary pressures, net interest margins (the ratio of net interest income to interest-bearing assets) were high. Additionally, the gap between interest rates in the domestic and EU markets reflected a high country risk premium, with Serbia being perceived as unstable during this time.

2. From 2013 to 2015, the macroeconomic stabilisation programme began, which included the necessary fiscal consolidation of the country. In other words, the instability encountered in 2012, manifested through pronounced and unsustainable dual deficits – the internal (budgetary) and external (external goods and services trade), along with an unsustainable structure of economic growth and political instability – required a socially unpopular response, which constrained economic growth in the short run, but was economically necessary and urgent. At the same time, the banking sector was addressing the legacy of irresponsible management and supervision from before 2012, leading to the delicensing of four banks, which also influenced the results during this period. By mid-2015, a comprehensive strategy for resolving NPLs was developed and adopted, with its implementation marking the beginning of efforts to strengthen the country's financial stability in the following period. Successful fiscal consolidation was made possible by the earlier stabilisation of two important cost drivers in Serbia – the exchange rate and inflation. The resolution of the inherited inflation problem allowed for robust monetary policy easing – the NBS key policy rate was reduced by 675 bp (from 11.25% to 4.5%), while movements in the EU led to the easing of the ECB monetary policy by 70 bp (from 0.75% to 0.05%).

3. From 2016 to 2019, the ensured and preserved macroeconomic stability in the country allowed for the start of an investment cycle and stronger economic growth, which, through higher quality credit demand, had a positive effect on both credit activity trends and the quality of bank assets. In other words, aside from a significant reduction in credit losses, the key factor influencing the results was the strong growth of quality credit activity (better creditworthiness of clients) during this period.

4. From 2020 onwards, the global and, consequently, domestic macroeconomic environment was heavily impacted by the crisis caused by COVID-19, followed by the energy crisis and a series of negative geopolitical events that shaped the global economic and political landscape [20]. After a decline in inflation caused by the pandemic-induced drop in demand and subsequent reductions in key policy rates, a sharp rise in both global and domestic inflation began in mid-2021. In response to these developments, monetary tightening occurred more quickly and synchronously than ever before. During this period, as in other economies, key factors influencing the banking sector's performance were interest rates. However, even at these interest rate levels, which were a response to global inflation, net interest margins were lower than in the period before 2013. Furthermore, credit losses were at their

lowest levels, significantly aided by the preservation of the economy despite all the challenges, as well as good risk management.

The data analysed indicate that, for much of the observed period, banks maintained relatively stable net interest income and operating costs until the sudden global tightening of monetary conditions. Changes in net results were primarily influenced by movements in credit losses. Amid such distribution of sources of the business result, credit risk was identified as the key factor affecting the financial result, with an increase in credit risk reducing profitability and adequate credit risk management leading to its growth. Perhaps even more important is the analysis of relative indicators, which shows that net income from credit-deposit transactions was on a declining trend, while operational efficiency improved. In addition to these general conclusions, it remains a fact that a profitability analysis is a complex process requiring deeper consideration of specific circumstances and factors for the country and period under analysis, such as the macroeconomic environment, regulation, degree of market concentration, risk management methods, and business models. This means that interpreting results requires taking all these factors into account and having an excellent understanding of them.

In this context, the paper provides a detailed analysis of the key determinants of banking sector's profitability in the Republic of Serbia:

1. Net interest income and interest rates,
2. Net income from fees and commissions and the digitalisation of banking services,
3. Credit losses and credit risk management,
4. Operating expenses and efficiency,
5. Competition and market concentration,
6. Banking regulations.

Net Interest Income and Interest Rates

The primary source of net profit in traditional banking is net interest income, i.e. the difference between interest income and interest expenses. This result is derived from core banking activities – collecting deposits and extending loans – and is crucial for evaluating the profitability and

financial health of a bank. *Interest income* is earned by banks through loans, investment in debt securities, and other interest-bearing assets, while *interest expenses* represent the costs of obtaining funds required to finance banking activities, such as interest paid on deposits, issued debt securities, financial borrowings, and other interest-bearing obligations. The relative ratio of net interest income to interest-bearing assets is the net interest margin (NIM) and is used as a key indicator of asset and liability management efficiency in a bank.

The factors that influence the level of net interest income and net interest margin are numerous and stem from both the business environment and regulatory framework, as well as internal factors specific to each bank. *For the purposes of this paper, the factors are divided into three categories*:

- Macroeconomic factors,
- Factors specific to the bank's operations (business model, structural gaps, banking risks, bargaining power…), and
- Accounting rules and standards.

Understanding the impact of these factors on net interest margin is essential for assessing a bank's ability to generate stable net interest income through different economic cycles.

Macroeconomic factors affect the broader economic environment in which banks operate and have a direct impact on the movement of interest rates and the level of credit activity. Economic growth generally increases the volume of banking business, thus boosting sources of interest income, but not necessarily. For example, the outcome will depend on whether the growth is sustainable. As expected, in times of recession, demand for credit decreases, and credit risk rises, which can negatively affect interest income. Banks also become more cautious when making loans, further reducing income and potentially leading to a drop in net interest margins. Simultaneously, depending on the monetary policy regime and the central bank's primary objective, monetary policy has both direct and indirect effects on the level of market interest rates. A rise in the key rate in conditions of persistent inflationary pressures increases interest income, which can positively affect the net interest margin, especially if banks can rely

on fixed-rate deposits that do not immediately respond to changes in the key rate. On the other hand, during periods of expansionary monetary policy, which is associated with low inflationary pressures and weak economic growth, a reduction in the key rate reduces interest income, while interest expenses on deposits may remain stable, especially if interest rates are already at exceptionally low levels. However, the final effects on the net interest margin are realised both through the level of interest rates and through credit demand (via impacts on economic activity and the local currency exchange rate).

Factors specific to a bank's operations concern how banks organise their business, including decisions regarding balance sheet structure and banking risks. Banks with a higher share of *variable-rate* loans respond more quickly to interest rate changes, while those with *fixed rates* have more stable interest income. Additionally, banks that *rely more on deposits* as their primary funding source typically incur lower asset collection costs, which positively impacts net interest income. Banks that maintain high liquidity levels, *invest in low-risk assets (e.g. government* securities with a strong credit rating), or keep higher deposit reserves, reduce the potential for earning interest income in favour of business stability. Investment in *riskier loans*, such as unsecured loans, can yield higher interest income but comes with higher credit risk and potentially lower interest-bearing assets in subsequent periods. These are just some examples of factors specific to a bank's operations.

Accounting rules and standards, such as the IFRS and IAS, *affect how interest income is calculated and how bank assets are valued.* Interest income on impaired assets is calculated using the effective interest rate on the net exposure [13, paragraph 5.4.1.b)], while for unimpaired financial assets, interest income is calculated using the effective interest rate on the gross value of the loan. This rule becomes relevant during periods of significant deterioration in a bank's loan portfolio, when a decline in value leads to a reduction in the base for interest calculation. Another important aspect is the application of the effective interest rate method for calculating interest income and expenses. *The nominal interest rate* is the rate expressed as a fixed or variable percentage applied annually to the amount of credit drawn [17, Article 2, paragraph 1, item 20]. *The effective*

interest rate, in addition to the cost of credit expressed through the nominal rate, includes the client's additional net fees related to the approval and repayment of the loan (e.g. application processing fees, servicing costs, etc.). *From an interest income perspective, this topic is important because income calculated at the nominal rate is always classified as interest income, while income calculated at the effective interest rate is not entirely the same.* IFRS 9 Financial Instruments defines which fees are and which are not part of the effective interest rate. According to the effective interest rate method in accordance with IFRS 9, application processing fees and other so-called upfront fees are recognised as interest income over the repayment period, while loan servicing costs are not recognised as interest income [13, paragraphs B 5.4.2 and B 5.4.3]. In other words, a bank's interest income also depends on its policy on fees and commissions related to loan approval. If upfront fees are higher than other fees and commissions, interest income will also be higher.

In the case of Serbia, the period from 2009 to 2023 provides an insight into the dynamic changes of numerous factors that shaped the structure of interest income and expenses of banks in various macroeconomic and microeconomic environments. During this period, there were significant changes in interest rates – banks operated under conditions of extremely low interest rates, which posed a challenge to maintaining net interest income, all the way to a period of sharp and unprecedentedly fast global interest rate hikes in the battle against rising inflation, which favoured an increase in net interest margin. Generally speaking, the period before 2013 was marked by an unstable exchange rate of the dinar against the euro, which experienced significant depreciation, contributing to high domestic inflation and a rise in NPLs. Interest rates in the domestic market were significantly higher compared to rates in the region due to negative domestic macroeconomic factors. The second period, from 2013 onwards, was marked by policies focused on macroeconomic stabilisation of the country, including the curbing of domestic inflation within one year, after which a cycle of sharp interest rate cuts began. Strategic resolution of the inherited NPLs was initiated and implemented, with the relative stability of the dinar exchange rate against the

Figure 2: Macroeconomic environment and financial sector trends in 2009-2023
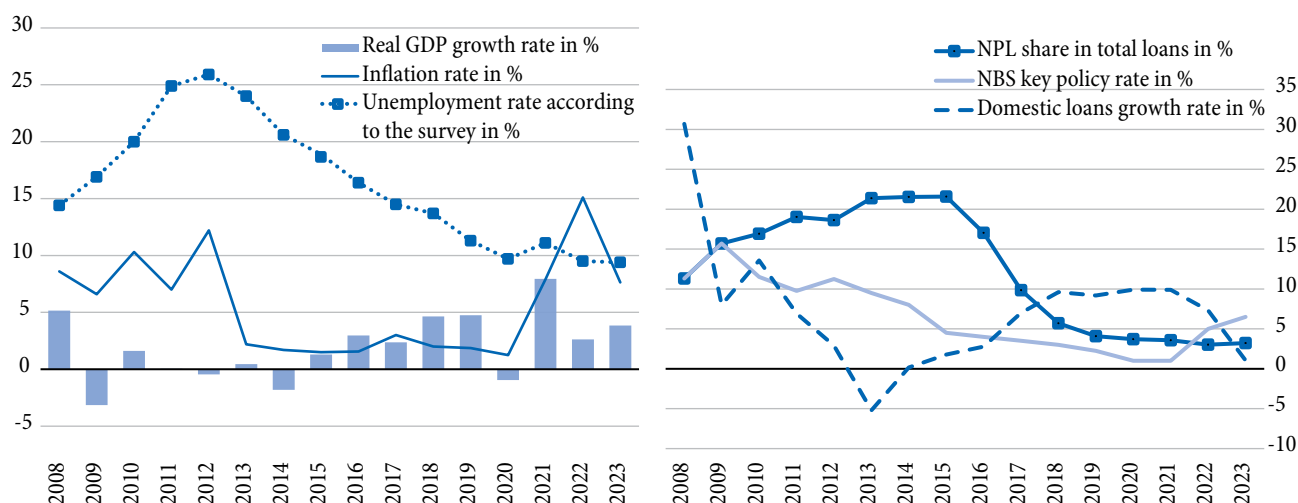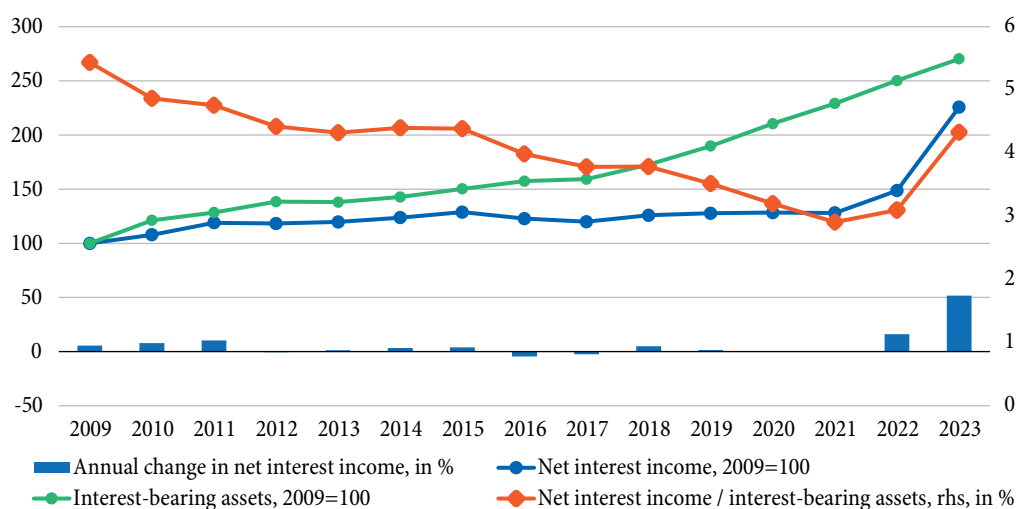

Source: NBS, SORS and the author's calculation

euro contributing significantly. After the implementation of necessary fiscal consolidation, economic growth accelerated strongly until the onset of the pandemic and a series of global macroeconomic shocks (Figure 2).

The main feature of the Serbian banking sector throughout the observed period, which is also typical of banking operations in general, is that long-term loans, as well as loans with variable interest rates, were more prevalent in the banks' assets. In contrast, deposits, as the dominant source of financing, were predominantly short-term and with a fixed interest rate. This asymmetry in the maturity and type of interest rates affected the movement of the net interest margin in different operating conditions.

When we correlate inflation movements with the key policy rate, we can see that until 2013, the key policy rate experienced more pronounced fluctuations in both directions, which created significant uncertainty for operations. After resolving the issue of domestic inflation, and especially since 2015, the NBS key policy rate was significantly reduced, which impacted net interest income despite the continuous increase in business volume. In the analysed period, interest-bearing assets recorded constant growth, accounting for 90% of total assets. In nominal terms, interest-bearing assets in 2023 were 2.7 times higher compared to 2009, and the share of loans in interest-bearing assets ranged from 60% to 65%. During the same

Figure 3: Dynamics of net interest margin (net interest income / interest-bearing assets)

Source: NBS and the author's calculation

period, the share of deposits in interest-bearing liabilities increased to 90%, and the ratio of deposits to loans grew from 80% to 130%. In such conditions, characterised by a sharp decrease in the NBS key policy rate (a reduction in the rate from 17.75% to 1% during 2009–2021, a decrease of 16.75 pp), as well as the rates of the ECB, whose policy is highly important given the euroisation of loans (down from 2.5% to 0% during the same period), despite the growth in interest-bearing assets, the net credit margin followed a downward trajectory. During this period, banks impacted net interest income by adjusting their financing structure, fostering credit growth, and altering the product mix by directing funds to higher-risk products with higher yields. This trend continued until 2022, when the global battle with inflation began, and in this context, a cycle of unprecedentedly rapid tightening of monetary policies was initiated, given the strength of the shock (Figure 3).

When analysing results by periods, we see that in the first three years of the overall observed period (2009–2023), due to the faster increase in interest income compared to interest expenses, net interest income grew at the rates of approximately 6%, 8%, and 10% (2009, 2010, 2011). Part of the growth in interest income was driven by increased credit activity, but also by the fact that this was a period characterised by exceptionally high interest rates in the domestic market under conditions of elevated domestic inflation.

Subsequently, from 2012 to 2016, we addressed the inherited issues, including the revocation of operating licences for four banks, which was done in order to protect the interests of depositors and restore confidence in the shaken system (mismanagement and supervisory failures in these banks prior to 2012 cost the state approximately EUR 800 mn). Efforts to resolve the inherited problem of NPLs commenced with the adoption of a strategy for their resolution. Considering the developments in home markets during this period, such as the sovereign debt crisis in several euro area member states, banks operated with heightened risk aversion and a focus on strengthening liquidity positions. Specifically, the share of investment in lower-risk but also lower-yielding securities within interest-bearing assets increased from 7% at end-2011 to over 23% at end-2016. In an environment of a significant decline in interest rates in the domestic market, enabled by the curbing of inflation, the absolute amount of interest income decreased, as did interest expenses. This was driven by banks' increased reliance on short-term domestic funding sources and a reduction in credit sources from affiliated entities abroad.

From 2016 until the escalation of global inflation, the banking sector operated under conditions of further interest rate reductions and negative EURIBOR values, leading to a continued decline in net interest margins (Figure 4), despite growth in credit activity. The macroeconomic environment during this period was characterised by constant economic growth, low inflation, declining unemployment, and relative exchange rate stability. A stable macroeconomic environment, supported by measures of the NBS and the Serbian Government,

Figure 4: The dynamics of benchmark interest rates, end-of-year values, in %
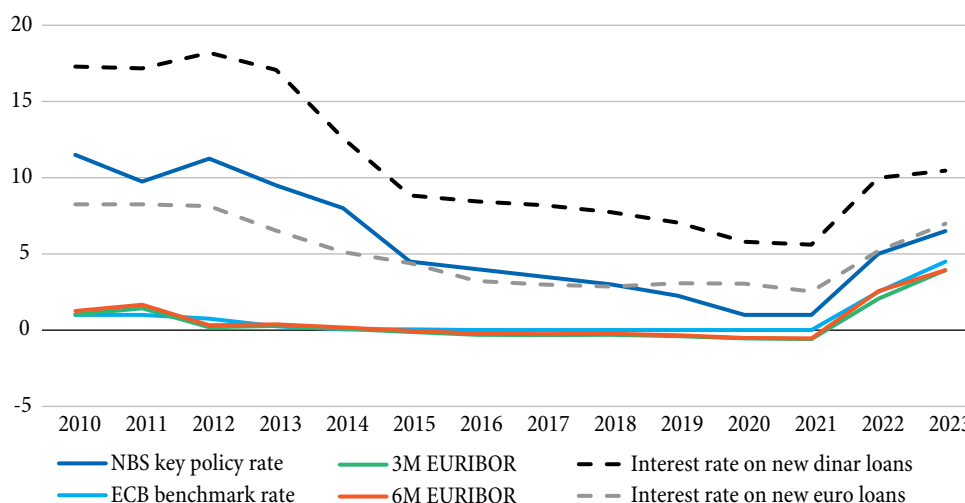
Source: NBS and ECB

facilitated the successful resolution of the inherited NPLs, significantly improving the quality of the banking sector's loan portfolio. Low interest rates created conditions for accelerated credit growth. The household sector was the driving force behind this credit expansion, particularly in cash loans, which recorded annual growth rates of 30%, increasing their share in interest-bearing assets from below 9% in 2016 to 13% by the end of 2021. Parallel to growth in cash loans in that period, their contribution to interest income rose from 20% to 33%, having a predominantly positive influence on interest income trends year after year. Maintaining interest income, despite the lowest loan interest rates on record (Figure 4), was also supported by double-digit growth in corporate credit activity, particularly in the areas of construction and real estate, supporting infrastructure projects and a new economic cycle. Conversely, provisions related to legal disputes over loan processing fees negatively impacted the net financial result of banks during this period. Some banks ceased charging such fees, which, under IFRS 9, form part of the effective interest rate. Consequently, their share in interest income declined from over 6% in 2016 to 4% in 2021 and then dropped below 2% in 2023. Furthermore, based on an NBS decision from 2015, banks refunded approximately RSD 6 bn to clients for interest charged through unilateral changes to interest rates before 2012.

The monetary policy tightening, which began at end-2021 and intensified in the spring of 2022 amid strong global inflationary pressures, led to the fastest-ever rise in policy rates of central banks, and consequently, a rise in market interest rates. Between April 2022 and July 2023, the NBS increased its key policy rate by 5.5 pp, while the ECB raised its rate by 4.5 pp. Such sharp rise in policy rates translated across markets into a marked increase in both interest income and interest expenses for banks. Specifically, annual growth in interest income amounted to 22% in 2022 and 72% in 2023. However, a significant portion of this growth was attributable to income from repo operations with the central bank, which serve as an instrument for sterilising excess liquidity that could generate inflationary pressures. Unlike previous years when such operations had a negative impact on interest income trends, in 2022 transactions with the NBS accounted for

10% of interest income growth, while nearly one-fifth of the increase in interest income in 2023 was driven by repo operations and other funds held with the NBS.

The general conclusion is that the stabilisation of macroeconomic conditions, particularly the curbing of inflation and the relatively stable dinar-to-euro exchange rate, coupled with employment and wage growth, positively impacted the expansion and quality of credit activity. Enhancements in risk management processes also contributed positively to outcomes. While net interest income increased in 2023 amid the fastest and most aggressive monetary tightening, the net interest margin in 2023 remained below the levels recorded before 2012.

Net Fee and Commission Income and Modernisation of Banking Services

Net fee and commission income is generated by banks through activities and services that are not part of their core credit-deposit operations, such as managing current accounts, executing payment transactions, issuing and processing payment cards, FX trading, guarantees, factoring, brokerage and dealer operations, or, for example, advisory services. For providing these services, banks charge fees and commissions, while the costs incurred in delivering these services constitute fee and commission expenses.

The key factors determining the level of this net income are the volume of business activities and the number and types of services offered by banks, which are also influenced by macroeconomic trends, supportive regulations, and the digitalisation of financial services. For instance, accelerated technological development contributes to the emergence of new forms of commerce (e-commerce), payment methods (online and mobile payments), and improved customer experiences (application-based solutions), thereby increasing the availability of these banking services.

When observing the share of net fee and commission income in net operating results, its relative stability is evident over a longer period, both in Serbia (Figure 5) and in the EU, with the share in Serbia remaining below the EU level [11, p. 17]. The growth in this share in 2021, in the case of Serbia, was primarily driven by net income

from FX trading, which most banks previously presented under net income/expense from exchange rate differences and the effects of contracted currency clauses. From 2021 onwards, completeness and comparability of net fee and commission income related to FX trading were achieved. This accounting change was the dominant driver of the increase in net fee and commission income for that year and the following two years. Additionally, there was growth in the number and volume of FX transactions, linked to the accelerated growth of foreign trade (28% growth in 2021 and 33% in 2022), as well as an increasing number of foreign nationals generating significant FX inflows, in conditions where Serbia has become a popular tourist destination. There was also an increase in net fee and commission income from payment operations, current account services, and payment card operations, particularly after the COVID-19 pandemic, which accelerated online transactions and modern payment methods. The growth of net fee and commission income was also influenced by adjustments in the pricing of banking services. In the summer of 2022, the NBS reached an agreement with banks to reduce fees and commissions by 30% for the following year. Simultaneously, through a special decision on payment accounts, the NBS required banks to offer customers the use of a package of the payment account with basic features for RSD 150 per month [9, Section 3]. The effects of these measures became visible as early as 2023.

The general conclusion is that the net income from fees and commissions was a relatively stable source of bank business results throughout the observed period. The growth that followed from 2021 is the result of an increase in the volume of services involving commissions on FX purchase and sale in conditions when Serbia becomes a popular tourist destination, as well as of strong growth in the number and type of payment services, especially after the COVID-19 pandemic, when online transactions and modern forms of payment recorded a robust rise.

Credit Losses and Credit Risk Management

Credit losses represent a key challenge for the banking sector, as they directly affect the results and stability of banks. From 1 January 2018, credit losses have been calculated in accordance with IFRS 9, which replaced the previously applicable International Accounting Standard (IAS) 39. The key innovation of this standard in the area of impairment is the transition from an incurred loss model to an expected credit loss model. This change was a result of the global financial crisis of 2008, which highlighted serious shortcomings in how banks and other financial institutions recognised and managed credit risk. The primary shortcoming is best described by the phrase "too little, too late," that is to say, IAS 39 relied on recognising losses only when clear evidence showed that a loan had become non-performing, i.e. when the borrower was unable to meet his

Figure 5: Dynamics of net fee and commission income share in net operating results in Serbia and the EU[1]
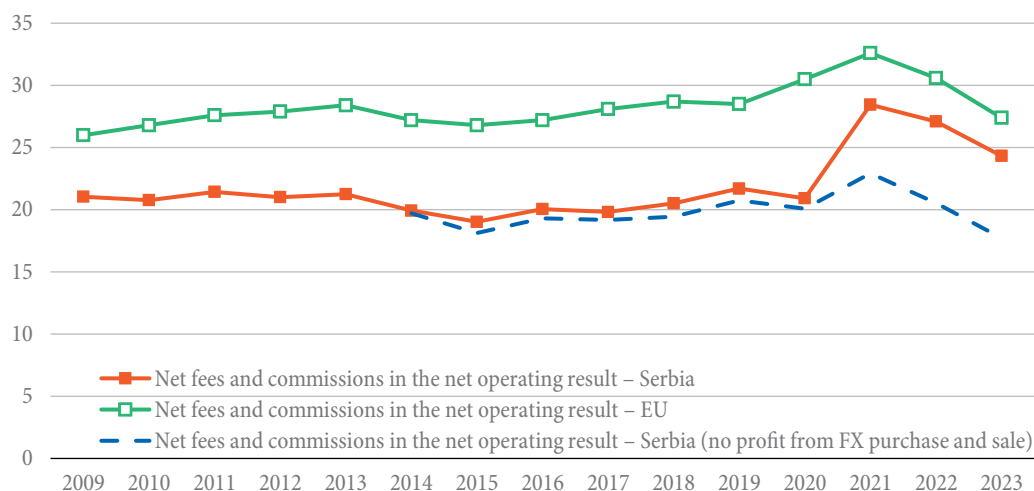
Source: NBS, EBA, and the author's calculations
[1] Data on types of operations through which banks generate net fee and commission income, including FX trading, have been available since 2014, though the completeness was not achieved until 2021.

obligations. This meant that banks were late in recognising credit losses, which led to an accumulation of credit risk and unpreparedness for crisis situations. Under the expected credit loss model, banks must make timely provisions, even before there is clear evidence of non-payment. This model allows for more proactive risk management.

Applying these standards, banks in Serbia recorded total net credit losses of RSD 515.0 bn during the observed period (2009-2023), or RSD 34.3 bn annually on average. To illustrate the significance of this amount, the registered share capital of the banking sector at end-2023 was RSD 381.7 bn. The dynamics of recognising such losses were not constant and varied over periods under the impact of different factors (Figure 6).

The most intense recognition of credit losses occurred between 2011 and 2016, when the net assets of banks were annually reduced by an average of RSD 55.8 bn due to these losses. This was a period marked by the materialisation of credit risk and a consequent sharp increase in NPLs. To address this issue, special diagnostic studies (Asset Quality Review – AQR) were conducted in 2015. These reviews were a key process in analysing the quality of bank portfolios and served as a foundation for improving regulatory and supervisory measures. The reviews were carried out under an arrangement with the IMF and included the 14 largest banks, covering 88% of total banking assets, using a unified and conservative methodology. The process was managed by the NBS, with the involvement of four audit firms and six valuation agencies. One of the primary objectives of

the reviews was to promote the conservative application of the IFRS, which *inter alia* highlighted the need for additional impairment, particularly for non-performing receivables. In just one segment – credit file analyses – special diagnostic studies identified a need to increase IFRS impairments for the analysed clients, mostly legal entities, by 44%, or EUR 349 mn [18, p. 12].

From 2017 onwards, credit losses slowed significantly, averaging RSD 15.7 bn annually up to 2023. Although extraordinary events such as the COVID-19 pandemic and measures to mitigate the adverse effects of rising interest rates on housing loans contributed to an increase in credit losses, they remained far below previous levels.

The intensity of the decline in credit losses is even more visible if it is put in relation to the loan amount (Figure 7). While at the peak of the recognition of credit losses, almost 4% of the value of loans was devalued annually, in the period after 2017 that indicator dropped to below 1%.

Assuming that the relative level of credit losses remained at the average level for the period from 2009 to 2016, the banking sector would practically operate at the verge of profitability until 2022 (Figure 8), and in two years it would have a negative result, which would greatly limit its capacities for credit activity growth and support for the real sector.
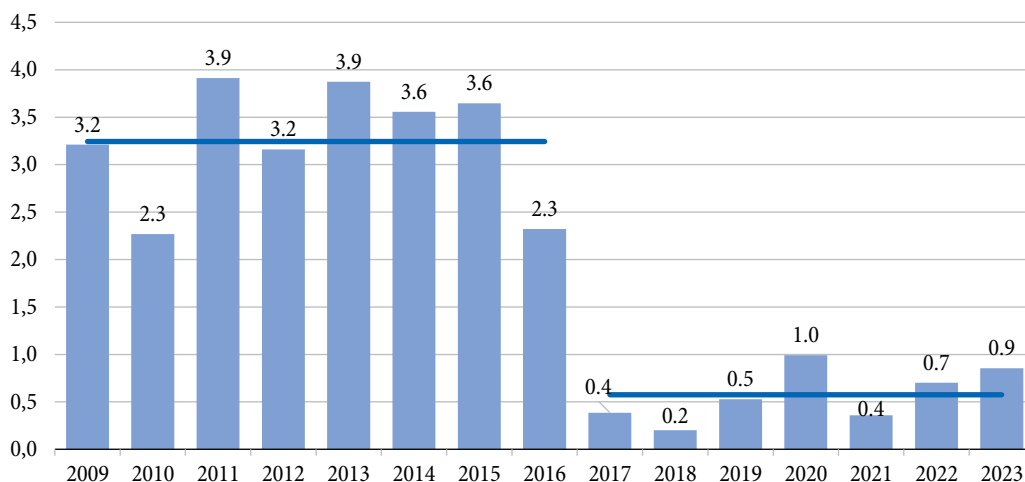
As for the factors that determine the amount of credit losses, the macroeconomic environment and the specifics of the bank itself stand out as two key ones. The macroeconomic environment in Serbia in the first

Figure 6: Credit losses (in RSD bn)
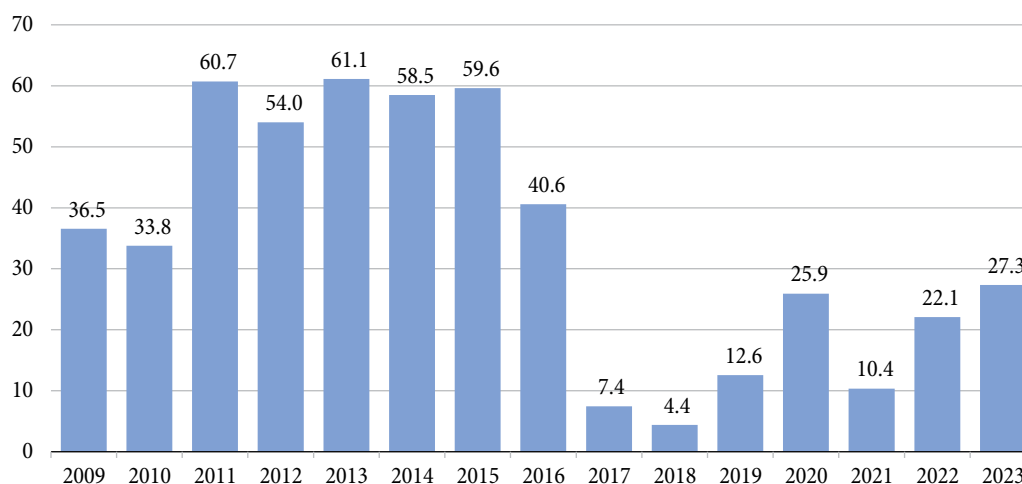
Source: NBS and the author's calculations

Figure 7: Loan loss rate (in %)

Source: NBS and the author's calculations

part of the observed period was characterised by major challenges such as the depreciation of the dinar exchange rate and high and volatile inflation accompanied by high interest rates (until 2013), which was followed by a period of necessary fiscal consolidation and macroeconomic stabilisation of the country, while from 2020 onward we were all affected by the subsequent global shocks (COVID-19, the decline in demand and economic activity followed by expansionary fiscal policies, the disruption of global value chains, the energy crisis, global inflation growth followed by a strong tightening of monetary policies). Nevertheless, even in such conditions, the Serbian economy has shown admirable resistance to global challenges. In general, the business cycle, i.e. the movement of the GDP and the exchange rate, were identified as the most significant determinants of credit risk.

Observed by sub-periods, in the first years of the observed period, due to weak economic activity, banks were faced with a higher degree of credit risk due to the lower creditworthiness of households and corporates, which resulted in an increase in allowances for impairment and the creation of significant loan loss provisions.

In the period since 2014, progress has been made at the macroeconomic level, including the launching of the investment cycle, which led to a decline in allowances for impairment. Namely, increased liquidity and solvency of economic entities, along with the strong growth in profitability, to which the relatively stable exchange rate of the dinar and the sharp drop-in interest rates significantly contributed, also meant better creditworthiness of clients, therefore the banking sector recorded a smaller volume of bad loans, which directly dampened the need for

Figure 8: Simulation of the movement of the banking sector's results, in RSD bn
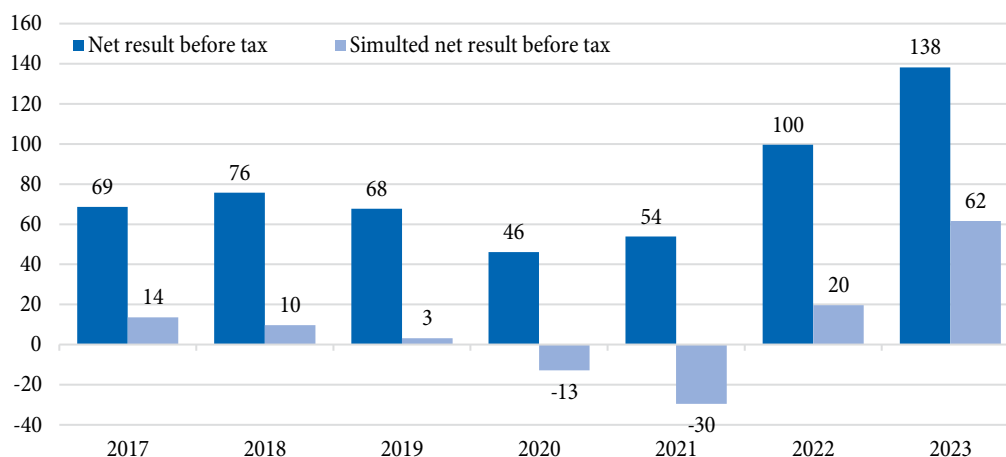
Source: NBS and the author's calculation

allowances for impairment. Better economic activity has had a positive impact on the creditworthiness of households and businesses, allowing banks to revise their estimates of credit losses.

During the period of high GDP growth, especially from 2017 to 2019, the need to create allowances for impairment was reduced, continuing in the period after the pandemic year, thus helping to further reduce credit losses.

When it comes to the impact of the exchange rate on the amount of impairment, it is indirect, through the credit risk, that is, the currency clause instrument. The currency clause, as a regulatory instrument, was introduced into the domestic legal system in 1993 in order to protect creditors from the devaluation of dinar claims in hyperinflation conditions. Originally, the 1978 law did not allow foreign currency payments in the country. However, with the deterioration of economic conditions in the late 1980s and early 1990s, the legislator had to adapt the legal framework. Amendments from 1993 made it possible for monetary obligations in foreign currency to be paid out in local currency according to the exchange rate valid at the time of the fulfilment of the obligation. The currency clause then became a key instrument in preserving the value of dinar obligations in conditions of high inflationary pressures. Although a law passed in 1995 prohibited FX payments between domestic persons, this prohibition was removed in 2000, which made it possible to contract obligations in dinars with a currency clause. The new Law on Foreign

Exchange Operations from 2002 explicitly permitted the use of the currency clause, provided that payments are made in dinars [19, pp. 54–56]. This legal change significantly contributed to the growth of credit activity in the Serbian banking sector, especially in the period from 2004 to 2008, when loans with currency clauses became dominant. The main reason for the expansion of these loans was the lower interest rate compared to dinar loans, but also inadequate financial education about the risks of foreign currency loans. Due to lower interest rates, households and corporates are exposed to the FX risk, which was especially pronounced in periods of crisis and strong depreciation of the dinar exchange rate against the euro, when, under the influence of the change in the dinar exchange rate, the growth of dinar loan instalments was extremely high. The strongest hikes in NPLs were recorded in the years with a high depreciation of the domestic currency, which was the period leading up to 2012 (Figure 9).

Then, as of 2016, the macroeconomic stabilisation of the country, which gained significant support from the ensured relative stability of the RSD/EUR exchange rate, was followed by a rise in employment and wages in the private sector and a fall in unemployment (Figure 2). Along with the adoption and implementation of the NPL Resolution Strategy, this resulted in a sharp decline in NPLs.

Moreover, the factor that determines the amount of credit losses, which is often not highlighted, are the

Figure 9: Growth in NPLs and movements in the dinar exchange rate

NPLs – annual change in RSD bn (lhs) ——— Nominal exchange rate of the euro (logarithmic value) (rhs)
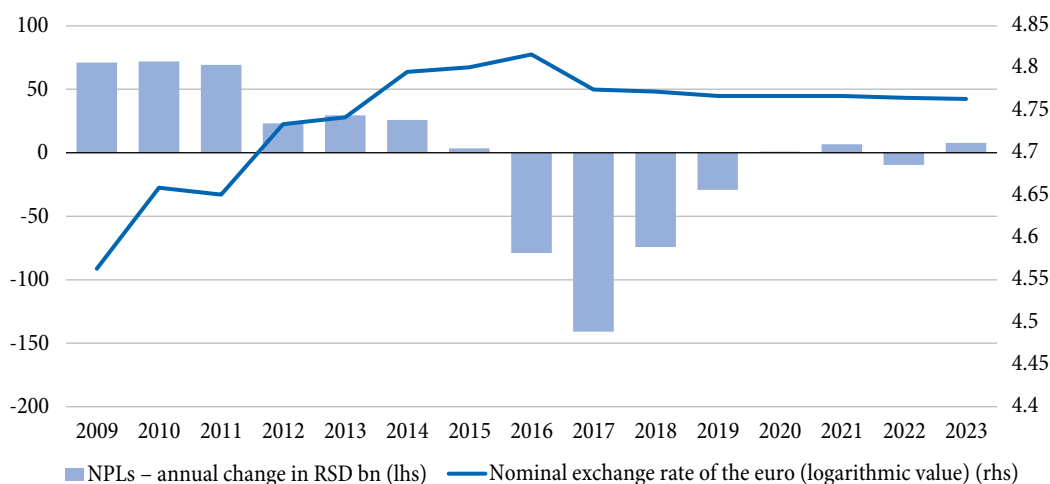
Source: NBS and the author's calculation

specifics of the bank itself, such as its business strategy, system and culture of risk management, as well as the managerial skills of the bank's management. Banks with clear management structures and precise accountability systems tend to better manage their loan portfolios, recognise early signs of customer issues, and take appropriate measures to mitigate potential losses. On the other hand, weaknesses in management, as well as insufficient expertise in risk analysis, can lead to bad decisions, which in turn increases the bank's exposure to credit risk, among other. The role of supervisory institutions is particularly important here. By continuously monitoring banks' operations and assessing their compliance with current regulations and best global practices, they put pressure on banks to constantly improve their risk management. The example of Serbia shows that a significantly better risk management, coupled with adequate and proactive supervision especially in the period since 2015, played a major role in the improvement of the quality of banking sector assets.
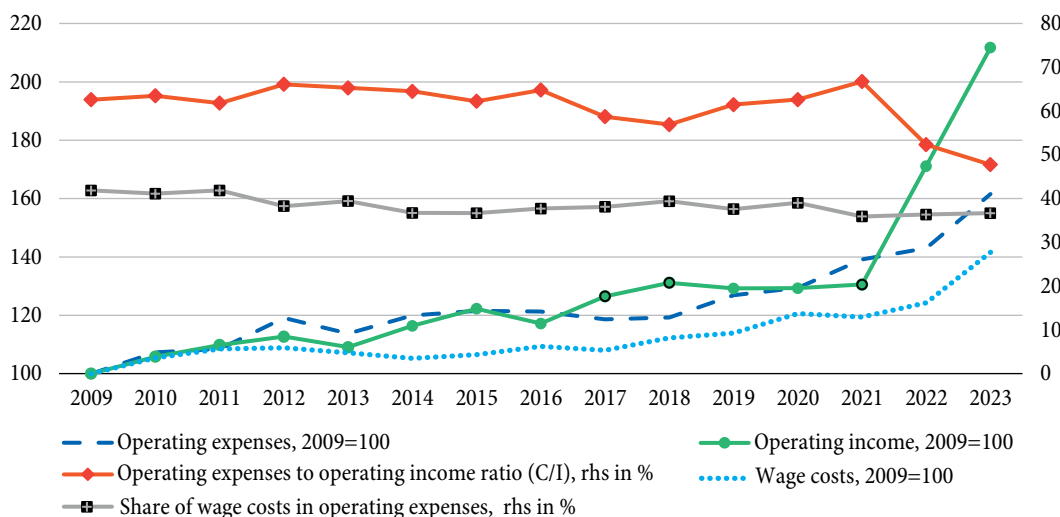
Operating Expenses and Operational Efficiency

Operational efficiency represents another important factor in the net result and profitability of banks. It is usually measured by the ratio of operating expenses to operating income (Cost to Income ratio – C/I). Lower values of this ratio suggest better operating efficiency and a greater ability of the bank to cover credit risk costs. *Operating expenses*

include all costs and expenses arising from the bank's operational activities, such as employee salary expenses, production service costs, depreciation expenses, intangible costs, and others, as well as provisions for liabilities. Cost management allows banks to achieve a stable net result even in the face of volatile market conditions. *Operating income* represents a bank's total net income generated from all banking operations. It includes net interest income, net income from fees and commissions, and other net operating income.

In the period up to 2022, the operational efficiency of banks in Serbia, measured by the ratio of operating expenses to operating income (C/I), was at a level of around 62%, ±5 pp. Looking at the structure of operating expenses, we can see that the share of wage costs in operating expenses also displayed stable movement, ranging between 35% and 41% throughout the period observed, while the global inflation bout led to their increase. Additionally, after 2018, there was a rise in provisioning and intangible costs. For example, legal disputes relating to the legitimacy of charging fees for processing loan applications led to the formation and recognition of significant provisioning expenses. Specifically, these costs increased the C/I ratio by 5 pp in 2021 and were the main cause of the rise in operating expenses in that year. Furthermore, the increase in intangible costs, which also include deposit insurance premium costs, was partly a result of the increase in the insured deposit base, which grew by about 70% during that period. The change in the methodology for the calculation

Figure 10: Dynamics of wage costs, operating expenses and operating income

Operating expenses, 2009=100
Operating expenses to operating income ratio (C/I), rhs in %
Share of wage costs in operating expenses, rhs in %
Operating income, 2009=100
Wage costs, 2009=100

Source: NBS and the author's calculation

of deposit insurance premium since the beginning of 2020 worked in the opposite direction, i.e. toward reducing the costs of deposit insurance premiums. Since then, the premium is calculated on the insured deposit amount up to EUR 50,000, rather than on the total amount of insured deposits [15, Articles 5 and 6].

A comparison with EU countries shows that after 2013, the efficiency of domestic banks was higher than that of EU countries [10, p. 15] [11, p. 15]. Observing the revenue side, we also see relative stability until 2022. At that point, as in other countries, in the context of rising interest rates in response to strong global inflation, there was an increase in operating income, which led to an improvement in banks' operational efficiency, as measured by the C/I ratio values (Figure 10).

The assessment of banks' operational efficiency should also be placed in the context of consolidation and dynamic modernisation of the Serbian banking sector in the period observed. These processes led to a reduction in the number of employees by a third and halving of the number of organisational units. On the other hand, additional costs arose on account of the integration of operations in cases of status change such as mergers, investments in digitalisation, IT infrastructure, and employee training. In the medium and long term, digitalisation enables higher-quality services that save time and money, benefiting both clients and banks.

Improved operational efficiency confirms banks' ability to balance between generating revenue and managing costs. Banks that successfully optimise their workforce, resources, and processes through digitalisation and automation can achieve significant cost savings in an increasingly challenging banking environment.

Competition and Concentration in the Banking Market

The correlation between the degree of concentration and the profitability of the banking sector has been probed by numerous studies, but the results are not conclusive. Research points to different conclusions depending on specific market conditions and other variables, which makes it difficult to draw a universal conclusion about

the correlation. Although the starting hypothesis is that banks' profitability increases with rising concentration, some studies have even found an inverse relationship, meaning that profitability goes down as concentration increases [3, p. 48]. The literature does not even support a unified stance on the correlation between competitiveness and operational efficiency [2, p. 16]. Additionally, in the context of operating in an environment of extremely low interest rates, which drag net interest margins down and have a negative impact on profitability, the relationship between accommodative monetary policies and increased concentration was also studied. The results show that the trimming of the ECB's reference interest rate mostly explains the rise in concentration in the euro area, but also that the ECB had a greater impact on the growth of concentration in banks outside the euro area than the monetary policies of those countries.

The widely accepted measure of market concentration is the Herfindahl-Hirschman Index (HHI), which is calculated as the sum of the squares of each bank's market share in the observed category (e.g. assets, interest income…). An index value up to 1,000 indicates low concentration (high competition), between 1,000 and 1,800 indicates moderate concentration, while values above 1,800 indicate high concentration (low competition).

In the past decade and a half, the number of banks operating in Serbia decreased from 34 in 2009 to 20 by

Table 1: Dynamics of banking sector concentration measured by HHI

Year	Number of banks	HHI of the balance sheet sum
2009	34	636
2010	33	629
2011	33	660
2012	32	678
2013	30	741
2014	29	794
2015	30	796
2016	30	813
2017	29	813
2018	27	779
2019	26	800
2020	26	786
2021	23	867
2022	21	936
2023	20	986

Source: NBS and the author's calculation

the end of 2023 (Table 1). In the first part of the period observed, the number of banks went down as a consequence of delicensing due to unsustainable operations in that period (four banks were delicensed due to mismanagement and supervisory deficiencies before 2012). However, the main reason for the reduction in the number of banks in the following years was the consolidation of the banking sector through mergers and acquisitions. The decisions of the owners, primarily of Greek banks, to exit the regional markets due to the reorganisation of operations following the financial crisis in Greece, influenced mergers by acquisition, leading to significant changes in the ownership structure and consolidation of the banking sector. The net results of banks during the period observed were also affected by status changes, as acquiring banks recognised gains from a bargain purchase in accordance with IFRS 3 *Business Combinations* [12, paragraph 34].

These events affected the concentration of the Serbian banking sector as measured by the Herfindahl-Hirschman Index (HHI) but kept it within the zone of high competition (the HHI index for the balance sheet total category in 2023 is 986).

Banking Regulations

In order to safeguard the stability of the financial system and protect depositors, the banking sector is subject to strict regulation. The core package of banking regulations consists of the Basel standards, which have been implemented in the EU through the CRR (Capital Requirements Regulation) and CRD (Capital Requirements Directive). This package is part of the reforms introduced after the financial crisis to improve the resilience of banks to risks and to strengthen financial stability. The CRR establishes uniform rules for minimum capital requirements and liquidity in the EU, while the CRD regulates the supervision and control of capital, including corporate governance and risk management. In Serbia, the Basel standards have been implemented by aligning domestic regulations with those of the EU.

The impact of these standards on the overall banking operations, including their profitability, is clear. In simple terms, the prescribed requirements affect the lending capacity of banks, which is an important source of the

banks' business result. The intensity of this impact depends on the banks' performance in terms of capital adequacy, risk management, and business organisation prior to the implementation of the new standards. The Serbian banking sector has been adequately capitalised and liquid throughout the entire period observed, with indicators above the prescribed minimum requirements, so the introduction of these standards has not significantly affected the performance of domestic banks.

In addition to exclusively banking regulations, the *application of accounting standards* also impacts banks' operations. In Serbia, IFRS have been applied throughout the entire period observed, and their application affects banks' operations as they define how banks value their assets, liabilities, and recognise credit losses and revenues. Since 2015, IFRS have been applied from the date determined by the relevant international body as the start date for their implementation [14, Article 21]. As a result, IFRS 9 began to be implemented at the beginning of 2018, just like in the EU and other advanced economies. This standard introduces the concept of expected credit losses as the basis for recognising allowances for impairment, replacing the previous concept of incurred credit losses from IAS 39. This increases caution and reduces volatility in banks' financial statements but may lower profitability due to higher allowances for impairment of financial assets. The standard also impacts reporting transparency, fostering greater investor confidence, but generates increased operating costs due to more complex accounting processes. Additionally, the concept of expected credit losses implies the gradual recognition of credit losses. Upon the initial recognition of a financial asset (such as granting a loan or investing in securities), credit losses are recognised at a certain percentage (impairment stage 1). Later, if there is a significant increase in credit risk (30 days or more past due), additional credit losses are recognised (impairment stage 2), so that if the financial asset becomes impaired (impairment stage 3), the immediate negative effect on profitability is reduced. According to data of the Serbian banking sector, the average allowances for impairment of financial assets classified in impairment stage 1 amount to 0.5%, at stage 2 to 5.6%, and in stage 3 (corresponding to the status of NPL) to 59%, which is

Figure 11: NPL coverage by allowances for impairment of NPLs and allowances for impairment of total loans

— Coverage of NPLs by allowances for impairment of NPLs
— Coverage of NPLs by allowances for impairment of total loans
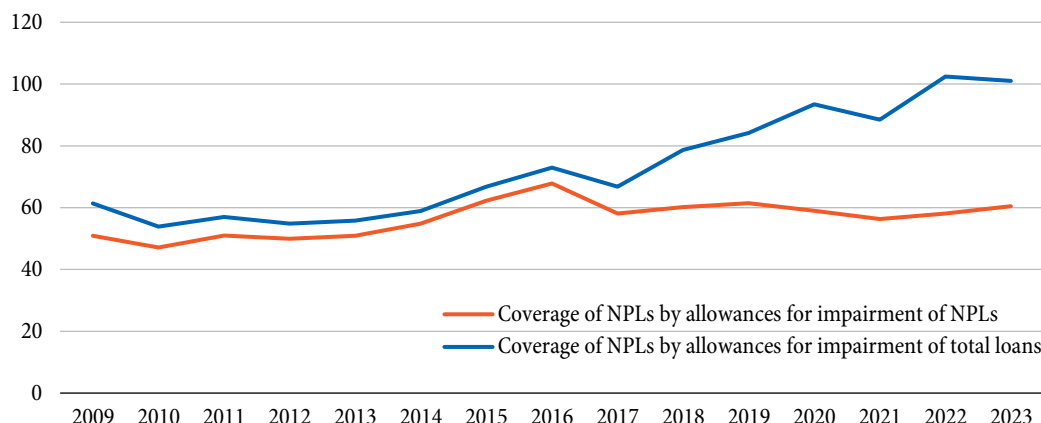
Source: NBS and the author's calculation

close to the values at the end of 2023. The impact of IFRS 9 on credit losses, or classification by impairment stages, is most clearly visible from the ratio of coverage of NPLs by allowances for impairment of total loans before and after the beginning of implementation (Figure 11). *In the current circumstances of low credit losses and a good quality credit portfolio, this effect cumulatively over five years amounts to approximately RSD 25 bn.*

In addition to the negative impact of regulations on bank profitability, a regulatory measure that was one of the factors behind the accelerated credit growth in the context of declining interest margins was the removal of the requirement for banks to include required reserve for estimated losses in the calculation of capital adequacy after 2018 [5, Article 460]. This was preceded by a measure in 2016 that introduced the gradual exclusion of required reserve for estimated losses from the calculation of capital

adequacy [4, Section 2] as a measure to encourage the reduction of NPLs. In this way, banks were given more room to finance the economic cycle, which led to an increase in risk-weighted assets (credit activity) while maintaining a relatively stable capital adequacy ratio (Figure 12).

In contrast, regulatory and other government measures related to the conversion of CHF-indexed loans with a partial write-off [16], the introduction of several moratoriums on loan repayment during the COVID-19 pandemic [6], [8], as well as temporary caps on interest rates for housing loans [7], had a one-off negative impact on bank results in 2019, 2020, and 2023, measured in billions of dinars. In the first case, this was due to the cessation of the recognition of financial assets, while in the other two cases, it was due to the modification of the value of financial assets in accordance with IFRS 9. All of these measures were implemented with the aim of preserving

Figure 12: Dynamics of risk-weighted assets, in RSD bn

Regulatory capital   — Risk-weighted assets   — CAR, rhs
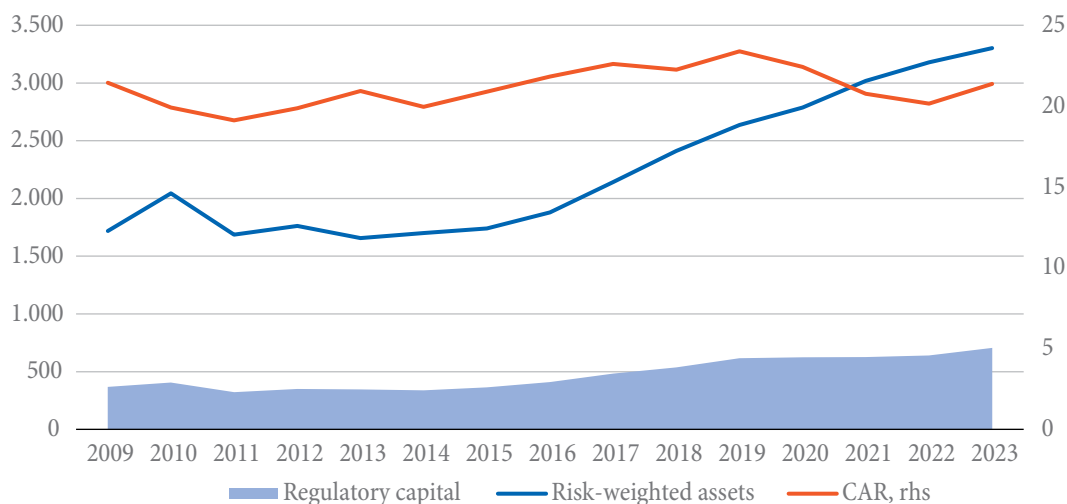
Source: NBS

the stability of the financial system in the face of strong external shocks.

In the coming period, the profitability of banks is expected to be influenced by the increasingly prevalent concept of Environmental, Social, and Governance (ESG) standards. Although these standards are not yet mandatory, they have become widely accepted, and some banks have already begun integrating them into their operations. The application of ESG standards to bank profitability can have both positive and negative effects. On the one hand, adapting to ESG requirements will lead to changes in the structure of the credit portfolio, including pulling back from profitable but environmentally risky sectors, as well as increasing operating costs. On the other hand, adhering to ESG principles can reduce business risks in the long run, improve reputation, and open up opportunities for new products, such as financing green projects, which can positively impact profitability and competitiveness.

Comparing Operating Results of the Corporate and Banking Sector

The analysis of the banking sector's performance cannot be fully understood without a broader economic background and comparison with the results of other economic entities. Banks are key financial intermediaries that provide liquidity and support investments in almost all sectors, but with a strong synergistic effect, as their profitability is closely tied to macroeconomic conditions and economic cycles. The state of the economy affects the level of credit

activity, credit losses, and other key factors that shape the results of the banking sector. In favourable economic conditions, when the economy is growing, there is an increased demand for loans, a reduction in credit losses, and greater opportunities emerge for a positive business result. Conversely, during periods of recession or macroeconomic shocks, rising unemployment, dented consumption, and reduced economic activity can fuel an increase in NPLs, which negatively impacts banks' profitability.

Given such interdependence, the comparison of the results of the banking sector with those of the corporate sector yields a better understanding of the extent to which banks have managed to adapt to volatile conditions and to which their business outcomes are a result of external macroeconomic factors versus internal management factors. The most desirable outcome occurs when their results move in the same direction, meaning they contribute to each other's success.

For the purposes of comparing the banking and the corporate sector, relative indicators such as Return on Assets (ROA) and Return on Equity (ROE) were used. These indicators allow for a more objective assessment of business performance, eliminating the impact of absolute differences between the banking sector and other industries of the economy. Since the banking sector and the overall corporate sector have different structures and numbers of entities, using absolute values, such as total profit or loss, would not provide useful information for the analysis.

The data presented in Figure 13 indicate that, for most of the period observed, the corporate sector generated

**Figure 13: Return on assets of corporates and banks in 2009-2023**
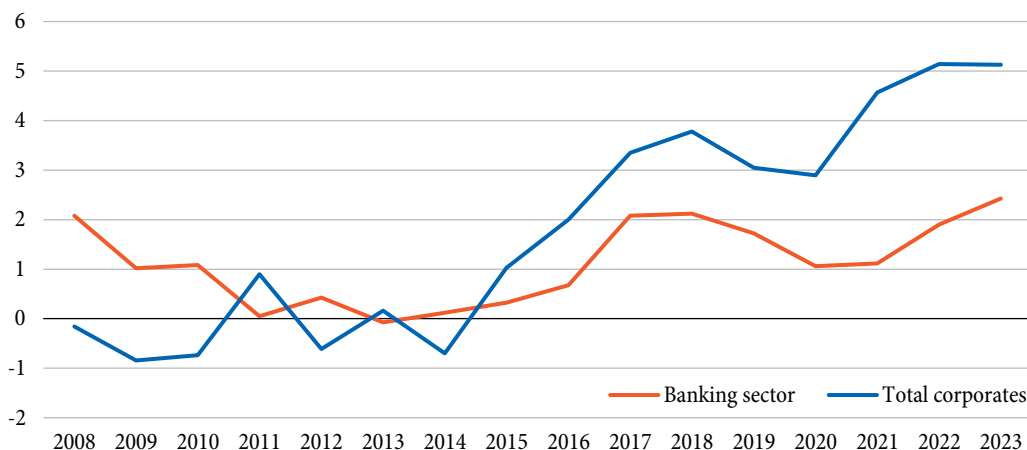
Source: NBS, SBRA and the author's calculation

higher rates of return on assets compared to banks. This is also reflected in the average value of this indicator, which was nearly doubled for the corporates compared to banks: 1.94% versus 1.07%. This result was achieved despite the fact that, at the beginning of the period observed, specifically from 2009 to 2014, the return on assets for the corporates was negative, while from 2015 onwards, the profitability of the corporate sector consistently trended higher. The same holds true even in years like 2022 and 2023, when, in the context of strong interest rate hikes in the fight against inflation, banks achieved a return on assets close to that of 2008.

This suggests that the corporate sector benefits more from a stable macroeconomic environment than the financial sector, meaning that in times of growth, the corporate sector is capable of generating more value per unit of resources engaged than banks [21]. Of course, following the global economic crisis of 2008, a policy of very cheap money was pursued for a long time to stimulate economic growth, which typically leads to a decline in bank profitability [1, p. 17]. However, this was not the case in Serbia, where inflation, due to domestic factors, remained high and volatile until 2013, causing interest rates to stay elevated.

Figure 14: Return on assets, by industry, in %
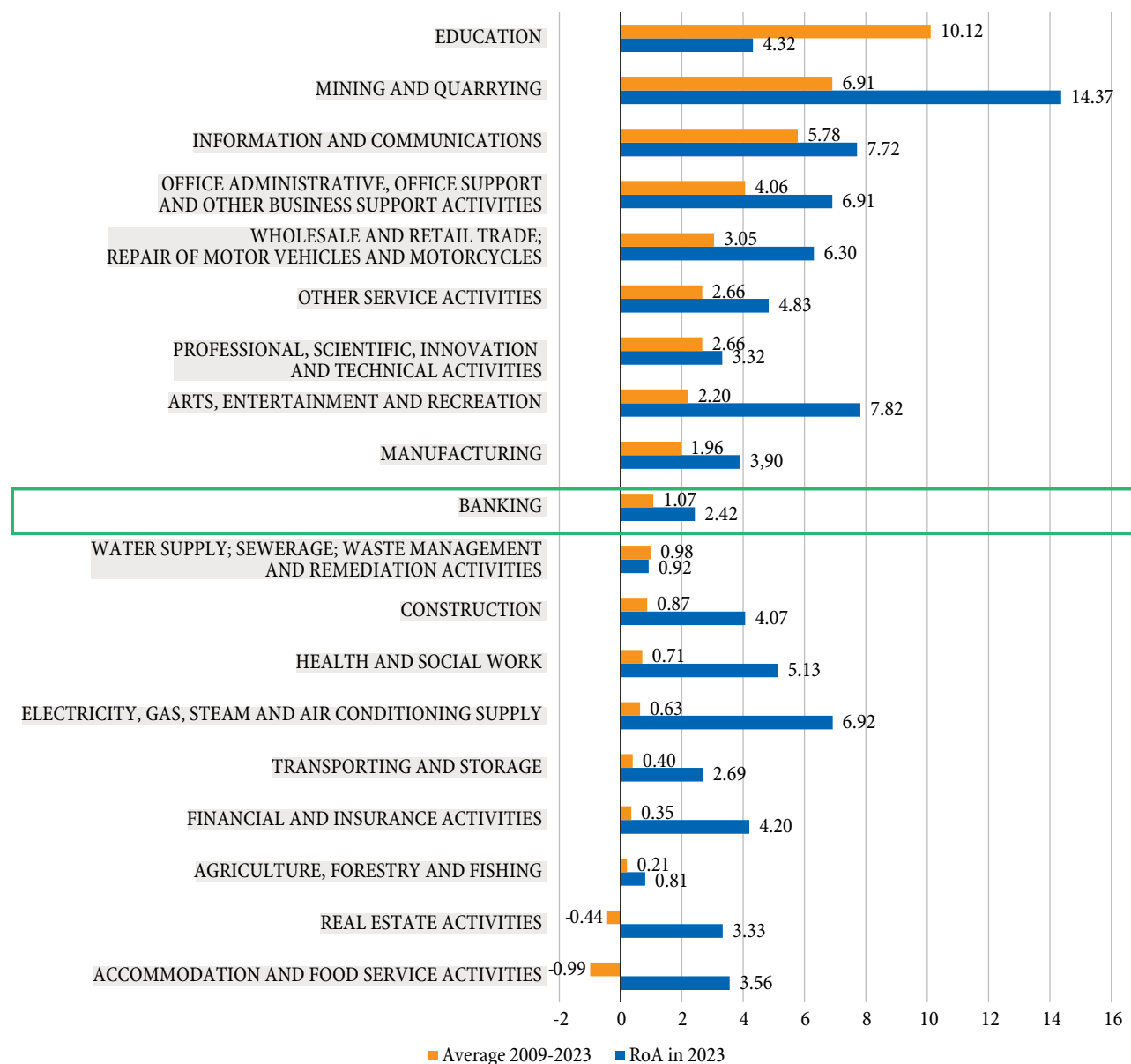
Source: NBS, SBRA and the author's calculation

In addition to the aggregate data for the banking sector and the economy, the assessment can be further deepened by analysing the structure of ROA across industries, considering that the corporate sector encompasses a wide range of different sectors and industries, each varying in structure, dynamics, and economic outcomes. This heterogeneity means that while some industries experience significant growth and contribute to overall economic expansion, others may face pressures from various factors such as changes in demand, production costs, regulatory changes, and other influences. Due to this diversity, comparing the business results of banks with individual sectors of the economy provides a more comprehensive insight into how macroeconomic conditions impact different sectors and industries within them.

By comparing the performance results of banks with the results of different sectors of the economy (Figure 14), both in the last year and as averages for the observed period, a clearer understanding of the banking sector's performance relative to the broader economic environment can be gained. While interest rates and credit activity are important factors influencing bank results, different industries may have different growth and profitability drivers. This comparison also reveals which sectors of the economy outperform the average, which may point to specific sources of growth but also potential vulnerabilities.

When considering performance measured by the average return on assets over the period from 2009 to 2023, the banking sector ranks in the middle, while certain industries, such as mining and information technologies (IT), show significantly higher figures. When focusing solely on the last year, which was a record year for the banking sector, only two industries performed worse in terms of return: water supply and agriculture. This confirms the previously stated claim that the corporate sector benefits greatly from macroeconomic stability and favourable business conditions.

Final Considerations

The profitability of the Serbian banking sector in the period 2009-2023 was strongly influenced by macroeconomic conditions, as well as specific characteristics of the banking system. The analysis showed that the key determinants of profitability during this period included interest rates changes, credit risk management, and the ability of banks to adjust their business strategies to volatile economic conditions.

One of the principal conclusions is that net interest income and interest margins remained the dominant source of profitability for the banking sector throughout the entire observed period. Banks managed the structure of assets and liabilities in a way that preserved the stability of net interest income, despite global and local challenges such as low interest rates. This indicates the resilience of the sector and its ability to adapt to economic policies, particularly the monetary policies of the NBS and ECB.

Relatively stable net income from fees and commissions represented a sort of a profitability buffer, which banks successfully maintained and strengthened through the modernisation of operations in response to technological competition.

However, a significant challenge for the banking sector came in the form of credit losses, especially in times of crisis. The movement of credit losses was largely dependent on macroeconomic factors such as GDP growth and exchange rate. The greatest pressures on bank profitability were seen during recession when the rise in NPLs gathered pace, leading to the need for greater provisioning and a reduction in net results. Nevertheless, thanks to the stabilisation of macroeconomic conditions, banks were able to scale down credit losses significantly after 2015, which positively impacted their overall financial performance.

Operational efficiency of banks also played an important role in business performance results. Banks continuously improved their efficiency through cost optimisation and business rationalisation, which led to an improvement in the cost-to-income (C/I) ratio. Although banks faced rising operating expenses, especially in terms of provisioning and intangible costs, they managed to adapt their business models in a way that maintained stability in operational results. This segment became especially important during periods of particularly low interest margins, when operating expenses had to be strictly controlled to maintain a positive outcome.

Another factor that shaped profitability was the degree of concentration in the banking sector. Although the analysis of the relationship between increased concentration and the profitability of the banking sector in Serbia was not the subject of this paper, it is a fact that the consolidation of the banking sector had an impact on its profitability through the effects of recognising gains from bargain purchase in accordance with IFRS 3 Business Combinations.

Regulations, as the final factor analysed, also played an important role in shaping the performance of the banking sector. The implementation of international standards, such as the Basel standards and IFRS 9, significantly influenced the way banks manage credit risks and liquidity. While the introduction of these standards did increase transparency and resilience of the sector, it also led to higher operating expenses and the recognition of expected credit losses, which, in some periods, posed a challenge to maintaining profitability.

Also, the comparison of the relative performance of the banking sector and the rest of the economy indicates that the real sector benefits significantly more from macroeconomic stabilisation and growth. During most of the observed period, the corporate sector generated higher return on assets compared to banks, as confirmed by the average value of this indicator, which was almost twice higher for corporates than for banks: 1.94% vs. 1.07%. This result was achieved despite the fact that at the beginning of the observed period (2009–2014), return on assets for the corporate sector was negative, while since 2015, the earning capacity of the corporate sector has consistently been at a higher level. The same holds true even in years like 2022 and 2023, when, in conditions of strong interest rate growth in the fight against inflation, banks achieved a return on assets similar to that of 2008.

The general conclusion is that the stabilisation of macroeconomic conditions in the country since 2013, particularly tackling of inflation and the relatively stable exchange rate of the dinar against the euro, along with the rise in employment and wages, have fully reflected in the growth of the volume and quality of credit activity. The improvements in risk management processes have also had a positive impact on the results. Thanks to the stabilisation of macroeconomic conditions, banks were able to significantly reduce credit losses. Although net interest income increased in 2023 amid the fastest and most aggressive tightening of monetary policies ever, the net interest margin in 2023 was still lower compared to the period before 2012.

Specifically, the analysis of the period from 2009 to 2023 on the case of Serbia offers insight into the dynamic changes of numerous factors that shaped the structure of banks' interest income and expenses in various macroeconomic and microeconomic environments. This period was marked by significant changes in business conditions – from exceptionally low interest rates, which posed a challenge for maintaining net interest income, to the sharp and unprecedented global increase in interest rates in the fight against surging inflation, which was conducive to a rise in net interest margins.

Generally, the period up to 2013 was marked by a volatile exchange rate of the dinar against the euro, with considerable depreciation, which negatively impacted domestic inflation and the level of NPLs. Unstable domestic macroeconomic conditions led to interest rates in the domestic market being much higher than in the region.

The second period, starting from 2013, was marked by policies aimed at the macroeconomic stabilisation of the country and curbing of domestic inflation within a one-year period, to which the establishment and preservation of the relative stability of the dinar exchange rate against the euro provided a major contribution. This also enabled the beginning of a cycle of strong interest rate cuts. A strategic approach was implemented to resolve the inherited issue of NPLs. At the same time, after the necessary fiscal consolidation was carried out, economic growth accelerated strongly, until the emergence of the pandemic and multiple global macroeconomic shocks.

Conclusion: The profitability of the Serbian banking sector during the observed period was shaped by a complex set of internal and external factors. Key challenges came from macroeconomic shocks, credit risk, and regulatory changes, with banks managing these risks through adjustments to their business strategies and optimisation of operating expenses. Future challenges, such as growing competition and further regulatory pressures, will require

continued adjustments to ensure the sector's long-term sustainability. Just as Winston Churchill once said, "Success is not final, failure is not fatal: it is the courage to continue that counts." This thought perfectly illustrates Serbia's path toward strengthening its economic stability.

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graduated from the Faculty of Economics in Priština, on 14 May 1981 as the student of the generation. She was elected Member of Parliament in six parliamentary convocations. From March 1998 until October 2000, she served as Minister of Economic and Ownership Transformation in the Serbian Government. Her book "Monetary Policy – No Final Victories" was published in 2018, "My Answers – a Contribution to the History of Banking in Serbia in 21st Century" in 2020, and another one "The Turning Point – Balance is the Key to Success" in 2021. She has served as Governor of the National Bank of Serbia since August 2012. In June 2018 she was re-appointed for another six-year term of office, starting from August 2018. The reputable Banker monthly declared Governor Jorgovanka Tabaković the best governor in the world and the best European governor for 2020. She is a widow and mother of three children: Ivana, Milena and Nikola.

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EFFECTIVE INTEREST RATE (annual, calculation as of 23/08/2024)	4,84%	4,55%
TAX LIABILITY (0%)*	0,00 RSD	0,00 RSD
TOTAL PAY-OUT (deposit+interest)	1.011.939,89 RSD	1.022.640,80 RSD

* In line with the Law on Individual Income Tax, tax on capital income from interest is not paid.
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THE SPILLOVERS OF U.S. MONETARY POLICY SHOCKS ON CESEE COUNTRIES: A GVAR ANALYSIS

Prelivanja šokova u monetarnoj politici SAD na CESEE zemlje – GVAR analiza

Abstract

This paper studies the effects of policy tightening by the Federal Reserve System (Fed) on Central, Eastern and Southeastern European (CESEE) countries. To this end, the Global Vector Autoregressive Model (GVAR) was estimated, capturing the interlinkages between the economies based on trade flows. The obtained results indicate that U.S. policy tightening can have non-negligible effects on the real activity and financial conditions in CESEE economies. While the short-term effects on relatively persistent inflation may be beneficial in some of these countries, the primary risk moving forward comes from the negative impacts on the real sector. These arise from the contraction in the U.S. and Eurozone economies, as well as spillovers leading to higher interest rates in CESEE countries. The negative effects are particularly pronounced in countries with a higher level of foreign currency liabilities.

Keywords: *international monetary spillover, GVAR, risk premium, monetary policy*

Sažetak

Ovaj rad analizira efekte zaoštravanja monetarne politike Sistema federalnih rezervi (Fed) na zemlje centralne, istočne i jugoistočne Evrope (CESEE). Za tu svrhu korišćen je Globalni vektorski autoregresivni model (GVAR) koji uzima u obzir i međusobnu povezanost ekonomija preko njihovih trgovinskih veza. Dobijeni rezultati ukazuju na to da zaoštravanje monetarne politike u SAD može imati osetne efekte na realnu ekonomsku aktivnost i finansijske uslove u zemljama CESEE. Dok bi efekti na trenutno prilično persistentnu inflaciju mogli biti povoljni u kratkom roku u nekim od posmatranih ekonomija, negativni efekti, do kojih dolazi usled smanjenja ekonomske aktivnosti u SAD i evrozoni i efekta prelivanja na rast kamatnih stopa u CESEE ekonomijama, predstavljaju primarni rizik u narednom periodu. Negativni efekti će biti izraženiji u finansijski osetljivijim zemljama, odnosno zemljama sa većim stepenom obaveza u inostranoj valuti.

Ključne reči: *međunarodni kanal transmisije monetarne politike, GVAR, premija rizika, monetarna politika*

Introduction

Over the past two and a half decades, the degree of trade and financial integration overall, and of emerging market economies (EM) in particular, has significantly increased. Higher integration of the global economy increased the potential that the impact of domestic shocks may spill over to other economies, especially if the shock originates in one of or several key advanced economies (AE). What is more, the deepening integration gave rise to views that financial conditions and growth worldwide may be driven by a global financial cycle, which in turn is largely driven by monetary policy conditions in the U.S., and Europe ([5], [28]). While the debate about the extent of monetary policy spillovers has a long history in international economics (being part of the Mundell-Fleming framework), changes in monetary policies in AE and volatile capital flows in and out of integrating emerging markets have brought the spillovers back to the forefront of the policy and academic debate in recent years.

The recently announced changes in the U.S. trade policy significantly increased the level of uncertainty on the global goods and financial markets. The uncertainty about the potential effects of the changes in the U.S. trade regime on the economy is associated with a less dovish policy stance from the Federal Reserve System over the last quarter of 2024 relative to what has been communicated earlier in the year. The inflationary pressures that may arise due to higher tariffs and trade barriers can lead to slower than expected U.S. monetary policy relaxation or even the need for increase in the policy rate. In both cases, the underlying policy shock would have the policy tightening character.

In this paper, we study the spillover effects of the U.S. monetary policy tightening on the key macro-financial indicators of the Central, Eastern and Southeastern Europe countries. The analysis can provide some guidance on the expected effects of potential changes in the policy stance in 2025, abstracting of course from the Lucas critique. The spillovers can arise through multiple channels discussed in the earlier literature (see e.g., [23], [15]) – impacting economic activity, inflation, risk premium, interest rates and exchange rates in small open markets.

We use the global vector autoregression (GVAR) framework to model the variables of interest. We collect quarterly data for key macro-financial variables (GDP, inflation, short-term interest rate, country risk premium, nominal exchange rate) for the U.S., Czech Republic, Hungary, Poland, Romania, Serbia and Turkey over the 2005 Q1 to 2023 Q4 period. We use the brent crude oil prices as the global (exogenous) variable in the system. To mitigate potential omitted drivers, we also collect data for the Eurozone and use it for both the construction of foreign variables in the GVAR system and in GVAR estimation, though we do not explicitly focus on the Eurozone results. The foreign variables are computed using total trade weights which include both export and import flows. The model is estimated using the standard set of cointegrating restrictions which correspond to long-term theoretical economic relationships. The reaction function of the CESEE countries' macro-financial conditions to the U.S. policy tightening shock was analyzed based on the Generalized Impulse Response Function (GIRF). The GVAR methodology, which explicitly takes into account interconnectedness between the economies based on the observed trade patterns, is well-suited for studying the problem of interest. Unlike traditional single equation or VAR models, which focus on a single economy in isolation, GVAR accounts for cross-country feedback effects, allowing a more comprehensive analysis of how policy innovations in one economy can reverberate across the global economic system. This is also in line with modern central banking practices which are increasingly taking into account developments in the international environment when making policy decisions.

The obtained results suggest that changes in U.S. trade policy in 2025, which could lead to explicit or implicit tightening of U.S. monetary policy, may have non-negligible effects on real activity and financial conditions in the CESEE economies. The estimated responses indicate that U.S. monetary policy tightening would spillover to an increase in local interest rates. In line with the previous empirical literature (see e.g., [1], [12], [14]), the estimated country responses display a certain degree of heterogeneity. The increase in local interest rates is more pronounced and persistent in Turkey, Serbia, and Romania, which is consistent with the estimated nominal exchange rate

depreciation pressures and a rise in the country risk premium. Given the relatively higher share of foreign currency liabilities in these countries, there is a stronger incentive for monetary authorities to maintain higher interest rates to prevent capital outflows and mitigate the risk of currency depreciation.

Inflation dynamics in response to the U.S. monetary policy innovation also exhibit a heterogeneous pattern. Inflation slows down in Romania in the first year following the shock, but the effect is not persistent and becomes statistically insignificant after two years. In Hungary, Poland, and Turkey, prices do not respond significantly, while the shock has a negative and more persistent effect on inflation in the Czech Republic and Serbia. While the short-run effects on now relatively persistent inflation may be beneficial for some CESEE countries, the estimated negative effects on the real output represent the primary risk going forward. The expected increase in the risk premium and potential depreciation pressures may necessitate a monetary policy response and a tightening of domestic financial conditions could lead to additional, second-round negative effects on real output, discussed in [11].

The remainder of the paper is structured as follows: The next section outlines relevant literature. The following section sets the conceptual framework. The subsequent section presents the data and variable construction. The results and their discussion are provided before the concluding section.

Literature Review

This paper is related to a rapidly growing empirical literature that studies the global spillovers of policy innovations in advanced economies. The dominant position of the United States and Eurozone in global trade and finance implies significant potential for spillovers which can propagate through several channels, including exchange rates, capital flows, trade linkages, and financial markets. Theoretical framework for small open economies' responses to external monetary shocks is well established in the literature (see e.g., [23]). [15] show that in response to a rise in foreign interest rates in advanced economies, primary the U.S., small open economies typically experience higher domestic

interest rates, a decline in foreign reserves (associated with central bank interventions), exchange rate depreciation, lower inflation, and reduced GDP growth.

One strand of the literature focuses on the identification of the transmission mechanisms through which the spillovers can occur. One of the key channels is the exchange rate, where policy actions, such as policy rate tightening in the AE can lead to currency depreciation in other economies, which in turn impacts trade flows and inflation through traditional competitiveness and pass-through channels (see [6]). The exchange rate changes are closely connected with changes in capital flows dynamics, where changes in interest rates or risk sentiment can induce significant, and often sudden, shifts in cross-border capital flows, affecting local asset prices and exchange rates. Furthermore, monetary policy changes in major economies can affect global demand conditions through trade linkages, leading to changes in output and inflation in trading partner countries (see e.g., [7]). The findings are empirically confirmed by [19], who document strong and heterogeneous spillover effects from U.S. interest rate hikes, leading to declining output growth, increased inflationary pressures, and exchange rate depreciation in emerging markets, particularly when accompanied by heightened policy uncertainty. [20] also show that increasing domestic interest rates as a response to monetary tightening in the US is consistent with the fact that tighter U.S. monetary policy leads to capital outflows from emerging markets, while a higher emerging market policy rate, concurrent with a higher federal funds rate, can reduce outflows. [3] emphasized the increasing importance of the financial channel in transmitting monetary policy spillovers, arguing that globalization has amplified all three channels, though their net effects remain an empirical question. Similarly, [22] provide evidence that monetary policy shifts in advanced economies generate uncertainty spillovers across financial markets, influencing business cycle fluctuations in emerging markets.

Another strand of the literature focuses on studying the heterogeneity in the spillover magnitude across the countries, which can be associated with the degree of financial and trade openness, exchange rate regimes, and overall structure of the economy. [1] demonstrate that spillovers are more pronounced in economies with higher

trade openness and greater financial integration. [14] finds that U.S. monetary policy exerts significant output spillovers on other economies, sometimes exceeding its domestic effects. The extent of these spillovers depends on factors such as a country's trade and financial integration, de jure financial openness, exchange rate regime, financial market development, labor market flexibility, industry structure, and participation in global value chains. [12] analyze the effects of contractionary U.S. monetary policy on financial conditions, industrial production, and consumer prices in emerging markets, concluding that economies with greater vulnerabilities experience stronger responses to U.S. monetary shocks. Similarly, [16] highlights that the nature of the Federal Reserve's monetary policy response matters: spillovers tend to be larger when the Fed tightens policy to combat inflation rather than when it reacts to economic growth.

The challenges faced by monetary policymakers in economies with flexible exchange rates have gained increasing attention following the work of [8] and [28] (see also [30] for new era challenges). These studies analyze the trade-offs involved in international monetary transmission, particularly in economies where external debt is predominantly denominated in foreign currency. In such cases, a rise in the U.S. interest rate leads to domestic currency depreciation, which stimulates exports but also exacerbates balance sheet vulnerabilities by increasing the domestic-currency value of foreign-denominated debt. As a result, even economies with flexible exchange rates may experience constraints on their monetary autonomy, as central banks must balance the objectives of stabilizing economic activity and mitigating financial stability risks. This also gives rise to the importance of policy coordination. [15], among others, emphasize how coordinated global monetary policy actions can reduce adverse spillovers, particularly in times of economic crises.

The literature on spillovers to CESEE countries has expanded more recently as these economies have become increasingly integrated into the global financial system. Early studies, such as [21], studied the sensitivity of CESEE economies to external monetary policy shocks, emphasizing the role of global financial integration and capital markets. Not surprisingly, multiple studies, such

as [27], finds strong spillovers of European Central Bank (ECB)'s monetary policy innovations on both, countries which were in the process of joining the Eurozone as well as those, such as the Czech Republic and Poland, which maintained independent exchange rate regime.

The empirical studies for CESEE countries generally confirm the earlier findings on the key transmission channels and cross-country heterogeneity in responses. [17] showed that the U.S. monetary policy shocks can have strong effect on the currencies of CESEE economies, particularly those with floating exchange rates. The fluctuations in exchange rates directly affect trade balances and inflation, with the pass-through effect often being more pronounced in economies with higher external trade exposure. Similarly, [2] show the importance of the capital flows channel, where changes in interest rates in advanced economies tend to impact the foreign direct investment (FDI) and portfolio investment flows to CESEE markets. [4] suggest that countries with higher financial integration and reliance on foreign capital, such as Hungary and the Baltic states, are more sensitive to spillovers from global monetary policy, particularly with respect to interest rate changes and asset price movements. On the other hand, countries with more independent monetary policies, such as the Czech Republic, are to some degree insulated from global monetary policy but still experience indirect effects through trade and investment channels.

The results from this paper contribute to empirical literature by providing one of the handful studies that include measures of country risk premium as one of the endogenous variables in the GVAR system, thereby capturing one of the main spillover transmission channels discussed in theoretical literature. In addition, by using the updated sample which included the most recent period of policy tightening across the globe, the results can be useful for approximating the expected effects of potential policy changes in 2025 and the required policy response in CESEE countries.

Methodology Framework

The GVAR methodology has gained significant attention since the work of [24], who investigated the spillover effects

of aggregate supply and demand shocks in the United States on the global economy while accounting for the interconnectedness of various economies. The methodology was specifically designed to address the challenges associated with the high dimensionality of models that attempt to analyze the world economy, which comprises numerous individual countries. By incorporating both domestic and foreign economic variables, the GVAR provides a useful framework for studying potential spillovers of the policy changes in one economy on the other.

The GVAR methodology assumes that there are $N+1$ countries (regions) denoted by $i = 0,1,..., N$, where 0 denotes the reference country (in this paper, it will be the U.S.). Dynamics of macro-financial variables of interest are modeled through VARX model which includes local variables (country-specific variables), foreign variables specific to a particular country (country-specific foreign variables) as well as global variables which are weakly exogeneous to all countries in the system. Each country-specific foreign variable is created as a weighted average of that variable for all other countries in the sample, where the weight assigned to a country j corresponds to the share of trade between the countries i and j in the total trade of country i with all other countries in the model (see [24]).

In particular, the VARX*(1,1) model for country i (ignoring higher order lags) can be represented by the following expression:

$$x_{it} = a_{i0} + a_{i1} t + \Phi_i x_{i,t-1} + \Lambda_{i0} x^*_{i,t} + \Lambda_{i1} x^*_{i,t-1} + \Psi_i \theta_t + u_{i,t}, \quad i=0,1,... N \text{ and } t=1,2,..T \quad (1)$$

where: $x_{i,t}$ is the vector of dimensionality $k_i x1$ which contains domestic variables;

$x^*_{i,t}$ is the vector of dimensionality $k^*_i x1$ which contains foreign variables specific for country i;

$$x^*_{i,t} = \sum_{j=0}^{N} \omega_{ij} x_{jt} \quad (2)$$

the weights ω_{ii} satisfy $\omega_{ii} = 0$, and $\sum_{j=0}^{N} \omega_{ij} =1$;

θ_t is the vector of global variables;

and $u_{i,t}$ is the vector of dimensionality $k_i x1$ with shocks specific for every country i which are assumed to be serially uncorrelated with expected value of 0 and non-singular covariance matrix.

The equilibrium error correction representation of the VARX* (1,1) model can be written as:

$$\Delta x_{it} = c_{i0} - \alpha_i \beta'_i [z_{i,t-1} - \gamma_i (t-1)] + \Lambda_{i0} x^*_{i,t} + \Psi_i \Delta \theta_t + \Gamma_i \Delta z_{i,t-1} + u_{i,t} \quad (3)$$

where $z_{i,t-1} = (x_{i,t}, x^*_{i,t})'$, α_i is a $k_i \times r_i$ matrix of rank r_i, and β_i is a $(k_i + k^*_i) \times r_i$ matrix of rank r_i.

To estimate the cointegrating vector we impose several well-known theoretical restrictions discussed in more detail in the following section.

The conventional GVAR (see [24]) estimates each individual country model under the assumption of weak exogeneity of foreign and global variables, i.e., it is assumed that each economy except the reference country can be viewed as a small open economy whose impact on the global economy is negligible. The assumption is plausible in our case as we focus on the CESEE countries whose impact on the reference (the U.S.) economy is negligible. The maximum likelihood tests of the weak exogeneity of foreign variables hypothesis indicate that this assumption is indeed met in our sample. In addition, we include the data for Eurozone in the model to avoid heavily biasing trade weights for the construction of foreign variables and to allow for the indirect propagation of the U.S. shocks to CESEE countries via reaction of the Eurozone macro-financial conditions. Once the individual models are estimated, they are combined to obtain a solution of the global model. The obtained models are used to track the spillover of shocks in different variables through impulse response function analysis.

Following [10] and [24], the shock propagation is analyzed using the generalized impulse response function (GIRF). The generalized impulse responses are invariant with respect to the order of variables and countries in the GVAR model, which is of particular importance in the case of macroeconomic systems, since identifying the order of countries and variables can be challenging based on the theoretical restrictions. Namely, in the case of the GIRF, a shock is assumed in only one element, e.g., j-th element in u_t, corresponding to the l-th variable in the i-th country using the historical error distribution. The generalized impulse response function is given by the following expression:

$$GIz : \varepsilon_{il} \left(n, \sqrt{(\sigma_{ii,ll})}, I_{t-1} \right) =$$
$$E(z_{t+n} | \varepsilon_{ilt} = \sqrt{(\sigma_{ii,ll})}, I_{t-1}) - E(z_{t+n} | I_{t-1}) \qquad (4)$$

where $I_{t-1} = (z_t, z_{t-n}, \dots .)$ represents the model's information set at time *t-1*. Assuming that underlying structural shock ε_t has a multivariate normal distribution, the effect of a shock of one standard error at time t on the expected values of z at time $t + n$ will be given by:

$$\psi_j(n) = \frac{1}{\sqrt{\sigma_{ii,ll,}}} F^n G^{-1} \Sigma s_j, \qquad n = 0,1,2, \dots N$$

Data and Variables

We collect data for gross domestic product (GDP), inflation rate, short-term interest rate, dollar nominal exchange rate and Emerging market bond index (EMBI), a common proxy for the country risk premium, over the period from 2005 Q1 to 2023 Q4 for the USA, the Eurozone, the Czech Republic, Hungary, Poland, Romania, Serbia and Turkey. The selection of CESEE countries is based on data availability of a consistent series of EMBI indices as well as on the prevailing exchange rate regime.

Data for GDP and inflation is collected from Eurostat, while three-month interbank interest rates, foreign exchange rates, EMBI and Brent crude oil price are collected from Bloomberg.

Vector x_{it} contains the following domestic variables that are included in the model: y_{it} (gross domestic product), $\Delta p_{i,t}$ (inflation rate), r^s_{it} (short term interest rate), $embi_{it}$ (EMBI risk premium), e_{it} (nominal exchange rate vs dollar).

In a general case, when, for country i data is available for all abovementioned variables, vector $x_{it} = (y_{it}, \Delta p_{i,t}, r^s_{it}, embi_{it}, e_{it})$ represents the vector of domestic variables, while vector $x^*_{it} = (y^*_{it}, \Delta p^*_{i,t}, r^{s*}_{it}, embi^*_{it}, e^*_{it})$ represents the foreign variables vector specific for country i.

The variables are defined in the following way:
y_{it} – the logarithm of real GDP: $y_{it} = \ln \left(\frac{GDP_{i,t,2010=100}}{GDPdeflator_{i,t,2010=100}} \right)$
$\Delta p_{i,t}$ inflation rate: $\Delta p_{i,t} = p_{i,t} - p_{i,t-1}$, where $p_{i,t} = \ln (CPI_{i,t})$
r^s_{it} short term interest rates – the three month interbank interest rate transformed in line with [24]: $r^s_{it} = 0{,}25 \ln \left(1 + \frac{R^s_{i,t}}{100} \right)$ where R^s_{it} stands for annualized short term interest rates.
$embi_{it}$ the logarithm of EMBI index: $embi_{it} = \ln(EMBI_{i,t})$

$e_{it} = \ln(E_{i,t})$ – the logarithm of nominal exchange rate with respect to dollar, defined such that increase in the nominal exchange rate implies stands its appreciation:

After defining domestic variables, the next step is to define the foreign variables specific to each country using weights that reflect trade relations. Corresponding foreign variables that relate to each individual country $x^*_{it} = (y^*_{it}, p^*_{i,t}, r^{s*}_{it}, embi^*_{it}, e^*_{it})$ are calculated using the generic formula:

$$x^*_{it} = \sum_{j=0}^{N} \omega_{i,j} x_{i,t}$$

The weights used in calculation of foreign variables, $\omega_{i,j}$ are defined as the share of country j in the total trade (imports + exports) of country i. The own weight, $\omega_{ii} = 0$ and the weights sum to 1. When calculating the weights, positive weights were assigned only to those countries for which there is available data for a specific variable, so that the weights always add up to 1. For example, since the variable $embi_{it}$ does not exist for the Czech Republic, while it does exist for example for Serbia, when calculating $embi^*_{it}$ for Serbia, the Czech Republic was assigned a weight of 0, while when calculating the variable e^*_{it} for Serbia, the Czech Republic, for which data on the nominal exchange rate exists, was assigned a weight corresponding to the sum of imports and exports from Serbia to the Czech Republic in relation to total imports and exports of Serbia. The weights are calculated based on data on total trade between the countries in the sample. Imports and exports data are taken from the World Integrated Trade Solutions portal and cover the full sample period from 2005 to 2023. In the case of the reference economy, i.e., the United States, the domestic variable $e_{it} = 0$, since this variable will be defined through foreign variables, as the weighted average of the exchange rates of other countries against the dollar.

Empirical Model Results

This section presents the results of empirical analysis. We first focus on preliminary steps in estimation and then present the estimates of the main results.

The preliminary steps include testing the order of integration of model variables, determination of the VARX*(p,q) order and testing of the number of cointegrating

vector restrictions. Reduced rank estimator of the GVAR models is based on the assumption that all endogenous and exogenous variables included in the model have exactly one unit root (see [24]). This implies testing the order of integration of the included variables as the first step in the analysis. We used the standard ADF test, as well as the WS test, which is based on weighted symmetric estimates of the ADF type (see [29]). The Schwartz Bayesian (SBC) criterion was used in determining the number of terms to include in both tests. The macro-financial variables we study are typically found to be integrated of order 1 (I(1)) in the literature, which is also indicated by the majority of the results of the unit root tests we run. The results of the unit root tests (Table 1) indicate that at the 5% significance level, we can conclude that all variables have exactly one unit root, except for the inflation variable, which is found to be stationary.

The VARX*(p,q) order, i.e., the number of lagged domestic (p) and foreign variables (q) included in the model, is determined using the Akaike information criteria. In determining which foreign variables are included in the individual country specification, we follow the approach outlined in [24] which looks at the country's position in the global economy. In the equation for the U.S., therefore, the CESEE interest rates were excluded from the set of foreign variables. On the other hand, in equations for CESEE countries all foreign variables are included. Oil prices as a global variable are included in all country specifications. Finally, the selection of deterministic components included in each country's equation is based on the results of the maximum likelihood test as in [29]. Details of the procedure are described in Section A.10 of [29].

The GVAR methodology allows for introduction of the long-run relationships that are consistent with economic theory with the goal of providing additional theoretical underpinnings to the otherwise fully reduced-form model (see e.g. [29]). In addition, [26] have shown that individual VARX* models can be derived as a solution to a DSGE model, where the long-run relationships of the overidentified equations can be tested and, if valid, introduced as constraints. In line with the literature and variables included in the empirical model, which are: $x_{it} = (y_{it}, \Delta p_{i,t}, r^S_{it}, embi_{it}, e_{it})$ $x^*_{it} = (y^*_{it}, \Delta p^*_{i,t}, r^{S*}_{it}, embi^*_{it}, e^*_{it})$, we test the following theoretical relationships:

Fisher's equation, i.e., the stationarity of the real interest rate:

$$r^S_{it} - \Delta p_{i,t} \sim I(0)$$

Uncovered interest rate parity:

$$r^S_{it} - r^{S*}_{it} \sim I(0)$$

Stationarity of the real exchange rate:

$$e_{it} - \Delta p_{i,t} + \Delta p^*_{i,t} \sim I(0)$$

Table 1: Unit root test results

Domestic Variables	Critical Value	USA	EURO	ROMANIA	CZECH	HUNGARY	POLAND	SERBIA	TURKEY
interest rate (with trend)	-3.45	-1.258	-1.933	-1.507	-1.586	0.290	-2.775	-5.537	-2.966
interest rate (no trend)	-2.89	-1.939	-2.000	-1.710	-1.882	-1.013	-2.389	-1.191	-2.946
interest rate (first difference)	-2.89	**-2.896**	-3.443	-5.012	-3.402	-3.143	-4.344	-6.136	-4.604
foreign exchange rate (with trend)	-3.45		**-3.962**	**-4.229**	-2.748	**-4.024**	**-4.681**	-3.305	0.007
foreign exchange rate (no trend)	-2.89		-1.370	-0.594	-1.939	-0.082	-1.022	-0.972	3.273
foreign exchange (first difference)	-2.89		**-6.307**	**-6.804**	**-6.765**	**-6.870**	-6.962	-6.414	-6.495
embi (with trend)	-3.45					-2.791	-3.127	-3.548	-3.567
embi (no trend)	-2.89					-2.747	-2.690	-2.900	-2.298
embi (first difference	-2.89					**-6.270**	-6.120	-7.191	-6.639
gdp (with trend)	-3.45	-2.254	-2.692	-2.592	-2.570	-1.560	-2.942	-1.746	-2.381
gdp (no trend)	-2.89	0.280	-1.046	-0.940	-1.246	0.175	-1.056	-0.682	-0.178
gdp (first difference	-2.89	**-7.059**	**-7.150**	**-6.874**	**-6.225**	**-6.710**	-5.829	-6.330	-6.503
inflation (with trend)	-3.45	**-7.381**	-3.452	**-3.720**	**-5.564**	-0.583	-1.461	**-4.434**	**-4.404**
inflation (no trend)	-2.89	**-7.381**	-3.300	-3.805	-5.287	-0.580	-1.113	**-4.297**	**-3.595**
inflation (first difference	-2.89	**-12.09**	-8.478	-9.875	-9.557	**-8.619**	-9.965	-7.649	-8.138

Source: Authors' calculations
Note: The table reports the results of the ADF test for the presence of unit root. The values in bold imply that the null hypothesis is rejected at the 5% significance level.

Long-term constraints were introduced into individual VARX* models and the results from the maximum likelihood test justify the validity of the introduced cointegrating vector restrictions. Given the importance that the introduction of long-term constraints may have on the model estimates, we complement the results from the statistical tests with the analysis of the persistence profiles.

The persistence profile shows the speed at which long-term relationships converge towards an equilibrium state following the shock. The persistence profiles (PP) were introduced by [25] with the aim of studying the effects of systemic shocks on the dynamics of long-run relationships. PPs refer to the time profiles of the effects of systemic shocks or shocks specific to certain variables related to cointegration relationships and provide visual evidence regarding the empirical validity of long-run relationships. At the moment of the shock, PP has a value of 1 and should converge to a value of 0 as time approaches infinity (see [25]). If the rate of convergence to the cointegration relationships turns out to be very slow, then this is an important indicator that the given cointegration vector is incorrectly specified, which may be a consequence of the fact that the number of cointegration vectors is not well specified or if long-term identification restrictions are imposed that are not supported by the data. See [25] for a discussion of PP in cointegration VAR models and [10] for the implementation of PPs in GVAR.

In Figure A1 in the Appendix, it can be seen that all persistence profiles display a trajectory aligned with stable behavior, i.e. after the shock, they tend to converge

towards a zero value. In contrast, the persistence profiles of the basic model which does not include any restrictions display non-converging behavior (Figure A2). The results from both statistical tests and persistence profiles analysis indicate that the introduction of the long-run restrictions is supported by the data and contributed to achieving model stability.

Next, we present the estimates of the generalized impulse responses. For each country/variable pair, we focus on the relatively moderate-run responses corresponding to the first eight quarters (two years) following the shock. This aligns with our goal of understanding the short and mid-term effects of policy tightening shocks. To keep the number of figures manageable and for easy comparability, we display the cumulative response of all country-level variables after one (left panel) and two years (right panel) rather than displaying all quarterly responses for each country/variable pair in the separate figures. Figures 1-5 display the responses of CESEE macro-financial variables to one standard deviation innovation in U.S. federal funds rate, which corresponds to approximately fifty basis points. In each figure, the square denotes the estimated response of the given variables, while the upper and lower diamond indicate the width of the 90% bootstrap confidence band.

Figure 1 displays the response of output in SEE countries to one standard deviation policy tightening shock by the Fed. The results imply statistically significant effect on the real activity across the CESEE countries after one year, except Romania for which the response is not statistically significant. The shock has a stronger effect

Figure 1: The response of output to the U.S. policy shock
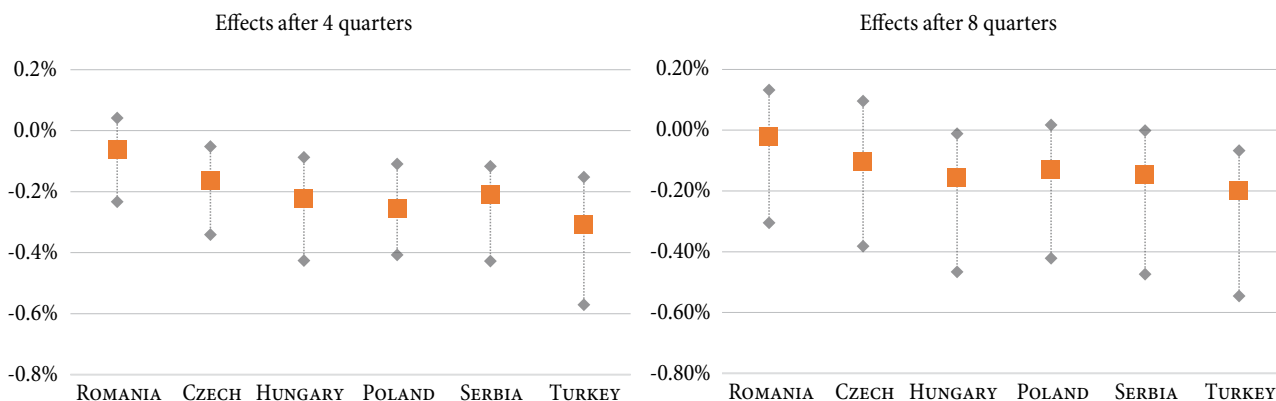
Source: Authors' calculations
Note: The figure reports the response of output after 4 quarters (left panel) and 8 quarters (right panel) of the country in column to one standard deviation shock in the US federal fund rate. The square shows an estimated response. The 90% bootstrap confidence band is displayed by the line.

after one year and the impact tends to die out slowly over the subsequent year. In line with the earlier literature, we observe a certain degree of heterogeneity in responses which tends to be stronger in the case of Turkey and Poland initially, and Turkey, Hungary and Serbia after two years, relative to other economies. Nevertheless, the same obtained sign of the country responses exhibit is in line with [18] who emphasized the similarity in the business cycles dynamics in Serbia and neighboring countries.

The impulse response functions presented in Figure 2 indicate that the U.S. monetary policy tightening would spillover to increase in local interest rates in the short run, as all responses are statistically significant. The effect is again the strongest for Turkey, followed by Romania and Serbia, countries with a relatively higher share of foreign currency liabilities. In such economies, there may be stronger pressure on the monetary policy authorities to keep interest rates at a higher level in order to prevent capital

outflows and potential effects on currency depreciation. The obtained results are broadly in line with studies conducted in the earlier period [9] and [13] who observed the existence of a transmission mechanism in short-term interest rates, i.e. that the increase in the Fed interest rate by 1 s.e. (around 0.4%) is accompanied by an increase in the short-term interest rates of other CESEE countries.

The estimated response of domestic interest rates is in line with the estimated responses of country risk premium, measured by EMBI index for countries with sufficient data availability (Figure 3). The EMBI index increases over the first four quarters for Turkey, Serbia, and to some extent Hungary and begins a slow reversion to the pre-shock level in the second year, while remaining elevated relative to the pre-shock level. The estimated spike in risk premium in turn is aligned with an observed response in domestic interest rates which serves to mitigate potential capital outflows.

Figure 2: The response of short-term interest rates to the U.S. policy shock
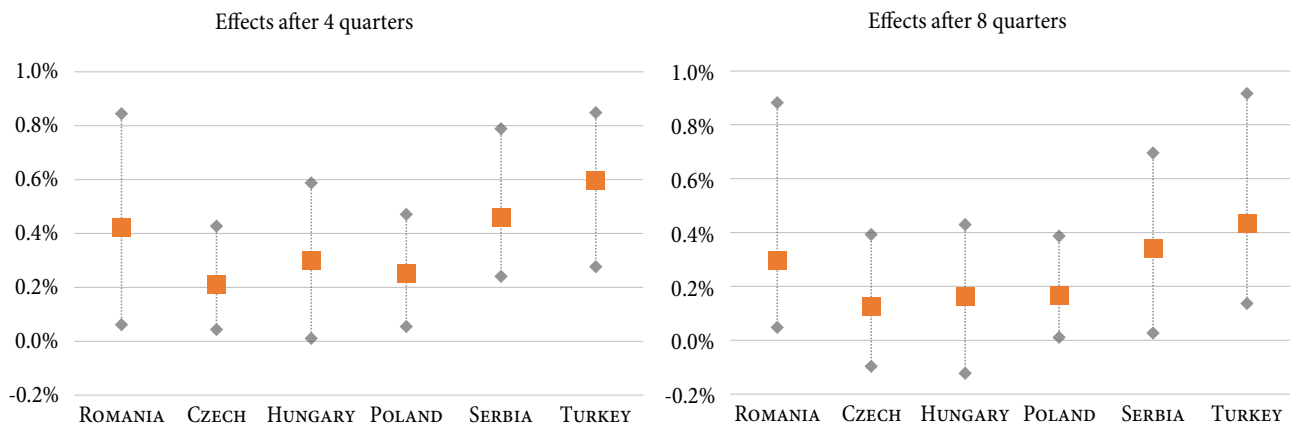
Source: Authors' calculations
Note: The figure reports the response of short-term interest rates after 4 quarters (left panel) and 8 quarters (right panel) of the country in column to one standard deviation shock in the US federal fund rate. The square shows an estimated response. The 90% bootstrap confidence band is displayed by the line.
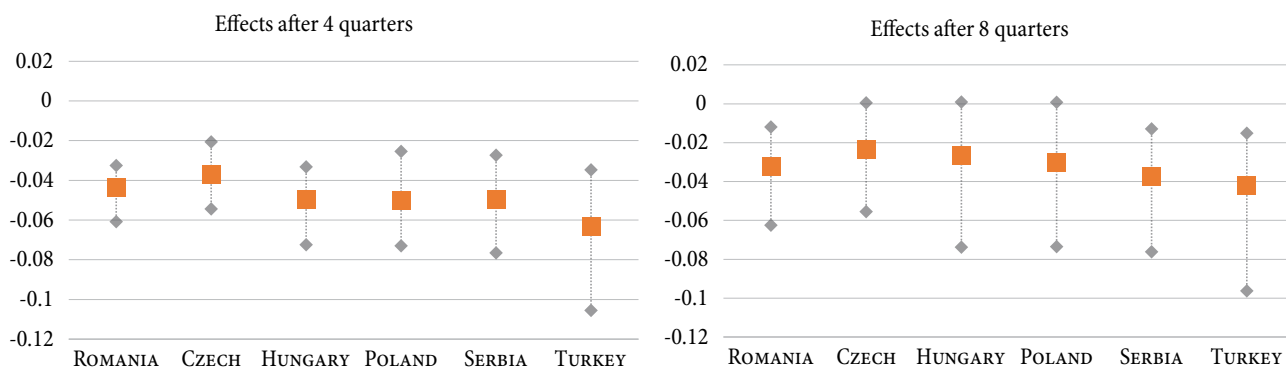
Figure 3: The response of EMBI index to the U.S. policy shock
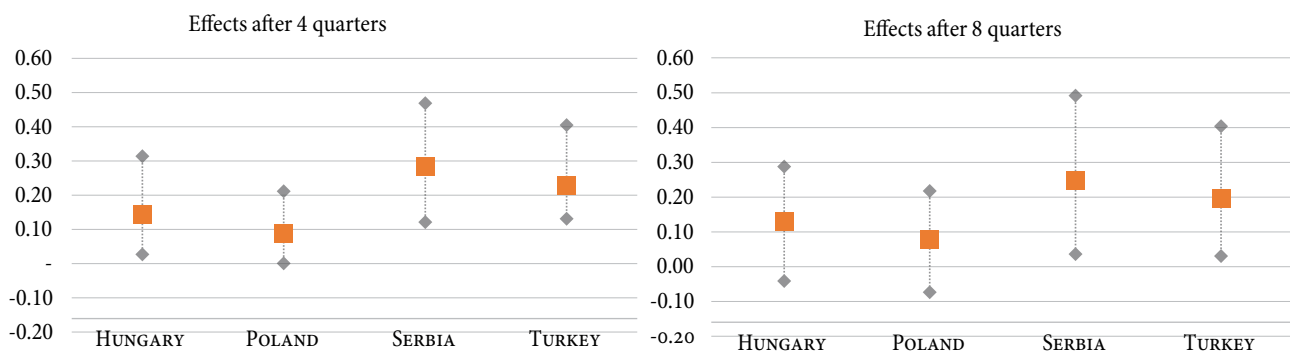
Source: Authors' calculations
Note: The figure reports the response of EMBI index after 4 quarters (left panel) and 8 quarters (right panel) of the country in column to one standard deviation shock in the US federal fund rate. The square shows an estimated response. The 90% bootstrap confidence band is displayed by the line.

In line with elevated risk-premium pressures and potential rebalancing of global investors' portfolios, i.e., the withdrawal of capital from riskier markets and investments in US securities, which offer a better risk-adjusted return, all CESEE countries exhibit a depreciation of the local currency against the dollar in the first year following the shock (Figure 4). The Turkish lira displays the strongest depreciation over the first year, with slight gains in the second year following the shock. In contrast, the shock effects are not persistent for currencies of CEE countries, which tend to revert to pre-shock levels as the estimated responses in the second year are not statistically significant.

Inflation dynamics in response to the shock exhibit a more heterogeneous pattern (Figure 5). Inflation slows down in Romania in the first year following the shock, and the effect is not persistent and becomes statistically insignificant after two years. Prices do not respond in a statistically significant manner in Hungary, Poland, and

Turkey. The lack of response in the latter is likely driven by strong domestic inflationary pressures which lead to the fact that changes in the global financial environment have a limited direct effect on the inflation path. The shock has negative and more persistent effect on inflation in the Czech Republic and Serbia. The results for the former are likely to reflect stronger ties with the Eurozone economies, which also exhibit a drop in inflation following the U.S. monetary policy tightening and lead to inflation spillovers. The results for Serbia are likely to reflect relatively stronger tightening of the domestic monetary policy that we see in the interest rate responses and smaller level of the pass-through of the depreciation in the dollar foreign exchange rate relative to the movements in the exchange rate versus euro.

Overall, the results are indicative of the fact that changes in the U.S. trade policy in 2025 which may give rise to explicit or implicit tightening in the U.S. monetary policy may have non-negligible effects on the real activity

Figure 4: The response of the dollar foreign exchange rate to the U.S. policy shock

Source: Authors' calculations
Note: The figure reports the response of dollar foreign exchange rate after 4 quarters (left panel) and 8 quarters (right panel) of the country in column to one standard deviation shock in the US federal fund rate. The square shows an estimated response. The 90% bootstrap confidence band is displayed by the line

Figure 5: The response of inflation rate to the U.S. policy shock
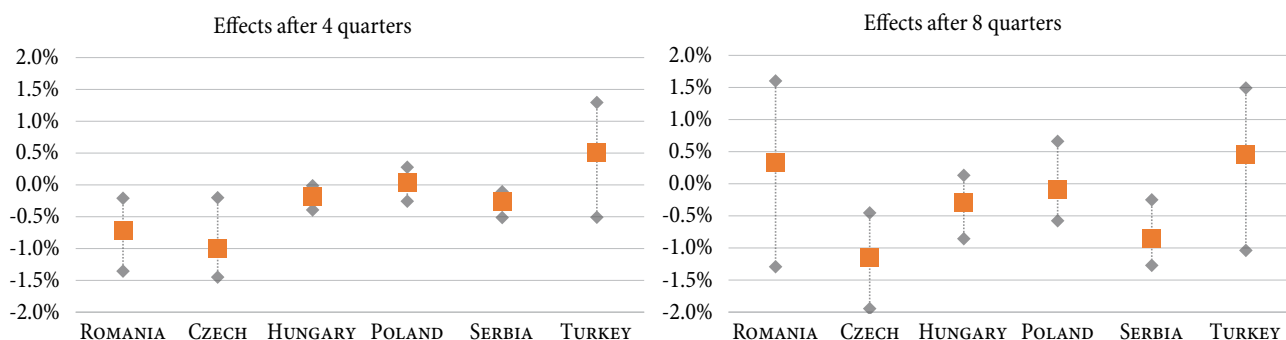
Source: Authors' calculations
Note: The figure reports the response of inflation rate after 4 quarters (left panel) and 8 quarters (right panel) of the country in column to one standard deviation shock in the US federal fund rate. The square shows an estimated response. The 90% bootstrap confidence band is displayed by the line.

and financial conditions in the CESEE economies. While the effects on now relatively persistent inflation may be beneficial in the short run in some of these countries, the negative effects on the real sector present the primary risk going forward. The expected increase in the risk premium and potential depreciation pressures may require a monetary policy response and tightening of domestic financial conditions which in turn can lead to second round negative effects on the real output.

The results presented should be analyzed taking into consideration two caveats. First, the empirical model does not explicitly take into account foreign exchange market interventions which may affect the propagation of the shock to some of the observed variables. This is because, for all countries in the sample (except Serbia), consistent data on foreign exchange market interventions was not available. The interventions are thus implicitly contained in the results through the movement of the exchange rate variables, which may, to some extent, drive the obtained exchange rate responses. Introducing foreign exchange market interventions as a separate variable in the model is the basis for future research on this topic. Second, the estimation period included the zero lower bound period in the U.S., as well as the period of unconventional monetary policy measures in the U.S., Eurozone and some of the CESEE countries. We control for this by including additional country-specific dummy variables for the identified periods of active unconventional policy measures. The obtained results with modified empirical specification are qualitatively similar to the ones presented in the paper, providing some robustness against model misspecification. However, more explicit control for the effects of unconventional monetary policy measures warrants further research.

Concluding Remarks

The deepening integration of the CESEE countries into the global trade and financial system led to potentially increasing exposure of these economies to global monetary policy spillovers. In this paper, we analyzed the extent to which monetary policy tightening by the Fed tends to spillover to the real sector and financial markets in the CESEE economies. We used the GVAR modelling framework to explicitly control for the interconnectedness between the economies in relation to their trade flows and enable that the propagation of the monetary policy shocks in the U.S. can realize through multiple channels discussed in the previous theoretical literature. We explicitly added the country risk premium as an endogenous variable in the system to control for the effects that policy tightening in the United States may have on the capital markets of CESEE countries (capital outflows) and, consequently, on the interest rate and exchange rate movements in these countries.

The results indicate that changes in U.S. trade policy in 2025, which may lead to explicit or implicit tightening in the U.S. monetary policy, could have non-negligible effects on real activity and financial conditions in the CESEE economies. The estimated responses suggest that the U.S. monetary policy tightening would spillover to increase in local interest rates. The increase in local rates is more pronounced and persistent in Turkey, Serbia, and Romania, consistent with the relatively larger share of foreign currency liabilities in these economies and correspondingly estimated nominal exchange rate depreciation and a rise in country risk premium. Inflation dynamics in response to the U.S. monetary policy innovation also exhibit a heterogeneous pattern. Inflation slows down in Romania in the first year following the shock, but the effect is not persistent and becomes statistically insignificant after two years. Prices do not respond in a statistically significant manner in Hungary, Poland and Turkey, while the shock has a negative and more persistent effect on inflation in the Czech Republic and Serbia.

The estimated negative effect on real output in all CESEE economies, however, represents a primary risk going forward. Moreover, the estimated increase in the risk premium and potential depreciation pressures may necessitate a monetary policy response and tightening of domestic financial conditions can have additional, second-round negative effects on real output.

Appendix

Figure A1: Persistence profiles: Model with overidentifying long-run restrictions
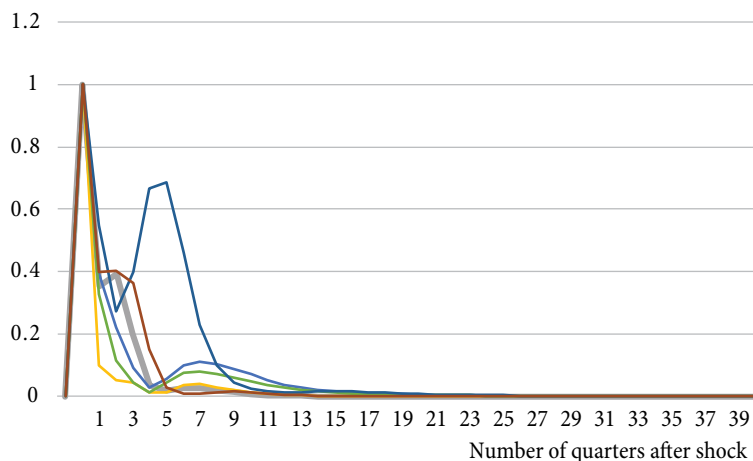
Number of quarters after shock

Source: Authors' calculations
Note: The figure reports the persistence profiles of the response of cointegrating relationships to the system wide shock in a model with overidentifying long-run restrictions.

Figure A2: Persistence profiles: Unrestricted model
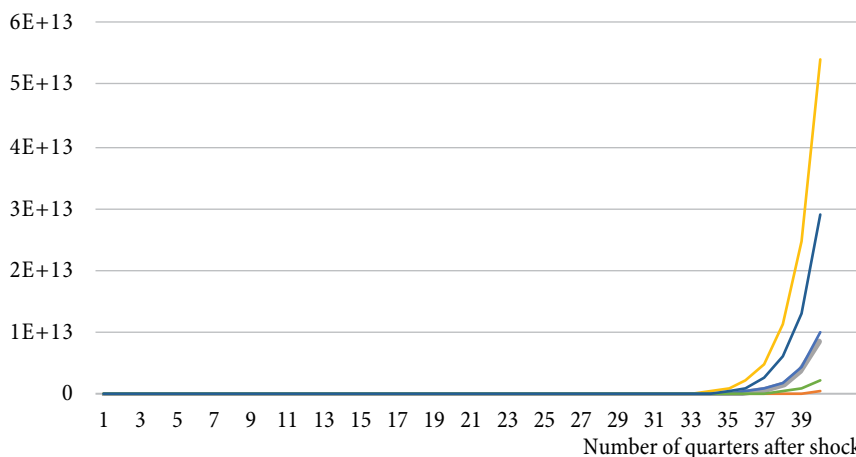
Number of quarters after shock

Source: Authors' calculations
Note: The figure reports the persistence profiles of the response of cointegrating relationships to the system wide shock in an unrestricted model.

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TAX MORALE IN SERBIA: STYLIZED FACTS AND POLICY CONSIDERATIONS

Poreski moral u Srbiji – stilizovane činjenice i politike

Abstract

Tax morale is a set of intrinsic, non-monetary factors that shape people's willingness to pay taxes even in the absence of coercion. Empirical studies show that close to a third of the variation in the shadow economy and tax evasion between countries can be explained by factors related to tax morale. This paper outlines stylized facts about tax morale in Serbia, measured using internationally comparable data from the seventh wave of the European Values Survey (EVS) 2017-2022. According to these results, about 78 percent of people in Serbia report a high level of tax morale – 9 percentage points below the EU average and 4.5 percentage points lower than the rest of Central and Eastern Europe (CEE), which ranks Serbia 25th among 31 European countries. The level of tax morale depends on formal and informal institutions – the most important being trust in the government and satisfaction with the quality of public goods and services. EVS data indicate that the degree of citizens' trust in the government and the public sector in Serbia is close to the European median, and slightly below the EU and the CEE average. On the other hand, the World Bank data on the quality of governance show that the index of government effectiveness (which indicates the quality of public goods and services) in Serbia, which rose until 2017, is still significantly below the EU and CEE average – Serbia is ranked 30th among 36 European countries. For a more significant step forward in improving tax morale in Serbia in the long run, it is necessary to take systematic and comprehensive action in the direction of improving the quality and availability of public goods and services, enhancing the trust in the government through strengthening institutions and the rule of law, improving the fairness of the public finance system, increasing investment in fundamental public services such as education and health care, eliminating tax amnesties, and upholding a value system based on honesty.

Keywords: *investments, savings, economic growth, economic policy, tax morale, shadow economy, public finance*

Sažetak

Poreski moral predstavlja skup unutrašnjih, nemonetarnih faktora koji oblikuju spremnost ljudi da plaćaju porez čak i kada ne bi postojala prinuda od strane države. Empirijska istraživanja pokazuju da se gotovo trećina varijacije u sivoj ekonomiji i utaji poreza između zemalja može objasniti faktorima povezanim sa poreskim moralom. U ovom radu predstavljene su i analizirane stilizovane činjenice o poreskom moralu u Srbiji, merenom na bazi međunarodno uporedivih podataka sedmog talasa Evropske ankete o vrednosnim stavovima (EAVS) 2017-2022. Prema tim rezultatima oko 78 odsto ljudi u Srbiji iskazuje visok stepen poreskog morala, što je za 9 procentnih poena ispod proseka EU i za 4,5 procentnih poena niže od proseka Centralne i Istočne Evrope (CIE), čime se Srbija svrstava na 25. mesto među 31 evropskom zemljom. Nivo poreskog morala zavisi od neformalnih, kao i formalnih institucija – od čega posebno značajan uticaj imaju poverenje u državu i zadovoljstvo kvalitetom javnih dobara i usluga. Podaci iz EAVS ukazuju da je stepen poverenja građana u državu, odnosno javni sektor u Srbiji približan evropskoj medijani, a tek nešto ispod proseka EU i CIE. S druge strane, podaci Svetske banke o kvalitetu upravljanja ukazuju da je indeks zadovoljstva ispitanika efektivnošću javnog sektora (kojim se meri kvalitet javnih dobara i usluga) u Srbiji, koji je rastao do 2017. godine, i dalje znatno ispod proseka EU i CIE, tako da je po vrednosti ovog indikatora Srbija rangirana na 30. mestu, među 36 evropskih zemalja. Za osetniji iskorak u unapređenju poreskog morala u Srbiji u dugom roku, neophodno je sistemsko i sveobuhvatno delovanje u pravcu unapređenja kvaliteta i dostupnosti javnih dobara i usluga, jačanje poverenja u državu kroz osnaživanje institucija i afirmaciju vladavine prava, unapređenje pravičnosti sistema javnih finansija, te povećanje ulaganja u fundamentalne javne usluge poput obrazovanja i zdravstvene zaštite, prestanak prakse sprovođenja poreskih amnestija i afirmaciju sistema vrednosti zasnovanog na poštenju.

Ključne reči: *investicije, štednja, ekonomski rast, ekonomska politika, poreski moral, siva ekonomija, javne finansije*

Introduction

The efficient collection of tax revenues, which minimizes the shadow economy and tax evasion, is of fundamental importance for the sustainability of public finances and economic growth. According to the neoclassical economic model, tax evasion (and the shadow economy, which is mostly motivated by tax-savings reasons) is regarded as a matter of rational choice under uncertainty, with people balancing the benefits of evasion (tax savings, which are proportionate to the level of tax burden) and expected costs of evasion (fines a taxpayer would face if detected, which depends on the probability of detection and statutory fines). Therefore, according to this approach, the shadow economy and tax evasion depend on the level of tax burden, the efficiency of tax enforcement (probability of detection) and statutory fines, with individual's risk aversion also playing an important role. However, empirical studies have shown that the estimated level of tax evasion and the shadow economy based on these factors would be significantly lower than the actual level, which means that other factors, beyond those encompassed by the rational choice model matter too. In that respect, behavioural economics offers significant insights, suggesting that, to some extent, people are willing to pay their taxes regardless of enforcement, which refers to tax morale. Tax morale is an intrinsic, non-monetary set of motives that drive people to pay taxes, i.e. their willingness to pay taxes even if there was no enforcement mechanism. Empirical literature indicates that between 20% and 30% of the variation in the level of the shadow economy and tax evasion across countries may be attributed to the differences in the level of tax morale in those countries, suggesting that it is a relevant phenomenon and an important determinant of tax evasion decision and the shadow economy [25].

The shadow economy in Serbia was on decline since the mid-2010s, due to some policy reforms (digitalization and strengthening of Tax Administration, improvement in coordination across audit agencies, reform of the penalty policy, mild cut in the labour tax wedge, flexibilization of labour market institutions, etc.) and some secular trends (decrease in unemployment, cashless transition, change in the structure of the retail sector, etc.). In spite of a considerable decrease, the shadow economy in Serbia is still relatively pronounced, with estimates ranging from 21.1% to 23.6% of GDP [13]. To make further progress in reducing the shadow economy, it is of fundamental importance to continue reforming and strengthening the Tax Administration and other rule-of-law institutions [12]. However, in addition to that, a policy action in terms of reinforcing tax morale in that respect may also play a significant role. In that sense, the aim of this paper is to provide empirical stylized facts and policy analysis with respect to strengthening tax morale in Serbia. The topic of reducing the shadow economy gained an additional importance in the aftermath of the COVID-19 pandemic, when countries widened their deficits considerably, with substantial impact on their debt levels [19].

The level of tax morale and its determinants are usually evaluated by means of laboratory experiments or social surveys. In this study, tax morale in Serbia is evaluated using data from the seventh wave of the World Values Survey (WVS)/European Values Survey (EVS), 2017-2022, conducted on a representative sample of more than 2.5 thousand 18+ individuals. The results suggest that around 78% of people in Serbia declare a substantial degree of tax morale, arguing that it is unjustifiable to cheat on taxes, which is 9 percentage points below the EU-27 average and 4.5 percentage points lower than the Central and Eastern Europe (CEE) average. Serbia ranks 25th in Europe according to the declared level of tax morale, among 31 European countries for which the comparable WVS/EVS data are available. After a sharp decline in the late 2000s, the reported level of tax morale in Serbia rebounded in the latest wave of the WVS/EVS, but only to the levels reported in the early 2000s. This means that over the last 25 years there was no substantial improvement in the overall level of tax morale in Serbia. Mapping the tax morale data from WVS/EVS suggests that declared level of tax morale in Serbia is higher among elderly people than among younger generations, also being higher among women than among men. Reported tax morale is also higher among retired people and those who are fully employed than among the unemployed or those working part-time. In terms of the sector of occupation, the tax morale indicator is higher among civil servants

than among those working in the private or NGO sectors. Finally, the declared level of tax morale tends to decline as education and income levels rise.

Out of the three sets of determinants of tax morale (formal and informal institutions, and socioeconomic characteristics), only formal institutions are under the government's direct influence in the short and mid-run. According to the WVS/EVS data on trust in government (in broader terms – encompassing many segments of the public sector), Serbia is close to the European median in terms of the overall trust in government, lagging only slightly behind the EU-27 and CEE averages. The second relevant driver of tax morale – satisfaction of people with public goods and services is measured using the World Governance Indicator on government effectiveness. The results show that the value of this indicator for Serbia in 2023 was considerably below the EU-27 and the CEE average, thus Serbia being ranked 30th in Europe, with only six countries having weaker performance in that respect. The data also show that government effectiveness, as measured by this indicator, was rising in Serbia until 2017 but has stagnated since then, thus indicating a modest satisfaction of people with the availability and quality of public goods and services. For a pronounced step forward in the development of tax morale in Serbia, a systemic and comprehensive policy action is needed, focusing on strengthening both formal and informal institutions, with the particular focus on improving the quality and availability of public goods and services and the rule of law.

The rest of this paper is organized as follows. Section 2 provides theoretical and conceptual considerations with respect to tax morale and the shadow economy. In Section 3, the determinants of tax morale are evaluated through a review of the respective empirical literature. Section 4 outlines the methodology and data used in this paper for the evaluation of tax morale in Serbia, while Section 5 provides the statistical results and discussion of the size, dynamics, and drivers of tax morale in Serbia. Section 6 concludes and provides a menu of policy options that can be used for a systemic improvement in tax morale in Serbia.

Tax Morale and the Shadow Economy

Government intervention in an economy is justified when it can result in an increase in overall social welfare, which is the case with the provision of public goods, regulation of externalities, or correction of market imperfections (e.g. information asymmetry and negative selection; moral hazard). Considering the social, technological and economic changes the world has faced in the last century, the functions of government have been expanding beyond the rule of law, defence and provision of basic infrastructure, to include the government intervention in education, social security (pension, health and unemployment insurance), industrial policies, etc. Consequently, the size of government and the volume of government spending in Europe increased substantially, from below 10% of GDP at the beginning of the 20th century to 40-50% of GDP at the end of the 20th century, which is the volume of spending in most European governments nowadays as well. The rise in government spending required a proportionate increase in tax revenues to ensure the sustainability of public finance. This is why tax systems expanded by adding new types of taxes – personal income tax and general consumption tax being added in most countries in the first half of the 20th century, while tax rates were substantially increased.

An increase in the number of taxes and a rise in the level of tax burden may be associated with the reluctance of taxpayers to pay taxes duly, especially if there is no effective system of tax enforcement. In that respect, under the neoclassical approach, tax evasion decision is modelled within the framework of rational choice under uncertainty. This means that the tax evasion decision is a matter of rational choice made by individuals, considering the benefits of evasion (savings in taxes, which directly depend on tax rates) and the costs of evasion (fine/penalty they would be facing if detected, which depends on the probability of detection and legal penalty scheme). Therefore, under the neoclassical approach [1], the volume of tax evasion depends on the level of taxes (the higher the tax rates, the higher the evasion will be), the statutory penalties (the higher the fines and penalties, the lower the tax evasion) and the probability of detection, which reflects the efficiency of tax administration (the higher the probability, the lower the tax evasion). In addition, the propensity to evade may

depend on the level of a taxpayer's income, with the sign of the impact of income on tax evasion being dependent on the individual's risk aversion.

Although the neoclassical approach (Allingham-Sandmo model) provides a coherent framework for the analysis of tax evasion decisions, empirical studies have shown that the volume of tax evasion in developed countries, when estimated based on actual rational choice parameters (tax burden, probability of detection, fines, risk aversion), would be substantially below the actual volume of tax evasion, which means that a significant fraction of tax evasion decision can be attributed to the other factors beyond those encompassed by the neoclassical model. Building on this, the behavioural approach to tax evasion analysis emerged, with the two sets of models: i) models not based on expected utility, and ii) models based on social effects. Under the first set of models (not based on expected utility), tax evasion decisions also depend on ambiguity in terms of the probability of detection. On the other hand, in the later set of models (based on social effects), tax evasion decision is not regarded as an individual's mere utility maximization under uncertainty, thus pointing out the importance of social and cultural factors in shaping tax evasion/compliance decision. Under this model, an individual's tax evasion decision is considered as a trade-off between private interests (tax costs) and both private and public interests (provision of public goods). Therefore, models based on social effects imply that tax evasion decision is also influenced by a taxpayer's intrinsic views and motives with respect to tax compliance [21], thus laying the groundwork for the identification of tax morale. In that respect, tax morale is defined as the set of intrinsic, non-monetary motives that drive people to comply and pay taxes, beyond the factors encompassed by the neoclassical approach [15]. In other words, tax morale reflects the willingness of people to pay taxes voluntarily.

The shadow economy refers to legal economic activities that are done informally, outside official records, with savings in tax costs and other regulatory costs being the main motives to do transaction informally. Therefore, it is regarded that the factors shaping the tax evasion decision also fundamentally drive the size of the shadow economy. The relevance of tax morale as a determinant of tax evasion and the shadow economy is confirmed by many empirical studies. In the paper by Torgler and Schneider, it has been shown that the correlation between tax morale and the shadow economy in Europe is significant, with considerable negative elasticity between the two phenomena [24]. Similarly, [10] has shown that an increase in tax morale by 0.05 percentage points is associated with a decrease in the shadow economy by around 2.8 percent of GDP. According to many empirical studies, the shadow economy in Europe ranges from around 10% of GDP in Western and Northern Europe to more than 30% of GDP in Central and Eastern Europe [13]. If the shadow economy and tax evasion decision was only a matter of maximizing expected utility, the variation in the shadow economy across European countries could be explained by differences in tax burden, probability of detections, fines policy, and risk aversion across those countries. However, the differences between European countries in

Figure 1: Determinants of variation in the shadow economy
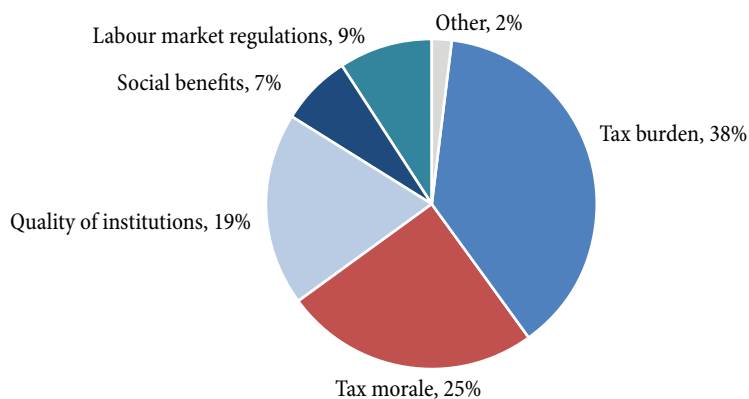
Source: [23], author's calculations

terms of these parameters are not large enough to explain such a substantial variation in the shadow economy and tax evasion, which means that other factors matter too. According to [25], 20-30% of the variation in the shadow economy and tax evasion between countries may be attributed to differences in tax morale, which points to the relevance and policy importance of this concept. In their study [24], Torgler and Schneider summarized the results of 12 studies on the shadow economy across the countries, with tax morale being the second largest driver, explaining around 25% of the variation in the shadow economy across the countries (Figure 1).

Determinants of Tax Morale: A Literature Review

As it is empirically confirmed that tax morale can substantially influence tax evasion decisions, the next question refers to the transmission mechanism through which tax morale impacts the shadow economy and tax evasion, which is an important precondition for identifying the direct determinants of tax morale. In this regard, sociological, economic and political studies have identified three sets of mechanisms through which tax morale may shape the shadow economy and tax evasion decision [15]: i) Intrinsic motivation – altruism, pride, self-respect and other positive feelings associated with honest behaviour and compliance, ii) Reciprocity – treating tax payment as part of the social contract, which implies that taxpayers pay their taxes and receive in exchange a set of goods and services from the government sector; iii) Social norms – the willingness of people to pay taxes influenced by the prevailing social norm, meaning that if it is unacceptable to cheat the government by underpaying taxes, non-compliance imposes psychological costs, reinforcing tax morale and encouraging tax payment.

Further to the theoretical and empirical literature, tax morale is a multidimensional issue shaped by many factors, which can be grouped based on different criteria. As the aim of this study is to evaluate tax morale in Serbia and outline policy recommendations aimed at strengthening tax morale, the direct determinants of tax morale will be classified into three categories: formal institutions, informal institutions, and socioeconomic characteristics

of the society. While formal institutions can be largely influenced by government policies, the impact of policies on informal institutions is weaker, with some effects being attainable, though only in the long run. Finally, in most empirical studies, socioeconomic characteristics are treated as a vector of control variables.

Formal Institutions and Tax Morale

Formal institutions encompass the established laws, regulations, and procedures that structure political, economic, and social interactions within a society. Considering the above-mentioned reciprocity principle, in line with the social contract, citizens perceive taxes as their payments to the government for the provision of a wide range of public goods and services. In this regard, people's willingness to fulfil their obligations under this social contract will fundamentally depend on:

a) Trust in government – According to many empirical studies, trust in government in a broader sense (in the cabinet of ministers, presidency, parliament, judiciary, police, public officials, tax administration, political parties, etc.) is one of the key drivers of tax morale (see: [11]). With an increase in their trust in government, citizens become more convinced that the government's obligations under the social contract will be met, which raises their willingness to pay taxes.

b) Government effectiveness and quality of public goods and services – A large body of empirical research suggests that tax morale depends on the perceived fairness and effectiveness of the government [3]. Higher effectiveness of government spending implies enhanced availability and quality of public goods and services provided by the government. Therefore, higher effectiveness of government spending is associated with greater satisfaction of citizens with the availability and quality of public goods and services, which may encourage them to deliver on their part of the social contract – i.e. to pay taxes. In addition, government transparency provides an additional assurance to taxpayers regarding the effectiveness of government spending, which is also expected to have an incentivizing impact on tax compliance.

c) *Perception of fairness of the public finance system* – The willingness of people to pay for public goods and services also largely depends on their perception of the fairness of the public finance system, including horizontal and vertical equity in the distribution of tax burden, fairness in the allocation of government spending, and fairness and transparency in tax enforcement (see: [11]). Linked to that, it is also evident that the overall willingness of people to pay taxes is negatively affected by the degree of economic inequality in a society [26], which means that the design of tax and benefits policies that effectively reduce economic inequality may yield a dividend in terms of an increase in tax morale. Empirical studies on Serbian businesses suggest that negative evaluation of the tax authorities by businesses is associated with lower tax morale, which means that an improvement in taxpayers' perception of the tax authorities' activities could result in an increase in tax morale and tax compliance ([17]).

d) *Strength of the relationship between government and citizens* – As the financing and production of public goods is a matter of collective decision-making with substantial redistributive effects, the willingness of people to pay taxes is expected to rise if public decisions are made by the authorities closer to the citizens (e.g. local governments), as well as if citizens have a stronger feeling that they actively participate in the decision-making process. In this regard, there is a set of empirical studies suggesting that tax morale is positively linked with the degree of decentralization in the country as well as with the frequency of referenda [23]. For example, according to [16], *ceteris paribus*, in the Swiss cantons with more frequent referenda, tax evasion is lower by around 30% in comparison to the cantons in which referenda are held less frequently.

Informal Institutions and Tax Morale

Informal institutions refer to the socially shared unwritten norms, values and beliefs. As individuals act and live as part of social groups, many economic and social decisions are made by taking into account the prevailing norms, values and beliefs in society, because violating social norms may result in internal sanctions (such as shame,

guilt, etc.) or external penalties (such as social stigma). In that respect, empirical literature suggests that informal institutions may shape tax morale, in several manners:

a) *Culture* – Culture is seen as a broad set of social norms that are rather persistent over time [15], which may shape the behaviour of people in different aspects, including tax evasion decision. For example, study by [6] points to the different level of tax morale in the East and West Germany, attributing that to cultural differences. Similarly, [14] found that the tax morale of first-generation immigrants to Europe, exhibited in the host country, is strongly linked to the tax morale in their country of origin.

b) *Patriotism* – A sense of belonging, national pride and (profound) patriotism increase the psychological costs of tax evasion, with a positive impact on tax morale and tax compliance in general [20]. Although the link between patriotism and tax morale is stable, it is non-linear, with a significant rise in tax morale in the episodes of collective threats (such as wars, natural disasters, etc.).

c) *Religion* – There is compelling empirical evidence that the degree of religiosity in society is closely (positively) linked to the level of tax morale [22], although there is no evidence of variation of the degree of tax morale across mainstream religions (see: [11]).

d) *Sense of community* – A stronger feeling of belonging to the community, social responsibility and civic participation also increase the psychological costs of evasion, which is why they are positively related to the level of tax morale in society [4].

e) *Peer behaviour and societal trust* – The attitude of individuals towards (non)compliance is also shaped by the prevailing behaviour of their peers. If there is a strong level of trust in society (i.e. there are social norms which imply that untrustworthy behaviour is stigmatized), it will also have a positive impact on the overall level of tax morale [4], [11].

Socioeconomic Characteristics and Tax Morale

In addition to the factors that directly shape people's stance towards tax evasion, compliance decision may also be shaped by socioeconomic and demographic characteristics of the population. In that respect, empirical studies (summarized

in: [11]) suggest that there is a significant variation in tax morale across age (elderly people reporting higher levels of tax morale), gender (women exhibiting higher tax morale than men), marital status (married people reporting stronger tax morale then single), income (tax morale being positively linked to economic status and life satisfaction), employment status (full-time employees and pensioners showing a higher degree of tax morale than self-employed or unemployed individuals). The impact of education on tax morale can be ambivalent – while education raises awareness of the importance of paying taxes for the provision of public goods, it also develops critical thinking skills, making more educated people more likely to spot government spending inefficiencies [2]. Nevertheless, the results of several econometric studies suggest that the positive impact of education on tax morale prevails. Apart from basic socioeconomic and demographic characteristics, tax morale is also positively associated with the degree of personal moral integrity and the degree of support for democracy, while higher aversion to ethnic diversity is linked to lower tax morale.

Measurement of Tax Morale: Methodology and Data

Being an intangible phenomenon, tax morale cannot be measured directly but can rather be indirectly estimated. In the economic literature, there are two approaches to estimating tax morale: i) laboratory experiments, or ii) surveys.

The willingness of people to pay taxes or to evade them is fundamentally linked to the well-known "free rider" problem, which is a concept describing the propensity of people to maximize their own utility by paying less for public goods than the value these goods provide to them, expecting that other people will pay for public goods and services. The results of laboratory experiments [5] show that, on average, people would voluntarily contribute about 50% of the full amount for the provision of public goods, which means that free rider problem is pronounced, but also suggests that people show a considerable degree of tax morale. The experimental results also suggest that tax morale decreases with an increase in the total

number of taxpayers, while the possibility for taxpayers to communicate with each other before starting the game encourages cooperation. It is also shown that tax morale declines when the opportunity cost of giving increases.

Considering the limitations of experiments, tax morale is more often evaluated by means of representative surveys. In this respect, most empirical studies use data from the World Values Survey (WVS), European Values Survey (EVS) or other surveys (Life in Transition Survey; European Social Survey, etc.). The WVS is a global survey on people's values and beliefs across different countries, which started in 1981 and has since become one of the most widely used cross-national and time-series surveys, covering more than 60 countries. Thus far, there have been seven waves of WVS, with the most recent one covering the period 2017-2022. The WVS and EVS measure tax morale through a question asking people whether cheating on taxes is justifiable – respondents provide their answer by selecting an option on the Likert scale from 1 to 10 (1 – never justifiable; 10 – always justifiable). This means that a lower mean value of the indicator implies a higher degree of tax morale. Although surveys provide useful insights into people's values and beliefs, the results should be interpreted with caution, considering the general limitations of surveys, primarily related to the issues connected with honesty of survey participants when providing answers to sensitive questions.

In this study, tax morale in Serbia is measured using data from the 7th wave of the WVS/EVS (2017-2022). The survey was conducted on a representative (full probability) sample of the population aged 18 years and older, with 2,566 individuals providing answers to the questions on tax morale. The survey was done by means of face-to-face interviews.
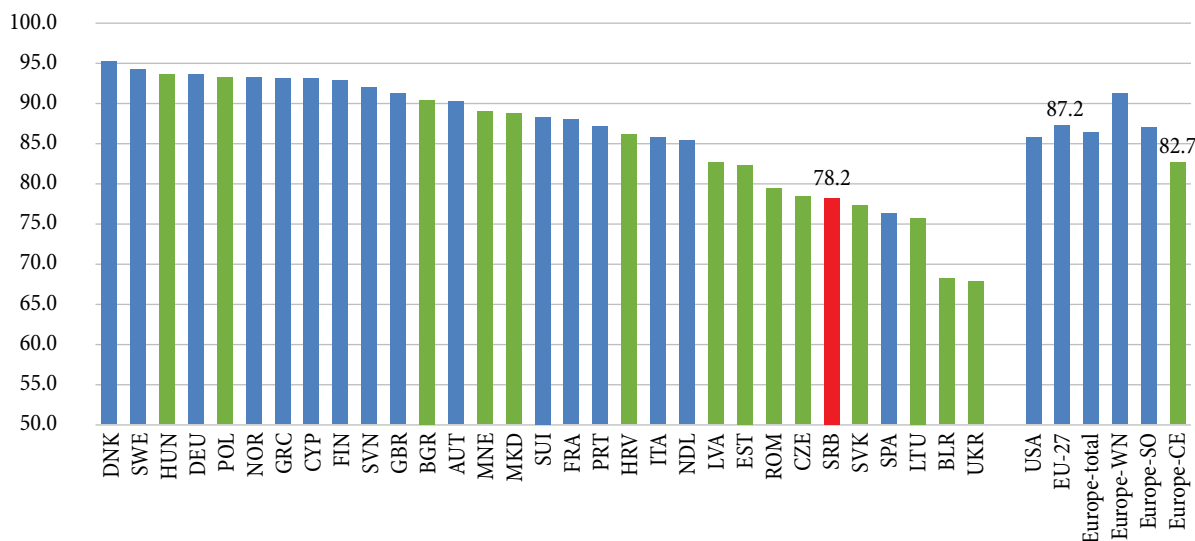
Tax Morale in Serbia

Stylized facts

a) Level of tax morale
According to the WVS/EVS data, close to 64% of people in Serbia indicated that cheating on taxes is never justifiable, while the share of those who reported that cheating on

Figure 2: Tax morale 1a – Share of the population who believe that cheating on taxes is mostly not justifiable (%)

Source: Author's calculations using the WVS/EVS data

taxes is either never justifiable or mostly unjustifiable stood at around 78% of respondents, with the mean answer being 2.56 (Table 1).[1]

Table 1: Tax morale in Serbia – Is cheating on taxes justifiable?

	Total (%)	Cumulative (%)
1 - Never justifiable	63.9	63.9
2	6.8	70.7
3	4.2	74.9
4	3.3	78.2
5	4	82.2
6	2	84.2
7	2.1	86.3
8	1.6	87.9
9	0.8	88.7
10 - Always justifiable	7.7	96.4
Don't know	1.9	98.3
No answer	1.7	100.0
Mean	**2.56**	
Std Dev.	2.81	
(N)	2566	

Source: WVS/EVS Database and author's calculations

When compared to other European countries (Figure 2), Serbia ranks 25th among 31 European countries in terms of the reported level of tax morale. The share of respondents who reported a substantial degree of tax morale in Serbia (78.2%) is 9 percentage points lower than the EU-27 average and 4.5 percentage points lower than the Central and Eastern Europe (Europe-CE) average.[2]

In a broader context, WVS/EVS data suggest that reported level of tax morale is higher in developed European countries (Europe-WN), somewhat lower in Southern Europe, and the lowest in the CEE. This is in line with findings from other empirical studies, which suggest that tax morale is lower in Eastern Europe compared to Western Europe, which is explained by the institutional crisis experienced by ex-communist economies [9].

As questions on taxes are regarded as sensitive, it is useful to conduct a robustness check of the results using an alternative (control) question. Since social benefits provided by the government can be treated as negative taxes, the control question on tax morale is based on the people's attitude toward claiming government benefits. The results (Figure 3) indicate that 72.9% of survey participants in Serbia reported that claiming government benefits to which they are not entitled is not justified, which ranks Serbia 25th among the 31 European countries. The reported degree of tax morale in Serbia, based on the alternative indicator, is lower than the Europe average by 9.8 percentage points, while being lower than the CEE average by 7.1 percentage points.

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1   For the purpose of this analysis, tax morale, in due course, will be measured by the share of the population who reported that cheating on taxes is never justifiable or mostly unjustifiable (i.e. those who opted for options 1-4 on the Likert scale).

2   For the purpose of this analysis, all 31 European countries are grouped into three cohorts: Western and Northern Europe (Europe-WN), Southern Europe (Europe-SO) and Central and Eastern Europe (Europe-CE).

Figure 3: Tax morale 1b – Share of the population who believe that claiming government benefits to which you are not entitled is mostly not justifiable (%)
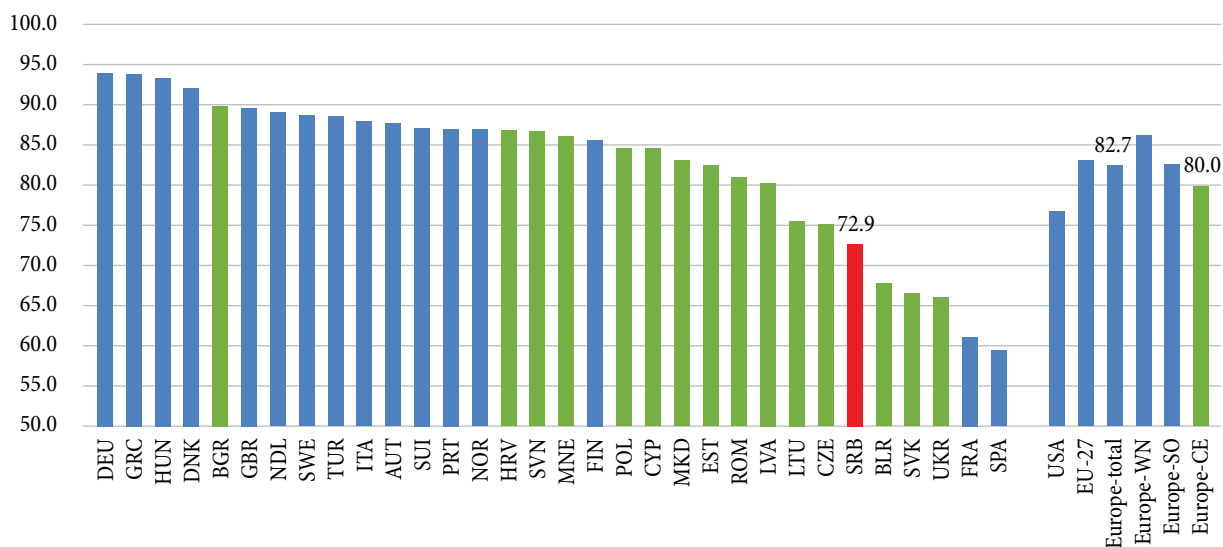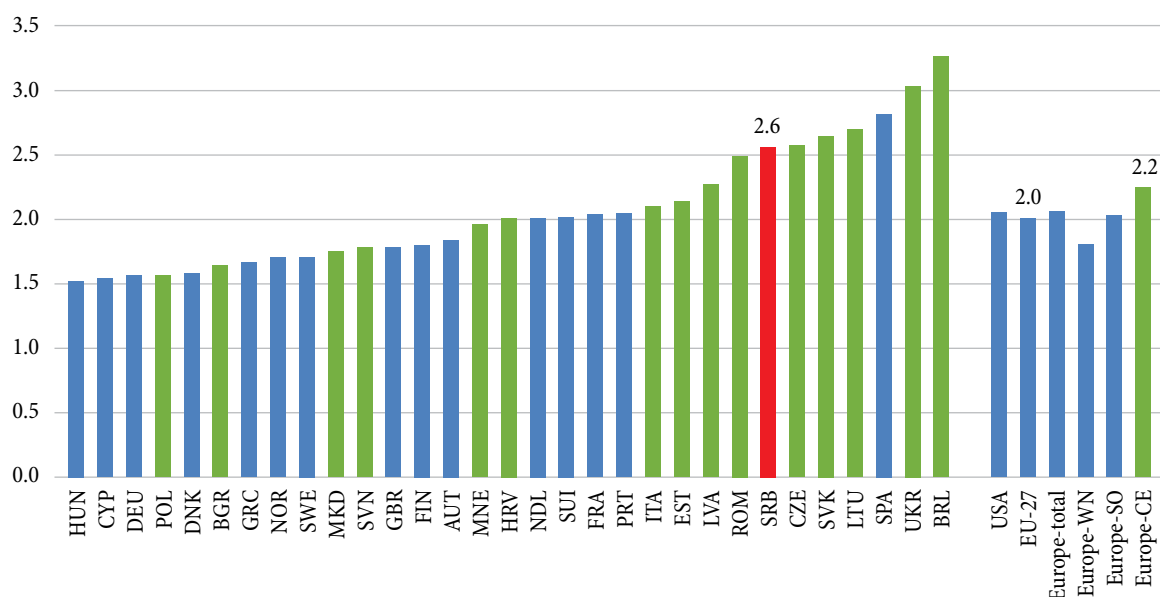

Source: Author's calculations using the WVS/EVS data

An additional way to measure the degree of tax morale in Serbia, in comparative terms, is to calculate the mean answer on the Likert scale, with a lower mean value implying a higher degree of tax morale. According to the results, for the question on cheating on taxes (Figure 4), the mean value for Serbia stood at 2.56, which is 0.6 percentage points higher than the EU-27 average and 0.4 percentage points higher than the CEE average. Only six European countries reported a higher mean value of

this indicator, thus indicating a lower level of tax morale than in Serbia.

Relatively similar results are obtained based on the mean value of the answer to the question on claiming government benefits without meeting the eligibility criteria. The mean value for Serbia on this indicator stood at 2.8, which is 0.6 percentage points higher than the EU-27 average and 0.4 percentage points above the CEE average (Figure 5).

Figure 4: Tax morale 2a – To what extent is it justifiable to cheat on taxes? 1 - never justified; 10 - always justified (mean value)

Source: Author's calculations using the WVS/EVS data

Figure 5: Tax morale 2b – To what extent is it justifiable to claim government benefits to which you are not entitled? 1 - never justified; 10 - always justified (mean value)
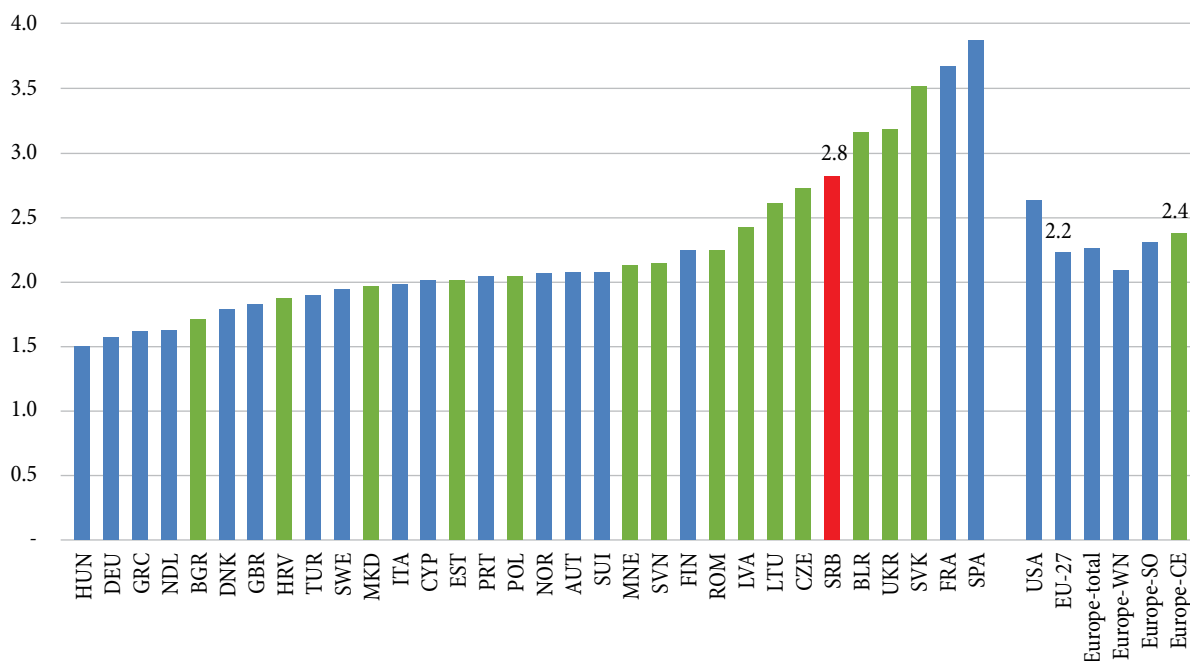
Source: Author's calculations using the WVS/EVS data

b) Trends in tax morale

Since Serbia participated in four waves of WVS/EVS, the data on tax morale are available for four periods, which allows for the evaluation of trends in the reported tax morale. Building on the available data (Figure 6), the reported level of tax morale showed a slight increase or stagnation (depending on the indicator) in the early 2000s, followed by a substantial decline at the end of that decade. Finally, the reported level of tax morale in the fourth wave (2017-2022) rose substantially, thus getting closer to the levels reported in the early 2000s. The presented data indicate that over the last quarter-century, there was

no improvement in the reported degree of tax morale in Serbia, as both indicators in the fourth wave fall short of their respective values in the first wave.

c) Mapping tax morale

Calculating the reported degree of tax morale by socio-economic and demographic cohorts can provide valuable insights for understanding tax morale and for tailoring the policies aimed at strengthening it. Pursuant to the results (Table 2 and Table 3), elderly people in Serbia report a higher degree of tax morale, which may be explained by their risk aversion as well as by the fact that many of them

Figure 6: Tax morale trends in Serbia – Share of the population who believe that cheating on taxes or benefits is not justifiable (%)
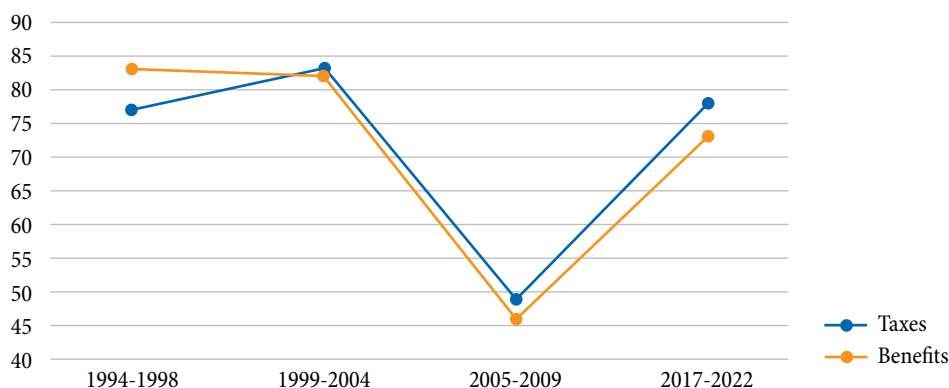
Source: Author's calculations using the WVS/EVS data

are direct beneficiaries of government services (healthcare, the pension system, etc.). This finding, which is rather robust for both indicators of tax morale (tax-based and benefits-based), is also in line with findings in empirical studies on other countries.

With respect to gender, women in Serbia report a somewhat higher level of tax morale, rather than men, which may be explained by women's higher degree of risk aversion, linked to the fact that they are more often supported family members. In terms of the marital status, married individuals in Serbia show a higher degree of tax morale compared to singles, which could be explained by the fact that married people often feel more bound by the social norms (as they share the responsibility for their family).

In terms of the labour market status, the results indicate that retired people, as well as those who are full-time employed, declare a higher degree of tax morale in comparison to the unemployed or part-time employed

individuals. It should be noted that, according to the tax-based indicator, self-employed individuals report higher tax morale than those who are full-time employed, which is in contradiction to findings for other countries. On the other hand, according to the benefits-based indicator, the reported degree of tax morale of self-employed persons in Serbia is somewhat lower than that of full-time employed individuals. At the same time, people employed in the government sector report a higher level of tax morale than those who work in private and NGO sectors, which can be explained by the fact that civil servants are aware that their salaries depend on overall tax compliance. In addition, those working in private and NGO sectors often have more flexible arrangements (working part-time or freelancing), which may also shape their stance towards tax morale.

Regarding the role of education and income, the results indicate that individuals with higher levels of

Table 2: Tax morale 1a – Share of the population in Serbia who believe that cheating on taxes is never justifiable or mostly unjustifiable – by socio-economic ad demographic characteristics

		Never justifiable (%)	Mostly unjustifiable (%)	Mean
Age	16-29	48.2	65.8	3.5
	30-49	61.6	76.5	2.8
	50+	72.8	85.0	2.0
Sex	Female	65.7	80.3	2.4
	Male	62.0	76.1	2.7
Marital status	Married	65.7	80.4	2.4
	Single	54.9	71.1	3.1
Labor market status	Full-time employed	63.1	77.0	2.7
	Part-time employed	30.4	64.2	3.9
	Self-employed	65.3	71.8	3.0
	Unemployed	59.4	78.7	2.5
	Retired	76.2	87.6	1.9
Sector of employment	Government	63.7	79.5	2.6
	Private	64.2	77.7	2.7
	NGO	64.8	81.7	2.5
Education	Lower	71	85.1	2.1
	Middle	62.8	76.1	2.6
	Higher	55.7	72.4	3.2
Income level	Lower	72.8	84.4	2.1
	Middle	57.8	72.5	3.0
	Higher	68.6	82.8	2.3
Urban-rural	Urban	63.5	77.8	2.7
	Rural	65.0	79.4	2.3

Source: Author's calculations using the WVS/EVS data

Table 3: Tax morale 1a – Share of the population in Serbia who believe that it is never justifiable or mostly unjustifiable to claim government benefits to which you are not entitled – by socio-economic characteristics

		Never justifiable (%)	Mostly unjustifiable (%)	Mean
Age	16-29	44.2	62.7	3.5
	30-49	54.3	72.8	2.9
	50+	62.1	77.4	2.4
Sex	Female	55.9	73	2.8
	Male	55.9	73	2.8
Marital status	Married	56.8	74.3	2.7
	Single	51.7	69.1	3.0
Labor market status	Full-time employed	55.5	71.2	3.0
	Part-time employed	40	71.6	3.9
	Self-employed	52.4	74.4	3.0
	Unemployed	54.4	73.5	2.7
	Retired	61.9	78.4	2.4
Sector of employment	Government	54.9	71.4	3.0
	Private	55.2	72.8	2.9
	NGO	53.8	76.3	2.9
Education	Lower	64	80.9	2.2
	Middle	54	70.9	3.0
	Higher	47.4	65.1	3.5
Income level	Lower	62.5	81.6	2.3
	Middle	48.1	65.9	3.3
	Higher	65.6	79.3	2.4
Urban-rural	Urban	56.6	73.9	2.9
	Rural	54.3	70.6	2.7

Source: Author's calculations using the WVS/EVS data

education and higher incomes in Serbia report lower tax morale on average than those with lower education and income. A potential explanation for this could be that more educated people are more likely to identify inefficiencies in government spending and services, which may discourage them from tax compliance. Finally, individuals in rural areas report somewhat higher tax morale than those in urban areas, although the difference is relatively small.

Results presented in Table 2 and 3 show only the descriptive statistics (averages) by socioeconomic and demographic cohorts. To claim the causality between socioeconomic and demographic characteristics, econometric modelling would be required. However, even these results may provide tentative guidelines for government actions aimed at boosting the tax morale in Serbia. In this regard, the findings suggest that measures and policies to promote tax morale in Serbia should be more intensively targeted at younger cohorts, men and single people, as well as the unemployed, and those with higher education and higher incomes.

Determinants of Tax Morale in Serbia

As discussed in Section 2, tax morale is shaped by formal and informal institutions as well as by socioeconomic characteristics of the population. Since only formal institutions are under a direct influence of government, the analysis of the key determinants of tax morale in Serbia will be focused on factors linked to formal institutions. According to many empirical studies presented in Section 2, the trust in government and government effectiveness (i.e. people's satisfaction with public goods and services) are two main institutional factors that shape the degree of tax morale. Therefore, this study will particularly focus on these two sets of factors.

a) Trust in government

Further to the results presented in Figure 7, around 27% of the population in Serbia declared having trust in the government in a broader sense, which is somewhat below the EU-27 average and close to the CEE average. This places Serbia near the European median in terms of citizens' trust in government. Since Serbia's performance in terms of tax morale is substantially lower than its trust in government, this may hint at the pronounced importance of other factors.

However, the analysis of citizens' trust in particular branches of government in Serbia conveys a different message. According to the WWS data, the solid overall trust in government is mainly driven by high trust in the

Figure 7: Share of the population who fully or mostly trust in government, in Europe (%)
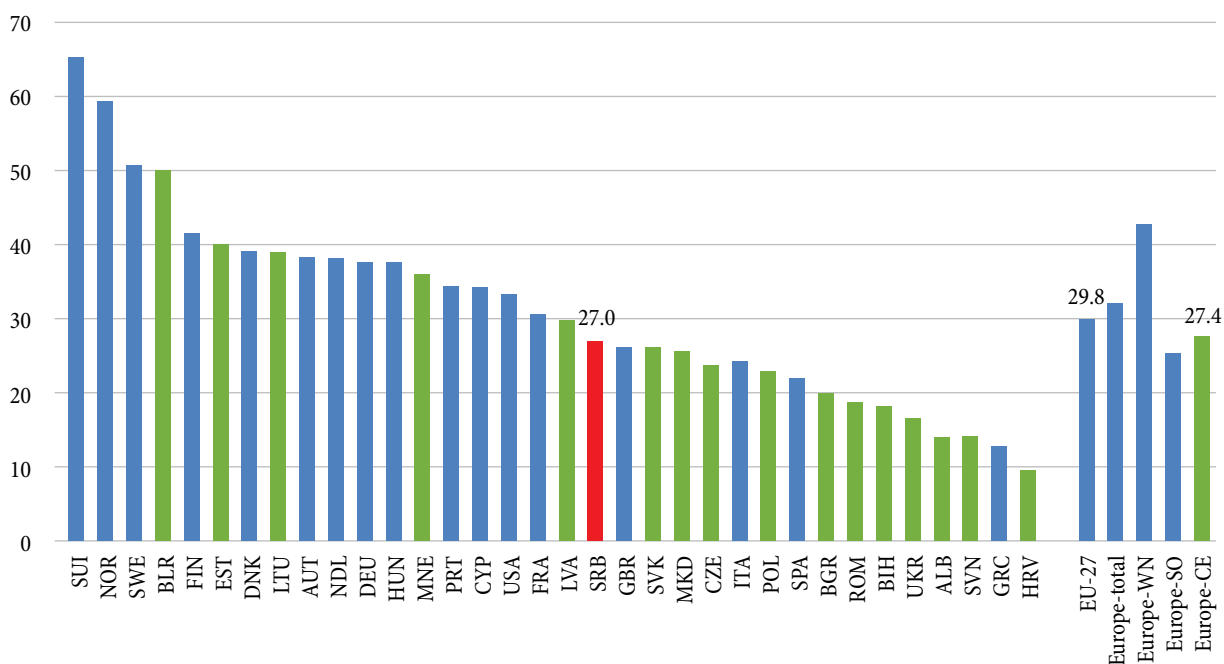
Source: Author's calculations using the WVS/EVS data

army, universities and police (between 45% and 60%), while trust in the judiciary, cabinet of ministers and parliament is significantly lower (below 30%). Since the cabinet of ministers and parliament have a crucial role in shaping government spending policy, low confidence in those branches of government tends to discourage tax morale in Serbia.

b) Government effectiveness

It is well established that higher government effectiveness, which results in the greater availability and quality of public goods and services, motivates people to pay taxes, thus boosting tax morale [3], [11]. One way to measure government effectiveness is to use the World Governance Indicator (WGI) on government effectiveness, which captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. The WGI government effectiveness indicator may range from -2 to 2, with higher values indicating a higher degree of government effectiveness.

According to the results (Figure 8), in 2023, the value of the WGI government effectiveness indicator for Serbia stood at 0, which is substantially below the EU-27 average (0.9) and the CEE average (0.3). With this score, Serbia ranked 30th in Europe, with only six countries having weaker performance in this regard. The data also show that government effectiveness, as measured by this indicator, was on the rise in Serbia until 2017, but has stagnated since then (Figure 9).

The results regarding government effectiveness align with Serbia's overall performance in terms of the declared level of tax morale, suggesting that a low level of satisfaction with the availability and quality of public goods and services is one of the key drivers of the modest level of tax morale in Serbia.

The EBRD's Life in Transition Survey database provides data on the willingness of people to pay more taxes for financing particular government functions, offering useful information on the citizens' perception of government priorities. This can yield important insights, as directing more funds to the government functions that are seen as priorities by citizens, may also promote their tax morale, i.e. stimulating them to pay more taxes. The results (Figure 10) show that taxpayers in Serbia see healthcare, the pension system, education and (means-tested) social benefits as priorities, which is why 55-65% of them are willing to pay more taxes for these services.

Figure 8: WGI – Government effectiveness index in 2023 (mean)
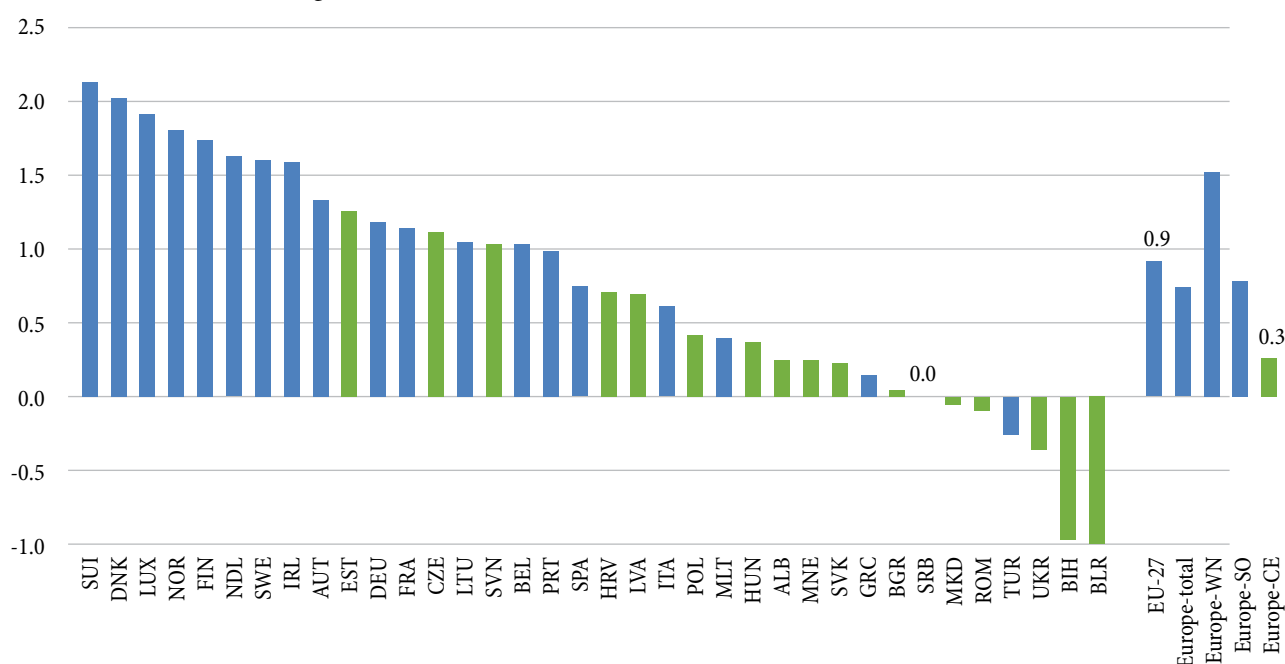
Source: Author's calculations using the World Governance Indicators Database (the World Bank)

Figure 9: Government effectiveness in Serbia, 1996-2023 (mean)
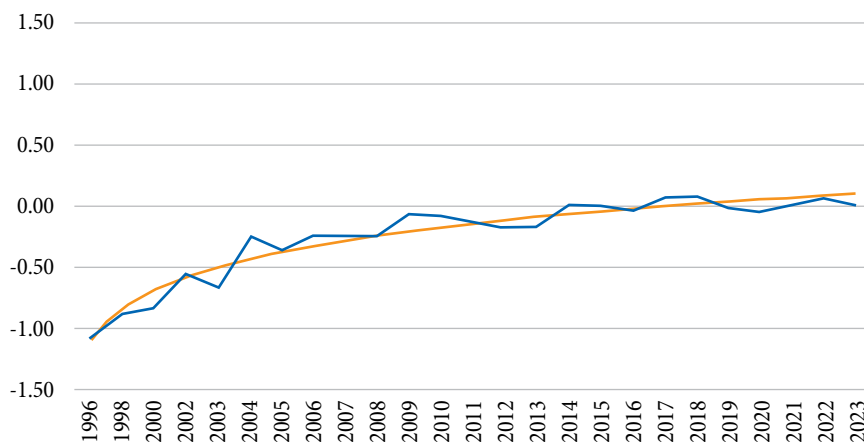
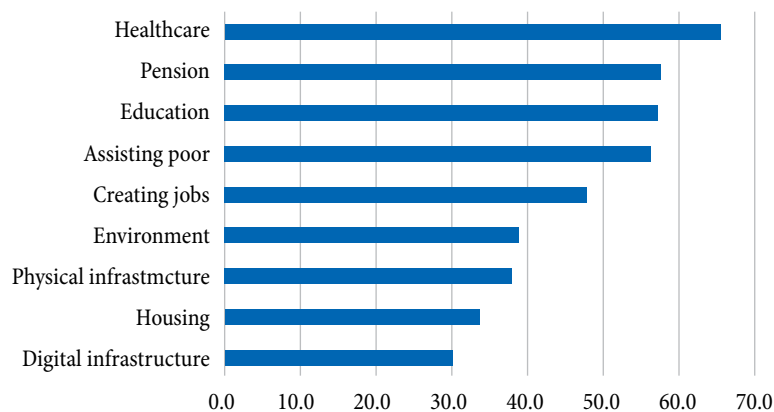Source: Author's calculations using the World Governance Indicators Database (the World Bank)

On the other hand, the propensity to pay more taxes for government spending aimed at creating new jobs, protecting the environment, developing physical and digital infrastructure and housing services is significantly lower.

Concluding Remarks and Policy Considerations

According to recent empirical studies, the shadow economy in Serbia is estimated to be around 21-23% of GDP, depending on the estimation methods [18]. Although it has been declining over the last decade, the shadow economy in Serbia is still relatively pronounced compared to other EU countries, which has significant consequences for public finance and growth, considering that a sustainable budget balance is a prerequisite for the implementation and effectiveness of many other policy instruments [8]. Since (illegal) savings in tax costs are

the main motivation behind the shadow economy, policy measures aimed at reducing the shadow economy should focus on addressing the main drivers of tax evasion. In this respect, further improvement in the government's capacities for efficient tax enforcement is of fundamental importance. Empirical studies ([24] and [25]) suggest that tax morale is also a significant factor of the level of the shadow economy. The results presented in this study indicate that there is a considerable gap in the level of tax morale in Serbia in comparison to the EU and CEE averages. Therefore, it is concluded that coherent policy actions aimed at systematically strengthening tax morale could yield a significant impact on the reduction of the shadow economy and tax evasion in Serbia. Considering the multidimensional character of tax morale, the policy mix in that respect should also be multi-layered and long-term oriented, with a strong focus on the considerations discussed in due course.

Figure 10: Share of the population in Serbia who are willing to pay more taxes for government functions (%)

Source: Author's calculations using Life in Transition 2022-2023 data

Strengthening the trust in government – Enhancing the overall level of trust in the public sector, particularly in those branches of government which play a crucial role in designing, implementing and enforcing public policies (executive institutions, parliament, judiciary), is one of the crucial instruments for improving tax morale, as higher trust in government would provide assurance to taxpayers that tax revenues are to be spent efficiently and effectively. In this regard, each of these goals – strengthening the rule of law, improving the transparency of government institutions, tackling corruption, promoting democracy, and developing inclusive institutions – is considered a *condition sine qua non* for the effective enhancement of tax morale.

Improving the availability and quality of public goods and services – As citizens perceive taxes as the price they pay for a set of goods and services provided by the government, the improvement in the availability and quality of public goods and services is one of the crucial ways to encourage people to pay their taxes. Considering the findings presented in this study (Figure 10), strengthening government spending on healthcare, education, the pension system and assistance to the poor would be particularly appreciated by Serbian taxpayers. In addition to an increase in spending on these functions, the improvement in the efficiency of spending (allocation criteria, monitoring of implementation, etc.) is also important. Although investment in infrastructure is not perceived as one of the taxpayers' priorities, it is very important for economic growth. Therefore, to strengthen the growth perspective and encourage tax morale, it would be beneficial to keep public investments high, but with considerable improvement in terms of the system for selecting, contracting and implementing infrastructure projects. Only under these assumptions would higher government spending on infrastructure result in welfare-improving outcomes, with a positive impact on tax morale.

Improving the transparency of government budget – Informing citizens on the ways tax revenues are spent, in an effective and easy-to-understand manner, can considerably motivate taxpayers to pay their taxes. In that sense, publishing "the citizens' budget" (with illustrative and easily understandable data on the use of the government budget) and sending it annually to all taxpayers could raise awareness among the public about the importance of paying taxes duly. In addition to the information on the purpose for which tax revenues are spent, this report could also provide information on Serbia's tax levels (relative to other European countries), in order to tackle the widespread view that taxes in Serbia are rather high, from the comparative perspective.

Increasing fairness and equity of the tax-benefit system – Empirical studies for other countries and survey results for Serbia suggest that the perception of fairness in the public finance system plays an important role in shaping citizens' stance towards tax compliance. In this regard, reforming the tax system to moderately enhance its vertical equity and redistributive effects, as well as strengthening means-tested social benefit programs targeted at the poor (rather than providing unconditional benefits to wider cohorts of population), may help promote tax morale among Serbian taxpayers.

Slashing the practice of "tax amnesties" – Tax amnesties refer to limited-time opportunities offered by governments to taxpayers with unpaid taxes, allowing them to settle their liabilities with reduced or no penalties. These amnesties aim to help governments recover unpaid taxes and encourage compliance, while providing taxpayers with a way to resolve their debts without harsh repercussions. In spite of that motive, the studies on this topic (see: [2]) suggest that tax amnesties typically do not yield significant positive effects on tax revenues but may rather have the opposite effect in the mid and long run, as offering tax amnesties sends a negative signal to taxpayers who have timely and duly settled their tax liabilities. In that respect, the government should occasionally reaffirm the message that tax amnesties will not be offered in the future.

Improving public perception of the operations of law enforcement institutions – Improving the perception of fairness and non-selective approach in the operations of law enforcement institutions may also play a significant role in promoting pro-compliance behaviour of people. In that respect, ensuring transparency in their activities and maintaining open communication with the public is very important.

*Strengthening pro-compliance social norms by means of informational tax nudge*s – As outlined in this study, social norms substantially shape individuals' stance on tax compliance. Changing social norms is a complex task, for which a longer time perspective is needed. However, enhancing the perception of pro-compliance social norms could be achieved even in a shorter time frame. Taking into account insights from behavioural economics, one way to raise the awareness of the pro-compliance social norms is to use informational tax nudges, by sending an annual brief to all taxpayers stating, for example, that eight out of ten people in Serbia pay their taxes duly (with actual figures calculated using Tax Administration data).

Developing horizontal and vertical trust in the society – Many studies have pointed out that tax morale is higher in societies with greater societal trust. In order to raise the trust within the society, a comprehensive, persistent and long-run oriented approach is needed, with the focus on: promoting accountability and transparency in decision-making processes, involving citizens in the decision-making process through public consultations and participatory governance, encouraging ethical behaviour and integrity among leaders, maintaining open lines of communication between institutions and the public. In addition, penalizing untrustworthy behaviour (by means of legal instruments and stigma) is also important.

Acknowledgments

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THE MANAGERIAL ART OF TRANSFER PRICING: UNDERSTANDING ITS COMMERCIAL AND FINANCIAL IMPLICATIONS

Umetnost upravljanja transfernim cenama – razumevanje njihovih komercijalnih i finansijskih implikacija

Abstract

Achieving superior results compared to those that would have been achieved in independent business activities, as a common goal of connecting independent legal entities, requires decision-makers to identify sources of value in the global market. The paper explores two mechanisms that parent companies can use in pursuit of satisfactory financial results. Firstly, having a greater number of alternatives in making business decisions related to sales in the internal/external markets, defining internal prices, controlling and allocating costs, managing capacity, etc. And secondly, utilizing sources of competitive advantage based on exposure to financing sources that wouldn't be available in independent operations, whether they are reflected in the possibility of internal financing or access to additional external sources. Given that the parent company plays a key role in decision-making (at the level of individual companies and at the level of the economic group), the question arises as to what additional sources of value are available because of integrated operations, and whether their quantification has a measurable impact on the financial performance of the group. In this sense, transfer pricing, which is the focus of our analysis, plays an important role and represents an attractive research area. The key objective of this paper is to examine the impact of commercial and financial aspects of transfer pricing on the performance of economic groups operating in the territory of the Republic of Serbia in 2022, based on the consolidated result of the group and the individual result of the parent company, using a cross-sectional study.

Keywords: *transfer pricing, performance measurement, strategic management accounting, commercial transactions, financial transactions*

Sažetak

Ostvarivanje superiornih rezultata u odnosu na one koji bi bili ostvareni u nezavisnim poslovnim aktivnostima, kao opšti cilj povezivanja samostalnih pravnih entiteta, zahteva od donosioca odluka identifikovanje izvora vrednosti na globalnom tržištu. Rad istražuje dva mehanizma koja matična preduzeća mogu koristiti u potrazi za zadovoljavajućim finansijskim rezultatima. Prvo, raspolaganje većim brojem alternativa donošenjem poslovnih odluka koje se tiču nabavke/prodaje na internom ili eksternom tržištu, definisanja internih cena, kontrole i alokacije troškova, upravljanja raspoloživosti kapaciteta itd. I drugo, korišćenje izvora konkurentskih prednosti po osnovu pristupa izvorima finansiranja koji ne bi bili dostupni u samostalnom poslovanju, bilo da se oni ogledaju u mogućnosti internog finansiranja ili pristupu dodatnim eksternim izvorima finansiranja. Budući da matično preduzeće ima ključnu ulogu u odlučivanju (na nivou pojedinačnog preduzeća i na nivou ekonomske celine), postavlja se pitanje koji su dodatni izvori vrednosti dostupni kao posledica integrisanog poslovanja, i da li njihova kvantifikacija ima merljiv uticaj na finansijski i prinosni položaj grupe. U tom smislu transferne cene, koje su u fokusu naše analize, imaju važnu ulogu i predstavljaju atraktivno istraživačko područje. Ključni cilj u radu je da, polazeći od konsolidovanog rezultata grupe i pojedinačnog rezultata matičnog preduzeća, korišćenjem studije preseka, ispitamo uticaj komercijalnih i finansijskih aspekata transfernih cena na performanse ekonomskih celina koje su poslovale na teritoriji Republike Srbije u 2022. godini.

Ključne reči: *transferne cene, merenje performansi, strategijsko upravljačko računovodstvo, komercijalne transakcije, finansijske transakcije*

Introduction

The pricing of tangible and intangible goods, services and capital transferred between parent companies and their subsidiaries, especially in cross-border transactions, presents serious challenges to management. Operating in a complex and variable sociopolitical and economic environment, companies attempt to create and maintain a competitive advantage, by leveraging the benefits of location, technology, and access to capital markets and other limited resources offered by new markets. This becomes particularly significant considering that transfer prices determine the success of companies, not only of individual enterprises, but also the success of economic group. Moreover, the challenge of defining an adequate transfer pricing system in such conditions will continue to grow given the need for compliance with companies' business model, current and future business and technological process, competitive conditions on the markets, regulatory frameworks, and the chosen business strategy. Management is expected to find an optimum transfer pricing system that enables maximization of profits, minimization of taxes, and meeting other corporate objectives while complying with the tax and financial regulations of their parent country and requirements of the host countries in which their subsidiaries operate.

Focusing on the economic development of the Republic of Serbia, it is notable that in recent years it has largely relied on direct foreign investments and other forms of cooperation with foreign companies, which increased the complexity of business organization and lead to the creation of new economic groups. Fiscal policy, reflected in relatively low corporate and value-added tax rates, as well as tax exemptions and financial incentives, contribute to significant inflow of foreign capital. As a result of such transactions, the ownership structure of companies operating in our country is changing in favor of foreign owners. Since financial markets are still underdeveloped, the capital placement often occurs directly through internal capital markets within the economic groups themselves. By adding the technology and knowledge transfers, the use of natural and human resources, as well as existing infrastructure, the problem of valuing such transactions, i.e., determining the prices at which these goods, services, and capital are transferred, is becoming increasingly significant in our country. Although the number of economic groups relative to the total number of business entities is not high, they have a strong impact on overall economic trends, as evidenced by the fact that economic entities account for approximately one-third of total revenues and expenses and hold one-third of the financial capacities of the Serbian economy.

Existing research does not fully explain the managerial implications of transfer pricing on financial performance achieved in complex organizations. This paper addresses the impact of commercial and financial implications of transfer pricing on performance attained by the parent company and the economic group it manages. The structure of the paper is designed to reflect this, in which we discuss strategic management control at the core of empirical research, transfer pricing financial outcomes and transfer pricing in the Republic of Serbia.

Strategic Management Control at the Core of Empirical Research

In general, the objectives assigned to transfer prices in intercompany transactions within economic groups can be multiple. Consequently, the goals of empirical research on transfer pricing can be diverse. Numerous fiscal studies examine the role of transfer pricing in creating an optimal taxation system that will prevent and/or discourage tax evasion and ensure equality and neutrality in taxation. On the other hand, when dealing with individual enterprises, studies focus on examining the role of transfer pricing in minimizing total tax liabilities, i.e., maximizing post-tax profits. With the development of corporate governance, the importance of transfer pricing in the overall management process has been recognized, leading to an increase in the number of studies examining the impact of transfer pricing on the theory, practice, and design of management control systems. Although transfer prices for tax reporting purposes do not have to be accepted for management purposes, research has shown that companies rarely maintain dual transfer pricing systems, making the alignment of their multiple

objectives an imperative for successful business operations. On top of tax-related objectives, transfer prices can also be assigned goals related to creating company's competitive position, which becomes particularly important with international economic groups. Additionally, due to the establishment of numerous internal relationships within complex corporate systems, many internal, management-driven goals can arise. As a result of high information specialization, transfer prices play a significant role in transmitting information along the entire value chain, where they become an instrument for conveying strategy, while simultaneously signaling the need for strategy changes in response to signals coming from external and internal environment.

One of the more dominant approaches in researching the managerial role of transfer pricing is the contingent theory, in which models for comparative analysis of organizations are developed depending on the context of their operations. In other words, the alternative design of management systems is explained by different needs for control mechanisms that arise as a result of environmental factors. In the field of transfer pricing, studies most often focus on examining the design of transfer pricing that would best suit the various environmental influences such as technology, size, structure, and performance of the organization, corporate strategy, differences in tax legislation of the countries in which related parties operate, the competitive position of related parties in local markets, import and business connection restrictions, or even local culture.

Studies based on a contingent approach are particularly characteristic of early studies on the managerial aspects of transfer pricing. Early research finds that transfer prices can be assigned different goals depending on the demands arising from the environment, where the effectiveness of achieving these goals has a measurable outcome in the form of differences in financial performance [10]. Furthermore, by isolating factors from internal and external environment over time, it was found that the role of transfer prices as instruments of strategic change can be explained by the evolution of the organization, i.e., factors that have conditioned changes in the company's operations during its life cycle [3]. In addition to above, empirical research

provides evidence on the relationship between management's perception of environmental factors and the design of transfer pricing systems. The research shows that the likelihood of transfer prices being determined using the market method is higher if maintaining good relations with the local partner is more important to management, and that the likelihood of using one of the cost methods is higher if management pays more attention to controls in foreign trade, which are often used in developing countries as one of the mechanisms to prevent profit outflow [6].

Furthermore, one of the fundamental questions regarding transfer pricing is the delegation of decision-making where tax and managerial goals often conflict. Studies show that the centralization of tax decision-making prioritizes the internal goals of the economic group and the maximization of total profit, at the expense of compliance with local tax requirements, thereby increasing the risk of tax audits. It is believed that this risk can be overcome by pairing centralized tax decision-making with sophisticated tax planning strategies, especially concerning services and intellectual property, thereby simultaneously reducing the risks of tax audits and the number of conflicts in coordinating internal goals [2]. Other research show that transfer pricing systems aligned with tax rules can be successfully integrated into management control systems, especially when transfer pricing systems are transparent both internally and externally, when can be easily revised in cases of serious management problems, and are flexible enough to face volatile business conditions [21].

On the other hand, some research starts from two sets of transfer prices, one for tax purposes and the other for internal management goals. The authors find that the two prices are independent if the tax is calculated using formulas in all relevant jurisdictions, but are interconnected if the tax amount is determined according to the arm's length principle. Both prices decrease with the increase in potential penalties for non-compliance with tax rules. Whereas, the tax transfer price decreases, and the internal transfer price increases with the rise in marginal production costs. The authors find that the optimal internal price is equal to the weighted average of the marginal production cost and the optimal tax transfer price, increased by a portion of the marginal cost of potential penalties for non-

compliance with the arm's length principle [22]. Similar studies conclude that the optimal internal transfer price should be equal to the weighted average of pre-tax marginal costs and the most favorable transfer price determined according to the arm's length principle [1].

Alternatively, some studies hold an opposing view, arguing that companies with intra-company trade do not set the optimal price based on rules applicable to independent entities, but use transfer prices as a strategic secret mechanism, transferring intermediate goods between divisions at prices higher than marginal costs, resulting in double profits compared to competitors that are not divisionally organized. The authors find that an additional advantage of this practice is avoiding the controls in regulated markets [34].

Focusing on decision-making process, some studies argue that using a single price for both managerial and tax purposes leads to certain problems, such as eliminating negotiations over transfer prices, which can increase conflict situations. Due to the significant administrative burden associated with transfer prices, decision-making regarding profit margins is greatly simplified, which can result in suboptimal decisions. Previous cost centers were converted into profit centers with expanded responsibilities for tax decision-making purposes, while remaining at the cost center level for production decision-making, thus creating an imbalance in authority and distortions in measuring the performance of organizational units and their management [9]. Some researchers find that this issue can be overcome with negotiated transfer prices where organizational units are granted with authority to coordinate their activities and goals, hence avoiding distortions that can result in inefficient allocation of divisional profits, which is characteristic of centralized decision-making focused on the economic group overall. It is considered that negotiation perfectly reflects the arm's length principle and allows all stakeholders to be included in the decision-making process [25].

Having all that in mind, the necessity of integrated research on both fiscal and non-fiscal aspects of transfer pricing is becoming more evident. Researchers find that managing tax liabilities is not the only goal of a global strategy and that effective tax planning is at the heart of managerial decisions [27, 29, 30]. Furthermore, studies identify the immediate effects of aligning transfer pricing systems with tax rules on the design of management control systems, with a consequent impact on the planning, evaluation, and reward processes, and argue that changes in management control systems cannot be understood without understanding the process of aligning with the tax legislation requirements to which multinational companies are exposed [8]. Moving to the level of cost decision-making, complementary result is identified that the allocation of general costs related to the provision of services is significantly influenced by the tax regulatory environment [32]. Furthermore, some authors track the development of tax empirical research in the field of accounting and find that future research needs to expand beyond documenting tax issues and focus on quantifying the tax aspects and limitations they entail [33]. They expect further theoretical development to support the development of methodology used in empirical research, which has not yet been developed sufficiently to encompass both fiscal and non-fiscal impacts on accounting practice. The authors conclude that gaining new knowledge requires an interdisciplinary approach that will not neglect managerial-accounting aspects of transfer pricing. Supporting the same viewpoint, the research presented below aims to provide answers regarding the strategic-managerial role of transfer pricing.

Transfer Pricing Financial Outcomes

One of the biggest limitations of previous studies is the absence of quantification of the established models and definition of measurable impacts of transfer pricing on financial performance. In an attempt to achieve greater levels of objectivity, newer studies relay on financial statements and other statistical bulletins information to collect quantitative data. A similar approach is taken in this paper, where the impacts of prices determined in internal commercial and financial transactions are first quantified, and then their influence on achieved financial performances is examined.

Resent research in the field of commercial transactions, investigates the evidence of transfer pricing being motivated

by tax issues, specifically questioning whether prices set in intercompany trade are sensitive to the corporate tax rate. It is concluded that the value of internal transfers decreases with the increase in the statutory tax rate in the country producing the good and/or providing the service and exporting it to related parties, and increases in the country importing the good and/or service with a preferential tax system [7]. Similar results are found by researchers focusing on the European area. For example, it was estimated that the tax base in France in 2008 was reduced by 8 billion dollars as a result of profit reallocation to countries with preferential tax systems [35]. Furthermore, examining the impact of profit reallocation by French multinational companies, studies find that the deviation of internal prices from those determined according to the arm's length principle is particularly pronounced if the dependent enterprises are established in countries considered to be tax havens [12]. On the other hand, studies find that branches of Danish multinational companies operating in countries with lower tax rates reduce the value of their exports on average by 5.7% to 9.1%, corresponding to an unreported export value of 141 million dollars in 2006 and a tax revenue loss of 3.24% of the total reported value of Danish multinational companies [11].

Even though the commercial aspects of transfer pricing are often examined in relation to tax incentives, more and more studies focus on their impact on capital placement and overall investment volume. Testing a sample that includes 27 countries during the period 2006-2014, a study finds a negative impact of transfer pricing regulations on the level of investment by multinational companies compared to national companies. The results show that investment in foreign subsidiaries is on average about 11 percent lower after the introduction of tax rules, compared to investments in similar companies that are entirely domestic [14]. Similarly, researchers test how limitations on interest tax deductibility, so-called thin-capitalization rules, and transfer pricing regulations by the host country affect the level of investment and employment of foreign subsidiaries. The results show that, compared to the unrestricted case, in the presence of a typical thin-capitalization rule, the sensitivity of foreign direct investment to the tax rate is about twice as large.

Additionally, the research shows that the introduction or tightening of such a rule has significant negative effects on the level of investment in high-tax countries. However, a significant correlation between transfer pricing regulations and the level of foreign direct investment was not confirmed in this research [4].

In terms of using debt as a source of tax savings, an economic group can structure its activities in several ways to minimize tax burden, including using debt instead of equity as a strategy or organizing an internal capital market to achieve maximum tax efficiency. The existence of such market provides economic groups with an additional source of financing not available to individual enterprises. Multinational companies have an additional advantage in this regard, as they can internally finance beyond the borders of the individual entity's country and replace external debt with internal capital derived from retained earnings and capital reserves of other enterprises that may operate under different tax rules. The most common strategy in the internal capital market is borrowing from subsidiaries located in low-tax countries and internally lending to subsidiaries in high-tax countries, which reduces profits due to interest expenses in high-tax countries, while these are taxed at lower rates as income in low-tax countries.

Numerous studies show that the capital structure of affiliated entities of multinational companies is sensitive to the tax rate in the host country of the affiliate [17, 13, 20]. These studies mainly focus on examining the debt ratio calculated in relation to capital and/or assets, finding evidence of the impact of higher tax rates on higher indicator values, both in multinational and national environments [19], or on examining the tax effects on the total value of internal debt [26]. Generally speaking, the empirical literature supports the view that internal financing is sensitive to taxes. However, the results of previous research do not provide unique conclusions about whether and to what extent internal debt is used for profit reallocation or if these effects reflect conventional understanding of financial leverage. On a sample of all German multinational companies operating in the period 1996-2005, researchers find evidence that international internal financing is used in groups with entities exposed to

lower tax rates and that the size of such internal financing increases with the increase in the difference between the host country's tax rate and the lowest tax rate faced by the group's entities. The study finds that an increase in the host country's tax rate by 10 percentage points increases the debt-to-equity ratio by about 2.1 percentage points [5]. Similar findings are obtained by using data from the U.S. Bureau of Economic Analysis, which report that an increase in the tax rate by 10 percentage points is associated with an increase in leverage measured relative to the assets of the affiliated entity [15]. Furthermore, based on financial statement data of European companies, it was found that an increase in the marginal effective tax rate by 10 percentage points results in an increase in overall leverage by 2.59 percentage points [20]. In addition to internal financing through debt, researchers find that the financing structure of subsidiaries located in developing countries is more sensitive to tax incentives and that the marginal effect of a tax rate change on the financing structure is twice as high as in developed countries [18]. However, many previous studies, although finding effects on financial leverage and the total value of internal financing, consider these effects relatively small and insignificant mechanisms for profit shifting. A common explanation for such behavior is the numerous regulatory limitations on this type of financing.

This paper explores the strategic dimensions of transfer pricing by analyzing its commercial and financial impacts and assessing their influence on the performance of companies, both at the group level and within the parent company.

Transfer Pricing in the Republic of Serbia: Sample and Data

In recent years, the economic development of the Republic of Serbia has heavily relied on foreign direct investments and partnerships with international companies [28, 31]. This increased the complexity of business organization and led to creation of new economic groups. The attractiveness of fiscal policy, characterized by relatively low corporate and value-added tax rates, along with tax exemptions and subsidies, shaped investor perceptions and influenced

decision-making processes, thereby boosting the inflow of foreign capital into the country [16]. Given that financial markets are still underdeveloped [23], capital placement often occurs directly through the organization of internal capital markets within the economic entities themselves. By adding other factors, such as transfer of technology, knowledge, the utilization of natural and human resources, and existing infrastructure, the challenge of valuing these transactions. i.e. determining the prices at which these goods, services, and capital are exchanged, is becoming increasingly important in our country.

Considering that the overall goal of connecting independent legal entities is economic interest and achieving superior results compared to those that would have been achieved in independent business activities, the following question arises: To what extent the price of internal transfers between related parties can affect the financial position and performance of the economic group? This research is not limited to the overall performance of economic group, but also examines the impact on the performance of the parent company that controls the group and, as such, plays the role of the main decision-maker in the group. It is precisely in this relationship between the consolidated and individual results of the company responsible for managing it, where the impact of commercial and financial aspects of transfer pricing on the performance of economic groups operating in the territory of the Republic of Serbia is being sought.

The sample includes economic groups whose parent companies are established in the Republic of Serbia and which, according to accounting regulations, were required to submit consolidated financial statements for the year 2022. A total of 664 economic entities, which include 2,173 dependent and affiliated legal entities within their consolidation circle, submitted correct consolidated reports. Considering the total number of economic groups, the number of economic units is not high, but their impact on overall economic trends is strong. This is clearly indicated by the fact that, in 2022, economic units realized slightly less than a third of the total revenues and expenses of the economy, while their share in the generated net profit and net loss of the economy was 30.6% and 28.8%, respectively. They also accounted for almost a third of the business

assets and capital of the economy, as well as a fifth of the total realized loss. The achieved results indicate the relevance of these groups as economic participants and the significant impact their performance has on overall economic activity.

From the total number of economic groups that operated in 2022 in the territory of the Republic of Serbia, the sample includes economic entities that met the following criteria:

- Accuracy of submitted financial statements,
- Legal form and status of parent companies (the sample includes legal entities characterized by corporate management forms with limited liability of members for the company's obligations, i.e., active parent legal entities established in the form of joint-stock companies or limited liability companies),
- Size of the parent company determined according to accounting regulations (based on the assumption that larger companies have more complex intercompany relationships, the sample includes economic groups whose parent companies are classified as large companies according to the financial statements for 2022. Large companies, unlike smaller ones, more frequently engage in significant intercompany transactions that can have implications for transfer pricing, thin capitalization, tax-favorable leases, financial arrangements, and consequently more complex flows between entities).

A total of 142 economic groups met the aforementioned criteria.

A selection of financial ratio analysis indicators is used to help identify the scope of internal transactions and quantify the impact of these transactions on the profitability and financial position of the economic group and the entity managing it. Since the disclosure of information on transfer pricing is not a mandatory requirement for externally oriented financial reporting, the identification of intercompany transactions in the research is based on the balance sheet and income statement positions related to transactions between related parties. The greatest challenge has been identified on the side of commercial intercompany transactions, where existing balance sheet schemes do not prescribe a separate position for business revenues and expenses from transactions with related parties. To overcome the lack of information on operating revenues and expenses arising from transactions with related parties, the notes accompanying the financial statements were reviewed, and it was found that although the reporting practice regarding the disclosure of transactions with related parties varies, most parent companies in the sample disclose these transactions.

In the following, the disclosed intercompany commercial and financial relationships of parent companies with their subsidiaries are presented (see Figure 1). The relationships are measured as stake of intercompany revenues and expenses in total revenues and expenses reported by parent companies. On the revenue side, financial activities take 26.71%, while commercial activities take around 18% of total revenues indicating that with one quarter, i.e. one fifth in total revenues are impacted by the prices determined in intercompany transactions, leaving a significant space for parent companies' management team to administer transfer pricing and coordinate their decisions to diverse transfer pricing goals. On the other side, parent companies

Figure 1: Related parties stake in revenue, expenses, net effects
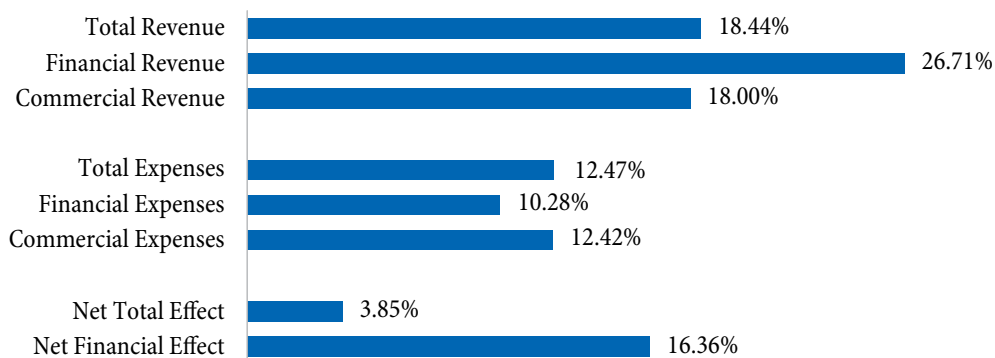
Source: Authors' calculations

have reported a slightly lower stake in total expenses with related parties, 10.28% for financial and 12.42% for commercial activities. On average, most parent companies from the sample have a positive outcome from commercial and financial activities.

The results show that the stake of net financial effects, compared to differences between financial income and expenses, is higher compared to the net effects from commercial activities. In other words, the company earns more profit from its financial activities than from its core commercial activities. The lower net effects from commercial activities could mean that part of the profit from commercial transactions is being transferred elsewhere as part of company's strategic efforts to optimize their business process and improve overall profitability. The lower profitability in commercial activities could imply that some of the profits is being shifted to related entities in different jurisdictions with more favorable tax conditions. Additionally, the company might be allocating more resources to financial activities, potentially at the expense of its commercial operations, due to strategic shift or a temporary focus on capitalizing favorable financial market conditions. Alternatively, the parent company might be strategically diversifying its income sources to reduce dependency on its primary business, leading to lower commercial net effects.

In the next step, this research seeks the impact of transfer pricing in the difference of performance indicators between the parent company and the economic group that parent company has control over. In order to examine the impact of commercial and financial internal activities on the overall performance of the parent company and of its economic group, a set of indicators has been calculated. The ratios are as follows (see Table 1):

Focusing on financing activities, the research indicates that average debt level of parent companies was lower compared to the average debt at the economic group level. This finding suggests that the internal capital market within the group was effectively utilized where capital among the entities within the group was redistributed. This could be a strategic move to leverage debt for growth and expansion while maintaining lower debt levels at the parent company level to present a stronger financial position. Overall, the utilization of the internal capital market highlights the group's ability to manage its financial resources efficiently, by reducing the need for external financing and optimizing the allocation of resources, while balancing the benefits of internal funding with the implications of higher leverage.

On the other hand, the results regarding the profitability of the parent company and its economic group are not conclusive. From the perspective of operating activities, the research indicates that the economic group, on average, was more profitable than the parent company. This suggests that the group's collective operations generated higher returns. However, when examining the net profit margin, the research reveals that the parent company achieved a higher level of profitability. This indicates that, despite the group's overall operational success, the parent company managed to retain a greater proportion of its revenue as profit after accounting for all expenses. These findings highlight that both commercial and financial internal transactions can have significant impact on the performance of the parent company and the economic group.

The information outlined above is illustrated in more detail in the accompanying Table 2.

In this paper, empirical research is designed with a focus on examining the strategic management aspects of

Table 1: Differences in performance ratios between parent company and its economic group

	Range	Minimum	Maximum	Mean	Std. Deviation
D/E	27.05694	-1.77676	25.28018	0.605845	3.366883399
Capital Turnover Ratio	110.0749	-24.7916	85.28325	0.732284	7.575951494
Operating Profit Margin	1.45627	-0.52952	0.92675	0.005758	0.101837043
Net Profit Margin	1.1382	-1.05589	0.08231	-0.01553	0.092146405
ROA	0.31398	-0.14008	0.1739	-0.00385	0.027299549
ROE	7.92418	-0.67623	7.24795	0.07504	0.743462234

Source: Authors' calculations
Note: The difference is calculated as group's indicator minus parent company's indicator

transfer pricing on achieving the common interests of legal entities grouped within economic groups, i.e., examining the impact of intercompany transfers on the potential to strengthen the position of the entire group compared to the possibilities available to the parent company as an individual entity. The research is addressing the following question: What is the impact of the commercial and financial effects of internal transfers on the achieved difference in the performance of the group and the performance of its parent company? The parent company, placed at the center of business decision-making at both the individual company and economic group levels, has a key role in identifying additional sources of value from integrated operations and assessing their pricing components, i.e. in transfer prices. By understanding these interconnected activities, we can gain deeper insights into the factors driving profitability and identify potential areas for improvement.

Research Methodology and Findings

This paper examines the combined effects of commercial and financial aspects of transactions between related parties on the performance of the group and its parent company. Aiming to identify the impact of internal transfers, the model is based on making comparisons between results achieved by economic group and results achieved by its parent company. A binary logistic regression (LOGIT) model is developed to model the probability that the performance of the economic group is superior to the performance of the parent company, due to the fact that more strategic options are available to the group in comparison to the alternatives available to the parent company, presuming it conducted its business independently. From a statistical standpoint, a binary logistic model is used to model the

probability that an event, one of two possible alternatives, will occur, where the logarithm of the event's probability is calculated as a linear combination of one or more independent variables. In binary logistic regression, the dependent variable can only be binary, taking two values denoted as "0" and "1", which indicate failure and success, respectively. In this paper, the variables are coded as "0" if the selected indicator is lower at the group level compared to the parent company's indicator (taking a negative value), and coded as "1" if the selected indicator achieves a positive value. On the other hand, predictors can be both categorical and continuous variables. In the model presented below, the variable related to the parent company's success is continuous, while the dependent variables related to commercial and financial aspects of transfer pricing are binary variables.

Starting from the net performance of parent company (measured by net profit rate), the model tests the impact of commercial effects of transfer prices (measured by differences in operating profit rate) and the impact of the financial effects of transfer prices (measured by the debt/equity ratio indicator) on the achieved difference in performance of the economic group and its parent company (measured by return on equity (ROE)). It is expected that a greater difference in the commercial and financial results between the group and the parent company will result in a higher probability that the performance of the group will be superior compared to the performance of the parent company.

In more details, the variables used in the research are calculated as follows:

Dependent Variable:

Y: A binary variable indicating the difference in the performance of the entity group, measured by ROE,

Table 2: Overview of performance indicators per parent company and its economic group

	Parent Company		Economic Group	
	Mean	Std. Deviation	Mean	Std. Deviation
D/E	1.760795	2.176784	2.36664	4.051599
Capital Turnover Ratio	5.218402	11.08164	5.950686	12.62857
Operating Profit Margin	-0.15255	2.704012	-0.14679	2.626254
Net Profit Margin	-0.08638	1.992314	-0.10191	2.079719
ROA	0.092358	0.094136	0.088508	0.093423
ROE	0.221857	0.327529	0.296896	0.904366

Source: Authors' calculations

and the performance of the parent company, taking values 0 and 1:

- 0 if the ROE of the economic group < ROE of the parent company
- 1 if the ROE of the economic group > ROE of the parent company

Explanatory Variables:

X_1: Net profit margin of the parent company (continuous variable)

X_2: A binary variable indicating the difference in the debt-to-equity ratio (D/E) between the economic group and the parent company, taking values 0 and 1:

- 0 if the D/E of the economic group < D/E of the parent company
- 1 if the D/E of the economic group > D/E of the parent company

X_3: A binary variable indicating the difference in the operating profit margin between the economic group and the parent company, taking values 0 and 1:

- 0 if the operating profit margin of the economic group < operating profit margin of the parent company
- 1 if the operating profit margin of the economic group > operating margin rate of the parent company

The following results are obtained (see Table 3):

Based on the obtained results, the following regression equation is presented:

$$ln(\frac{p}{1-p}) = 0.952 + 3.855\,X_1 - 1.157\,X_2 - 1.359\,X_3$$

Where p = P(Y=1), i.e., the probability that the dependent variable Y takes the value 1, or the probability that the ROE of the economic group is greater than the ROE of the parent company. This probability equals to:

$$p = \frac{1}{1+e^{-(0.952+3.855\,X1-1.157\,X2-1.359\,X3)}}$$

Model Interpretation:

- Interpretation of β_0 (constant)
- $\beta_0 = 0.952 \rightarrow$ If all explanatory variables take the value 0, the probability that the dependent variable Y takes the value 1, i.e., the probability that the ROE of the economic group is greater than the ROE of the parent company, equals $\frac{1}{1+e^{0.952}} = 0.278$.
- Interpretation of β_1 (related to the profitability level of the parent company):

$\beta_1 = 3.855 \rightarrow$ If the net profit rate of the parent company increases by 1, then $ln(\frac{p}{1-p})$ will increase by 3.855, or $\frac{p}{1-p}$ will increase by approximately 47.22 (assuming other explanatory variables remain unchanged). This means that the probability that the dependent variable Y takes the value 1 will also increase.

Table 3: Logistic regression model summary

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	173.040[a]	.154	.206

Classification Table

Observed		Predicted		
		ROE		Percentage Correct
		group < parent company	group > parent company	
Step 1 ROE	group < parent company	55	17	76.4
	group > parent company	30	40	57.1
Overall Percentage				66.9

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1	X1	3.855	1.648	5.473	1	.019	47.220
	X2	-1.157	.391	8.754	1	.003	.314
	X3	-1.359	.403	11.383	1	.001	.257
	Constant	.952	.365	6.816	1	.009	2.592

- Interpretation of β_2 (related to the effects of financial effects):

  $\beta_2 = -1.157 \rightarrow$ If X_2 takes the value 1, i.e., the D/E of the economic group is greater than the D/E of the parent company, then $ln(\frac{p}{1-p})$ will be lower by 1.157 compared to cases where X_2 takes the value 0 (assuming other explanatory variables remain unchanged).

- Interpretation of β_3 (related to the effects of commercial effects):

  $\beta_3 = -1.359 \rightarrow$ If X_3 takes the value 1, i.e., the operating profit rate of the economic group is greater than the operating profit rate of the parent company, then $ln(\frac{p}{1-p})$ will be lower by 1.359 compared to cases where X_3 takes the value 0 (assuming other explanatory variables remain unchanged).

The research indicates that the greater the profitability of the parent company, the greater the overall success of the entire economic group. A parent company that demonstrates higher profitability is often better positioned to make strategic decisions that enhance the performance of the entire group. Consequently, the greater the profitability of the parent company, the higher the likelihood that the economic group will be more profitable. By exerting control, a successful parent company is likely to be in a position to implement unified policies across all subsidiaries, ensuring consistency and efficiency, effectively allocating resources across the group, leveraging its position to negotiate better commercial and financial terms and having a stronger oversight and governance ensuring that subsidiaries adhere to best practices and regulatory requirements. Furthermore, regarding total debt, the study highlights that parent companies operating within internal financial markets possess greater flexibility to conduct financial transactions that might have been unavailable if they operated as standalone entities. This increased financial capacity can result in a higher debt-to-equity (D/E) ratio at the group level. The study indicates that when the D/E ratio is higher for the group than for the parent company alone, the probability of higher overall profitability of the group in comparison to its parent tends to decrease. This result could be attributable to the economic group reaching its

maximum level of indebtedness. At this point, the negative effects of financial leverage, such as higher debt financing costs, increased risks, and operational constraints, can deplete resources and become a significant burden on the group. In such scenarios, financial leverage at the group level negatively impacts the group's performance. When viewed from parent's perspective, a parent company that relies on a lower leverage is better positioned to manage the entire group in a manner that enhances overall profitability. By maintaining a more conservative debt-to-equity ratio, the parent company can exert more effective financial control and stability across the group that support sustainable growth and profitability for the entire economic group. Lastly, the model illustrates the commercial effects of intercompany transactions, revealing that a higher overall operating margin does not necessarily mean a better performance for the entire group. This finding shows that while intercompany transactions may lead to higher group operating margins, they do not always translate into better group performance. From a commercial standpoint, when viewed from the parent company's perspective, the stronger the parent company, the higher the probability that the economic group will perform better. This suggests that the parent company's strength and strategic management play a crucial role in driving the overall success of the group, beyond just the operating margins.

Conclusion

The aim of the presented research is to investigate the strategic implications of transfer pricing on financial performance. The study examines whether commercial intercompany transfers and intercompany financing policies serve as instruments for achieving the strategic goals of the company, resulting in superior performance. By focusing on the differences in profitability achieved by the group and its parent company, the research aims to provide evidence that a strategic approach to transfer pricing management leads to superior group performance compared to the performance that the parent company, as an individual entity, would achieve in its operations.

The study illustrates that commercial and financial effects, measured by the difference in operating profit margins and the difference in debt levels between the economic group and the parent company managing it, show a negative relationship with the achieved difference in performance between the group and its parent company, measured by the difference in return on equity (ROE). Although this finding may seem surprising at first glance, it actually highlights several key insights. Firstly, a stronger parent company is more likely to implement effective strategies and make decisions that positively influence the entire group's performance. This is because a strong parent company can leverage its resources, expertise, and market position to drive growth and profitability across the group. Secondly, the negative relationship between the differences in operating profit margins and debt levels and the performance difference suggests that higher leverage and operating margins at the group level do not necessarily translate into superior performance of the group. Instead, these factors may introduce financial strain and inefficiencies that detract from the group's overall profitability. Lastly, it is important to consider the context in which this research is applicable. The results could be partially attributed to the fact that the study is conducted in a country characterized by a relatively underdeveloped capital market. In such environments, the ability of the parent company to effectively manage and allocate resources becomes even more critical to the success of the entire group. The underdeveloped capital market may limit external financing options, making the internal financial management and strategic decisions of the parent company even more crucial.

In summary, the study highlights the importance of the parent company's strength and strategic management in driving the overall success of the economic group. While higher operating margins and leverage at the group level may seem advantageous, they do not always lead to better performance. Instead, the parent company's ability to leverage its resources and expertise plays a crucial role in achieving superior group performance, especially in countries with underdeveloped financial markets such as Republic of Serbia.

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GENERATIVE AI: A NEW GENERAL-PURPOSE TECHNOLOGY FOR GROWTH AND RESEARCH

Generativni modeli veštačke inteligencije – nova tehnološka revolucija za ekonomski rast i istraživanje

Abstract

Building on the review of the explosive achievements of Generative AI in its breakout year 2023 in our previous paper [52], this paper focuses on continued AI developments in 2024, its impact on growth, economic research, and the design and conduct of macroeconomic policy. GenAI has matured to become a true general-purpose technology of the new industrial revolution. The promise of Generative AI has moved from the 2023 hype phase of experimental applications to practical implementation and tangible results based on improved model capabilities, personalized content, energy efficiency, and autonomous agents focused on results. Improved model capabilities, driven by the further development of large LLM-based models and multimodal applications done by specialized AI companies, are now accompanied by the proliferation of small language models customized to company-specific processes and product needs. The year 2024 brought a significant development of "generative agents," which autonomously perform complex tasks and deliver desired results in legal and financial market services. As a transformative technology, AI has a significant impact on economic growth, research, and policymaking. It enhances productivity through automation, improves decision-making, and faster innovation. It can simulate economic scenarios, predict macroeconomic variables, and generate new hypotheses for research and policy design. Key areas for future research include labor markets, capital allocation and inequality. The fast progress of GenAI poses challenges (job displacement, algorithmic bias, and ethical concerns) and necessitates balanced policy interventions. Ethical dimensions, particularly bias and accountability in algorithmic decision-making, are critical for ensuring that AI benefits society. Policy recommendations include ensuring the equitable distribution of AI benefits, providing equal access to AI technologies, reducing the digital divide, investing in digital infrastructure, AI literacy and reskilling, and establishing robust ethical frameworks. Policies to promote inclusive growth, adapt to changing labor markets, and ensure transparent and accountable AI deployment would allow governments to harness GenAI potential while safeguarding societal well-being.

Keywords: *artificial intelligence (AI), AI singularity, general pre-trained transformers (GPT), ChatGPT, large language models (LLM), small language models (SLM), generative AI models (GenAI), machine learning (ML)*

Sažetak

Nadovezujući se na pregled eksplozivnih dostignuća generativne VI u prelomnoj 2023. godini dat u našem prethodnom radu [52], ovaj rad se fokusira na razvoj VI u 2024. godini, njen uticaj na rast, ekonomska istraživanja i definisanje makroekonomske politike. GenVI je tokom prošle godine postala „tehnologija opšte namene" nove industrijske revolucije, slično parnoj mašini i električnoj energiji u prve dve. Očekivanja su se pomerila iz faze hiperoptimizma, zasnovanog na eksperimentalnim aplikacijama u 2023. godini, u realnu sferu fokusiranu na praktičnu implementaciju i opipljive rezultate zasnovane na poboljšanim karakteristikama modela, personalizovanom sadržaju, energetskoj efikasnosti i „generativnim agentima" fokusiranim na rezultate. Poboljšane karakteristike velikih modela zasnovanih na LLM i multimodalnim aplikacijama koje su razvile specijalizovane AI kompanije, sada su praćene proliferacijom malih jezičkih modela prilagođenih specifičnim procesima i potrebama proizvoda pojedinih

kompanija. 2024. godina donela je značajan razvoj „generativnih agenata" koji autonomno obavljaju složene zadatke i isporučuju željene rezultate u pravnim uslugama i uslugama na finansijskim tržištima usluga. GenVI kao transformativna tehnologija ima značajne implikacije za ekonomski rast, istraživanja i vođenje makroekonomske politike. Ona povećava produktivnost kroz automatizaciju, poboljšava donošenje odluka i ubrzava inovacije. Ona simulira ekonomske scenarije, predviđa makroekonomske varijable i generiše nove hipoteze za istraživanje i testiranje ekonomskih politika. Ključne oblasti za buduća istraživanja uključuju tržišta rada, alokaciju kapitala i nejednakost. Brz napredak GenVI donosi izazove (gubitak radnih mesta, pristrasnost programskih algoritama i etička pitanja), što zahteva prave mere ekonomskih politika. Etičke dimenzije, pristrasnost i odgovornost u donošenju odluka, ključne su za osiguranje da VI koristi društvu. Preporuke ovog rada za ekonomsku politiku uključuju osiguranje pravedne raspodele koristi VI, obezbeđenje jednakog pristupa VI tehnologijama, smanjenje digitalnog jaza, ulaganje u digitalnu infrastrukturu, VI pismenost i prekvalifikaciju, kao i uspostavljanje robusnih etičkih okvira. Politike za promociju inkluzivnog rasta, prilagođavanje promenama na tržištima rada i osiguranje transparentne i odgovorne primene AI omogućile bi vladama da iskoriste potencijal GenVI dok štite dobrobit društva.

Ključne reči: *veštačka inteligencija (VI), VI singularnost, generativni unapred obučeni transformatori (GPT), ChatGPT, veliki jezički modeli (LLM), mali jezički modeli (SLM), generativni VI modeli (GenVI), mašinsko učenje (ML)*

Introduction

The year 2024 witnessed significant advancements in artificial intelligence (AI), particularly in the domain of generative AI (GenAI), reinforcing its transformative potential across industries, research fields, and societal applications while enhancing productivity. Building on the momentum from prior years, 2024 emphasized both technological innovation and practical integration, making AI more accessible and versatile than ever before.

One notable development was the increased adoption of GenAI in enterprise settings. Leading companies launched pilot programs that integrated GenAI capabilities into their digital platforms, aiming to improve integrated business planning and decision-making processes. These initiatives demonstrated the potential of GenAI to enhance operational metrics, such as forecast accuracy and inventory management, leading to substantial productivity gains.

Another key trend in 2024 was the maturation of GenAI technologies beyond the initial hype phase based on experimental applications discussed in Vujović [52]

and a move to practical implementations, where GenAI, in tandem with other AI technologies, is used to standardize processes and deliver tangible benefits (results). Industry leaders emphasized the importance of moving beyond the novelty of GenAI and focusing on its real-world applications to drive innovation and efficiency.

Furthermore, the widespread adoption of GenAI was already evident across various business functions. A McKinsey survey [44] revealed that 65% of organizations were regularly using GenAI in at least one business function (most commonly in marketing, sales, and product development) where it generated significant value. This enabled companies to streamline workflows, enhance customer experiences, and develop innovative products and services, thereby reinforcing the transformative impact of GenAI on the global economy. These developments underscored the growing importance of GenAI as a powerful tool to achieve competitive advantages and drive growth through technological innovation such as:

- *Improved Model Capabilities*: Large Language Models (LLMs), such as OpenAI's GPT-4 and Google's Gemini 2, demonstrated unprecedented capabilities in reasoning, collaboration, and multimodal understanding. As Korinek discussed in [37], [38] and [39], model functionalities were expanded to include more robust decision-making, ethical reasoning, and real-time adaptability. Multimodal systems became more integrated, allowing seamless transitions between text, image, and video generation, paving the way for enhanced user applications in industries like healthcare, media, and education.

- *Personalization and Context-Awareness:* During 2024, GenAI models achieved a new level of contextual understanding and personalization to adapt to individual user needs, leveraging advancements in reinforcement learning from human feedback (RLHF) and fine-tuned datasets specific to individual users or organizations. This progress facilitated the development of personalized education systems, healthcare diagnostics, and customer service platforms.

- *Energy Efficiency and Sustainability:* Responding to growing environmental concerns, GenAI models

saw breakthroughs in energy-efficiency during 2024 both through innovations in hardware and software optimization techniques.

- *Autonomous Agents and Collaboration:* Generative agents, which autonomously perform complex tasks while collaborating with humans and other AI systems, were deployed in sectors ranging from legal services to financial markets, offering automated high-level decision-making processes while ensuring alignment with human objectives.

This enabled enhanced integration into industries and research such as:

- *Healthcare and Biotech:* GenAI allowed drug discovery and personalized medicine, leading to a reduction in the cost and time required for clinical trials. Healthcare providers utilized AI-powered diagnostics and treatment recommendation systems to improve patient outcomes.

- *Economic Research and Policymaking*: Economists and policymakers adopted GenAI to model macroeconomic scenarios, simulate policy impacts, and analyze real-time data. This enabled more responsive and evidence-based decision-making. Enhanced forecasting tools predicted inflation, unemployment, and market trends with greater accuracy, informing central bank policies and fiscal interventions.

- *Creative Industries:* AI-generated content became a staple in entertainment, advertising, and journalism. Models capable of producing high-quality, human-like narratives and visuals disrupted traditional workflows while raising questions about intellectual property and creative authorship.

The fast development of GenAI models and agents raised some challenges and ethical considerations requiring:

- *New Regulatory Developments:* National and international regulatory frameworks for AI, such as the EU AI Act, are needed to balance innovation with ethical considerations (data privacy, algorithmic fairness, and accountability in decision-making).

- *Treatment of Bias and Inequality:* Despite advancements, challenges remain regarding unintended algorithmic bias and the potential exacerbation of socioeconomic inequalities. The digital divide widened as high-resource nations and organizations capitalized on AI innovations while low-resource settings lagged behind. Policymakers and researchers called for more inclusive AI development practices to bridge these gaps.

- *Misinformation and Content Authenticity:* The proliferation of AI-generated content heightened concerns about possible misinformation (hallucinations) and the use of deep-fake technologies. While AI-driven detection tools improved, the arms race between creators and regulators underscored the need for continued vigilance and proactive measures.

The developments in AI and GenAI during 2024 underscored their transformative potential while highlighting the need for sustainable and equitable integration into society. Future research and policy should focus on aligning these technologies with societal values, addressing ethical challenges, and ensuring broad-based benefits. As organizations continue to explore and implement GenAI technologies, the potential for further advancements and applications remains vast. GenAI output, which closely resembles human outputs, has profound implications for economic growth, research, and policymaking. As a transformative general-purpose technology, GenAI holds the potential to boost productivity by automating and augmenting cognitive tasks, drive innovation by accelerating research and development cycles, and enhance macroeconomic policymaking through data-driven insights and predictive capabilities. GenAI models, particularly large language models (LLMs) like OpenAI's GPT series or Google's BERT, are capable of performing complex tasks traditionally associated with human cognition, such as writing, translating, and even generating novel research ideas [24]. In the context of economic growth, GenAI can enhance productivity by automating cognitive tasks, facilitating faster and more efficient decision-making, and accelerating the innovation process across various sectors [29]. In economic research, GenAI tools enable economists to quickly process large volumes of data, identify new research avenues, and generate novel hypotheses, which could lead to breakthroughs in theory and practice [37]. For macroeconomic policymaking, GenAI's predictive abilities and scenario modeling can

assist in crafting evidence-based policies and improving fiscal and monetary strategies [13].

The transformative potential of GenAI can reshape traditional economic paradigms. With advancements in machine learning and natural language processing, GenAI has the ability to reduce transaction costs, enhance the speed and accuracy of economic modeling, and democratize access to economic research. As such, understanding the implications of GenAI is crucial for economists, policymakers, and researchers who aim to harness its capabilities while managing the associated risks, such as job displacement, inequality, and bias in algorithmic decision-making (see [24] and [46]).

The structure of the paper proceeds as follows: the next section provides a brief review of background and theoretical issues; Section 3 examines the multifaceted impact of GenAI on economic growth by exploring the potential for GenAI to drive productivity and innovation; Section 4 explores the implications for economic research, highlighting the role of GenAI in data processing and hypothesis generation and testing; Section 5 discusses the potential applications of GenAI in macroeconomic policymaking, particularly in forecasting and real-time policy evaluation; Section 6 considers the challenges and risks associated with GenAI, including ethical concerns and the digital divide; the last section concludes.

Background and Theoretical Considerations

Existing research on artificial intelligence (AI) and economic growth highlights its transformative potential as a general-purpose technology capable of driving productivity, innovation, sectoral and employment shifts. It is estimated that close to 80% of jobs in the U.S. economy could see at least 10% of their tasks done twice as quickly with generative AI. Andrew McAfee's report [42] delves into the transformative potential of GenAI on the economy. GenAI enables widespread productivity gains by enabling tasks to be completed more quickly and efficiently. This technology is already delivering large productivity gains, which will increase and spread over time as people and organizations come up with complementary innovations that leverage generative AI's capabilities.

McAfee's report concludes that GenAI can be considered a "general-purpose technology" powerful enough to accelerate overall economic growth and promote innovations with the potential to positively transform economies and societies. Unlike previous general-purpose technologies, such as the steam engine, electrification, and internal combustion engine which brought changes over decades, GenAI's effects are anticipated to be felt more quickly due to its ability to diffuse rapidly via existing infrastructure (the internet) and its ease of use owing to its natural language interface. This technology is already resulting in overall productivity improvements enabling the acceleration of economic growth.

Generative AI will reduce demand for some skills, increase demand for others, and create demand for entirely new job categories. Fears of large-scale technological unemployment are probably overblown. The history of general-purpose technologies shows that the growth they bring is accompanied by strong demand for labor, albeit often in new occupations: more than 85% of total U.S. employment growth since 1940 has come in entirely new occupations.

The rapid changes brought by generative AI will require prompt and effective reskilling efforts. Generative AI itself can be a valuable tool in this effort and in improving the performance of entry-level employees and in addressing wage inequality. Because generative AI accumulates knowledge and makes it available on demand, it is particularly effective at improving the performance of entry-level employees.

Multiple authors emphasize that AI catalyzes growth by enabling more efficient resource allocation and fostering innovation through enhanced decision-making and prediction capabilities. Acemoglu and Restrepo [2] explore AI's dual impact on productivity and labor markets, noting that while automation displaces certain tasks and jobs, it also generates new opportunities and jobs in complementary sectors. Additionally, Brynjolfsson, Rock, and Syverson [22] argue that AI technologies amplify human capital by automating routine tasks and allowing workers to focus on higher-value activities, contributing to overall economic growth. They also emphasize the productivity paradox associated with AI, noting that

measurable gains often lag behind initial adoption due to the need for complementary organizational changes and workforce adaptation. Most studies caution against uneven adoption and potential disparities, highlighting the importance of policy interventions to manage transitions and distributional impacts.

The role of AI in economic research and policymaking has also received significant attention. AI-driven tools have been shown to enhance economic research by automating literature reviews, generating hypotheses, and processing large datasets, as demonstrated by McKinsey Global Institute surveys and report [43]. Tools such as machine learning models and generative AI systems enable predictive analytics for macroeconomic indicators and scenario analysis, offering valuable insights for fiscal and monetary policy. For instance, the IMF has used AI to forecast inflation trends and identify financial vulnerabilities, thus improving policy responsiveness. Despite its promise, scholars underscore the need for frameworks to address risks such as algorithmic bias and lack of transparency, advocating for the development of ethical and regulatory standards to guide AI's integration into economic research and governance.

On the policy front, McKinsey Global Institute's annual "State of AI" surveys [44] illustrate how AI accelerates decision-making by improving forecasts for inflation, labor market trends, and fiscal policies. Similarly, the IMF recent studies highlight the utility of machine learning models in real-time monitoring of systemic financial risks, enabling policymakers to respond more effectively to emerging crises. Despite these advancements, many studies caution against uneven AI adoption, stressing that disparities between regions and sectors could exacerbate inequality and hinder inclusive growth. Together, these studies illuminate both the opportunities and challenges AI presents for economic research and policymaking, underscoring the need for adaptive strategies to maximize benefits while mitigating risks.

The theoretical framework for understanding how Generative Artificial Intelligence (GenAI) influences productivity and economic growth can be built around the traditional notion of technological progress and its effects on factor productivity. As with past technological revolutions, GenAI reduces the cost of performing specific tasks and allows for more efficient allocation of resources. One key mechanism through which GenAI influences productivity is by automating cognitive tasks traditionally performed by humans. This automation frees up human labor to focus on higher-value activities, potentially boosting overall economic output [24]. GenAI can reduce the time and cost associated with data analysis, decision-making, and draft content generation, allowing firms to achieve higher productivity without increasing their labor inputs [29]. In economic research, AI models can quickly process large datasets, identify trends, and generate new hypotheses, effectively accelerating the pace of knowledge creation and innovation [38].

Another significant mechanism through which GenAI influences productivity is its ability to reduce transaction costs, a concept central to economic theory (Coase theorem). Transaction costs refer to the costs associated with coordinating economic activity, including search, information, bargaining, and enforcement costs. By automating tasks related to these activities, GenAI reduces the friction involved in transactions across a variety of industries. In the financial sector, AI-powered tools such as chatbots and algorithmic trading platforms help reduce the costs of customer service and market research, while enhancing the speed and accuracy of trading strategies [19]. Similarly, in the manufacturing sector, AI can streamline supply chain management by predicting demand more accurately and optimizing production schedules, thus reducing the need for costly inventory management [24].

GenAI also plays a crucial role in enhancing innovation. By automating certain aspects of the research and development (R&D) process, it allows firms to redirect resources toward more complex and creative tasks. This is particularly evident in industries where GenAI assists in ideation and prototyping. In biotechnology, for example, GenAI is used to design novel proteins, accelerating the development of new drugs and medical treatments. In creative industries, GenAI provides tools that assist in generating novel content, allowing creators to experiment with new ideas and rapidly prototype designs. The role of GenAI in facilitating faster innovation cycles aligns with endogenous growth theory, which emphasizes the

role of knowledge and technological progress in driving long-term economic growth. By enhancing the speed and scale of innovation, GenAI contributes not only to sector-specific productivity improvements but also to broader economic growth by fostering technological diffusion and cross-industry spillovers.

Finally, GenAI improves decision-making processes by providing more accurate, data-driven insights and enhancing the ability of firms and policymakers to predict economic outcomes. Through the use of predictive modeling and scenario analysis, GenAI enables decision-makers to assess the potential impacts of various economic policies or business strategies before implementation [13]. In the context of macroeconomic policymaking, for instance, AI-driven models can simulate the effects of changes in fiscal or monetary policy on key indicators such as inflation, unemployment, and GDP growth. By integrating large datasets and real-time information, GenAI helps policymakers make more informed decisions, reducing the uncertainty inherent in economic forecasting [8]. This improvement is critical for maintaining economic stability and fostering growth in an increasingly complex and interconnected global economy.

The integration of Artificial Intelligence (AI) into economic theory and practice has garnered increasing attention in recent years, particularly with regard to its potential to drive economic growth. Early studies on AI's economic impact focused largely on automation's effect on productivity, labor markets, and industrial organization [24]. These works primarily emphasized the role of AI in automating routine tasks, which is expected to enhance productivity by allowing workers to focus on higher-value activities [1]. More recently, research has shifted towards understanding how advanced AI, particularly generative AI models, can influence innovation, knowledge creation, and decision-making processes. Chui et al. [29] explore how AI is poised to drive productivity gains across a range of sectors, from healthcare to finance, by automating cognitive tasks that were traditionally carried out by skilled professionals. This broader conception of AI's potential challenges previous productivity theories, suggesting that AI not only replaces certain types of labor but also augments human creativity and problem-solving abilities [24].

In terms of economic research, AI, and more specifically, GenAI models such as OpenAI's GPT-4 and Google's BERT, are reshaping the methodologies employed by economists. Korinek [38] notes that these advanced AI systems have significantly improved the efficiency and scope of economic analysis by automating data analysis, model testing, and hypothesis generation. AI tools allow researchers to process and analyze large datasets far more efficiently than traditional methods, thereby expanding the range of economic questions that can be tackled within the same time frame. Additionally, as observed by Brynjolfsson et al [19], GenAI's ability to generate natural language text from structured data has been particularly useful in literature reviews, allowing researchers to synthesize vast quantities of academic work and identify new research directions more effectively.

The role of AI in policymaking is another area of significant interest in the literature. Several studies have explored how AI can improve the design and evaluation of macroeconomic policies. For instance, Binns [13] discusses the potential of AI-driven models to assist in scenario analysis, enabling policymakers to simulate the effects of different policy interventions on economic variables such as inflation, unemployment, and GDP growth. These AI models can also enhance real-time policy monitoring by identifying early warning signs of economic instability or financial crises, as demonstrated in recent applications in financial market monitoring by Tufano et al. [49]. Furthermore, the ability of AI to forecast economic trends with greater accuracy than traditional econometric models suggests that its role in guiding monetary and fiscal policies could become increasingly important in the future [8]. These studies illustrate that the role of AI in economic research and policymaking is expanding rapidly, with profound implications for the way economists conduct research, design policies, and interpret economic phenomena.

Impact on Economic Growth

The impact of Generative AI (GenAI) on economic growth is multifaceted, with potential productivity improvements across a variety of sectors. In industries

such as manufacturing, healthcare, and finance, GenAI has demonstrated its capacity to reduce inefficiencies and automate labor-intensive tasks, which in turn enhances overall productivity. In manufacturing, AI-powered systems optimize production schedules, predict demand with greater accuracy, and reduce the need for costly inventory management, all of which contribute to lowering costs and improving the efficiency of the production process [24]. In healthcare, GenAI has revolutionized diagnostic processes by analyzing medical images, interpreting lab results, and even predicting patient outcomes with a level of precision that exceeds traditional methods. This not only improves healthcare delivery but also increases productivity by allowing healthcare professionals to focus on more complex tasks that require human judgment and expertise [29]. In finance, GenAI has facilitated the automation of customer service and fraud detection, thereby reducing costs and improving decision-making [13]. By enhancing productivity, these improvements contribute to overall economic growth.

Beyond productivity, the adoption of GenAI also has profound implications for labor markets, capital allocation, and R&D investments. The displacement of routine and cognitive tasks by AI has led to significant shifts in labor markets. While automation has replaced some low-skill and repetitive jobs, it has also created demand for higher-skilled positions in AI development, data science, and machine learning engineering [21]. Furthermore, GenAI's ability to enhance decision-making processes in both the private and public sectors can lead to more efficient capital allocation [29] which, in turn, also encourages higher levels of investment in R&D, as firms seek to remain competitive in an AI-driven economy. Overall, GenAI has the potential to foster a surge in technological advancements, further accelerating economic growth [38].

The Macroeconomic Impact of GenAI on Growth

The macroeconomic impact of GenAI is seen through its potential to drive productivity, economic growth, and innovation across a variety of sectors. Labor market disruption, wage polarization, and economic inequality are potential challenges. To harness the full potential of GenAI while minimizing its risks, policymakers need to adopt strategies that promote inclusive economic growth, invest in education and reskilling, and ensure equitable access to AI technologies. As GenAI continues to evolve, its role in shaping the future of economies around the world will be increasingly central to discussions on sustainable development and global prosperity. The macroeconomic impact can be observed through several key dimensions:

Productivity and Economic Growth: GenAI has the potential to significantly boost productivity across various sectors by automating complex cognitive tasks, improving efficiency, and accelerating innovation. By streamlining processes in many industries, GenAI reduces costs, increases output, and enhances the speed of decision-making. AI-driven systems help optimize production and inventory management, enable faster prototyping, modeling, research, and facilitate the development of new products and services. In healthcare, AI systems accelerate diagnostic processes and drug discovery, enhance patient outcomes, and help address complex global health challenges. These productivity gains lead to increased economic growth, with a positive spillover effect on broader economic activity. The underlying advancements in technology can drive long-term growth by creating new markets and improving the overall efficiency of existing industries.

Labor Market Disruptions and Wage Polarization: The integration of GenAI into the economy is expected to have a profound impact on labor markets. While AI automation can displace workers in routine, low-skill jobs, it also creates demand for high-skill workers, particularly in AI-related fields like data science, machine learning, and systems engineering. This shift is likely to exacerbate wage polarization, allowing high-skilled workers in AI-intensive sectors to capture a disproportionate share of economic gains, while low-skill workers face greater displacement risks and stagnant wages. The growing reliance on AI also accelerates the shift from manual labor to cognitive labor, which will require substantial investments in reskilling and workforce development in line with new technological demands. Policymakers will need to implement measures to address these inequalities through education reforms and social safety nets to support displaced workers.

Capital Allocation and Investment: GenAI can transform the way capital is allocated in the economy. By enhancing the precision of forecasting and risk assessment tools, AI enables more efficient investment decisions in both private and public sectors. AI-powered tools will allow firms and financial institutions to better assess market trends, optimize resource allocation, and manage investment portfolios, which can improve the overall efficiency of capital markets. Moreover, AI's ability to accelerate research and development (R&D) cycles by optimizing simulations, modeling, and experimentation is likely to spur further investment in innovation and R&D. This in turn, can lead to long-term technological advancements, driving sustained economic growth.

Macroeconomic Policy Design and Forecasting: GenAI has the potential to revolutionize macroeconomic policy design and forecasting. AI-driven models allow for the simulation of a wide range of economic scenarios, enabling policymakers to better understand the potential effects of fiscal and monetary policies before implementation. GenAI models can model more realistically the real-life impacts of tax cuts, stimulus packages, or interest rate adjustments, thus helping governments to anticipate outcomes more accurately and make more informed policy decisions.

AI's ability to process vast amounts of real-time data also improves forecasting capabilities, providing more timely predictions of key economic indicators such as inflation, unemployment, and GDP growth. Traditional econometric models often struggle to account for the complexities and volatility of modern economies, especially in the face of external shocks like financial crises or pandemics. GenAI's enhanced forecasting ability can help governments and central banks to more effectively respond to economic fluctuations and adapt policies in real time.

Economic Inequality and Distribution of Wealth: The macroeconomic impact of GenAI is also closely tied to its effects on economic inequality. The automation of cognitive tasks and the increased demand for high-skill labor are likely to widen the gap between high- and low-income individuals and sectors. The benefits AI-driven productivity and wealth increases may be disproportionately concentrated in AI-intensive industries, leaving other sectors and workers behind. This could exacerbate existing disparities in wealth and income if not corrected by policy measures aimed at mitigating the potential for widening inequality. These could include progressive taxation, universal basic income, and policies aimed at improving access to education and training for displaced workers or lower income groups.

Global Economic Integration and Competitiveness: GenAI has the potential to further integrate the global economy by enabling faster communication, cross-border trade, and the development of global supply chains. AI-powered tools can optimize logistics, predict demand more accurately, and reduce trade barriers, fostering greater global economic interconnectedness. However, this also raises concerns about global competition and the potential concentration of AI capabilities in a few large tech firms or advanced economies. The dominance of AI-driven companies in a few countries could lead to economic imbalances and exacerbate the digital divide between nations. To address these challenges, international cooperation and governance frameworks will be essential. Ensuring that AI development is inclusive and accessible across borders can help ensure that all nations can benefit from AI's potential and prevent the monopolization of AI technologies by a few actors.

The Microeconomic Impact of GenAI on Growth

The microeconomic level impact of GenAI has the potential to stimulate significant growth by enhancing firm-level productivity, reducing costs, fostering innovation, introducing new products, improving resource allocation, and gaining a competitive edge in the market. AI enables firms to operate more efficiently by automating routine tasks and augmenting the productivity of high-skilled workers. This transformation also requires firms to invest in workforce development to acquire the skills needed in an AI-driven environment. Ultimately, the widespread adoption of GenAI has the potential to drive growth at the firm level, with broader implications for industry dynamics and economic expansion. The microeconomic impact of GenAI can be observed through the following dimensions:

Productivity Enhancements: GenAI is a powerful tool for increasing productivity within firms by automating repetitive, labor-intensive tasks, augmenting labor productivity in non-repetitive tasks and improving decision-making processes. In manufacturing, GenAI can optimize production schedules, predict equipment failures, and streamline supply chains, enable faster production times and cost savings. In services, AI-driven automation improves efficiency by handling routine inquiries and data processing tasks, allowing human employees to focus on more complex, value-added activities.

The cumulative effect of these firm-level productivity gains will contribute to overall economic growth as more output will be produced with fewer inputs, raising the potential for higher profits, wages, and economic output in the long term.

Cost Reduction and Efficiency: GenAI's ability to identify inefficiencies in operations, reduce waste, and achieve substantial cost reductions. In retail, for example, AI systems can forecast demand more accurately and allow optimized inventory management. Lower costs and increased operational efficiency will generate savings that can be invested in expanding production, increasing marketing efforts, or developing new products and services, thereby fostering microeconomic growth.

Innovation and Product Development: GenAI accelerates innovation by enhancing firms' ability to develop new products, services, and business models. AI-driven tools allow businesses to rapidly prototype and test new concepts, simulations, and designs. AI is already being used to speed up drug discovery, software development and access to new technology. The increased pace of innovation enables firms to compete, attract new customers, and expand their market share, contributing to microeconomic growth within individual sectors.

Labor Market Dynamics and Skill Development: GenAI can create some labor displacement in certain low-skill or routine jobs, as well as new opportunities for high-skill workers. GenAI will increase demand for hi-skill expertise in AI-related fields, such as machine learning, data analysis, and systems integration. Firms will invest in training and upskilling their workforce, promoting the development of new human capital, including retraining of workers displaced by AI-driven automation and allocating them to more strategic, creative, and decision-making roles. In the longer run, this may foster higher levels of human capital development, which can drive long-term growth and productivity improvements.

Competitive Advantage and Market Structure: The integration of GenAI can reshape the competitive landscape within industries. Firms that adopt AI technologies early gain a competitive edge by improving their operations and product offerings faster than competitors. They can enhance customer experience, optimize marketing, and streamline operations to secure a dominant position in the market. Furthermore, GenAI can lead to new business models and market structures. AI may enable the creation of personalized products or services at scale, or entirely new ways to connect with customers.

Market Efficiency and Consumer Welfare: Efficiencies brought about by GenAI will have positive implications for consumer welfare through lower prices and improved affordability for consumers. In retail and entertainment, GenAI will provide the ability to analyze consumer behavior and preferences and enhance the overall customer experience. This increased customization can drive higher levels of consumer engagement and spending, contributing to firm-level growth.

Resource Allocation and Capital Investment: GenAI improves resource allocation within firms by enabling more precise forecasting, optimizing supply chains, and streamlining production processes. Moreover, the application of AI in financial decision-making improves capital allocation decisions, as AI-driven tools can analyze large datasets to predict market trends, assess investment opportunities, and optimize portfolio management. By improving decision-making, firms can direct their capital more effectively toward high-return investments, further driving growth.

Empirical Studies

Empirical studies examining the impact of Generative AI (GenAI) on economic growth are still emerging. Two studies offer valuable insights into how AI, particularly generative models, affects productivity, innovation, labor

markets, and the measurement of GDP and broader economic performance.

The first, by Brynjolfsson and Collis [20], addresses the failure of GDP to capture the true value of often free digital goods and services provided by AI and delivered via the internet. They estimate that the median digital service client in the US is willing to pay annually more than USD 32 thousand for digital services (including USD 17.5 thousand for search engine services, USD 8.4 thousand for email, USD 3.6 thousand for maps/GPS, USD 1.2 thousand for video news clips and movies, and about USD 1.5 thousand for combined e-commerce-social media-music, and messaging).

Given that these services account for a substantial increase in well-being and underestimate the contribution of AI and GenAI services, they propose a revised measure of GDP: GDP-B, capturing the welfare gains (consumer benefits) of new and free goods and services.

The second is an ILO empirical study [33] study of GenAI potential effects on job quantity and quality based on task and occupational exposure to generative AI (particularly GPT-4). They find that clerical work is the most exposed, with 24% of tasks highly exposed and 58% moderately exposed. Other occupations have significantly lower exposure rates, with highly exposed tasks ranging between 1% and 4%, and medium exposure not exceeding 25%. The primary impact is expected to be the augmentation of workers' abilities by automating specific simpler tasks within jobs (such as data entry and info search), freeing up clerical workers time to engage in more complex problem-solving tasks. Certain tasks within jobs may be automated albeit full automation of occupations and jobs appears less likely at this stage. This could lead to changes in job roles and responsibilities, but not necessarily a reduction in overall employment given the expected expansionary impact of GenAI on economic growth.

Based on [33], the effects of Generative AI may vary significantly across countries and gender. In high-income countries, 5.5% of total employment is potentially exposed to automation, compared to just 0.4% in low-income countries. This disparity is due to differences in occupational structures and the availability of IT infrastructure to support AI integration. The study finds that AI-induced automation and augmentation are more likely to affect clerical jobs, given their significant representation in jobs exposed to AI.

The potential effects on job quality (increased work intensity or reduced autonomy) need to be managed properly to support quality employment and transition to AI-based systems and tools. Social dialogue is needed to ensure that the integration of AI into the workplace benefits all workers, companies, and society as a whole.

According to [33], tasks and occupations most exposed to GenAI automation are:

- Clerical and Administrative jobs, involving tasks such as data entry, scheduling, and basic customer service, which are repetitive and routine,
- Basic analytical jobs, including routine data analysis and reporting,
- Simple content creation jobs, such as drafting standard documents, generating routine reports and marketing materials.

On the other end of the labor market spectrum, GenAI will generate new demand for high skills in:

- AI and machine learning expertise (in neural networks, large datasets and natural language processing),
- Programming and software development (with proficiency in Python and prompt engineering skills),
- Advanced data analysis skills and big data management critical for training AI models,
- Understanding and implementing ethical guidelines for AI development and deployment,
- AI integration and deployment of AI into existing systems and workflows,
- General AI strategic management skills.

As ILO study [33] concludes, policies that support orderly and fair labor market transition should reflect:

- Displacement of jobs (involving routine and repetitive tasks),
- Augmentation of existing jobs by automating routine tasks,
- Creation of new job opportunities, particularly in tech-related fields and creative jobs,
- Potential skill adaptation to work effectively alongside AI (including digital literacy, data analysis, and the ability to interpret AI-generated insights),

- Uneven sector-specific impacts in high-tech and science (STEM) fields, creative and service industries.

Transformation of Economic Research

Generative AI (GenAI) has significantly accelerated data analysis, modeling, and hypothesis generation in economic research, transforming how economists process information and generate insights. By leveraging advanced machine learning models such as large language models (LLMs), GenAI enables researchers to analyze vast datasets with unprecedented speed and accuracy. For example, tools like OpenAI's GPT-4 can summarize complex economic literature, extract relevant data, and identify trends across studies, streamlining the traditionally labor-intensive process of literature reviews. Similarly, natural language processing (NLP) systems are used to analyze text-based datasets, such as policy documents or consumer sentiment surveys, uncovering patterns and relationships that inform economic modeling and policy decisions. These capabilities not only enhance the efficiency of existing research workflows but also open avenues for exploring previously intractable questions.

In modeling, GenAI has proven invaluable for improving the precision and scalability of economic simulations. Machine learning frameworks can integrate vast and heterogeneous datasets – such as trade flows, labor market dynamics, and financial transactions – into predictive models that generate robust forecasts and counterfactual scenarios [50]. For instance, during the COVID-19 pandemic, AI models were used to simulate the economic impact of policy measures, such as stimulus packages and lockdowns, providing real-time guidance to policymakers [28]. Additionally, GenAI tools have been employed to optimize macroeconomic forecasting, with models like OpenAI's Codex assisting in the development and testing of econometric code, reducing time spent on technical implementation.

GenAI also facilitates hypothesis generation by identifying novel patterns in data and proposing testable economic theories. By analyzing correlations and causal relationships across large datasets, AI systems can pinpoint underexplored areas in existing literature or suggest new

variables to consider in economic models. For example, NLP tools have been used to analyze the historical relationship between public sentiment and market fluctuations, revealing nuanced dynamics that traditional econometric methods might overlook, as stressed by Brynjolfsson and McElheran [23]. This capability not only enhances the rigor of economic research but also democratizes access to advanced analytical tools, allowing researchers in resource-constrained environments to contribute to the global body of knowledge.

The adoption of specific GenAI tools in economic research underscores their growing relevance. GPT models assist with text-based tasks such as drafting reports, analyzing survey responses, and summarizing academic papers. NLP systems like Google's BERT are employed for sentiment analysis and policy evaluation, while machine learning platforms (such as TensorFlow and PyTorch) facilitate large-scale data analysis and predictive modeling. As these tools become more integrated into economic research workflows, they promise to not only enhance productivity but also expand the frontier of economic inquiry, though their adoption must be accompanied by critical evaluation to address issues of bias, transparency, and accessibility.

Korinek [38] provides a comprehensive examination of the evolving role of large language models (LLMs) in economic research, with a particular focus on their collaborative and reasoning capabilities. He highlights the significant recent advancements in LLMs' ability to reason and work collaboratively with human researchers, enhancing the efficiency and scope of economic analysis. The ongoing maturation of AI tools, which have transitioned from mere search engines and computational assistants to active contributors to the research process, enabling more robust analysis, hypothesis generation, and scenario testing.

LLMs can now assist in addressing complex economic questions by improving data processing, synthesizing large volumes of literature, and generating novel insights through advanced reasoning capabilities. Korinek [38] identifies the growing ability of LLMs to collaborate with human researchers in iterative problem-solving, facilitating a more dynamic and interactive research process. These developments have profound implications for the speed

and breadth of economic inquiry, enabling researchers to tackle previously intractable problems more efficiently. He discusses the potential for LLMs to enhance the reproducibility of economic research by standardizing the processes of data analysis and model development, but cautions about the limitations of LLMs, particularly in their ability to address complex causal relationships and their susceptibility to biases embedded in training data, which necessitates careful scrutiny by researchers.

Implications for Macroeconomic Policy

The advent of GenAI holds significant implications for the design, forecasting, and evaluation of macroeconomic policies. One of the key ways in which GenAI can contribute to policy design is through its enhanced big data handling and modeling capabilities. By leveraging machine learning algorithms, AI can simulate a wide range of economic scenarios and model complex systems that were previously difficult to capture using traditional econometric techniques. AI-driven models can simulate the effects of fiscal interventions such as stimulus packages, tax cuts, or government spending, providing policymakers with a clearer understanding of potential outcomes under varying conditions. This ability to model counterfactual scenarios allows for more informed policy decisions, as AI tools can predict the potential economic consequences of different policy measures before they are implemented [23]. Additionally, AI models can be used to optimize policy interventions in real-time, adapting to changing economic conditions and ensuring that fiscal and monetary policies remain effective under evolving circumstances [38].

GenAI's ability to improve forecasting in macroeconomics represents another transformative change in the field. AI models, particularly those using large-scale data analysis, can improve predictions of key macroeconomic variables such as inflation, unemployment, and GDP growth. Traditional econometric models often struggle with capturing the complexities of modern economies, especially in the face of shocks such as financial crises or pandemics. However, machine learning techniques, including neural networks and time series forecasting,

can process vast amounts of real-time data, identifying patterns and trends that might otherwise be missed. For instance, AI-powered tools can integrate a wide variety of economic indicators, such as employment rates, consumer sentiment, and international trade flows, to generate more accurate and timely forecasts [50]. During the COVID-19 pandemic, AI models were used to predict the economic impact of lockdowns and government policies, offering policymakers a critical tool for navigating uncertainty [28]. The ability to predict economic outcomes with greater precision enables governments and central banks to make more informed decisions about interest rates, fiscal stimulus, and other macroeconomic policies.

Furthermore, GenAI plays a crucial role in the real-time evaluation of policy outcomes. Traditional economic evaluation methods often rely on slow, retrospective analysis, which can delay the assessment of policy impacts. In contrast, AI tools can provide continuous feedback by processing and analyzing data as it becomes available. This capability enables real-time monitoring of macroeconomic indicators and the effectiveness of policy interventions. For example, AI can assess the impact of a new tax policy on consumer spending, track shifts in unemployment following a stimulus program, or analyze the effects of monetary tightening on investment levels. By providing immediate insights, AI tools allow policymakers to make timely adjustments to policies, thereby enhancing their ability to respond to changing economic conditions. In this sense, AI does not only serve as a forecasting tool but also as a dynamic feedback mechanism that ensures policies remain adaptive and relevant in an increasingly complex global economy.

In sum, GenAI is revolutionizing macroeconomic policy by improving the design, forecasting, and evaluation of economic interventions. Its ability to model complex economic systems, predict key variables with greater accuracy, and provide real-time feedback positions AI as a transformative tool for policymakers. As AI continues to evolve, it is likely that these tools will become central to economic decision-making, enhancing the responsiveness and effectiveness of macroeconomic policies in addressing the challenges of a rapidly changing world.

Korinek's work [39] addresses the profound implications of generative AI (GenAI) and large language models (LLMs) on economic theory, research, and policymaking. He argues that the rapid development of AI technologies, particularly in the context of LLMs, represents a paradigm shift for the economy and poses significant challenges for economic policy. There are several critical areas where AI will directly influence structural issues including inequality, labor markets, and the allocation of resources. AI's potential to enhance productivity and innovation also raises concerns regarding its effects on income distribution, as automation may displace workers in low-skill sectors while simultaneously increasing demand for highly skilled workers in technology-driven industries.

AI also presents policy challenges in areas such as education, social stability, macroeconomic management, antitrust regulation, intellectual property, and environmental sustainability. Proactive policy measures are needed to ensure equitable distribution of benefits of AI-driven growth, while mitigating risks associated with economic disruption and technological monopolies. Global cooperation on AI governance is needed, given the cross-border nature of AI's impact and the necessity of establishing international frameworks for effective regulation and ethical use, while also ameliorating the growing digital divide.

Korinek [39] underscores that AI's rapid development is not just a technological shift but a paradigm change that will reshape key facets of economic theory and practice. He asserts that while AI has the potential to significantly boost productivity, enhance innovation, and drive economic growth, it also brings a host of challenges that require careful policy consideration. A case in point is the potential GenAI impact on economic inequality. By automating cognitive tasks traditionally performed by humans and augmenting labor productivity in high-skilled jobs, GenAI is likely to exacerbate wage polarization, as low-skilled workers in routine jobs may face displacement, while demand for high-skilled workers in AI-related fields increases. Potentially, we may observe a growing divide between sectors that are AI-intensive and those that are not, and the implications for income distribution across different skills and socioeconomic groups. This trend will necessitate targeted policy interventions in education and

workforce development to ensure that individuals can adapt to the new demands of the labor market.

Macroeconomic implications of AI adoption may also be significant. The microeconomic displacement of labor through automation may lead to changes in aggregate demand, consumption patterns, and overall economic stability. This, in turn, raises concerns about the long-term effects of AI on traditional macroeconomic (fiscal and monetary) policy tools. Policymakers will need to adapt and recalibrate existing frameworks to address the economic shocks AI may produce. Moreover, Korinek [39] highlights the need for new regulatory approaches to manage AI's role in market structures, including antitrust measures to prevent monopolistic practices by large AI firms, and intellectual property regulations to address the challenges posed by AI-driven innovation.

Social and political ramifications of widespread GenAI adoption are also significant. The risks of social opposition to growing use of AI and political instability (and even unrests) arising from job displacement and widening inequality must not be underestimated. Timely policies that promote social safety nets, fair distribution of AI's economic benefits, and investments in skills training to prepare the workforce for the new technological landscape are, thus, of utmost importance. The same principles apply to the environmental implications of AI, particularly regarding the high energy consumption required for large-scale machine learning models and sustainable AI development practices.

Given the cross-border nature of AI's development and deployment, a global governance framework for AI would be most appropriate, based on international cooperation, to ensure that AI technologies are developed and regulated in line with shared global prosperity, global standards on AI ethics, transparency, and accountability, to prevent AI from exacerbating global inequalities and to ensure that its benefits are widely shared.

Challenges and Risks

While GenAI offers significant opportunities for enhancing economic growth and efficiency, it also raises several challenges and risks that must be addressed to ensure that

its benefits are widely shared. These include algorithmic bias, job displacements, data privacy concerns, and increased inequality through the digital divide. Policymakers and economists must work collaboratively to develop solutions that mitigate these risks, ensuring that the deployment of GenAI leads to inclusive and sustainable economic outcomes.

Algorithmic bias, which arises from the data used to train AI systems, may inadvertently perpetuate or even exacerbate existing biases, leading to discriminatory outcomes in hiring, credit scoring, and law enforcement [46]. Thus, AI algorithms can reproduce racial and gender biases present in training datasets, which can result in unfair treatment and outcomes for marginalized groups [7]. Policymakers must address these biases through improved data governance and transparent AI models that can be audited for fairness [11].

Job displacements can be a significant challenge in sectors where routine cognitive tasks are common. AI's ability to automate tasks such as customer service interactions, document review, and data analysis raises concerns about the future of work, especially for workers in industries most susceptible to automation. Although AI will create new job opportunities, job displacements may disproportionately affect low- and middle-skilled workers, exacerbating income inequality and social stability [1] unless accompanied with reskilling and retraining programs and universal basic income initiatives to mitigate the negative effects on affected workers [12].

Data privacy is another critical issue. AI systems that rely on large-scale data collection, can inadvertently expose sensitive information or be vulnerable to data breaches, creating risks for individuals and organizations [54]. Robust data protection frameworks are needed to ensure that individuals' privacy rights are respected. Existing EU General Data Protection Regulation is an important step toward protecting data privacy which will need to be updated to address emerging threats.

Digital divide which refers to disparities in access to AI tools, poses another challenge that could exacerbate inequality between regions and countries. As GenAI systems become more integral to economic and social processes, the divide between those who have access to cutting-edge technologies and those who do not could widen, disproportionately impacting lower-income individuals and developing countries. Access to advanced AI tools requires not only physical infrastructure (reliable internet connectivity) but also the skills and resources to effectively utilize these technologies. Countries and communities that are unable to keep pace with technological advancements risk falling further behind economically, widening global inequality. As noted by Brynjolfsson and McAfee [24], the digital divide has the potential to concentrate economic power in technologically advanced regions while leaving others at a disadvantage. To mitigate these risks, it is essential that policy frameworks prioritize equitable access to education, infrastructure, and technology, ensuring that the benefits of AI are shared more broadly and reducing the risk of exacerbating existing inequalities [27].

As GenAI becomes an increasingly integral part of the global economy, policymakers must take proactive steps to promote equitable access to AI technologies. Programs that support the provision of affordable internet access, as well as AI technologies, are crucial for fostering inclusivity. Cooperation within countries (between developed urban and less developed rural areas) and internationally is vital to building the necessary technological and institutional frameworks to leverage AI for economic growth [27]. Ensuring that AI technologies are accessible to all segments of society can help to democratize the economic benefits of AI and prevent a concentration of power in technologically advanced regions. Investing in digital infrastructure, AI literacy, and reskilling effort are critical areas for policy action.

Finally, policymakers must establish robust ethical frameworks for the use of GenAI in decision-making and policymaking. As AI tools increasingly inform policy decisions, it is crucial to ensure that these systems operate in a transparent, accountable, and ethical manner. Ethical guidelines should focus on ensuring fairness in AI outcomes, preventing discrimination, and safeguarding privacy rights (confirmed with regular AI audits for fairness, transparency, and compliance with ethical standards) [11].

Conclusion

Generative artificial intelligence (GenAI) has emerged as a general-purpose technology, a transformative force with

profound implications for economic growth, research, and policymaking. As evidenced throughout this paper, the integration of GenAI into various sectors offers the potential to enhance productivity through automation, improve decision-making, and accelerate innovation. By automating cognitive tasks across industries, such as legal document processing, healthcare diagnostics, and financial analysis, GenAI promises to reduce transaction costs and streamline processes [24]. Moreover, the ability of GenAI models to simulate economic scenarios, predict macroeconomic variables, and generate new hypotheses opens up new avenues for economic research and policy design [29]. However, as this technology rapidly evolves, it also brings significant challenges, including risks related to job displacement, algorithmic bias, and ethical concerns [46]. These potential disruptions necessitate thoughtful policy interventions to ensure equitable access, mitigate negative social impacts, and promote responsible use of AI in decision-making.

The transformative potential of GenAI is undeniable if accompanied by rigorous research to address the complex challenges it poses. Future research should focus on the long-term effects of GenAI on labor markets, the evolution of capital allocation in AI-driven economies, and the implications of AI for global inequality [24]. Additionally, further investigation into the ethical dimensions of AI, particularly concerning bias and accountability in algorithmic decision-making, is critical for ensuring that AI technologies are deployed in ways that benefit society as a whole [11]. As the capabilities of GenAI continue to expand, interdisciplinary research of its economic, social, and regulatory impacts will be crucial for shaping sustainable growth while safeguarding individual rights and societal well-being. Lastly, future research should explore the intersection of GenAI and global governance to manage the potential geopolitical risks associated with the uneven distribution of AI technologies [27]. By addressing these research gaps, policymakers and scholars alike can better navigate the opportunities and risks presented by GenAI in the years to come.

Tentative general policy recommendations for Serbia coming out of this paper include suggestions to:

- *Ensure equitable distribution of AI benefits:* As generative artificial intelligence (GenAI) becomes an increasingly integral part of the global economy, policymakers must take proactive steps to ensure that its benefits are equitably distributed, and its risks are mitigated.

- *Provide equal access:* Programs that support the provision of affordable internet access, as well as AI technologies, are crucial for fostering inclusivity. International cooperation is also vital, as developing nations may need support in building the necessary technological and institutional frameworks to leverage AI for economic growth [27]. Ensuring that AI technologies are accessible to all segments of society can help to democratize the economic benefits of AI and prevent a concentration of power in technologically advanced regions.

- *Reduce digital divide:* The rapid development and deployment of AI systems have the potential to exacerbate existing inequalities, particularly between developed and developing countries, as well as within societies where access to technology is uneven [24]. Policymakers should focus on reducing the digital divide by ensuring that marginalized communities have the necessary infrastructure, skills, and resources to participate in and benefit from AI advancements.

- *Invest in digital infrastructure, AI literacy, and reskilling:* As AI systems continue to disrupt labor markets, particularly through automation, there is an urgent need for reskilling programs that can help workers adapt to the changing demands of the workforce. Reskilling initiatives should target workers in industries most susceptible to automation, such as manufacturing, retail, and customer service, with an emphasis on AI-related competencies. Public-private partnerships can be instrumental in these efforts through joint training programs and career transition support.

- *Establish robust GenAI ethical frameworks:* Since GenAI tools increasingly inform policy decisions, it is crucial to ensure that these systems operate in a transparent, accountable, and ethical manner. Algorithmic bias and lack of fairness are significant concerns that could undermine the legitimacy of AI-driven policies. Ethical guidelines should focus

on ensuring fairness in AI outcomes, preventing discrimination, and safeguarding privacy rights. AI audits and regular reviews of AI systems could help assess their fairness, transparency, and compliance with ethical standards. Moreover, policymakers should ensure that AI-driven decisions are interpretable and could be challenged if necessary.

This would help foster public trust in AI tools and ensure that they are used responsibly. Additionally, regulatory frameworks, such as the European Union's General Data Protection Regulation (GDPR), provide useful models for setting data protection and privacy standards that can be applied to AI technologies in various sectors. Establishing comprehensive ethical guidelines will be essential to managing the social and economic risks associated with GenAI, and to ensuring that its deployment serves the public good. In short, as GenAI continues to shape the national and global economy, policymakers must take action to promote equitable access to AI technologies, invest in education and reskilling, and establish ethical frameworks for AI use. These policy recommendations are crucial for ensuring that the benefits of AI are widely shared, that individuals and communities are equipped to adapt to the changing labor market, and that the deployment of AI is transparent and accountable. By addressing these challenges, governments can harness the full potential of GenAI while safeguarding societal well-being.

It should be stressed that GenAI is revolutionizing macroeconomic policy by improving the design, forecasting, and evaluation of economic interventions. Its ability to model complex systems, predict key variables with greater accuracy, and provide real-time feedback positions GenAI models as a transformative tool for policymakers. In the near future AI will likely become central to economic decision-making, enhancing the responsiveness and effectiveness of macroeconomic policies. To follow this trend, macroeconomic policy in Serbia should actively pursue:

- *Changes in Policy Design* due to enhanced ability to model big data and allow the simulation of complex economic scenarios. This helps policymakers understand potential outcomes of fiscal and monetary interventions, leading to more informed decisions.

- *Improved Macroeconomic Forecasting* of key macroeconomic variables (such as inflation, unemployment, and GDP growth) by processing vast amounts of real-time data to identify patterns and trends often missed by traditional models.

- *Real-Time Evaluation and Feedback* on policy outcomes by analyzing data as it becomes available. This enables real-time monitoring of macroeconomic indicators and the effectiveness of policy interventions in economic and social dimensions, allowing for timely adjustments.

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COMPETITIVENESS OF GENERATIONS Z AND ALPHA IN THE AGE OF GENERATIVE AI

Konkurentnost generacija Z i Alfa u doba generativne veštačke inteligencije

Abstract

Major societal events such as wars, economic crises, and pandemics are key forces shaping generational identities and differences. However, technology also plays a pivotal role in defining each generation's experiences and opportunities. Millennials came of age during the rise of the Internet, when the ability to search for basic information online was considered revolutionary. Over time, the Internet has become the backbone of modern economies, commerce, and daily life. In contrast, Generation Z grew up in the era of smartphones and social media, experiencing unprecedented real-time connectivity. Simple functionalities like taking and posting photos directly from a phone redefined communication and self-expression, while social media platforms became indispensable tools for networking, job seeking, and information sharing. Technological advancements also shaped career trends, with Millennials gravitating toward computing and information technology. On the other hand, Generation Z pioneered entirely new professions, such as content creation, aimed at capturing and retaining audience attention. Currently, Generation Alpha is being raised in the transformative age of artificial intelligence. This generation will influence and be influenced by AI, engaging in a reciprocal relationship that will redefine the technological landscape and further shape generational dynamics in the years to come. For the purposes of this study, we conducted research among 505 members of Millennials, Generation Z, and Generation Alpha to understand the extent to which and the ways they use GenAI, as well as how they perceive the impact of this technology on their future.

Keywords: *GenAI, Artificial Intelligence Preparedness Index (AIPI), Global Talent Competitiveness Index (GTCI), Millennials, Generation Z, Generation Alpha, Serbia*

Sažetak

Veliki događaji, poput ratova, ekonomskih kriza ili čak pandemija, predstavljaju promene koje su oblikovale generacije i razlike među njima. Zajedno sa njima, značajan uticaj dolazi i iz razvoja tehnologije. Pre trideset godina, milenijalci su odrastali uz evoluciju interneta, kada je korišćenje interneta za pretraživanje osnovnih informacija bila mogućnost koja se smatrala izuzetnom. Danas je to temelj razvoja ekonomija, trgovine i samog društva. Pripadnici generacije Z odrastali su uz evoluciju pametnih telefona i društvenih mreža, gde je interakcija u realnom vremenu, zajedno sa najjednostavnijim funkcionalnostima poput slikanja i objavljivanja fotografije direktno sa telefona, predstavljala izuzetnu mogućnost. Danas su pametni telefoni uređaji koji su sastavni deo života svakog od nas, a društvene mreže neizostavna platforma za povezivanje, traženje posla i deljenje informacija. Uz razvoj interneta, među milenijalcima popularna zanimanja su se pronalazila u oblasti računarstva i informacionih tehnologija, dok je generacija Z stvorila potpuno nova zanimanja kreatora sadržaja za privlačenje pažnje publike. Danas, pripadnici generacije Alfa odrastaju u eri veštačke inteligencije, u kojoj ćemo takođe imati dvosmernu ulicu i interakciju u oblikovanju pejzaža u kome se razvija i ova nova tehnologija i sama generacija. Za potrebe ovog rada sproveli smo istraživanje među 505 pripadnika milenijalaca, generacije Z i Alfa kako bismo razumeli u kojoj meri i na koje sve načine koriste GenAI i kako vide uticaj ove tehnologije na njihovu budućnost.

Ključne reči: *generativna veštačka inteligencija, indeks pripremljenosti za veštačku inteligenciju (AIPI), globalni indeks konkurentnosti talenata (GTCI), milenijalci, generacija Z, generacija Alfa, Srbija*

Introduction

Two dominant trends have marked the last decade: very intensive technical and technological improvements, reflected in the fascinating growth of ICT, including the emergence of completely new AI concepts such as Generative AI (GenAI), socio-economic trends marked by COVID-19, the fragmentation of the global economy, the disappearance of the unipolar world, and finally, a series of new wars in the world.

Each generation is shaped by the context in which it grows, and over the past two years, we have placed a special focus on how emerging trends influence new generations. In last year's paper for the Kopaonik Business Forum (KBF) 2024, we highlighted how the development of the digital economy and the Fourth Industrial Revolution present new challenges for economic science, with a particular emphasis on the behavior of new generations – Gen Z and Alpha – as consumers [40]. In the paper for KBF 2023, we concluded that Gen Z in Serbia has clear expectations and demands of their future employers, prioritizing mental health, financial stability, and opportunities for advancement when selecting a job [39].

Generations Z (Gen Z) and Alpha are being educated in this very complex environment in which the Internet, networks, and AI permeate all spheres of the economy and society. Their predecessors, the Millennials, grew up with the evolution of the Internet, which could only be used to search for basic information at that time. In contrast, the AI can learn and make predictions based on its learning, while the GenAI can create completely new content. As Hamirani states, while AI should be thought of as a "highly skilled worker," GenAI should be seen as an "innovative artist or creator"[15].

With the development of the internet, popular careers among Millennials were found in the fields of computing and information technology. In contrast, Gen Z has created entirely new professions as content creators, capturing the attention of audiences. Now, Generation Alpha (Gen Alpha) is growing up in the era of artificial intelligence, where we are witnessing a two-way interaction shaping both this new technology and the generation itself. In this paper, we explore how the era of Generative Artificial Intelligence is impacting the current workforce – Millennials and Gen Z – how their jobs and roles within companies are evolving, and how the up-and-coming Gen Alpha is integrating GenAI into their daily lives.

GenAI Opportunities and Challenges

The world we live in today, with GenAI, has introduced a series of opportunities that can elevate our civilization to the highest levels, but it also presents enormous uncertainties and threats that could dehumanize it. In this critical period, as we stand at significant turning points, we must find the right solutions by carefully considering both opportunities and risks. In the search for these solutions, we will first examine the insights of the wisest minds – primarily leading Nobel laureates – before consulting other important institutions and authors.

Nobel laureate Michael Spence emphasizes that GenAI, along with other technologies, has the potential to drive a significant increase in global productivity [41]. To unlock its full economic potential, AI must be accessible to all sectors of the economy and equally available to all types of companies, from the largest corporations to SMEs. Spence argues that GenAI represents our best chance to alleviate supply-side constraints because it has the potential not only to reverse the trend of declining productivity but also to ensure sustainable productivity growth. However, he stresses the importance of overcoming the challenges it brings, particularly regarding the misuse of technology and data [41].

James Manyika and Michael Spence are convinced that GenAI can generate sustainable productivity gains [24]. They estimate that GenAI could increase global GDP by $4 trillion per year, with an additional $11 trillion coming from non-generative AI and other forms of automation. For comparison, the world's fourth-largest economy, Germany, produces approximately $4 trillion annually. These estimates align with those of the McKinsey Global Institute, which projects that the GenAI and similar technologies will primarily result in productivity gains [29]. If these innovations can be effectively harnessed, AI could reverse the long-term productivity decline that many advanced economies are currently experiencing.

Daron Acemoglu and Simon Johnson, both Nobel laureates in economics for 2024, present an optimistic outlook on AI's impact on growth. They estimate that AI applications could boost productivity by 1.5 percentage points per year over the next decade [2]. This aligns with Goldman Sachs' projections, which predict a 7% increase in global GDP – equivalent to about $7 trillion in additional output—with the potential to reach as much as 10% in the case of "explosive growth" [12].

Erik Brynjolfsson, Danielle Li, and Lindsey R. Raymond, leading economists in the digital economy, suggest that AI could significantly boost productivity by as much as 14% or more. They provide compelling evidence that AI enables the implementation of best practices by high-performing workers and helps newly hired employees climb the learning curve more quickly. Their research also indicates that AI improves customer sentiment, increases employee retention, and enhances workplace learning [6].

Productivity gains arise because GenAI systems capture the behavioral patterns of the most productive workers, including skills that have previously resisted automation. In earlier technological phases, computers and software transformed the economy by performing certain tasks more accurately and efficiently than humans, but these systems required detailed instructions. Many activities – such as writing emails, analyzing data, or creating presentations – have long resisted automation because they rely on tacit knowledge. Machine learning (ML) algorithms operate differently from traditional computer programs: instead of following explicit instructions, they learn from examples. This is why GenAI can make the best practices of highly skilled workers accessible to others, thereby increasing overall productivity.

Gita Gopinath, the IMF's First Deputy Managing Director, emphasized at the Global Summit on AI that GenAI holds great promise for improving quality of life and health, as well as accelerating scientific discoveries [13]. AI could deliver significant economic benefits, particularly in terms of boosting productivity, which would be invaluable in the global economy's recovery at a time when medium-term growth prospects are weaker than they have been in decades. However, she also pointed out that AI presents significant uncertainty and risks, especially regarding security, privacy, disinformation, and ethical concerns [13]. In an interview for the IMF's Chief Economics series, Yuval Noah Harari stated that while AI can provide tremendous benefits for humanity, it also poses an existential threat if it escapes human control [16].

Gita Gopinath also highlights an economic risk associated with GenAI that has received little attention: its potential to exacerbate economic crises. She warns that while another global downturn is inevitable, the widespread adoption of AI could turn an ordinary recession into a deep and prolonged economic crisis by causing large-scale disruptions in labor markets, financial systems, and supply chains [13]. AI's impact on labor markets is particularly concerning. Past waves of automation have shown that companies invest in automation during economic booms without cutting jobs, even as labor's share of value-added declines. However, during downturns, businesses lay off workers, revealing the extent to which automation can replace human labor. In the next crisis, AI is expected to threaten a broader range of jobs than ever before, including high-skilled, cognitive roles. Estimates suggest that 30% of jobs in advanced economies, 20% in emerging markets, and 18% in low-income countries are at risk of AI-driven displacement. The net effect could be unprecedentedly high unemployment, with profound implications for financial stability and debt repayment [13].

Geoffrey Hinton, a pioneer in AI and winner of the 2024 Nobel Prize in Physics, warned in a December interview with the BBC that the pace of technological change is "much faster" than expected. He stated that there is a "10% to 20% chance that AI could lead to human extinction within the next three decades." Hinton also noted that humanity has never before encountered intelligence superior to its own. In May 2023, he resigned from Google to freely discuss the risks posed by the unchecked development of AI. He expressed particular concern that some individuals could use GenAI as a weapon against others, warning that humans may soon be as intellectually inferior to AI as three-year-olds are to adults [18].

Ian Bremmer, president of the Eurasia Group, and Mustafa Suleyman emphasize that while AI will drive revolutionary scientific advancements, it will also enable

toxic disinformation that could disrupt democratic processes and lead to economic instability [4]. This transformation will fundamentally reshape the global balance of power, creating an unprecedented challenge for political institutions worldwide. To mitigate risks, new regulatory norms and governance mechanisms will be necessary to balance the interests of various geopolitical actors. At the same time, many key players in the AI revolution will come from the private sector, necessitating close coordination at the state level.

All technologies evolve, but AI is hyper-evolutionary. Its rate of improvement will far exceed Moore's Law, which successfully predicted that computing power would double every two years. Tasks that once took weeks now happen in seconds. The technologies driving AI will continue to become cheaper and more accessible. make active participation in AI development a strategic priority. Just as the Cold War was As a result, governments and corporations alike must defined by nuclear competition, today's geopolitical struggle will center on global competition over AI.

The Impact of GenAI on Competitiveness

GenAI can provide a significant contribution to improving competitiveness. At the company level, AI significantly improves productivity through numerous processes, as we have already mentioned in the text. Among them are (i) automation (reducing the time and costs for content creation), (ii) personalization, which allows for the adaptation of products and services to the customer, which increases their loyalty and satisfaction, and (iii) encouraging innovation because it facilitates the development of new innovative and unique products.

On a global level, the countries that quickly adapt to new trends and adopt GenAI will achieve a significant competitive advantage. GenAI has opened up space for the democratization of access to new technologies, enabling smaller companies and even individuals to access tools for creating high-quality content and products at significantly reduced production costs for now automated, highly complex processes. We are witnessing small businesses using GenAI to create marketing campaigns without hiring expensive agencies. However, if companies rely too much on GenAI alone, they could lose an important component that is reflected in human creativity.

In all segments of Porter's five forces of competition model [34], [37], digitalization and the Internet of Things (IoT) have fundamentally changed the traditional model of competitiveness, and GenAI is changing the dynamics of each of Michael Porter's five forces of competition [34]. Let's start in order:

- The bargaining power of suppliers is rising in the era of smart product components, IoT, and AI, with new players like AI analytics entering the market. Suppliers can leverage this to demand higher prices or better terms, but car manufacturers can counteract by using GenAI to predict demand and optimize inventory, influencing supplier dynamics.
- For buyers, IoT and GenAI enhance product differentiation and allow companies to better segment, customize, and price products while building closer relationships with customers. However, GenAI also empowers buyers by enabling informed comparisons and choices, as seen in e-commerce through personalized recommendations.
- The threat of substitutes grows in the digital economy. IoT and GenAI expand product functionality, as seen with smartphones replacing multiple devices by integrating health and activity tracking. Low switching costs amplify this threat, especially when AI-powered substitutes dominate markets.
- New entrants pose a significant challenge, particularly in IoT markets where barriers include high costs, complex product designs, and advanced IT infrastructure. GenAI helps startups scale quickly and innovate, posing a threat to incumbents unless agile companies act first to leverage data and GenAI, gaining first-mover advantages.
- Rivalry in the digital economy is multifaceted, extending beyond price competition due to digital products' near-zero marginal costs. For instance, in media, GenAI accelerates content creation, increasing competition but potentially compromising creativity.
- GenAI transforms all aspects of Porter's five forces model. While it increases competitive pressure and lowers barriers to entry for new players, it also

increases customer power and enables the rapid emergence of substitutes. Companies that want to remain competitive must strategically use GenAI to differentiate, optimize costs, and deliver personalized experiences to customers.

Innovation & Talent

To achieve this, the name of the game is innovation. According to GII, in 2024, compared to 2022 (Figure 1), Serbia improved its position – the rank is now 52, and it was 55. Serbia has overtaken Montenegro but is still lagging behind Bulgaria (38), Croatia (43), and Romania (48). Shortly, Serbia should improve this rank and be around 40th place in the world.

To improve the ranks, it is necessary to look at the structure of the GII Serbia (Figure 2). Within the GII, the Innovation Inputs sub-index has been improved (rank is 47, it was 55), while the Innovation output sub-index has deteriorated (now 60, it was 58). Within the Innovation Inputs, two positions – Infrastructure and Market sophistication – have been improved, but the position of the Institutions has deteriorated. Within the Innovation output, there is a significant deterioration in the Creative output and some improvement in the Knowledge and technology outputs.

The Global Talent Competitiveness Index (GTCI) in presented in Figure 3. In 2023, the rank was 53, while in 2020, it was 58. Serbia must improve its ranking and break into the top 40 in the world precisely because we

Figure 1: Global Innovation Index – GII
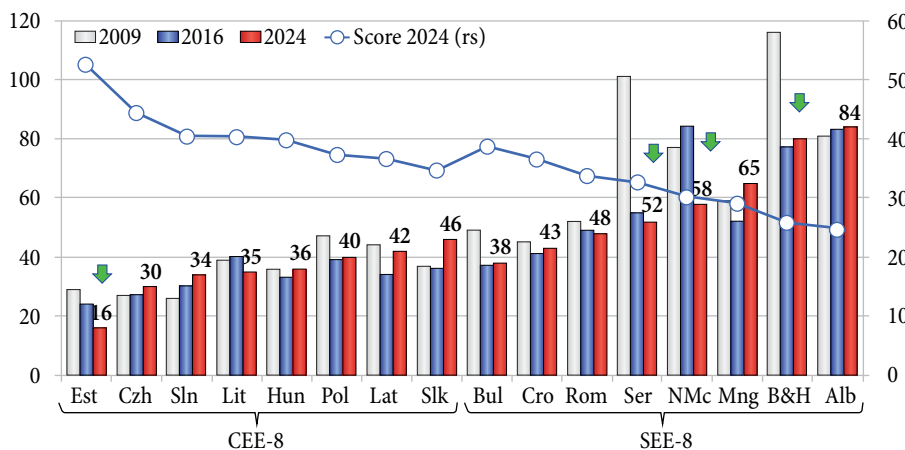
Source: WIPO

Figure 2: Serbia – GII - 52
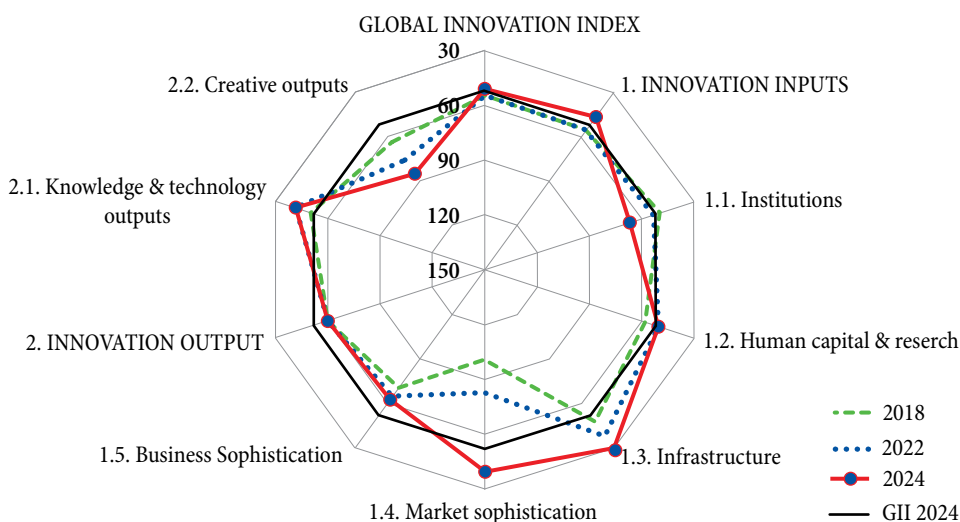
Source: INSEAD, GII

have talents that need to create the best possible conditions for development in Serbia.

Within GTCI, better results were achieved in Output (47) and slightly weaker in Input (54). There are three areas of regulatory and market landscapes and lifelong learning. Improvements were made in the Business and Labor Landscape (55 to 102), Internal Opening (42 to 80), Access to Growth Opportunities (53 to 81), Global Knowledge Skills (51 to 58), and Talent Impact (44 to 59).

What is the Readiness for the GenAI: A New AIPI Index

To monitor the development of GenAI among countries, the IMF has introduced a new indicator – AIPI (Artificial Intelligence Preparedness Index) across 174 countries. Bearing in mind the warnings highlighted by Gita Gopinath [13], the IMF, by introducing AIPI, wanted to monitor the economy-wide integration of AI by countries and different stages of readiness in leveraging the potential benefits of AI and managing the risks based on a rich set of macro-structural indicators that cover the countries' digital infrastructure, human capital and labor market policies, innovation and economic integration, and regulation and ethics [11].

According to AIPI (Figure 4), Serbia is ranked 51st in the world and the region just behind Romania (40), Croatia (42), and Bulgaria (43) and ahead of Albania (58), Montenegro (64), North Macedonia (76) and Bosnia and Herzegovina (96). Serbia should join the group of countries that are around the 40th place as soon as possible; in addition to the already mentioned countries, there are also Central European countries in the region, such as the U.S., Hungary (45), Slovakia (38) and Poland (37). This is a challenging task, but it is within the realistic framework of the possibilities that Serbia has in this area.

In order to answer the question of what the key directions of AIPI improvement are, we will decompose it into all four components and determine the distance to the frontier, that is, how far we are lagging behind the best (Figure 5). With a total AIPI of 51, we are in 67% of the best-performing country – Singapore. Looking at the components, we have the best results in Digital Information with 71% of the most successful country (we are lagging behind 29%) and in Human Capital & Labor Market Policy with 68% of the most successful country (we are lagging behind 32%). The worst result was achieved in Innovation & Economic Integration with 57% of the most successful countries (we are lagging behind 43%), and we have a slight lag in Regulation & Ethics with 66% of the most successful countries (we are lagging behind 34%).

Figure 3: Global Talent Competitiveness Index 2023 – Serbia
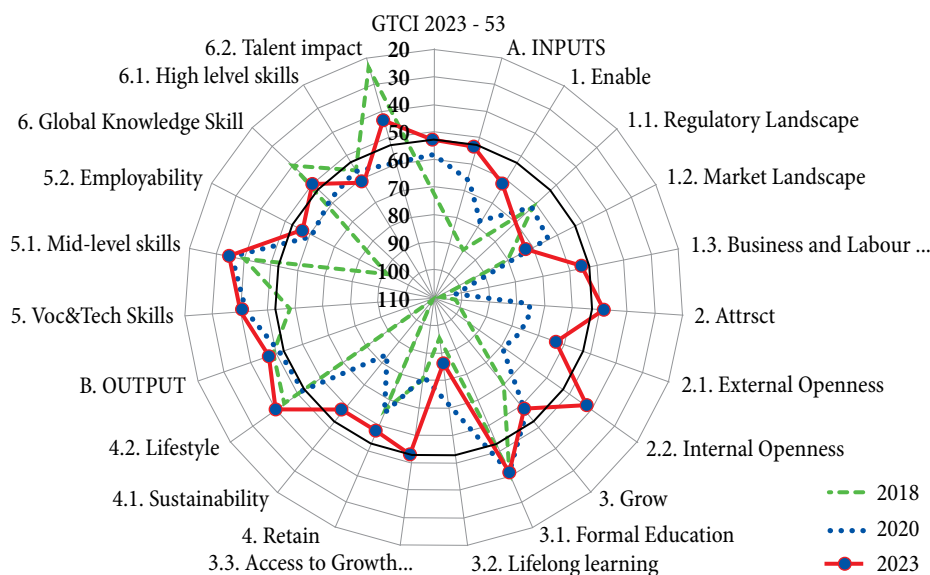
Source: INSEAD, GTCI

To reduce the lag in the Innovation and Economic Integration segment, which is the largest laggard, it is necessary to increase investments in R&D, the number of scientific publications, the number of patents on frontier technologies, and domestic credit to the private sector.

GenAI Impact on Millennials, Gen Z, and Alpha

Although countries are still preparing for the GenAI age, AI is dedicated to transforming the way different generations engage with and perceive technology, with each group experiencing its impact in distinct ways [7]:

- *Millennials (1981-1994)* grew up during the rapid rise of the Internet, mobile technology, and social media, making them comfortable with AI integration, which followed. For this generation, AI is primarily a workplace tool, but also a tool embedded in

their daily lives. They rely on AI for convenience, personalization, and efficiency in both personal and professional contexts. However, growing up in the era of big data has made Millennials particularly sensitive to issues like privacy and data security. While they appreciate AI's benefits, they are also critical of its ethical implications, questioning how personal information is collected, stored, and used. Millennials are known to have a "dual perspective" on AI – embracing its advantages while scrutinizing its potential downsides.

- *Gen Z (1995–2010)* is the first generation to grow up with AI integrated into daily life. Gen Z engages with AI constantly, from social media to gaming and educational platforms. They see AI as a tool for creativity and self-expression, using it to create content, personalize learning, and enhance their

Figure 4: AI Preparedness Index (AIPI) in 2023
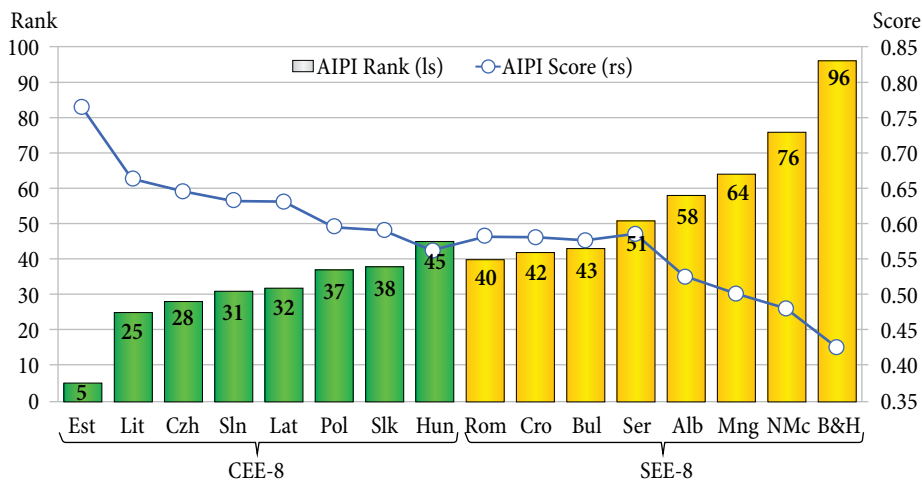
Source: IMF data

Figure 5: AIPI – Serbia and best performers – 51 (distance φ 67%)

Source: IMF

121
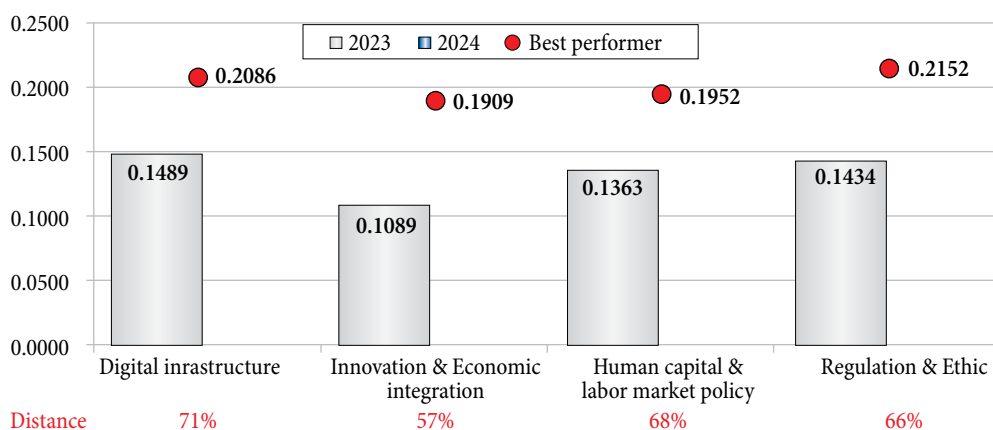
experiences. However, they are also critical of AI's societal implications, raising concerns about misinformation, bias, and ethical challenges.

- *Gen Alpha (2010-2024)*, sometimes referred to as AI natives was born in a world where AI is ubiquitous. Gen Alpha interacts with AI seamlessly through tools like educational platforms, smart toys, and voice assistants. AI plays a crucial role in their learning from a young age, offering personalized and gamified educational experiences. While too young to fully articulate their relationship with AI, early trends suggest this generation views AI as a natural part of life. A recent survey by Hosting Advice (2023) revealed that nearly 50% of children aged 7-14 are already using AI for learning, creativity, and exploring new topics.

Deloitte's survey on *Gen Zs and Millennials* revealed that individuals who frequently use GenAI at work tend to feel more excited about and trusting of the technology [9]. These frequent users are more likely to believe GenAI will enhance their productivity, free up time, and improve their work-life balance. Research among *younger teens* (aged 13-17) across the United States found that more than half of teens (53.7%) have used GenAI tools, a third (32.9%) have heard of GenAI but never used it, and a minority of them (13.4%) have never heard of these tools [3]. The ones who are users use it regularly – around a third of them use it every day and another third use it once or twice a week. Another research that looked at youth aged 14-22 also found that around half (51%) of them have used GenAI, but only 4% are daily users [17]. Most youth who have never used GenAI think it would not be helpful. Other *reasons* for not using the GenAI are association of the AI with cheating or stealing the work of others; not knowing how to use the GenAI tools; being concerned with privacy and sharing information with AI; not being aware of GenAI tools at all; and inaccuracy of information or bias in GenAI answers, respectively [17].

A *major concern* that teens across the US have with GenAI is privacy, i.e., the dissemination of their personal information and feeling like they are always surveilled. They see tech companies as the most responsible actors for ensuring the safety of GenAI tools, but they are also aware of their role, as well as that of their teachers, their parents, and the governments [3].

Lastly, there is one specific aspect of AI that sets it apart from any prior technology – its ability to *mimic the thinking of a social being*. Due to this ability, it is particularly important to examine how teenagers view GenAI on a social and emotional level. Bickham et al. showed that as much as half of teens in the US show openness to forming parasocial relationship – one-sided emotional attachments – with GenAI tools [3]. Interestingly, teens more often view Voice Assistants (VAs) as potential social companions compared to GenAI tools, which may be due to VAs being designed for conversational, spoken interactions, while GenAI tools typically rely on text-based interfaces that feel less personal. On the other hand, about one-third of teens express uneasiness about Gen AI, citing feelings of distrust or concern about its intentions. Most teens are aware of the duality of GenAI and whether it will enhance or weaken their social skills, attention span, and independent thinking [3].

GenAI Impact on Education

GenAI brings numerous opportunities and threats to educational systems. On the positive side, it can improve educational outcomes by meeting students where they are and adjusting to their needs [32], or it can support students in their creativity [30]. On the negative side, GenAI can widen the educational divide [21], provide inaccurate information [32], facilitate cheating [17], create bullying content [23], and amplify biases or privacy issues [17]. It is interesting that over two-thirds of parents in the US feel that the potential upsides of using AI in education outweigh or are equal to the possible downsides [31].

Around half (52%) of teens aged 13-17 across the US [3] have received some form of instruction at school on how to use GenAI for problem-solving or creative work, as well as how to use it ethically. However, less than half of teens (42%) have received instruction about recognizing bias and misinformation generated by AI tools. Regarding the use of GenAI in the classroom, 16% of teens said their schools allow the use but with specific restrictions, while 31% stated that rules around use differ based on the teacher.

The rest are not allowed to use GenAI in any of their classes. Also, this research showed that the use of GenAI is higher among boys who attend private schools and have highly educated parents. The findings of Bickham et al. align with other recent large-scale surveys, highlighting a mix of teen optimism about adopting GenAI and concerns over its potential drawbacks [3]. Teens consistently express fears about GenAI compromising their privacy, delivering inaccurate or biased information, and fueling accusations of cheating or plagiarism.

A lack of adequate education and guidance to address these issues further amplifies their anxiety. AI highlights the importance of digital literacy education, i.e. teaching students how to use GenAI for good purposes (such as adapting a lesson to fit their unique learning style), as well as finding ways to prevent students' overreliance on GenAI Research indicates that teens already recognize GenAI's value in learning, its potential to boost creativity, and its role in fostering social connections [22], [19], [23].

GenAI Impact on Work

Beyond education, GenAI will have a remarkable impact on the way people work. Primary, it will help in shortening the time needed to perform certain tasks, reducing the workload and the time spent on work. As one young person in the US noted: "I think that it will revolutionize efficiency at school and in the workplace, freeing up students and workers for higher-level activities. To me, AI is just as significant of an invention as the Internet was" [17].

One thing is certain – AI will have an unprecedented impact on the labor market, influencing both *jobs* and *workplaces*. It will not only reshape the current job landscape but also transform work environments, including organizational culture, employee interactions, and work setups [15].

Regarding the impact of the GenAI on *jobs*, it will be the single biggest revolution ever since the agricultural and industrial revolutions. According to a recent McKinsey report, the adoption of AI is expected to sharply accelerate the timeline for automation, potentially automating up to 29.5% of work hours in the U.S. economy by 2030 [28]. Moreover, this change is not limited to manual or routine tasks, but also tasks requiring creativity and interaction with people. Approximately 75% of the potential value from GenAI use cases is concentrated in four key areas: customer operations, marketing and sales, software engineering, and research and development (R&D).

Considering the impact of AI on the *workplace*, the introduction of GenAI will bring productivity gains primarily by increasing efficiency, but it will also pose certain challenges. Research from Columbia Business School highlights how AI can negatively impact team performance and coordination, sometimes reducing productivity [8]. While AI boosts efficiency on hand, employees may resist working with AI agents, which raises concerns about trust and job satisfaction as key factors of engagement and retention, and eventually – overall productivity. Another important change is that AI is driving a shift where individuals can transition from specializing in one or two skills to mastering multiple interconnected ones. To deepen GenAI integration, organizations will require stronger learning programs and a culture that supports teaching and learning across three dimensions: individual, organizational, and AI [15].

Leadership will play a critical role in shaping how GenAI is implemented and perceived in the workplace. Leaders will need to champion the ethical use of AI, ensure equitable access to its benefits, and foster an environment where employees feel empowered to collaborate with AI tools. Effective leadership will also involve addressing employees' fears and misconceptions about AI and providing clear communication about its purpose and limitations.

Survey Methodology

To understand how different generations are using GenAI in Serbia, we conducted an online survey among 505 individuals from younger generations, in January 2025. Nearly 80% of the participants belong to Gen Z (born between 1995 and 2010), while, notably, we had around 6 % representation from Gen Alpha (born after 2010) for the first time. Millennials participated in the survey with 15%. The survey comprised 32 questions, primarily structured as closed-ended queries with pre-defined responses or rating scales. We ensured a balanced distribution between female

(58%) and male respondents. The age distribution indicates that the majority falls within the 20-25 age group (51%).

Done by students at various levels of study, with more than half engaged in bachelor's studies, the survey drew participation primarily from individuals in Belgrade (70%). However, it is important to note that the survey achieved regional diversity, with students from all Serbian regions participating (Figures 6 & 6a).

Although most (58%) respondents are in bachelor's studies, 37% of them are working full-time, and 17% part-time. Others have experience through volunteering activities and internships, while 21% of respondents have no work experience. Our objective was to collect data that sheds light on the way different generations are using AI, not only in working environments but in school and everyday life. In this context, we aimed to compare the behavior of Millennials, Gen Z, and Alpha in Serbia with those of their global counterparts. To achieve this, the article compares results obtained from our conducted survey with similar

surveys conducted by renowned organizations such as Deloitte and Digital Wellness Lab [9], [3].

Generative AI is Becoming a Mainstream

GenAI has been in use for over two years, during which its tools have attracted hundreds of millions of users worldwide. However, the usage rates differ among different countries worldwide. For example, 67% of teens in the US, 55% of German teens, and only 29% of Japanese teens have used or tried using GenAI by the end of 2023 [22]. In Serbia, more than 85% of Millennials, Gen Z, and Gen Alpha use GenAI, meaning it has already become a mainstream tech tool used by different generations (Figure 7).

Another research, which looked at *younger teens* (aged 13-17) across the US found that more than half of these teens (53.7%) have used GenAI tools, a third (32.9%) have heard of GenAI but never used it, and a minority of them (13.4%) have never heard of these tools [3]. Also, the

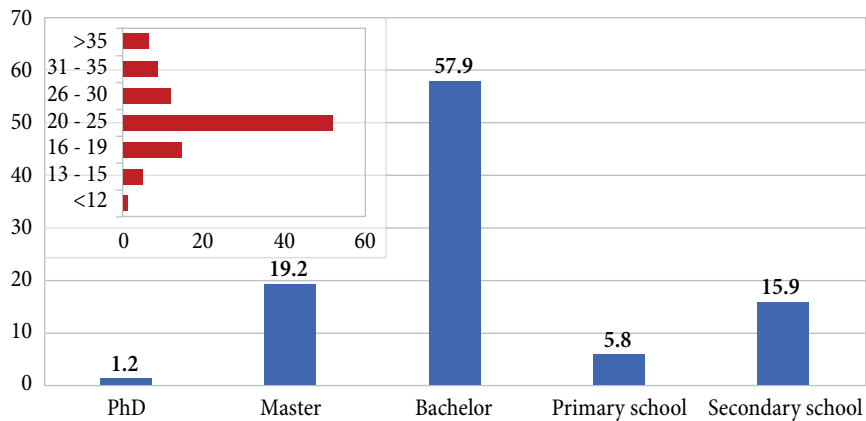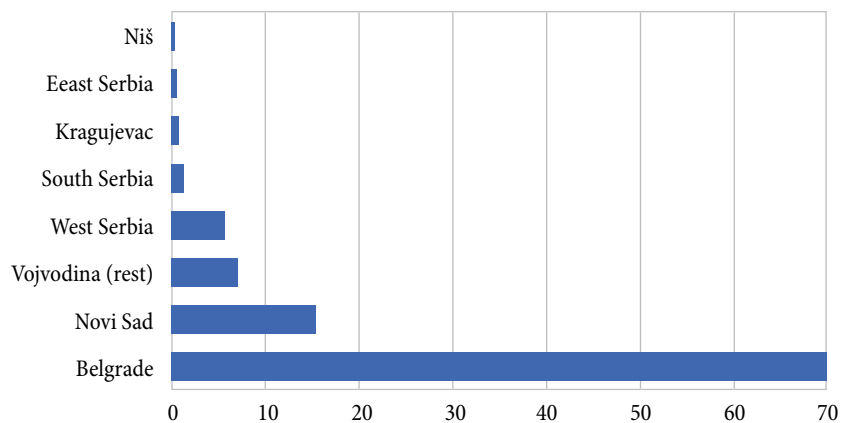**Figure 6: Demographics of the Sample**

Figure 6a: Demographics of the Sample

Source: Authors' survey

teens who are users of GenAI use it regularly – around a third use it every day and another third use it once or twice a week. Another research that looked at youth aged 14-22 also found that around half (51%) of them have used GenAI, but it indicated that only 4% are daily users [17].

In Serbia, Millennials, in particular, engage with AI daily, while the majority of individuals across all three generations use GenAI several times a week, with ChatGPT being the most popular tool. Notably, 53% of respondents in Serbia rate their skills in using ChatGPT as highly developed. Alphas, the first generation fully born in the 21st century, have grown up in a world shaped by both GenAI and the COVID-19 pandemic, which brought schooling into their homes. This generation began in the year when the first iPad and Instagram were launched and concluded in 2024, the year GenAI became the biggest trend [25]. India ranks as a top country of birth for Alphas and first in the adoption of GenAI technology [26], [10].

Additionally, Gen Alpha is growing up in homes with tech-savvy parents (Millennials), surrounded by different tech devices. For Alphas, GenAI is becoming an integral part of their daily routines. This is true for Gen Z as well, the first truly digital and global generation, who also use AI frequently (Figure 8).

As the world evolves with the integration of AI, human experiences with this technology remain varied and complex. For some, AI acts as a calming companion – an invaluable tool that enhances daily tasks with effortless precision. For others, however, it stirs a whirlwind of emotions, challenging their understanding of technology and the future.

A global survey conducted by Deloitte reveals that while uncertainty is the most common emotion reported by both Gen Z and Millennials when thinking about GenAI, excitement and fascination are not far behind [9]. Locally, based on the conducted survey, positive perceptions of

Figure 7: Do you use GenAI? (in %)
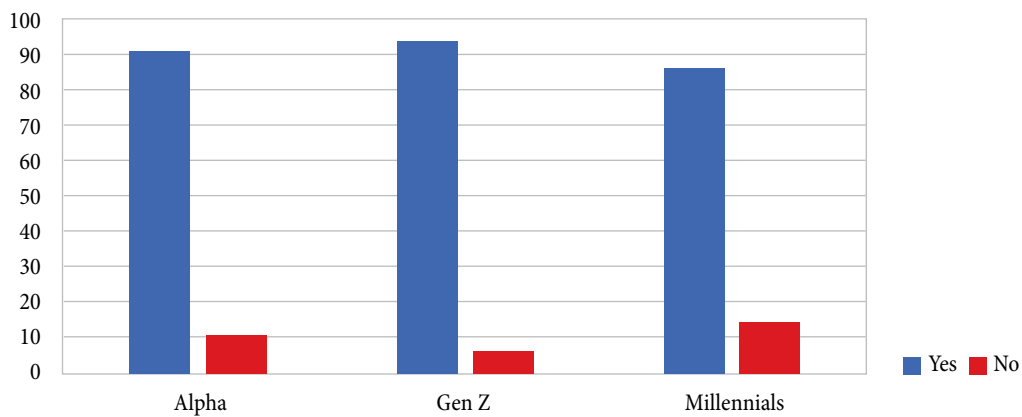
Source: Authors' survey

Figure 8: How often do you use GenAI? (in %)

Source: Authors' survey

125
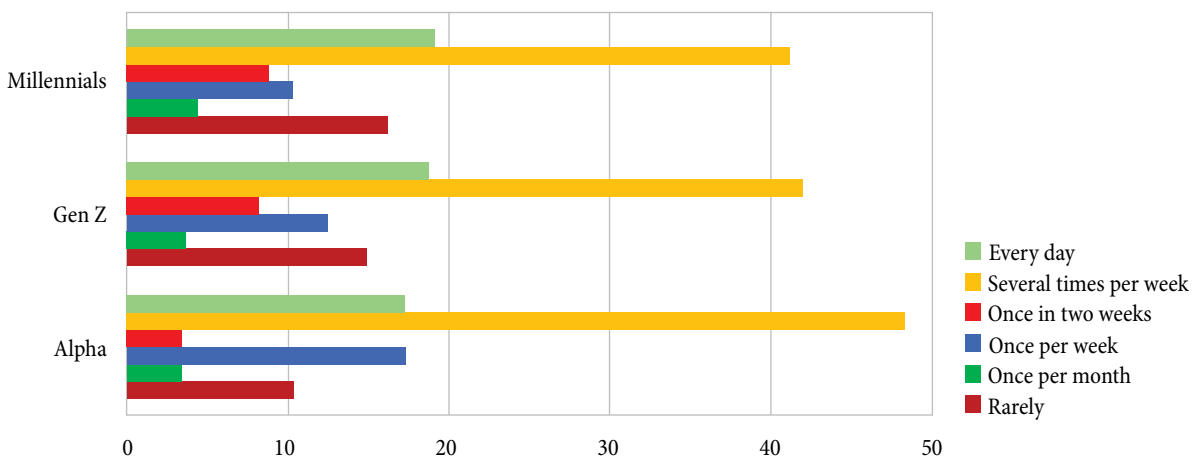
AI tend to grow with more hands-on experience. Among those who use AI, 80% do not feel unsafe, while this figure drops to just 50% among non-users, highlighting the role of familiarity in shaping attitudes toward technology. In Serbia, 37.6% of respondents described GenAI as trustworthy, seeing it as a reliable ally capable of simplifying tasks and providing valuable insights into the unknown. In contrast, only 15.3% reported feeling a deep sense of excitement when using AI (Figure 9). Nonetheless, fascination with technology is a strong emotion across all three generations. Users are captivated by the inner workings of AI and its remarkable abilities.

Compared to all other generations analyzed, Gen Z has the fewest individuals who report feeling excited while using AI (for example, only 3% of Gen Z feel excited, while this number is 5% among Millennials). This could be linked to the fact that Gen Z has encountered new technologies in general throughout their upbringing, while Millennials were introduced to them during adolescence. As a result,

the novelty and possibilities these technologies offer tend to have a somewhat greater impact on the excitement levels of Millennials. This is pretty much the same globally, where 37% of frequent GenAI users among Millennials are excited about it, while this percentage stands at 30% among GenZ [9].

Despite expressing concerns over the accuracy of information provided by GenAI tools, many young people globally are not verifying the information provided by these tools using additional sources. However, they do stress the importance of learning to use GenAI reasonably [3].

As already noted, younger generations in Serbia not only use GenAI, but a significant percentage also trust the answers generated by it. One-third of individuals across all generations only occasionally verify the accuracy of the information they receive from GenAI by consulting other sources (Figures 10 & 10a). This aligns with global trends, where around 30% of teens occasionally verify information generated by GenAI [3]. While younger generations are

Figure 9: How do you feel when you use GenAI? (in %)
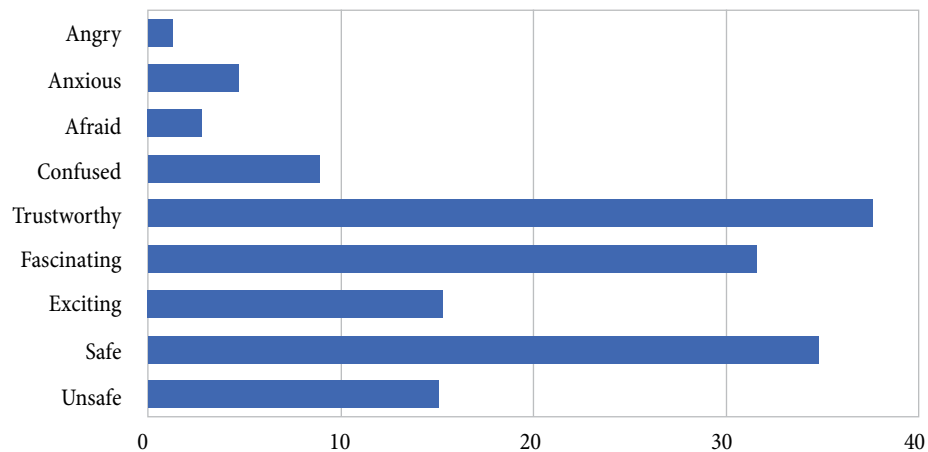
Source: Authors' survey

Figure 10: Do you check info generated by GenAI? (in %)
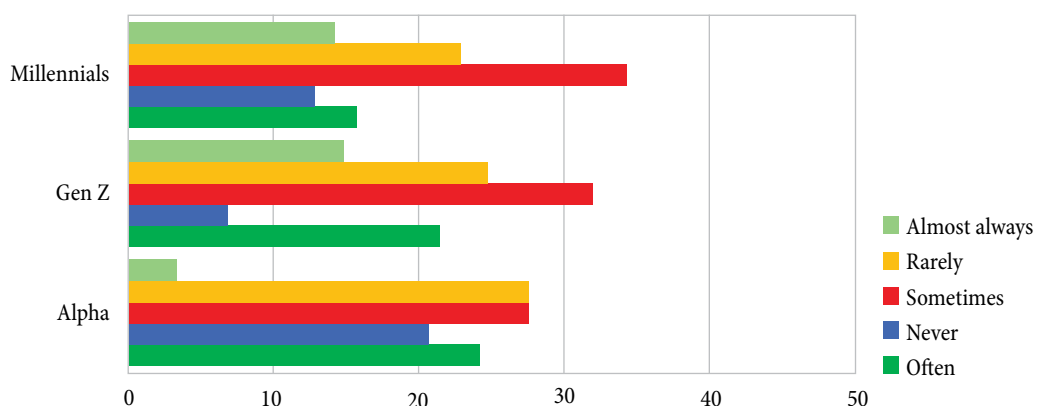
comfortable using GenAI, more mature generations are more likely to cross-check information through multiple sources, as they tend to be more critical consumers of digital content. McCrindle research indicates that Digital Detox will be a key trend in 2025, with 57% of Gen Z wishing social media had never been created, highlighting their critical stance towards its downside effects [27].

When it comes to obtaining reliable and accurate information, members of all three generations place the greatest trust in published books (97%), followed by internet search engines (94%) and then GenAI (80%), while traditional media are ranked the lowest (Figure 11). The results suggest that books continue to be seen as authoritative, well-researched, and written by experts. As for the higher trust in internet search engines compared to GenAI – it is probably a matter of time. Our survey indicates that nearly 40% of respondents now use GenAI for questions they previously directed to internet search engines. Traditional media are at the opposite end of the

spectrum, with minimal trust among Millennials, Gen Z, and Alpha (59% of respondents do not trust traditional media for obtaining reliable information). This reflects a growing skepticism toward mainstream outlets, particularly among younger generations.

The results obtained in this research match the results of similar surveys conducted in the US. After 50 years, we are witnessing that the number of people who do not trust traditional media prevails (38%) compared to those who absolutely trust (7%) and mostly trust (27%) traditional media [5]. Young people also consider traditional media as slow, highly influenced, and full of fake news. For the aforementioned reasons, they use digital-born media and mostly get information through social networks, such as TikTok, because they believe these channels are more authentic and provide information exactly when users need and want it [33].
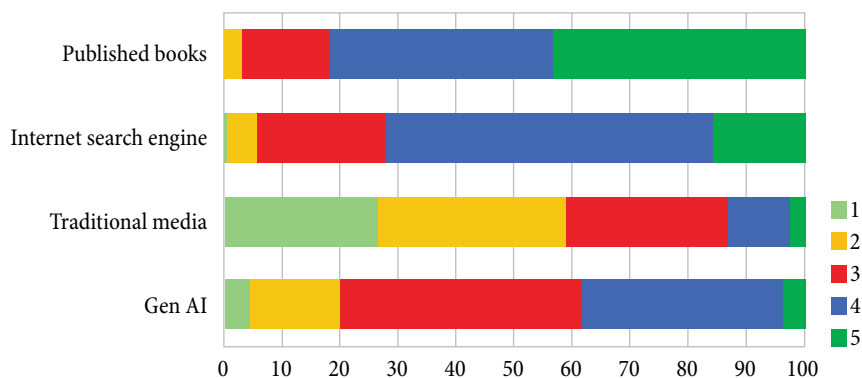
Millennials, Gen Z, and Alphas are early adopters of GenAI, actively exploring its potential beyond entertainment.

Figure 10a: Do you believe answers generated by GenAI? (in %)
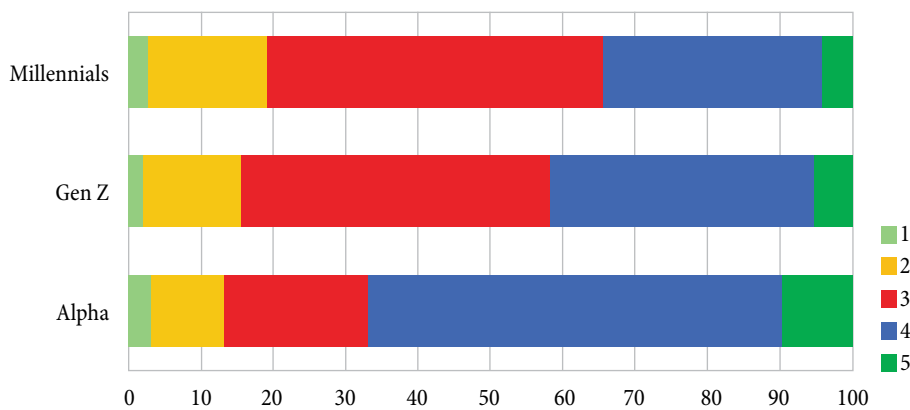
Source: Authors' survey

**Figure 11: Who do you trust the most?**

Source: Authors' survey

In the U.S., young people most commonly use GenAI for gathering information, assisting with schoolwork, brainstorming ideas, and facilitating communication, such as drafting emails or texts [3], [17]. The situation is similar in Serbia. Millennials and Zalphas in Serbia are also primarily using GenAI for gathering information – researching various topics, learning new things, and asking questions they have previously asked the Internet browsers (Figure 12). Also, GenAI is extensively utilized for writing essays, completing schoolwork, and preparing reports, which is particularly present among Gen Z and Alpha.

The Harvard Graduate School of Education (HGSE), which performed research on young people aged 14-22 (which mostly coincides with *Gen Z*) in 2024, found that the young people *who view GenAI positively* emphasize its potential to improve access to information, enhance creativity, and advance education, work, and communities [17]. They are excited about how GenAI can make learning and working more efficient, as well as the ease of accessing vast knowledge. Some see it as an opportunity to engage in meaningful conversations with a tool that seemingly holds unlimited knowledge. A young person within this research described their excitement as "being able to fully and properly converse with something that is supposed to have all the knowledge of the world." In terms of creativity, young people are enthusiastic about GenAI's ability to enhance artistic endeavors or assist those who struggle with creativity. Creativity is the only human feature that the majority of teens believe will not be replaced by GenAI [22].

In Serbia, the majority of Millennials and Zalphas believe that GenAI has a positive impact on their creativity and especially curiosity. On the other hand, 51% of respondents feel that it negatively affects their free time, while 48% feel that it increases their free time, suggesting mixed views on time management when using the GenAI technology (Figure 13).

Figure 12: For what purpose do you use GenAI? (in %)
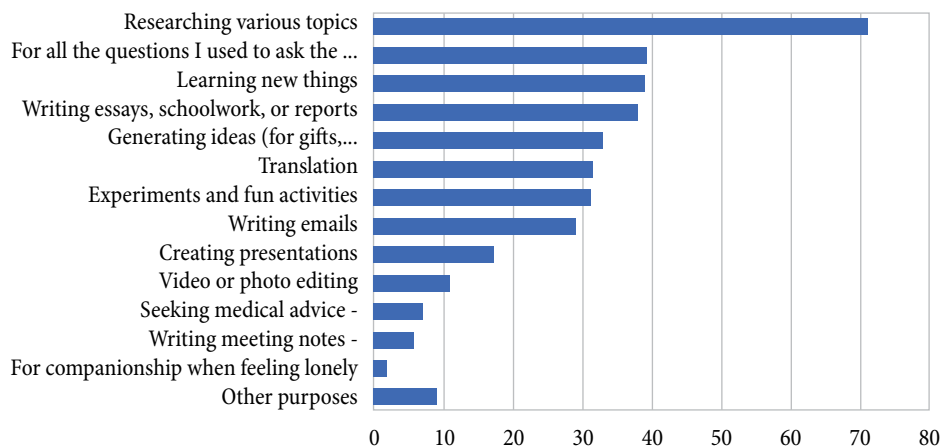
Source: Authors' survey

Figure 13: How do you assess the GenAI impact on your curiosity, creativity and free time?
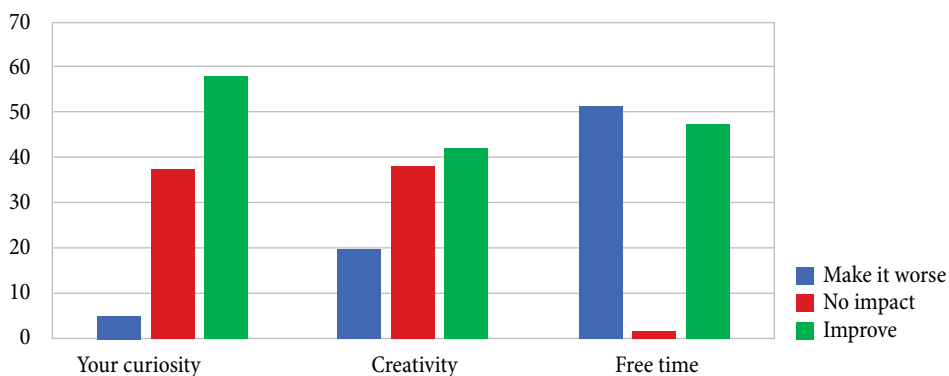
Source: Authors' survey

The HGSE research shows that those *who view GenAI negatively* highlight other negative impacts, such as job loss, intellectual property theft, misinformation, and privacy breaches [17]. Many fear GenAI could dominate job markets, harm creative industries, and facilitate the spread of "deepfakes" or "fake news." Privacy issues are also a major worry, with fears of personal data being stolen or misused. A broader anxiety about AI "taking over" underscores these concerns [17]. Deloitte's survey found that the increased use of GenAI correlates with heightened concerns as well [9]. In other words, regular users are more likely to worry about job displacement caused by automation and the challenges it might create for younger workers entering the workforce. These concerns stem from the potential automation of entry-level tasks that are typically performed by employees in entry-level positions.

When it comes to GenAI's negative aspects, respondents in Serbia are almost evenly divided regarding their concerns about GenAI collecting their data – 51% are not worried, while 49% are worried. When it comes to GenAI's impact on performance, jobs, and the creation of deepfakes, respondents are mostly concerned (39.3%) with GenAI creating deepfakes, while they are the least concerned (22.5%) with it eliminating jobs (Figure 14).

Concerns related to dwindling future job prospects are one of the largest worries of young people globally. For example, a white nonbinary young adult said for the HGSE research: "Society is becoming over-reliant on it, and people are losing their jobs to it even though it will do their jobs worse than them because it saves their employers money" [17]. Also, there are concerns that the 24/7 availability of AI tools may create expectations for employees to be equally accessible. Lastly, as AI systems are increasingly used for all aspects of work and education, there are rising concerns about bias, fairness, and accountability. Failure to address these concerns could erode trust in AI systems and create resistance among employees.
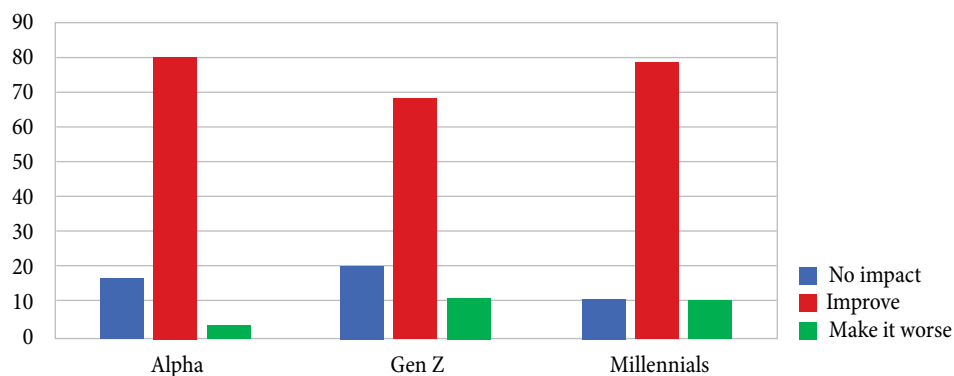
In Serbia, while Millennials and Alphas are more enthusiastic about AI's potential impact on their future

Figure 14: How concerned are you about the following things when it comes to GenAI?
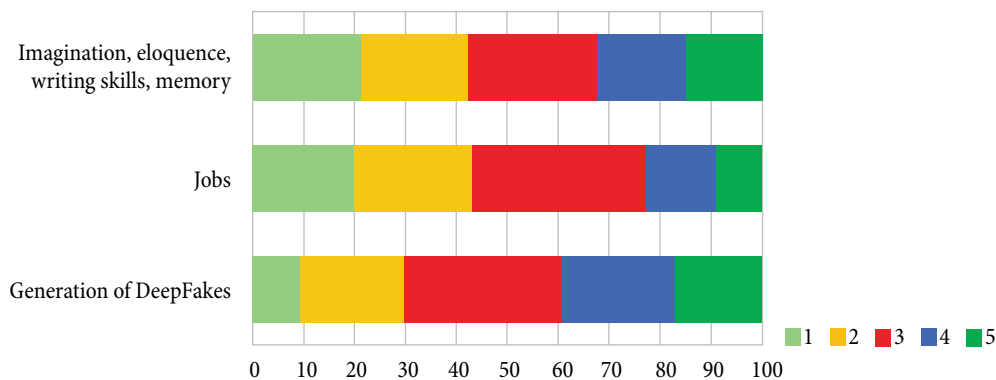
Source: Authors' survey

Figure 15: AI's impact in your future work/education

Source: Authors' survey

education and careers, Gen Z approaches it with slightly less enthusiasm and greater caution (Figure 15). As the first truly digital generation, Gen Z has been heavily exposed to social media during the most formative period of their lives. This experience contributed to making them the first generation to openly advocate for the importance of addressing mental health – not only on a personal level but also by expecting their future employers to prioritize it. These experiences, together with the Global Financial Crisis – the event that marked this generation, have shaped Gen Z to be more cautious when thinking about the future. One of their defining traits is their comparatively lower optimism, especially when contrasted with Millennials, who were raised by Baby Boomers – known for their positive outlook and forward-looking mindset.

In response to the previously mentioned challenges, globally, Gen Z and Millennials are prioritizing adaptability by focusing on reskilling and exploring roles that are less prone to automation. Despite these efforts, many feel their employers are not adequately preparing them for the changes GenAI may bring. While over a third of Gen Z (38%) and Millennials (36%) plan to participate in GenAI training within the next year, 20% of both groups have already completed such programs [9].

The situation is similar in Serbia (Figure 16), with more than 20% of early adopters reporting receiving the necessary training on how to use AI at school or work. The results related to Generations Z and Alpha would be even better if teaching staff used GenAI more. According to the data obtained for the purpose of developing The Strategy for the Development of Artificial Intelligence in the Republic of Serbia for the period 2025-2030 [14], only

5% of "Computer science" teachers (primary and high schools) use various AI tools in their work. As many as 45% plan to use AI in the future, even though they are not currently doing so. Also, not a small percentage of teachers believe that AI has no place in the classroom (18%).

Conclusion

The research highlights the growing adoption of GenAI among Millennials, Gen Z, and Gen Alpha in Serbia. All three generations primarily use the GenAI to research various topics, learn new things, and ask questions they have previously asked Internet browsers. Millennials are the most frequent users, often leveraging GenAI for everyday professional tasks, while Gen Z and Alpha are quickly adopting the technology, primarily using it for education and creative endeavors. The research also reveals certain generational differences in GenAI perception, with Millennials embracing GenAI enthusiastically and Gen Z demonstrating a more cautious approach stemming from their digital upbringing and concerns about privacy and misinformation. Also, the findings of the research underscore the role of familiarity in fostering trust, with hands-on experience significantly influencing positive perceptions of GenAI. Despite concerns about data privacy and job displacement, most young people in Serbia recognize the potential of GenAI to enhance creativity and curiosity, while they are less concerned with its negative impacts. However, the research also highlights certain challenges, such as limited teacher adoption of AI tools and the need for reskilling programs to better prepare young people for an AI-driven future.

Figure 16: Are you getting the necessary training on how to use GenAI?
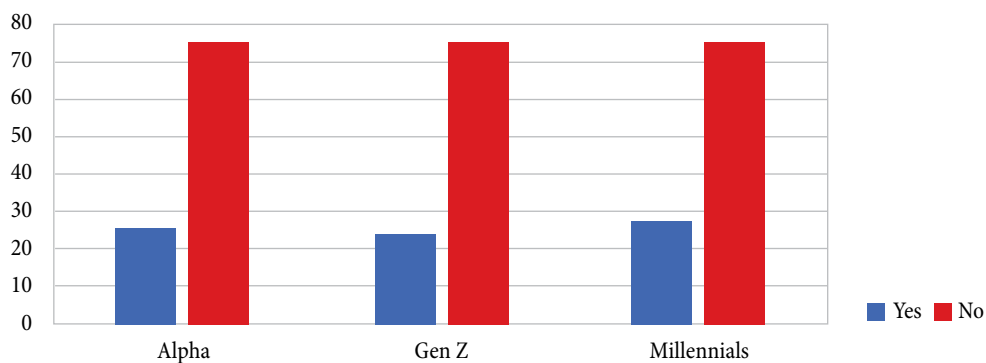
Source: Authors' survey

The research results align with global trends, offering valuable insights into how Serbian youth compare with their international peers. By understanding such generational dynamics, stakeholders can better address the opportunities and challenges posed by AI integration, ensuring its responsible and equitable use. Moving forward, fostering digital literacy, promoting ethical AI practices, and addressing the socio-economic implications of automation will be crucial in empowering younger generations to thrive in an AI-enabled world.

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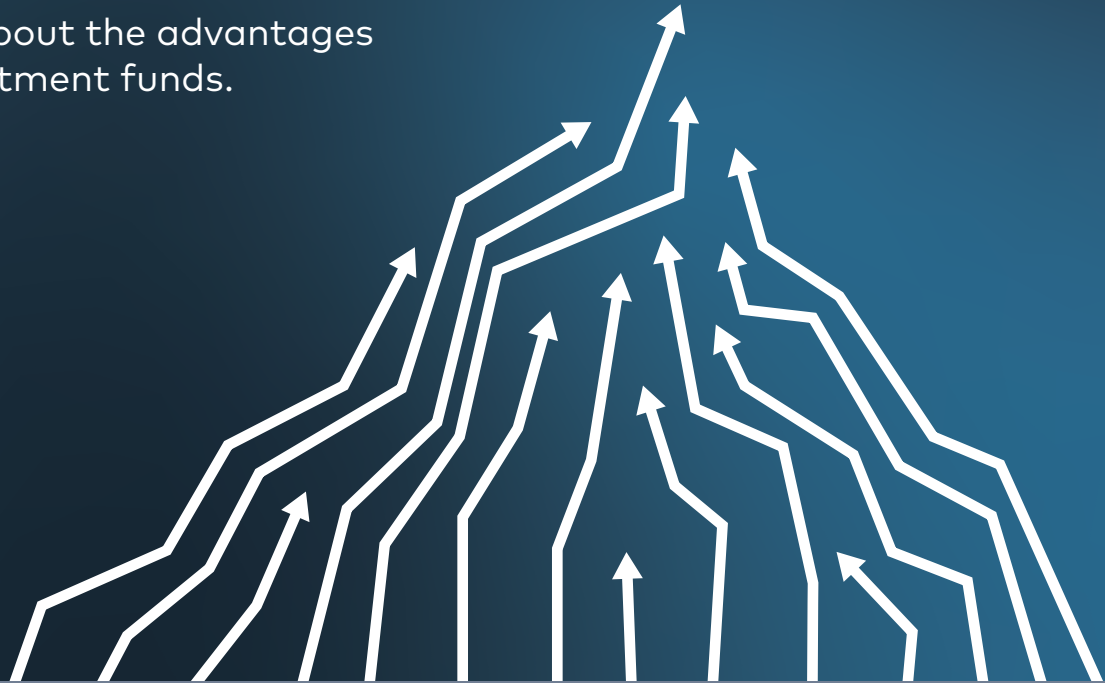
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DOES FOREIGN DIRECT INVESTMENT IMPROVE ENERGY EFFICIENCY? FIRM-LEVEL EVIDENCE FROM CEFTA 2006 ECONOMIES

Da li strane direktne investicije doprinose unapređenju energetske efikasnosti? Rezultati analize na nivou preduzeća iz privreda članica CEFTA 2006 sporazuma

Abstract

This study examines the impact of foreign direct investment on firm-level energy efficiency in CEFTA 2006 economies. Using firm-level data from 2,241 firms across seven CEFTA 2006 economies for the period 2017–2018, we employ propensity score matching to estimate the effect of foreign direct investment on energy intensity. Our findings indicate that foreign direct investment reduces firm-level energy intensity by between 1.67 and 1.89 percent points, representing approximately half of the mean energy intensity value for the entire sample. This suggests that foreign ownership and investment contribute to energy efficiency improvements, potentially through technology and knowledge transfers, which improves productivity. However, the magnitude and the statistical significance of the effect varies across countries, with stronger improvements observed in the firms operating in economies with higher energy self-sufficiency and lower reliance on fossil fuels, highlighting the role of broader energy market structures and environmental and energy policies in mediating the effects of foreign direct investment. We further explore the role of other internationalization factors, finding no significant impact of exporting and reliance on foreign-produced inputs on energy efficiency.

Keywords: *foreign direct investment (FDI), energy efficiency, energy intensity, foreign ownership, productivity, technology transfer, multinational enterprise (MNE), propensity score matching (PSM)*

Sažetak

U ovom radu istražen je uticaj stranih direktnih investicija na energetsku efikasnost firmi u privredama članicama sporazuma CEFTA 2006. Korišćenjem podataka na mikro nivou iz 2.241 preduzeća iz sedam privreda CEFTA 2006 integracije, koje se odnose na 2017. i 2018. godinu, primenili smo metodu sklonosti učešća u tretmanu, kako bismo ocenili uticaj stranih direktnih investicija na energetsku intenzivnost. Naši nalazi ukazuju na to da realizacije stranih direktnih investicija smanjuju energetsku intenzivnost posmatranih preduzeća za između 1.67 i 1.89 procentna poena, što predstavlja približno polovinu prosečne vrednosti energetske intenzivnosti svih preduzeća u uzorku. Ovakvi rezultati ukazuju na zaključak da strano vlasništvo i strane investicije doprinose poboljšanju energetske efikasnosti preduzeća u regionu putem transfera tehnologije i znanja, čime se unapređuje produktivnost preduzeća. Međutim, jačina i statistička značajnost ovih efekata varira između privreda unutar regiona, pri čemu su najjači efekti utvrđeni u slučaju preduzeća koja posluju u privredama koje karakteriše visok stepen energetske samodovoljnosti i relativno niske upotrebe fosilnih goriva. Ovakvi rezultati ističu značaj uloge širih struktura energetskih tržišta, kao i energetskih politika i politika zaštite životne sredine koji utiču na intenzitet efekata stranih direktnih investicija. Osim pomenutog, u radu je razmotrena i uloga drugih faktora internacionalizacije u unapređenju energetske efikasnosti, pri čemu nisu utvrđeni statistički značajni efekti izvoza niti korišćenja stranih inputa u proizvodnim procesima na energetsku efikasnost.

Ključne reči: *strane direktne investicije (SDI), energetska efikasnost, energetska intenzivnost, strano vlasništvo, produktivnost, transfer tehnologije, multinacionalne kompanije (MNK), metoda sklonosti ka učešću u tretmanu (PSM)*

Introduction

Energy efficiency is an important issue in contemporary economic and environmental policy literature [2; 21; 44; 58]. The economic activity of firms accounts for the largest share in global energy consumption [22; 28], making their energy efficiency strategies pivotal in addressing both economic and environmental challenges. The use of energy in industrial production significantly contributes to greenhouse gas emissions, which are the primary drivers of climate change, rising global temperatures, and increasingly extreme weather conditions [5; 35]. Understanding and improving energy efficiency at the firm level presents a pathway to mitigating these negative effects and reducing industrial carbon footprints while maintaining economic productivity.

In addition to environmental concerns, energy efficiency is a key determinant of firm competitiveness, particularly in economies with scarce energy resources [8]. This is especially relevant in the CEFTA 2006 region, where energy dependence presents a structural vulnerability [32; 51; 53], making energy efficiency a strategic necessity for firms aiming to build resilience against external shocks in the global economy. By improving energy efficiency, risks arising from fluctuations in global energy markets and disruptions in global value chains can be mitigated [14]Ahmed</author><author>Al-Muhtaseb, Shaheen</author></authors></contributors><titles><title>Climate Change and Energy Security: A Comparative Analysis of the Role of Energy Policies in Advancing Environmental Sustainability</title><secondary-title>Energies</secondary-title></titles><periodical><full-title>Energies</full-title></periodical><volume>17</volume><number>13</number><keywords><keyword>renewable energy policies</keyword><keyword>climate change mitigation</keyword><keyword>energy security</keyword><keyword>energy equity</keyword><keyword>environmental sustainability</keyword><keyword>World Energy Trilemma Index (WETI. Additionally, the evolving regulatory landscape, including the European Union's Carbon Border Adjustment Mechanism, underscores the urgency for its trading partners to align with stricter energy and environmental standards to remain competitive in international markets

[47; 55], and to adequately implement complementing trade facilitation measures, which is particularly important for small and medium enterprises in the integration [52]. Understanding the determinants of firm-level energy efficiency is therefore crucial for policymakers and business leaders alike.

The CEFTA 2006 economies provide a particularly compelling context for examining the internationalization-related drivers of firm-level energy efficiency. These economies, still undergoing economic transition, occupy a strategically important position in Europe, serving as both manufacturing hubs and logistical gateways between the European Union and emerging markets. Their relatively open economies have attracted substantial inflows of foreign direct investment, which has been a key driver of economic growth and structural transformation [30; 37; 48; 49]. However, while much of the discussion surrounding foreign direct investment in the region has centered on its contributions to employment, productivity, and trade [11; 20; 29; 41], its environmental consequences—including its precursors such as the impact on energy efficiency—have received comparatively less attention.

Foreign direct investment is often regarded as an important channel for technology diffusion which has the potential to improve firm-level energy efficiency [4; 13; 39]. However, its actual impact depends on the nature and motivations of foreign investment as well as the circumstances of the host country. If FDI inflows are driven primarily by lax environmental regulations and lower energy costs, foreign-owned firms may adopt energy-intensive production techniques that exacerbate energy consumption—an argument consistent with the pollution haven hypothesis [7; 43]. Conversely, multinational enterprises typically operate with more efficient technologies that enable them to compete with domestic firms [9; 31]. It is likely that such technology will be transferred through the channels of the system of multinational enterprises in order to support the competitiveness of foreign affiliates. Thereby, with increased investment in such affiliates, comes a greater extent of control and internalization of such technology transfers [13], which should result in more efficient usage of resources, including energy. Such process mirrors the idea of the pollution halo hypothesis [56], as

foreign-owned affiliates may outperform domestic firms in environmental performance and energy efficiency due to their superior technological endowments.

The existing literature on the effects of foreign direct investment on firm-level energy efficiency remains scarce and inconclusive. While some studies identify clear energy efficiency gains from foreign investment [5; 24; 59], others find limited or no impact [6; 10], and the mechanisms through which foreign direct investment influences energy efficiency remain insufficiently explored. The existing empirical evidence is also based only on individual country case studies, particularly China and other large emerging economies, with relatively few firm-level analyses conducted in transition economies such as those in the CEFTA 2006 region.

This research aims to address this gap by providing firm-level empirical evidence on the effects of foreign direct investment on energy intensity in CEFTA 2006 economies, shedding light on the extent to which foreign ownership contributes to energy efficiency improvements and the conditions under which these effects are most pronounced. Thereby, we contribute to the existing literature in several key aspects. To the best of our knowledge, this is the first study to examine the effects of foreign direct investment on firm-level energy efficiency in a multi-country, as well as the first one to consider these effects in the CEFTA 2006 region. This cross-country perspective allows us to isolate the effects of foreign direct investment from the specific environmental and energy policies of individual economies, offering a more precise estimation of the efficiency effect and providing insight into how circumstances of individual economies modulate it. Furthermore, our study is among the first to analyze firms from transition economies, a context where the relationship between foreign direct investment and energy efficiency remains largely unexplored.

Another key contribution of this study is its micro-level approach, which remains relatively rare in studies on foreign direct investment and energy efficiency. While macroeconomic analyses capture broad effects of foreign direct investment on energy efficiency, they abstract the firm-specific mechanisms through which these impacts effectuate. By focusing on firm-level data,

we identify individual causal pathway, shedding light on how foreign direct investment contributes to energy efficiency improvements through technology transfers between parent company and its affiliates. Additionally, our study contributes to the existing literature by employing propensity score matching to explicitly account for the selection of firms into foreign ownership, following the approach of Brucal, Javorcik, and Love [5]. This allows us to establish a causal relationship between foreign direct investment and firm-level energy intensity, rather than merely identifying correlations.

The aim of this study is to analyze how foreign ownership affects firm-level energy efficiency in CEFTA 2006 economies. We first develop a simple theoretical model describing the firm-level mechanism of foreign direct investment effects on energy intensity and deriving our main hypothesis – that foreign direct investment has a significant negative effect on energy intensity. We then expand our model with other relevant control variables and test it empirically. Beyond foreign ownership, we empirically examine additional internationalization factors that could contribute to improvements in firm-level energy efficiency, including exporting and the reliance on foreign-produced inputs. Finally, by considering other theoretically relevant determinants of energy efficiency, this study provides valuable implications for policymakers, relevant for enhancing energy efficiency of the economy through bottom-up approaches, leveraging foreign direct investment and technological modernization of firms.

Our empirical analysis is based on a firm-level dataset referring to the period 2017–2018, covering 2,241 firms from all seven CEFTA 2006 economies. To robustly test our hypothesis and estimate the effects of foreign direct investment on energy efficiency, we apply propensity score matching, allowing us to control for confounding factors that affect both indigenous domestic firms and foreign-owned affiliates. The results of our estimation support our initial hypothesis.

The remainder of this paper is structured as follows. Section 2 provides a literature review of theoretical and empirical studies investigating the effects of foreign direct investment on energy efficiency using various units of analysis. Section 3 presents the theoretical framework

from which our initial hypothesis is derived. Section 4 describes the data and methodology. Section 5 presents the empirical results and discusses the estimated effects of foreign direct investment on firm-level energy intensity and their regional heterogeneity. The final section concludes.

Literature Review

Numerous studies consider environmental effects of foreign direct investment [12; 35; 46; 50]. Based on their results, these studies can broadly be grouped into two categories: those supporting pollution haven hypothesis and those supporting pollution haven hypothesis [43; 56]. The effect of foreign direct investment on energy efficiency is a related topic to this body of literature. However, this issue has been less explored than the effects of foreign direct investment on emissions and pollution.

Theoretical frameworks directly concerned with foreign direct investment effects on energy efficiency are also somewhat limited. One relevant theoretical framework for this issue is proposed by Imbruno, Lo Turco and Maggioni [26], which shows that presence of foreign firms in upstream manufacturing and energy industries expands the supply of inputs for downstream domestic firms, which negatively affects their energy intensity. The conclusion is supported by the empirical analysis conducted by the same authors, based on Turkish manufacturing sector observed in the period between 2010 and 2015. Building upon foundations laid by Krugman [42] and Ethier [16], Imbruno and Ketterer [25] define another theoretical model which postulates that the influx of diverse material inputs improves firm-level productivity by improving complementarity of production materials. The increased productivity enables firms to maintain output levels, while decreasing the use of inputs, such as energy. As a results, energy intensity of production decreases.

The empirical literature on the effects of foreign direct investment on energy efficiency is similarly scarce. The existing studies can be categorized into macro-, meso-, and micro-level studies. Macro-level studies observe country-level flows of foreign direct investment on energy efficiency [24]. Meso-level empirical studies are mainly concerned with cities A notable example of such study is

Elliot, Su and Chen [15], who observed 206 cities in China between 2005 and 2008, and finding that foreign direct investment reduces city-level energy intensity. Thereby, the authors reported considerable regional heterogeneity of the energy efficiency effects.

Finally, micro-level empirical studies observe individual firms in trying to discern effects of foreign investment on energy efficiency [19; 25; 59]. The effects of other internationalization aspects, including sourcing from foreign suppliers [26], exports [19] and foreign training [10] are simultaneously considered.

One of the most closely related studies, conducted by Zhou et al. [59], investigates the effects of foreign ownership on firm-level energy efficiency in China using cross-sectional survey data from 2007 to 2011. Their findings suggest that foreign ownership decreases firm-level energy intensity by approximately 0.23% to 0.60%. Expanding on this, Gao and Ren [19] emphasize the role of regional and sectoral heterogeneity in modulating the impact of foreign investment on energy efficiency. Their study, based on the same dataset as Zhou et al., identifies that technology-intensive industries benefit the most from foreign investment in terms of energy efficiency gains. Additionally, they highlight that exports serve as a significant channel for energy efficiency improvements, finding that firms engaged in exporting experience an energy intensity reduction of 0.11% to 0.16%. Similarly, Bu et al. provide further evidence for efficiency gains by examining the effects of foreign ownership across different industry types in China. Their findings indicate that foreign ownership reduces energy intensity by 1.5% to 1.9% in capital-intensive industries, whereas no significant effects are observed in labor-intensive ones. These results underscore the importance of absorptive capacity, suggesting that industries with greater technological sophistication are better positioned to benefit from the efficiency-enhancing effects of foreign direct investment. Similar positive effects of foreign investment on energy efficiency have been documented in the Chinese service sector by Huang, Lin, and He [23], who find that foreign ownership leads to energy efficiency improvements.

Beyond China, Cole, Elliott, and Strobl [10] analyze the case of Ghana and find that foreign ownership does

not significantly impact total firm-level energy usage. However, their research reveals an interesting shift in the composition of energy consumption, with foreign-owned firms showing a greater reliance on electricity over fuel, which is considered a cleaner energy source in the context of their study.

Further supporting the notion that foreign involvement improves firm-level energy efficiency, Brucal, Javorcik and Love investigate the Indonesian manufacturing sector and show that foreign ownership reduces plant-level energy intensity by 30% within two years of a cross-border acquisition [5]. Their analysis of plant-level data from 1983 to 2008 attributes this efficiency gain to output expansion and technology upgrades, reinforcing the idea that foreign direct investment facilitates access to more efficient production methods. Similarly, research on the effects of importing foreign intermediaries in Indonesia suggests that firms integrating foreign-produced inputs experience notable improvements in energy efficiency.[25]

To sum up, the existing theoretical frameworks indicate possible positive and negative energy efficiency gains from internationalization. The findings based on micro-level inquiries are limited and focused on single countries, which does not allow for controlling the possible confounding effects of environmental and energy policies affecting the energy efficiency outcomes of foreign direct investment. However, collectively, these findings highlight that while the impact of foreign direct investment on energy efficiency varies across regions and industries, in the cases of sufficient technology differences and absorptive capacity, it has overwhelmingly positive effects. However, the economic significance of these effects ranges a lot, depending on which single country the study is based on. Economies of CEFTA 2006 integration have, to the best of our knowledge, not been subject to a similar inquiry. Given the region's transitional economic status and the increasing integration of its markets with the European Union, and specific policies affected by harmonization processes, the extent to which foreign direct investment affects energy efficiency improvements, remains an open empirical question. We address this gap in the literature with our empirical analysis presented in this paper.

Theoretical Framework

We present the motivation for our empirical analysis using a simple partial equilibrium model describing the energy use of a firm. We simplify the model by imposing several restrictive assumptions. First, in order to provide a framework that allows us to focus on energy usage only, we assume that the output of the firm is fixed. This means that we consider that output is given by previous contractual obligations and it cannot be changed. We denote this fixed output as . The output is sold at price level P which is exogenously determined. Another simplifying assumption is that the representative firm requires only energy (E) as an input to produce its fixed output and that its price is constant. We introduce foreign direct investment in the model, by assuming that foreign direct investment affects factor productivity. This effect could mean the transfer of new, more energy-efficient technologies, analogous to the pollution halo hypothesis [56]. In contrast, it could also mean the transfer of less efficient technologies, analogous to the pollution haven hypothesis [43]. We can describe this setup using the following equation:

$$\overline{Y} = A(FDI) \times E \qquad (1)$$

To make the model tractable, we concretize the functional form for factor productivity as $A(FDI) = A_0 FDI^\phi$, where A_0 represents the baseline productivity of indigenous firms in the host country, while ϕ denotes the efficiency gain parameter of foreign direct investment. Since we assumed that multinational enterprises possess more energy-efficient production technology that they are willing to transfer to the firm in which they invest, the efficiency gain factor is assumed to be strictly positive, i.e. $\phi > 0$.

Given our initial assumptions, we make the following proposition regarding the relationship between foreign direct investment and energy intensity:

Proposition. *The increase in foreign direct investment in a firm results in a decline in energy intensity.*

The proposition can be deduced from our initial setup. Namely, the production function of the firm can be rearranged to show the firm's energy demand function:

$$E = \frac{\bar{Y}}{A(FDI)} \qquad (2)$$

To derive energy intensity (*EI*), we divide energy demand by sales ($S = P \times \bar{Y}$), which yields:

$$EI = \frac{E}{S} = \frac{1}{P \times A(FDI)} \qquad (3)$$

After substituting concretized functional form for factor productivity in (3), we can define the effects of foreign direct investment on energy intensity for firms receiving investment as:

$$\frac{\partial EI}{\partial FDI} = -\frac{\phi}{P \times A_0 FDI^{\phi+1}} < 0 \qquad (4)$$

The equation (4) shows that, if our initial assumptions are met, and multinational possess superior technology to indigenous firms in terms of its efficiency, foreign direct investment will reduce energy intensity of the production. In other words, the larger foreign investment a firm receives, the greater improvements in energy efficiency will be. Moreover, if indigenous firms are more productive, the energy efficiency potential is reduced, and the efficiency gains are lower, which is in line with theories of Findlay [18] and Kokko [40]. It should be noted that if we assumed that multinational enterprises transfer less efficient technologies, i.e. if $\phi < 0$, energy intensity would be increased with foreign direct investment. The nature of the ϕ parameter is an empirical question, and the strategy for its estimation is explained in the following section.

Empirical Methodology

We base our empirical analysis on the model of energy intensity (*EI*). Energy intensity is, thereby, defined as the ratio between costs of energy and sales of a firm. The model specification is guided by our theoretical framework. The independent variable in the focus of our analysis is, thus, foreign direct investment (*FDI*), approximated as the share of foreign ownership in the observed firm.

In addition to it, we also consider other factors of internationalization which the related theoretical frameworks deem relevant. These include exports (*EXP*), imports of foreign inputs (*FI*), and imports of technology

(*IP*). However, in addition to foreign direct investment there is an array of various factors that could affect either energy efficiency directly or indirectly through effects on baseline productivity. For instance, to decouple the effects of foreign direct investment from the effects of economies of scale on energy efficiency, size of the company (*SIZE*) also needs to be controlled for. Innovation (*INN*) may result in adoption of more efficient business processes, and it is not necessarily tied to foreign direct investment, as indigenous firms may also invest in research and development activities. Similarly, the improvement of energy efficiency could be the result of capital investment (*INV*) unrelated to foreign capital. The firm may also improve their efficiency through experience (*AGE*) that accumulates over time. The specifics of the processes applied by the firm also play an important role in determining energy efficiency. For this reason, we consider capital intensity (*KL*) of firm's production, as well as sophistication of its processes approximated by the share of skilled in total workforce (*SKILL*).

Other industry-level characteristics not explicitly accounted for are controlled using industry dummy variables. Finally, differences in relevant policies are controlled using country-level dummy variables. This gives us the final specification of the baseline model, which can be represented by the following equation:

$$EI_i = \beta_0 + \beta_1 FDI_i + \beta_2 FI_i + \beta_3 SIZE_i + \beta_4 IP_i + \beta_5 INN_i + \beta_6 INV_i + \beta_7 AGE_i + \beta_8 EXP_i + \beta_9 KL_i + \beta_{10} SKILL_i + \Sigma_{j=1}^{J} \gamma_j I_{ij} + \Sigma_{k=1}^{K} \delta_k C_{ik} + \varepsilon_i \qquad (5)$$

where i denotes index of firms, j denotes industries, k denotes countries, I_{ij} denotes industry-level dummy variables, C_{ik} denotes country-level dummy variables, γ_j, δ_k, and ε_i are coefficients for industry and country fixed effects and the error term, respectively. Details about the definitions of variables used in this specification, as well as their descriptive statistics are presented in Table 1.

Our sample consists of 2,241 firms from all seven CEFTA 2006 economies. All the data comes from the 2018-2020 Enterprise Survey, conducted by the European Bank for Reconstruction and Development, the European Investment Bank, and the World Bank Group.[17] The region is suitable for exploring the effects of foreign direct

investment on energy efficiency, as all of its economies are open and strongly reliant on foreign investment, as evidenced by inflows normalized by the size of the economies [3; 38]. Additionally, the observed economies are highly integrated into international trade, which enables us to identify the role of other possible mechanisms of the effects of internationalization on energy efficiency at firm-level.

The data we use is cross-sectional and refers to 2018. For some variables, values in a minority of firms were unknown, which reduces the number of observations used for our baseline estimations to 1,842. Our baseline model is estimated by applying the ordinary least squares method. Thereby, we estimate robust standard errors clustered at the country level to address the potential issues of heteroskedasticity and autocorrelation.

The situation in the CEFTA 2006 region is, however, specific, in the sense that foreign investment often results from cross-border acquisitions. This means that the foreign equity shares we observe in the FDI variable are not the result of a random process, as targets of these acquisitions are usually already highly attractive domestic firms. Such firms could already have high levels of energy efficiency. This is illustrated in Table 2, where we make a comparison between foreign affiliates and indigenous firms.

The data presented in Table 2 highlight notable differences between foreign affiliates and indigenous firms across several key firm characteristics, indicating potential structural divergences between the two groups.

Notably, foreign-owned firms have nearly half the energy intensity of the indigenous firms, implying their much higher energy efficiency. However, they also differ in terms of other characteristics that are relevant for energy efficiency as well.

For instance, economy-of-scale effects on energy efficiency are far more present in foreign firms than in indigenous ones, as evidenced by firm size. On average, foreign affiliates are significantly larger, with a mean employment size of 247 compared to 72 for indigenous firms. At the same time, larger firms are more likely to be targets of foreign acquisitions.[33] The export intensity and investment indicators further illustrate structural differences between the two groups. Foreign-owned firms have a substantially higher mean export share (41.147%) than indigenous firms (15.968%), reinforcing the well-documented link between FDI and export orientation [34; 36]. On the other hand, investment levels (INV) appear notably lower for foreign affiliates (0.697) than for indigenous firms (2.691), suggesting that foreign firms may leverage existing capital more efficiently rather than relying on heavy new investment. Foreign affiliates also report higher innovation levels (0.376 vs. 0.223) and intellectual property acquisitions (0.152 vs. 0.073), while the capital intensity is lower in foreign affiliates compared to indigenous firms, which may reflect the sectoral composition of foreign direct investment inflows in the region. Similarly, skill intensity (SKILL) is somewhat higher among foreign-owned firms.

Table 1: Descriptive Statistics

Variable	Definition	Unit	Obs.	Mean	Std. dev.	Min	Max
EI	Energy intensity - the ratio of electricity costs and sales	Percent	1958	3.97	25.44	0	684
FDI	Foreign direct investment – share of foreign ownership in the equity of a firm	Percent	2228	8.76	27.26	0	100
FI	Foreign inputs – share of costs of foreign input in total inputs' cost	Percent	2106	50.12	40.74	0	100
SIZE	Size – number of workers	Workers	2186	89.91	250.98	1	8384
IP	Intellectual property purchase – dummy variable indicating if the firm purchased intellectual property	Unitless	2223	0.08	0.27	0	1
INN	Dummy variable indicating if the firm has introduced new business processes in the past 3 years	Unitless	2205	0.24	0.42	0	1
INV	Investment in equipment	Mil. EUR	2241	2.49	104.71	0	4954
AGE	Firm's age	Years	2230	18.58	13.81	0	204
EXP	Export share in total sales	Percent	2176	18.56	33.28	0	100
KL	Capital intensity – the ratio of assets and the number of workers	Thousands EUR per worker	2241	39.01	1410.80	0	66666
SKILL	Share of skilled workers in the total number of workers	Percent	2241	6.91	17.37	0	100

Source: Authors' calculation.

Table 2: Comparison of foreign affiliates and indigenous firms

Variable	Obs.	Mean	Std. dev.	Min	Max
Indigenous					
EI	1753	4.168	26.751	0	684.15
FI	1891	47.961	40.448	0	100
SIZE	1961	71.857	157.822	1	2249
IP	1999	0.073	0.259	0	1
INN	1979	0.223	0.417	0	1
INV	2014	2.691	110.45	0	4954.19
AGE	2014	28.518	141.788	0	204
EXP	1952	15.968	30.698	0	100
KL	2014	41.118	1486.258	0	66666.67
SKILL	2014	6.64	16.912	0	100
Foreign					
EI	205	2.328	7.695	0	88.355
FI	215	69.079	38.391	0	100
SIZE	225	247.276	607.267	1	8384
IP	224	0.152	0.36	0	1
INN	226	0.376	0.485	0	1
INV	227	0.697	4.43	0	53.741
AGE	227	27.819	134.84	1	134
EXP	224	41.147	44.555	0	100
KL	227	20.295	227.718	0	3421.62
SKILL	227	9.293	20.926	0	99

Source: Authors' calculation.

Bearing these differences in mind, a simple comparison of foreign and indigenous firms in terms of energy efficiency would likely result in biased estimates, as there could be confounding factors affecting both foreign direct investment and energy efficiency. Following the reasoning of Brucal et al. [5], we create a comparison group of domestic groups according to their likelihood of receiving foreign direct investment in order to infer the treatment effects of foreign investment, by applying propensity score matching [54].

We first determine the propensity score, by applying logistic regressions, where, as a dependent variable we consider whether a firm is foreign-owned or not, and as independent variables we use all the independent variables listed in Table 1, apart from foreign direct investment. The results of this estimation provide us with probability (propensity) scores of firms having foreign ownership given its other characteristics. The firms actually receiving foreign direct investment are then matched with the most similar domestic firms, as the matching is based on the propensity score. In our baseline estimations of treatment effects of foreign direct investment, we use the default one-to-one matching, but we check the robustness of the results by also applying one-to-many matching.

After the matching, the causal effects of foreign direct investment on energy intensity is estimated by imputing missing potential outcomes for each firm using an average of similar firms receiving foreign direct investment, and then by taking the average difference between the observed and potential outcomes for each firm. By applying this approach we reduce bias, as we use only comparable firms to estimate the effects of foreign direct investment. This allows us to not only detect and quantify the relationship between foreign direct investment and energy efficiency at the micro level but also to establish the causality from foreign direct investment to energy efficiency.

Results and Discussion

We present the estimation results for our baseline model in Table 3. Model (1) refers to the ordinary least squares estimation of the Equation (5). Models 2-4 refer to robustness checks for Model (1). For instance, in Model (2) we use alternative definition of foreign direct investment introducing it as dummy variable indicating whether the firm is foreign-owned or not rather than continuous variable. The other two specifications relate to slight changes in specification where alternative proxies were used for size and experience. In the first case, size was approximated by total assets value rather than the number of workers. In the second case, experience was approximated by the number of years of experience of the general manager, rather than the age of the firm.

Our estimation results indicate a significant negative relationship between foreign direct investment and energy intensity at the 5% significance level. Specifically, the estimated coefficient value suggests that a change in ownership for the wholly foreign-owned subsidies is associated with a reduction in firm-level energy intensity by 2.5 percent points. A similar statistically significant effect remains if the foreign direct investment is redefined as a dummy variable. Other changes in specification affect negligibly the economic and statistical effect of foreign direct investment on energy intensity. The result supports our theoretical argument that foreign direct investment

Table 3: Estimation results for the baseline model (dependent variable: energy intensity)

	(1)	(2)	(3)	(4)
FDI	-0.025**		-0.025**	-0.024*
	(0.010)		(0.009)	(0.010)
FDI-dummy		-2.138*		
		(0.951)		
FI	-0.007	-0.007	-0.007	-0.007
	(0.007)	(0.007)	(0.007)	(0.007)
SIZE	0.000	0.000		0.000
	(0.002)	(0.002)		(0.002)
IP	-2.898*	-2.924*	-2.885*	-2.906*
	(1.445)	(1.469)	(1.458)	(1.473)
INN	2.993	2.968	3.043	2.922
	(2.727)	(2.718)	(2.705)	(2.672)
INV	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
AGE	-0.001	-0.001	-0.001	
	(0.002)	(0.002)	(0.002)	
EXP	0.020	0.020	0.020	0.019
	(0.032)	(0.032)	(0.033)	(0.032)
KL	-0.000**	-0.000**	0.002	-0.000**
	(0.000)	(0.000)	(0.001)	(0.000)
SKILL	-0.005	-0.005	-0.005	-0.005
	(0.015)	(0.015)	(0.015)	(0.014)
ASSETS			-0.006*	
			(0.000)	
EXPERIENCE				0.042
				(0.035)
Constant	5.060**	5.079**	5.080**	4.248*
	(1.456)	(1.433)	(1.422)	(1.854)
Observations	1839	1842	1841	1839
Adjusted coefficient of determination	0.001	0.001	0.001	0.001

Source: Authors' calculation.
Note: Robust standard errors are presented in the parentheses. ***, **, and * denote coefficients significant at 1%, 5%, and 10% significance levels, respectively. In all specifications industry and country fixed effects are estimated but not reported.

results in technological efficiencies that reflect on energy intensity.

In addition to foreign direct investment, several firm-level characteristics also exhibit statistically significant effects on energy intensity. Notably, acquisitions of intellectual property are associated with reductions in energy intensity across all model specifications. This suggests that technology transfer, regardless of whether or not it is internalized within the system of multinational enterprise, results in improvements in energy efficiency of the firms in the CEFTA 2006 region.

Capital intensity (KL) is also found to be negatively associated with energy intensity at 5% significance level in three out of four model specifications, reinforcing the

notion that more capital-intensive firms tend to adopt more energy-efficient production techniques. Other firm characteristics were not found to exhibit a statistically significant effect on energy intensity.

Overall, our baseline findings provide strong evidence that foreign ownership is associated with lower energy intensity at the firm level in CEFTA 2006 economies. The robustness of this relationship across multiple model specifications supports the hypothesis that foreign direct investment contributes to improved energy efficiency, potentially through the transfer and application of more efficient technologies. The results imply that the technology level between the firms in CEFTA 2006 economies and parent companies in economies of origin are substantial and that the absorptive capacity in CEFTA 2006 is sufficient.

However, due to issues of confounding factors and possible biases of the ordinary least squares estimates outlined in the previous section, we further test the robustness of our findings by applying a propensity score matching approach. After constructing the samples using one-to-one and one-to-many matching based on the scores derived from the logit regression, we get a much more balanced subsample, suitable for isolating the effects of foreign direct investment. This is evidenced by the results presented in Table 4.

Table 4: Covariate balance summary

Variable	Whole	Matched one-to-one	Matched one-to-many
FI	0.575	-0.191	-0.146
SIZE	0.639	0.137	0.155
IP	0.166	-0.022	-0.061
INN	0.330	0.009	0.043
INV	-0.031	-0.032	-0.031
AGE	0.043	0.067	0.034
EXP	0.718	-0.003	0.011
KL	-0.020	0.047	0.040
SKILL	0.159	0.248	0.142

Source: Authors' calculation.
Note: The values refer to standardized differences across foreign direct investment treatment for the whole sample, and subsamples constructed using propensity score matching (variations of one-to-one and one-to-many matching).

Table 4 presents the standardized differences in covariates before and after propensity score matching, providing insights into the effectiveness of the matching procedure in balancing observable characteristics between treated (foreign-owned) and control (domestic) firms. The

values reported for the whole sample reflect the initial differences between foreign-owned and domestic firms prior to matching, while the values for matched one-to-one and matched one-to-many samples indicate the extent to which these differences have been reduced through propensity score matching.

As discussed previously, in the whole sample, several covariates exhibit substantial imbalances between foreign-owned and domestic firms, particularly export intensity, firm size, and the use of foreign inputs. Such pre-treatment differences underscore the necessity of employing propensity score matching to ensure a less biased estimation of the causal effect of foreign direct investment on energy intensity.

Following matching, the standardized differences across most covariates are notably reduced, indicating improved balance between treated and control groups. Under the one-to-one matching specification, the largest remaining imbalance is observed for skill and firm size. However, these values are near the accepted thresholds for balance diagnostics [57]. In the one-to-many matching specification, the imbalance in most covariates is further mitigated. These results imply that matching reduces systematic differences in firm characteristics, increasing confidence in the subsequent estimation of treatment effects. The estimation result of the average treatment effects is presented in Table 5.

Different columns refer to different variants of average treatment estimations. Namely, we consider different definitions of treatment and different matching approaches. Treatments denoted by foreign direct investment follow the standard definition of foreign direct investment, where non-residents need to have at least 10% equity share in the domestic company for it to be considered to be foreign-owned. Treatments denoted as

Table 5: Average treatment effects (ATE) estimates

Treatment	ATE	Standard error	Number of matches
Foreign direct investment	-1.895**	(0.833)	1
Foreign direct investment	-1.673**	(0.808)	3
Majority foreign-owned	-1.894**	(0.832)	1
Majority foreign-owned	-1.673**	(0.807)	3

Source: Authors' calculation.
Note: Abadie-Imbens standard errors are presented in parentheses. ** denote coefficients significant at 5% significance level.

majority foreign-owned set this share threshold to 50%. However, this change in definition results in a negligible change in both the economic and statistical significance of the average treatment effect. The change in the method of matching from one-to-one to one-to-many also does not affect the statistical significance of the foreign direct investment effect, but it does slightly reduce the intensity of the effect. Considering that the propensity scores we use in the matching procedure are random variables that are estimated using our sample, we adjust standard errors of our estimates to the large sample variance of the estimated treatment effects, following the approach of Abadie and Imbens [1].

The results from the propensity score matching analysis indicate that foreign direct investment has a significant negative impact on firm-level energy intensity. Regardless of the specification, the result is significant at 5% level. Specifically, firms that received foreign direct investment exhibit between 1.67 and 1.89 percentage points lower energy intensity compared to similar domestic firms that did not receive foreign direct investment. This supports the results derived from the ordinary least square estimates, although it indicates that the initial baseline estimates were somewhat downward biased. The empirical evidence also supports our theoretical framework and is in line with the models of Imbruno, Lo Turco, and Maggioni and Imbruno and Ketterer [25; 26].

Overall, our estimated effects of foreign direct investment on energy intensity for firms in CEFTA 2006 economies are comparable to previous empirical findings in other contexts. For instance, the strength of the energy intensity reduction effects are stronger in comparison to the case of China, when firms from all industries are considered [59]. Our findings are within the range of estimates reported by Bu et al., who consider only capital-intensive Chinese industries [6]. The differences in foreign direct investment effects on energy intensity between CEFTA 2006 economies and China could be attributed to the sectoral composition of the firms used in the sample. The estimated effects in our study are comparable to the results of Brucal, Javorcik, and Love determined using the data referring to the manufacturing sector of Indonesia [5], with slightly higher effects found

in the case of firms in the CEFTA 2006 region. The key factor driving this difference is likely the time frame of the analysis, as we base our results on cross-sectional data, whereas the result of Brucal et al. refers to the period between 1983 and 2008.

Finally, we explore the economy-level heterogeneity of foreign direct investment effects on energy intensity. For each country, we constructed subsamples of firms using the previously described propensity score matching methodology and its one-to-one variant. This variant was applied due to data limitations, as at country levels we could not achieve a consistent number of matches across countries. The results of our average treatment effects estimation are presented in Table 6, along with some characteristics of economy-level energy usage.

The results reveal considerable heterogeneity in the effects of foreign direct investment on energy intensity across economies. Namely, we observe significant reductions in energy intensity in the case of Albania, Bosnia and Herzegovina, Moldova, and Montenegro, while others exhibit insignificant effects. Furthermore, across the economies with significant effects, their economic significance varies significantly.

The country with the largest estimated reduction in energy intensity due to foreign direct investment is Albania where foreign ownership reduces energy intensity by over 5.3 percent points. Considering that mean energy intensity in the region is approximately 4%, the economic significance of the effect is large and may contribute considerably to the general competitiveness of Albanian firms. Incidentally, Albania also exhibits some of the lowest economy-wide energy intensity levels as well as the highest energy self-sufficiency rate indicating a greater reliance on domestic energy sources. The results could reflect specific energy-related policies in Albania as well as its specific economic structure. However, a more detailed explanation for this result would require a more extensive and focused case study.

Bosnia and Herzegovina, Moldova, and Montenegro show more modest, yet still significant, reductions in firm-level energy intensity following foreign direct investment. Most of these economies have higher energy intensity levels and relatively high carbon intensity. The continued high reliance on fossil fuels in energy supply in these economies implies that while foreign firms may use energy more efficiently, their energy mix likely remains largely dependent on carbon-intensive sources. Serbia, along with its Autonomous Province of Kosovo exhibits statistically insignificant effects of foreign direct investment on firm-level energy intensity. Similar results are obtained in the case of North Macedonia. In all cases, energy self-sufficiency is relatively lower and the share of fossil fuels in energy supply is higher. This could reflect higher energy costs which offset productivity gains from foreign investment resulting in the insignificant average effects. An exception would be Moldova, where a similar situation exists, yet the effects of foreign direct investment are significant. The exception could be explained by Moldova's lag in the transition process compared to other considered economies, which increases the technology gap between foreign and domestic companies and, despite high energy costs, the productivity gains from the transfer of technology offset the higher costs.

Table 6: Average treatment effects (ATE) estimates for individual economies

Country	ATE of FDI	Standard error	Energy intensity of the economy	Carbon intensity of the economy	Share of fossil fuels in energy supply	Energy self-sufficiency
Albania	-5.363**	(2.378)	2.6	120	60.1	85.4
Bosnia and Herzegovina	-0.877**	(0.369)	6.8	480	81.8	75.9
Moldova	-0.819**	(0.347)	5.7	270	78.4	20.2
Montenegro	-1.902***	(0.611)	n.a.	n.a.	n.a.	n.a.
North Macedonia	-4.591	(3.516)	3.5	230	78.9	44.4
Serbia	-2.706	(3.449)	5.5	390	86.8	65.3
Autonomous province of Kosovo	0.465	(3.988)	5.6	430	83.8	70.8

Source: Authors' calculation for ATE and standards errors, and International Energy Agency for economy-wide indicators [27].
Note: All estimations are based on samples constructed using the one-to-one variant of the propensity score matching. Economy-wide data for Montenegro was not available. All economy-wide indicators refer to 2018.

These findings suggest that FDI's role in enhancing energy efficiency is not uniform across economies and may depend on broader structural factors, including the energy profile and self-sufficiency of each country's economy, the situation in their energy markets, and the characteristics of their energy policies. Such findings corroborate previous conclusions of regional heterogeneity of foreign direct investment effects on energy efficiency in other contexts [19].

Conclusion

In this study, we analyzed cross-sectional data for 2,241 firms from the CEFTA 2006 region in order to determine micro-level effects of foreign direct investment on energy efficiency, using the propensity score matching approach. The results of our study provide new evidence on this issue, suggesting significant effects of foreign direct investment on improving the energy efficiency of firms in the region, confirming our initial hypothesis. On average, foreign ownership of firms causes the reduction of energy intensity by up to 1.89 percent points, which is approximately half of the average energy intensity for all the firms in the sample. We also identified considerable regional heterogeneity of these effects, with the strongest effects being present in the economies lagging in the transition process and in the economies with higher energy self-sufficiency.

Our results imply that multinational companies have more energy-efficient production technologies which have a strong energy-saving prospect. This discrepancy between multinationals and indigenous firms suggests that there is a potential for positive technological spillover and demonstration effects which could further contribute to energy efficiency improvements in the region over the long run. Given these results, policymakers could address the issues of energy efficiency in the region through promoting and attracting foreign direct investment, particularly in the more energy-intensive sectors. Also, the existing incentive schemes present in foreign direct investment policies in the region should account for this additional positive effect, as, at the moment, the incentives are primarily reliant on employment and regional development. In order to maximize the benefits of energy efficiency improvement,

policymakers could look into supporting greater linkages between foreign-owned and domestic firms. More generally, the results indicate the need to a more holistic approach in facilitating partnerships between investors and aligning them with Sustainable Development Goals, an example of which is the SDG investor platform [45].

The regional heterogeneity of foreign direct investment effects on energy efficiency implies that the adoption of more efficient production technologies could be fostered by reducing reliance on fossil fuels and improving energy self-sufficiency. The policymakers could, thus, maximize efficiency gains from foreign direct investment by adjusting energy policies and diversifying energy sources. Finally, the improvement in energy efficiency will make the observed economies, and particularly their export-oriented manufacturing sectors, more resilient to increasingly restrictive policies of the European Union, by adapting to the required standards, which is particularly important for emission-intensive industries in the region.

The results of our study also provide some insights for decision-makers in the individual firms seeking to improve energy efficiency. By establishing equity-based partnerships with foreign firms, domestic firms can acquire more efficient technologies that can reduce their energy intensity. Furthermore, the results imply the existence of possibilities of knowledge-sharing collaborations between the firms in the CEFTA 2006 region and foreign affiliates in the region, which could result in the adoption of more efficient technology. Finally, according to the results of our empirical analysis, improvements in energy efficiency could also be achieved through adopting more capital-intensive production processes and purchasing more efficient technologies from other firms.

While our study provides robust evidence of the positive effects of foreign direct investment on the energy efficiency of firms in the CEFTA 2006 region, it is limited to cross-sectional data. A more nuanced analysis accounting for individual firms' heterogeneity could be conducted when similar longitudinal firm-level data becomes available. This could be an interesting avenue for future research.

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