Research Papers
in Economics and Finance

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in Economics and Finance

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Contents

Preface

We are pleased to present the second issue of the *Research Papers in Economics and Finance* (REF) for 2025, published by the Poznań University of Economics and Business Press. This issue marks a small jubilee for the journal, as it is the 20th issue since its launch. The first issue was published in late 2016, and in 2026 we will celebrate the journal's 10th anniversary. Over this period, we have published over 100 scientific articles authored by researchers from around the world. With a strong commitment to maintaining the highest scholarly standards, we publish only manuscripts which have successfully passed a double-blind peer review process, following initial verification done by the Editorial Committee. All articles published in REF are available online in English under an open-access model. REF is currently a biannual journal, with this issue containing nine research papers.

Sebastian Kubala and Marcin Stanuch from Kraków University of Economics, together with Wioletta Kornaś from University of the National Education Commission in Kraków, present a study about the competitiveness of foreign thermal coal trade in European countries over the period 2010–2023. Their analysis reveals a dynamic and diversified nature of the changes in the competitive position of foreign coal trade in Europe. Although many European countries are gradually moving away from the use of coal, some countries continue to maintain competitiveness in this market, with Russia standing out in particular.

Mateusz Mikutowski, affiliated with the Poznań University of Economics and Business, examines the performance of debt collection agencies during economic downturns and financial crises, challenging the common belief that the sector is unaffected by economic cycles. The findings indicate that although the industry experiences a slowdown during crises, it is not crisis-proof. The study provides new empirical evidence on the cyclical vulnerability of a sector that has received limited attention in the existing literature.

Katarzyna Woźniak-Jasińska and Włodzimierz Lewoniewski, both affiliated with the Poznań University of Economics and Business, analyse the interactions between labour market outcomes, labour market policies and R&D investment in OECD

countries over the period 2011–2021. Their findings indicate that R&D investment was positively associated with the employment rate and labour force participation rate, and negatively associated with the unemployment rate. Furthermore, R&D-related indicators also had strong predictive value, highlighting the meaningful role of innovation investments in shaping labour market performance across OECD economies.

Asmaa Hamdy Abdelaziz Mohamed El Mahdy and Nour Amr Samir, both from October University for Modern Sciences and Arts (Egypt) investigate two key issues: the relationship between capital structure and firm performance among non-financial companies listed on the EGX30, and the moderating role of agency costs in this relationship. The results show that capital structure has a positive impact on firm performance, and that agency costs strengthen this positive relationship.

Another study by authors from the Poznań University of Economics and Business, Patryk Janusz Król and Krzysztof Kaczmarek, assesses whether central bank digital currencies (CBDC) can help reduce financial exclusion, using Nigeria's eNaira as a case study. Focusing on regions with high exclusion levels, the authors analyse whether a CBDC can improve access to financial services. Their findings highlight the potential benefits and limitations of adopting a CBDC to enhance financial access, offering insights relevant particularly for developing economies facing significant financial exclusion.

Okay Gunes and Armagan Aktuna-Gunes from the Université Paris I Panthéon-Sorbonne, together with Przemysław Garsztka and Jacek Jankiewicz form Poznań University of Economics and Business, estimate the value of domestic production and the size of Turkey's household informal economy. Informal earnings are calculated using household income declarations and the concept of full income, which assigns monetary values to time spent on non-market activities. A key finding is that higher domestic production reduces informal activity among the self-employed while increasing it among wage earners.

Ameeta Jaiswal-Dale, Romain M. Lorentz, Ernest L. Owens and Bhuvanesh Singh, affiliated with the University of St. Thomas in the USA, propose a practical framework for using blockchain to improve operational efficiency and financial performance in the Consumer Packaged Goods (CPG) sector. Although blockchain is often linked to cryptocurrencies, the study emphasises its real value in strengthening core business functions such as vendor selection, procurement and compliance monitoring. This interdisciplinary approach, which combines technology, business law and project management, demonstrates how even modest operational improvements can boost profitability in low-margin CPG industries and provides a foundation for broader future applications across other sectors.

Marcin Wiśniewski from Poznań University of Economics and Business and Daniel Budzeń from Gniezno College Milenium examine how to assess the financial condition of Polish local government units, focusing on key measures such as

the individual debt repayment, service ratio, the overall budget balance and the operating balance. While current assessments rely mainly on the budget and operating balances, the authors propose adding the primary balance as an additional indicator. The study analyses the financial situation of all Polish local governments from 2004 to 2023, and shows that the primary balance is a valuable and reliable measure of financial stability.

Finally, Krzysztof Łuczka, affiliated with the Poznań University of Economics and Business, addresses the absence of a dedicated price dynamics index for the poorest households in Poland and proposes the Subsistence-Adjusted Price Index (SAPI) as a new measure of living-cost changes. Unlike the Consumer Price Index (CPI), the SAPI reflects the real expenses of low-income households and enables regional comparisons. Using data on the subsistence minimum and inflation in Poland for 2006–2024, the study shows large disparities between these two indicators. The author recommends incorporating the SAPI into official statistics, arguing that it would strengthen social policy effectiveness and help reduce income inequality in Poland.

This jubilee issue of the REF would not have come to fruition if it had not been for the help, work, trust and support of the contributing authors, experienced reviewers and all those involved in the editorial and publishing process. We hope that this issue will provide both an enjoyable reading experience and an inspiration for further scientific research and discovery in the field of contemporary finance and economics.

Yours faithfully,

Piotr Manikowski
Editor

Assessment of the competitive position of foreign thermal coal trade in European countries in 2010–2023

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Abstract

The main objective of this study was to present changes in the competitiveness of foreign thermal coal trade in European countries in the years 2010–2023. The research used the adjusted RCA index, the Trade Coverage Index and the Import Penetration Index. The research results indicate that there has been a dynamic and diversified nature of the changes in the competitive position of foreign coal trade in Europe. Although many European countries are gradually moving away from the use of coal, there are still countries that maintain competitiveness in this market, in particular Russia.

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Introduction

Coal is the most important raw material for electricity generation in the world (EIA, n.d.). Its largest consumers are China (54%), India (18%), the USA (6%), Japan (3%) and South Africa (2.3%) (Phengsaart et al., 2023). Despite efforts to decarbonise, this raw material remains an important element of the energy mix in many European countries. Its role in ensuring energy security was particularly visible during energy crises, such as the reduction of gas supplies as a result of the Russian-Ukrainian conflict or pandemic shocks. During this period, not only changes in import and export were observed, but also the growing importance of coal costs and quality, which affected the competitive capacity of countries in this sector.

Coal trade research indicates the need to understand not only traditional market mechanisms, but also the impact of energy and environmental policies on the formation of the international coal market. The need to cope with competition and maintain or increase competitiveness requires further action to increase energy efficiency (Firlej & Stanuch, 2023). Countries such as Poland have had to face the challenge of electricity affordability and supply security, as reflected in the updated NECP. In this context, research on the export-to-import ratio of coal and its impact on the trade balance is crucial to understanding the directions of Europe's energy transformation.

The main objective of this study is to present changes in the competitiveness of foreign thermal trade in coal in European countries in the years 2010–2023. This analysis allows us not only to assess market dynamics, but also to indicate the challenges and opportunities in the coal sector, which, despite the trend away from fossil fuels, still plays an important role in the energy policies of many European countries (EURACOAL, 2024). These studies are important in several respects. Many analyses focus on the general goals of decarbonisation and their consequences for the energy sector, but few of them examine how climate policies shape foreign trade in coal, especially in terms of limiting imports. It is very important to simultaneously show the differences between individual countries in terms of the role of coal in their energy mix, as well as its position in foreign trade.

The research is based on the following hypotheses:

H1: The competitive position in foreign coal trade in European countries declined between 2010 and 2023, especially among EU member states.
H2: Russia increased their comparative advantage in thermal coal exports between 2010 and 2023.

Given the significant institutional and policy-related differences among European countries, this study must take into account the distinctions between EU and non-EU members, taking into account distinct decarbonisation strategies, regulatory

environments and the role of coal in their respective energy mixes. European Union countries have committed to ambitious emission reduction targets, largely phasing out coal, while non-EU countries such as Russia or Belarus pursue independent energy policies, often prioritising security of supply and maintaining a high share of coal in their energy mix.

1. Literature review

Coal remains an important raw material in Europe, despite the dynamic development of renewable energy sources (RES) and the ambitious climate goals of the European Union. Phasing out coal from electricity generation is essential to stop global warming (IPCC, 2022). This urgent need is reflected in the Glasgow COP26 'pact' to gradually reduce global coal consumption, which came after increasing political and financial pressure to implement decarbonisation policies (Yanguas-Parra et al., 2021). The energy transformation initiated by the EU Green Deal aims at gradually reducing the role of coal in the energy mix, which results, among other things, in the implementation of the Emissions Trading System (EU ETS) and stricter environmental standards, which have significantly reduced the profitability of coal investments (Holz et al., 2018). Carbon reduction strategies include the establishment of a carbon tax (Wang et al., 2019; Wang & Yu, 2021), a carbon tax (Jiang et al., 2020; Wang-Helmreich & Kreibich, 2019) and carbon pricing (Brauers et al., 2020; Osorio et al., 2020). Bódis et al. (2019) highlighted the role of solar PV in helping to transform European coal regions, and Böhringer and Rosendahl (2022) quantitatively evaluated the economic and environmental impacts of different scenarios using a CGE model.

The global structure of energy consumption is changing, as evidenced by the gradual decline in total coal consumption (Paltsev, 2016). In the European Union, Germany remains the EU's largest coal-based electricity producer in the share of energy mix (BP, 2021). This country has a long tradition of domestic coal mining, justified primarily by considerations of national energy security (Storchmann, 2005). Galgóczi (2019) points out that countries such as Poland and Germany face serious challenges related to the transformation of mining regions. Upper Silesia, being one of the key coal mining centres (Wehnert et al., 2017), requires comprehensive restructuring measures. In turn, Oei et al. (2020a, 2020b) examined the socioeconomic effects of coal phasing out in Germany, emphasising the importance of supporting policies for a successful transformation.

Geopolitics has a significant impact on the coal sector in Europe („European…", n.d.; Kotek et al., 2023). The reduction in natural gas supplies from Russia has tem-

porarily increased the demand for coal. This has forced many Member States to prioritise energy security over climate goals (Mišík, 2022). Countries like Hungary, Slovakia and Czechia were among the most vulnerable, facing potential gas shortages of up to 40% and significant economic impacts. These countries increased coal use and delayed coal phase-outs to maintain energy security (Gritz & Wolff, 2024). Germany and Italy expanded LNG infrastructure and increased coal-fired power generation. Germany, despite its climate commitments, temporarily postponed coal phase-outs and invested in new LNG terminals (Goldthau & Youngs, 2023; Prontera 2023). Poland, already coal-dependent, further leaned on coal to offset gas shortages, though it also accelerated renewable energy investments (Goldthau & Youngs, 2023).

The global energy crisis has highlighted the complexity of the energy transition challenge. On the one hand, coal still plays a significant role in ensuring short-term energy security. The global energy crisis has shown that eliminating coal as a key means of promoting energy transformation is a mistake in terms of energy security, as demonstrated by the European Union countries (Barrasso, 2022; Cohen, 2021). To replace fossil fuel imports from Russia, alternative sources of these raw materials are being sought, mainly in African countries (Harvey, 2022). Despite the general marginalisation of the coal sector in Europe, coal still plays an important role in ensuring energy security, especially in the context of high dependence on gas and oil imports. According to EURACOAL (2024), European coal resources, including lignite, can act as a strategic buffer in crisis situations. On the other hand, many studies emphasise the need for a rapid phase-out of fossil fuels, including coal, in order to achieve climate goals and avoid long-term environmental costs (Diluiso et al., 2021; Minx et al., 2024). This debate shows that the role of coal in the energy transition requires a balanced approach that takes into account both energy security and decarbonisation objectives.

The crises that occurred caused a significant decrease in energy consumption in many countries, which affected the market prices of natural resources (Dutta et al., 2020; Mensi et al., 2020). The analysed period includes two major crises: firstly, the COVID-19 pandemic (2020), which disrupted international trade and energy demand, and secondly, the outbreak of the war in Ukraine (2022), leading to widespread disruptions in fuel markets and a significant decrease in coal imports from Russia (Huang et al., 2023; Parra et al., 2021). Furthermore, the subsequent freeze of economic life did not immediately increase the demand for coal. This situation occurred in China, where the average level of coal consumption in power plants was the lowest in four years (Wang & Su, 2020).

At the same time, the literature points to the important role of foreign coal trade. Although many countries in the European Union have ceased coal production in recent years, coal consumption has declined at a much slower pace, resulting in an increase in import dependence. Wang et al. (2019) constructed a global

coal trade network covering the period 1996–2015, and Wang et al. (2021) constructed a coal import competition network from 1998 to 2017. In addition, Chen et al. (2022) examined coal trade from 1999 to 2018, analysing trade relations, scale and distribution to identify countries involved in coal trade.

2. Research methodology

The study was based on the statistical data on international trade of individual European countries in coal, briquettes and similar solid fuels produced from coal. The research focuses solely on trade in hard thermal coal, which dominates international flows. Lignite is excluded from the main analysis due to its local use and minimal cross-border trade. Similarly, coking coal is not analysed here. The research area was assumed to be European countries. The article uses abbreviated names of countries, according to the ISO 3166 symbol (Rozporządzenie, 2020). The study does not include countries that, according to the International Energy Agency (IEA), did not produce thermal coal in 2022: Andorra, Cyprus, Gibraltar, Luxembourg and the Faroe Islands (International Energy Agency, n.d.). Data were sourced from the International Trade Centre.

The time period 2010–2023 was chosen to encompass the latest phase of energy transition in Europe, including pre-pandemic stability, the COVID-19 shock, and post-2022 market turbulence following the war in Ukraine. These years capture key geopolitical, regulatory and economic trends shaping coal trade in the region. 2023 is the last year for which complete statistical data is available.

The analysis is based on volume data of coal exports and imports, which reflect physical quantities traded rather than their monetary value. This approach avoids distortions caused by price fluctuations, which are sensitive to geopolitical and economic factors.

As part of the foreign trade conducted by individual countries in the era of globalisation, it is important to check whether there is a high level of competitiveness in the transactions conducted. The research methods were selected to allow a comprehensive assessment of the competitive position of coal in international trade. The basic measure that allows one to examine this phenomenon is the RCA (Revealed Comparative Advantage Index) proposed by Balassa (1965). It is calculated according to the following formula:

$$RCA_i = \frac{X_{ij}}{\sum_{i=1}^{n} X_{ij}} : \frac{X_{iw}}{\sum_{i=1}^{n} X_{iw}} \tag{1}$$

where:
RCA_i – Revealed Comparative Advantage Index,
X_{ij} – export of i-th product by a given country j,
X_{iw} – export of i-th product by a group of countries w,
n – number of product types.

This indicator is primarily designed to determine the relative share of a product group in the export of a given country in relation to the share of the same product group in the export of the area compared (Kubala & Firlej, 2019; Szczepaniak, 2014). During interpretation, it should be noted that values below one mean that a given country does not have a comparative advantage in the reference market, while values above one indicate the existence of such advantages. However, this indicator has a disadvantage, as it is not limited from above. Therefore, it becomes reasonable to remove this interpretation difficulty by modifying this indicator in the following way (Dalum et al., 1998; Salamaga, 2013):

$$RCA_k^{(a)} = \frac{RCA^a - 1}{RCA^a + 1}$$

(2)

where:
$RCA_k^{(a)}$ – adjusted Revealed Comparative Advantage Index,
RCA – Relative Comparative Advantage Index (Balassa index),
a – any positive number (exponent).

The adjusted RCA index can reach values from –1 to +1. Values above zero indicate the existence of a comparative advantage in the export of a given product, while negative values mean that such an advantage does not exist. At the same time, the index indicates the strength of the existing advantage (Firlej & Kubala, 2018). Values closer to one indicate the existence of a stronger advantage, whereas the closer they are to negative one, the greater the lack of advantage.

The value of RCA indicators was calculated as the ratio of the export value of coal, briquettes and similar solid fuels produced from coal in a given country to the total export value of this product in European countries and the ratio of the export value of this country to the total export value in European countries. In the next step of the analysis, the adjusted relative comparative advantage indicator was used. In the calculations, the value of parameter a was assumed to be equal to 1.

The second indicator used to assess competitiveness is the Trade Coverage indicator, which illustrates the relationship between export and import of a given product. Its main purpose is to determine to what extent the revenues from export of a given product cover the costs related to its import. This indicator shows the level of export specialisation of a country in a given economic sector. It is calculated on the following formula:

$$TC = \frac{Ex}{Im} \qquad (3)$$

where:
TC – Trade Coverage Index,
Ex – export value,
Im – import value.

According to the adopted interpretation, an index value above one indicates a relative competitive advantage in the analysed area and confirms export specialisation. On the other hand, values below one indicate limited competitiveness in a given sector and signal the occurrence of a deficit in international trade.

The third indicator is the Import Penetration Index. It is a measure of the share of imports in the total supply of a given product or group of products on the market of a given country. It is used to assess the dependence of the domestic market on imports and to analyse the competitiveness of domestic production in the context of international trade (Nguyen et al., 2019). This indicator is expressed by the formula (Hellberg & Mannerson, 2019):

$$IPI = \frac{M}{D + M - E} \qquad (4)$$

where:
IPI – Import Penetration Index,
M – import volume,
D – production volume,
E – export volume.

An indicator value greater than 1 indicates that the country is dependent on imports, which means that the imported product constitutes a larger share of the domestic market than domestic production. A value of one indicates countries that import exactly as much as they produce, while values less than 1 indicate that the country produces more than it imports of a given product.

Selected methods are optimal for this study, as they allow for differentiation between exporting and importing countries, identify changes in the competitive position over time, and exclude distortions stemming from trade intermediaries or countries with negligible trade volumes. Although other approaches, such as price-adjusted quantitative models or econometric techniques, could complement the analysis, the selected indicators provide clear insight into broad market trends with the available data.

3. Results

The overall value of exports and imports of coal, briquettes and solid fuels in Europe in the years 2010–2023 shows variation (Figure 1). The value of imports of the raw materials considered gradually decreased for most of the first decade. This trend is related to the intensification of climate policy and the implementation of the EU ETS. The level of exports remains relatively stable until 2021. In 2022, the value of exports increased to a record level of almost USD 50 billion. This is the result of the energy crisis caused by the war in Ukraine, the reduction of natural gas supplies from Russia, and the search for alternative energy sources by European economies. A year later, the energy market stabilised.

Figure 1. The value of exports and imports of coal, briquettes and similar solid fuels produced from coal in European countries in 2010–2023

Source: own study based on data from the International Trade Centre (n.d.).

In the first stage of the analysis, the adjusted Relative Comparative Advantage Index (Table 1) was used. The a parameter value was assumed to be 1 in the calculations. Data on the adjusted comparative advantage index RCA of coal, briquettes and similar solid fuels produced from coal in European countries in the years 2010–2023 show interesting conclusions regarding the competitiveness of these countries on the coal market. Many countries have RCA values below 0 for most years of the analysed period, which means that they do not have a comparative advantage in the production of solid coal fuels. In some cases, such as Austria, Malta, Norway, Sweden and Switzerland, these values remained at a constant level of –1, which suggests a lack of competitiveness in this industry in a given period. However, in Eastern European countries, such as Belarus or Ukraine, larger fluctuations in the results are visible. For example, Belarus had a positive RCA value in 2019 and 2020, indicating a temporary comparative advantage, but since 2021

this value has turned negative. Ukraine also experienced periods with positive RCA values (2010–2014), but after 2017 its indicator fell to negative values, reaching –1 in 2020 and then improving slightly in 2023 to 0.06. In the case of Poland, there was a comparative advantage in 2010–2018 and in 2021. In the other years under analysis, the values achieved were slightly negative. Positive values were also recorded in the Netherlands in 2011–2012, in the Czech Republic in 2010–2015, and in Albania in 2023. Among the countries that showed a positive RCA index, it is worth highlighting Russia, whose index increased from 0.82 in 2010 to 0.90 in 2023, indicating an increase in the country's competitiveness in the production of coal and similar fuels. These changes are due to energy policy and the increase in coal mining in Russia, which allows it to strengthen its position in the coal market.

The table presenting the Trade Coverage Index of coal, briquettes and similar solid fuels produced from coal in European countries in the years 2010–2023 shows a large variation in results depending on the country and year (Table 2). Russia clearly dominates this table, with the highest values of the index in each year, which range from about 15 to over 200 in the years 2022–2023. This indicates its large share in the production and trade of coal and its derivatives in Europe, as well as significant exports of these raw materials. High values of the index are characterised by Denmark (except for 2012, 2018 and 2022) and the Czech Republic in the years 2010–2016. In the period under review, the value of exports exceeded imports simultaneously in Poland (in 2013 and 2015–2016), Belarus (2019–2020) and Estonia (2022).

In the last stage, the Import Penetration Index of coal, briquettes and similar solid fuels produced from coal was analysed (Table 3). The results achieved allow us to distinguish five groups with similar trends. The first group includes countries with a stable IPI close to 1, such as Austria, Croatia, Estonia (except for 2022), Finland, France, Ireland, Sweden, Portugal, Moldova, Switzerland, Iceland, Italy (except for 2015) and Malta. They are characterised by a balanced dependence on imports. The second cluster includes countries with a relatively high and stable IPI, such as Belgium, Lithuania, Latvia and the Netherlands. These are countries with a strong dependence on imports. The third group includes countries with a low IPI index, such as Poland, Bulgaria, Germany, Greece, the Czech Republic, Bosnia and Herzegovina, Montenegro, Northern Macedonia, Slovenia, Romania, Serbia, Hungary and Russia. They are characterised by a low dependence on imports, which indicates the dominance of domestic production in the economy. The fourth cluster distinguishes countries with atypical IPI values, such as Denmark and Belarus. These countries are characterised by fluctuations or anomalies in the values of the index, e.g. a very high IPI in Belarus in 2019 (5.48) or negative values in Denmark in some years. The last group includes countries with moderate and variable IPI, Albania, Norway, Slovakia, Ukraine, Spain and the UK. These countries show an upward trend, in the last years of the analysis reaching values above the level of 1.

Table 1. Adjusted comparative advantage index RCA of coal, briquettes, pellets and similar solid fuels produced from coal in European countries in 2010–2023

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
AL	−1.00	−0.99	−0.99	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	0.14
AT	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00
BY	−1.00	−1.00	−1.00	−1.00	−0.99	−0.88	−0.90	−0.67	−0.09	0.49	0.25	−1.00	−0.98	−0.99
BE	−0.17	−0.23	−0.30	−0.37	−0.50	−0.55	−0.58	−0.63	−0.66	−0.69	−0.69	−0.66	−0.65	−0.74
BA	−0.96	−0.96	−0.93	−0.94	−0.90	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−0.95	−1.00	−0.97
BG	−0.71	−0.69	−0.67	−0.66	−0.77	−0.80	−0.88	−0.92	−0.96	−0.98	−0.98	−0.99	−0.90	−0.94
CZ	0.53	0.50	0.33	0.23	0.13	0.04	−0.01	−0.14	−0.29	−0.42	−0.65	−0.39	−0.64	−0.67
DK	−0.94	−0.86	−0.99	−0.94	−0.89	−0.93	−0.97	−1.00	−1.00	−0.94	−0.94	−0.81	−0.98	−0.92
EE	−0.87	−0.99	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−0.94	−1.00
FI	−1.00	−1.00	−1.00	−0.99	−1.00	−1.00	−1.00	−0.97	−1.00	−1.00	−1.00	−0.88	−1.00	−0.90
FR	−0.96	−0.97	−0.96	−0.97	−0.95	−0.97	−0.96	−0.99	−0.99	−0.96	−0.96	−0.84	−0.97	−0.96
DE	−0.96	−0.96	−0.97	−0.96	−0.97	−0.97	−0.96	−0.97	−0.98	−0.96	−0.95	−0.94	−0.94	−0.93
GR	−0.98	−0.96	−0.94	−0.97	−0.96	−0.97	−0.94	−0.96	−0.95	−0.96	−0.98	−0.91	−0.95	−0.99
HR	−1.00	−1.00	−0.99	−0.83	−0.80	−0.60	−0.56	−0.71	−0.42	−0.79	−0.85	−0.74	−0.71	−1.00
HU	−0.99	−0.99	−1.00	−0.97	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00
IS	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−0.99	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00
IE	−0.96	−0.97	−0.94	−0.91	−0.91	−0.87	−0.86	−0.88	−0.85	−0.86	−0.82	−0.84	−0.91	−0.91
IT	−0.99	−0.99	−0.98	−0.99	−0.99	−0.97	−0.97	−0.98	−0.99	−0.98	−0.99	−0.96	−0.98	−0.96
LV	−0.89	−0.92	−0.95	−0.83	−0.63	−0.49	−0.93	−0.95	−0.93	−0.95	−0.97	−0.93	−0.66	−0.81
LT	−0.85	−0.89	−0.98	−0.90	−0.89	−0.85	−0.86	−0.79	−0.77	−0.82	−0.82	−0.84	−0.67	−0.82
MK	−0.85	−1.00	−0.89	−0.95	−1.00	−0.87	−0.96	−0.98	−0.99	−0.99	−0.99	−0.99	−0.98	−1.00
MT	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00

[19]

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
MD	−0.99	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−0.98	−0.93	−0.94	−1.00
ME	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−0.99	−1.00	−1.00	−1.00	−1.00	−0.99	−0.97	−1.00
NL	−0.17	0.05	0.02	−0.06	−0.18	−0.13	−0.14	−0.28	−0.38	−0.52	−0.46	−0.33	−0.37	−0.42
NO	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00
PL	0.53	0.43	0.34	0.45	0.34	0.33	0.29	0.21	0.02	−0.02	−0.04	0.02	−0.09	−0.11
PT	−0.96	−0.95	−0.97	−0.97	−0.98	−1.00	−0.98	−1.00	−0.99	−1.00	−1.00	−1.00	−1.00	−1.00
RO	−0.86	−0.97	−0.99	−1.00	−1.00	−0.99	−0.99	−0.99	−1.00	−1.00	−1.00	−1.00	−0.97	−0.98
RU	0.82	0.80	0.81	0.81	0.83	0.87	0.89	0.88	0.87	0.87	0.89	0.87	0.86	0.90
RS	−0.87	−0.95	−0.99	−0.97	−0.99	−0.99	−0.98	−1.00	−1.00	−0.99	−0.99	−0.99	−0.98	−0.99
SK	−0.97	−0.96	−0.95	−0.94	−0.95	−0.97	−0.97	−0.84	−0.83	−0.94	−0.90	−0.89	−0.92	−0.95
SI	−0.99	−0.97	−0.99	−0.95	−0.98	−0.98	−0.98	−0.98	−0.98	−0.99	−0.98	−0.99	−0.99	−0.99
ES	−0.62	−0.64	−0.59	−0.77	−0.66	−0.67	−0.81	−0.91	−0.92	−0.74	−0.66	−0.84	−0.69	−0.39
SE	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00
CH	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00	−1.00
UA	0.65	0.64	0.54	0.67	0.64	−0.15	−0.20	0.00	−0.87	−0.99	−1.00	−0.99	−0.07	0.06
GB	−0.73	−0.78	−0.76	−0.76	−0.79	−0.81	−0.81	−0.86	−0.83	−0.79	−0.66	−0.75	−0.86	−0.83

Source: own study based on data from the International Trade Centre (n.d.).

Table 2. Trade Coverage Index of coal, briquettes and similar solid fuels produced from coal in European countries in 2010–2023

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
AL	0.00	0.00	0.00	0.00	×	0.00	×	×	×	×	×	×	×	3.47
AT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BY	0.00	0.01	0.00	0.00	0.01	0.07	0.06	0.29	0.70	1.08	1.12	×	0.08	×
BE	0.49	0.39	0.41	0.42	0.39	0.37	0.36	0.30	0.27	0.26	0.29	0.41	0.42	0.29
BA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BG	0.02	0.03	0.05	0.08	0.04	0.05	0.05	0.03	0.02	0.01	0.01	0.00	0.04	0.06
CZ	3.46	2.44	2.56	2.13	1.46	1.33	1.22	0.69	0.53	0.38	0.24	0.38	0.22	0.21
DK	6.47	6.25	0.59	3.68	20.85	20.28	25.09	2.45	0.55	405.85	1.06	4.06	0.58	1.30
EE	0.10	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.10	0.00
FI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.04
FR	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.00	0.00	0.02	0.03	0.10	0.02	0.03
DE	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.02	0.02	0.04
GR	0.01	0.04	0.14	0.04	0.05	0.03	0.07	0.05	0.06	0.06	0.03	0.17	0.26	0.05
HR	0.00	0.00	0.00	0.03	0.04	0.09	0.10	0.11	0.36	0.10	0.08	0.09	0.11	0.00
HU	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IE	0.03	0.02	0.04	0.05	0.06	0.08	0.12	0.11	0.17	0.49	0.58	0.18	0.15	0.21
IT	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.01	0.01	0.02	0.01	0.03
LV	0.07	0.05	0.05	0.20	0.51	0.73	0.17	0.14	0.19	0.14	0.17	0.54	0.81	0.89
LT	0.13	0.08	0.02	0.09	0.12	0.18	0.20	0.27	0.34	0.29	0.41	0.35	0.66	0.69
MK	0.03	0.00	0.02	0.01	0.00	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.00
MT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.00	0.00	0.00
MD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.00

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
ME	0.02	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.07	×	0.00
NL	0.41	0.62	0.57	0.46	0.39	0.33	0.32	0.29	0.27	0.36	0.58	0.48	0.68	0.54
NO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PL	0.69	0.54	0.78	1.06	0.88	1.07	1.03	0.53	0.32	0.36	0.49	0.56	0.28	0.33
PT	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.21	0.00
RO	0.08	0.02	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.04	0.05
RU	54.17	28.62	15.27	15.40	19.60	22.04	34.61	28.57	42.36	43.49	38.82	42.59	200.4	214.2
RS	0.07	0.03	0.00	0.04	0.01	0.00	0.02	0.00	0.00	0.00	0.01	0.01	0.02	0.01
SK	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.03	0.04	0.01	0.03	0.03	0.02	0.01
SI	0.06	0.19	0.09	0.41	0.14	0.17	0.22	0.24	0.22	0.17	0.16	0.19	0.38	0.32
ES	0.09	0.07	0.08	0.07	0.10	0.08	0.06	0.02	0.02	0.16	0.41	0.10	0.15	0.50
SE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
UA	0.32	0.28	0.23	0.37	0.29	0.03	0.03	0.04	0.00	0.00	0.00	0.00	0.18	0.93
GB	0.05	0.03	0.03	0.04	0.04	0.05	0.12	0.09	0.10	0.19	0.43	0.26	0.11	0.32

Source: own study based on data from the International Trade Centre (n.d.).

Table 3. IPI index of coal, briquettes and similar solid fuels produced from coal in European countries in 2010–2023

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
AL	0.87	0.95	0.94	0.91	0.00	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46
AT	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
BY	1.00	1.01	1.00	1.00	1.01	1.07	1.05	1.28	2.07	5.48	3.29	×	1.03	0.00
BE	2.51	1.85	2.21	1.89	1.67	1.60	1.64	1.65	1.40	1.44	1.44	1.64	1.70	1.42
BA	0.17	0.16	0.13	0.16	0.19	0.18	0.17	0.16	0.18	0.19	0.17	0.19	0.09	0.09
BG	0.09	0.08	0.06	0.06	0.05	0.03	0.02	0.03	0.03	0.02	0.03	0.03	0.04	0.02
CZ	0.04	0.05	0.04	0.05	0.07	0.06	0.07	0.08	0.08	0.00	0.00	0.13	0.12	0.00
DK	−0.13	−0.10	−0.61	−0.04	−0.01	0.00	0.00	−0.96	1.00	1.00	0.00	×	0.00	1.00
EE	1.04	1.02	1.01	1.00	1.00	1.00	1.00	0.00	1.00	1.00	×	×	−0.09	×
FI	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.06	1.00	1.03
FR	1.01	1.01	1.01	1.01	1.02	1.01	1.02	1.00	1.00	1.02	1.03	1.07	1.02	1.02
DE	0.18	0.19	0.18	0.21	0.24	0.23	0.24	0.22	0.21	0.24	0.22	0.24	0.25	0.23
GR	0.01	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.02	0.01	0.00
HR	1.00	1.00	1.00	1.01	1.01	1.03	1.03	1.12	1.31	1.04	1.03	1.06	1.10	1.00
HU	0.16	0.14	0.14	0.13	0.13	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IS	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
IE	1.01	1.01	1.02	1.02	1.02	1.03	1.04	1.07	1.08	1.46	1.54	1.22	1.03	1.13
IT	1.00	1.00	1.00	1.00	1.00	0.00	1.01	1.00	1.00	1.00	1.00	1.00	×	1.00
LV	1.03	1.04	1.04	1.14	1.47	1.83	1.12	1.11	1.18	1.08	1.08	1.37	2.39	1.71
LT	1.11	1.08	1.02	1.09	1.11	1.18	1.17	1.27	1.39	1.30	1.42	1.32	1.65	1.91
MK	0.02	0.02	0.03	0.02	0.03	0.02	0.04	0.03	0.04	0.04	0.03	0.03	0.05	0.09
MT	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.07	1.00	1.00	1.00	1.00
MD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.02	1.00

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
ME	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NL	1.70	1.00	1.00	1.00	1.00	1.43	1.44	1.46	1.39	1.70	1.92	1.70	1.00	1.00
NO	0.11	0.13	0.15	0.10	0.11	0.14	0.16	0.66	0.70	0.76	0.85	0.82	0.92	0.90
PL	0.10	0.10	0.07	0.07	0.07	0.06	0.06	0.10	0.14	0.13	0.12	0.11	0.16	0.00
PT	1.00	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.00	1.42	1.00
RO	0.03	0.03	0.04	0.04	0.03	0.03	0.03	0.03	0.04	0.00	0.05	0.04	0.04	0.02
RU	0.01	0.01	0.10	0.10	0.10	0.09	0.08	0.09	0.09	0.08	0.10	0.09	0.07	0.06
RS	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.00	0.01	0.01
SK	0.59	0.62	0.00	0.00	0.00	0.65	0.66	0.69	0.75	0.00	0.72	0.76	0.79	0.79
SI	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
ES	0.00	0.00	0.78	0.76	0.81	0.90	0.90	0.87	0.88	1.15	0.00	×	×	×
SE	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CH	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01
UA	0.19	0.19	0.20	0.20	0.27	0.30	0.33	0.45	0.44	0.45	0.41	0.44	0.22	0.04
GB	0.58	0.64	0.72	0.79	0.78	0.73	0.67	0.75	0.82	0.68	1.06	1.02	0.99	1.07

Source: own study based on data from the International Trade Centre (n.d.).

[23]

4. Discussion

The results obtained are consistent with the research of Huang et al. (2023), who indicate that the outbreak of the conflict in Ukraine contributed to significant changes in the coal market. When the Russian Federation reduced coal exports, most countries were forced directly or indirectly to look for other sources of energy resources. This conflict deepened the shortage of natural gas supplies in European countries, which forced them to restart coal-fired power plants, in particular in Germany, Austria, France and the Netherlands („Bulgarian media…", 2024). These shifts underline the vulnerability of European energy security in times of a geopolitical crisis and highlight the ongoing reliance on fossil fuels despite climate objectives.

The research results are also consistent with the analysis made by Lee et al. (2011), who indicate that in the case of crises, disruptions in supplies also apply to countries indirectly related to the countries directly involved in the conflict. It should also be emphasised that throughout the research period, Russia has been competitive on the European coal market (Chambers, 2020). In addition, over the years, a slow decline in the importance of coal in foreign trade has been visible, which is caused by a gradual departure from the supply of this energy source (Jakob et al., 2020; Keles & Yilmaz, 2020). This transition reflects broader global trends towards decarbonisation but remains uneven and subject to external shocks. This is also confirmed by the research by Finkelman et al. (2021), at the same time as indicating that some countries (including Russia) are increasing their energy production and consumption. This transition reflects broader global trends towards decarbonisation, but remains uneven and subject to external shocks. This is also confirmed by research by Finkelman et al. (2021), which also indicates that some countries (including Russia) are increasing their energy production and consumption.

Moreover, the evolving regulatory environment within the European Union continues to exert pressure on coal markets, accelerating the need for diversification of energy sources (Igliński et al., 2024; Rabbi et al., 2022). Technological advancements in renewable energy and energy storage are likely to play a pivotal role in reducing coal dependency in the near future while balancing energy security concerns.

The findings highlight the crucial role of policy and institutional context in shaping trade flows. EU member states face stricter decarbonisation regimes and related investment constraints, leading to a rapid drop in coal import demand; non-EU countries such as Russia do not face such restrictions and remain active exporters. The division between thermal coal, coking coal and lignite is also relevant – only the first is widely traded internationally.

The main limitations of this research include the inability to fully disaggregate flows by coal type in some national statistics, difficulty in correcting for re-export effects in hub countries, and partial aggregation of intra-EU trade due to the customs union. Future research could employ panel data methods, country case studies or direct surveys of traders and utilities to further isolate market drivers and comparative advantages.

Conclusions

The conducted analysis of the competitive position of foreign coal trade in Europe in the years 2010–2023 indicates the dynamic and diverse nature of changes in the coal sector. The research results confirm the validity of hypotheses H1 and H2, indicating a decline in coal competitiveness among most EU countries and the maintenance of Russia's advantage until 2022.

The results show that although many European countries are gradually moving away from coal use in favour of more sustainable energy sources, there are still countries that maintain their competitiveness in this market. Russia, due to its significant natural resources and energy policy, dominates the European coal market throughout the research period. Central and Eastern European countries, such as Poland, the Czech Republic and Ukraine, show periodic comparative advantages, but their results are subject to significant fluctuations depending on local and global economic conditions.

The outbreak of the conflict in Ukraine in 2022 and the reduction of natural gas supplies from Russia caused rapid changes in the energy market, forcing many countries to temporarily return to coal as a key energy source. At the same time, differences are visible depending on the level of coal imports – countries such as Belgium and the Netherlands are characterised by high dependence on imports, while most countries of Eastern Europe and the Balkans rely on them to a lesser extent.

The results also indicate a general trend of decreasing the importance of coal in international trade, which is consistent with global trends of energy transformation and decarbonisation. However, armed conflicts, energy crises and specific regional conditions may temporarily change this direction. In the future, further research should focus on the impact of climate policies, renewable technologies and transformation of European economies on international trade of energy resources.

The results of this study should be disseminated both within scientific circles (energy economics, international relations, climate policy) and among policymakers at the EU and national levels, as well as energy sector stakeholders. Key find-

ings can inform national energy strategies, coal import contingency planning and electricity market risk assessments. The findings have measurable social utility. By clarifying coal import risks and competitive positions, the study supports more resilient energy policies and helps prepare for supply disruptions. Insights into the timing of trade shifts can guide targeted social support and structural adjustment in regions dependent on coal mining and coal-fired power production.

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Are debt collection agencies truly acyclical and crisis-proof?

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Abstract

This paper examines the resilience of debt collection agencies during economic downturns and financial crises, challenging the notion that the industry is acyclical. The motivation stems from a gap in academic literature assessing how economic cycles impact debt collectors' financial performance. Using a combination of case study analysis and statistical methods, the study evaluates the financial results and stock returns of 13 publicly listed debt collection companies over two major crises: the 2007–2009 financial crisis and the COVID-19 pandemic. Findings reveal that while the industry slows during crises, it is not immune. The contribution lies in providing new insights into the cyclical vulnerability of this under-researched sector.

Introduction

Business cycles and the financial condition of enterprises are among the most well-researched areas in literature related to economics and business. The economy's position in either a recession or recovery phase significantly influences the factors that affect the financial health of companies in various sectors. In the literature, this issue has been analysed for a long time, with researchers examining

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how different economic cycles impact revenues, profits, liquidity or the value of businesses. Schumpeter (1939) was one of the pioneers in analysing the issue of business cycles, emphasising that financial crises are an inherent part of the functioning of a capitalist economy, particularly affecting smaller enterprises with fewer reserves and financial resources to survive under less favourable conditions. These studies laid the foundation for many subsequent studies investigating the impact of economic cyclicality on the financial condition of companies.

A new approach to analysing dynamic time series and business cycles was proposed by Hamilton (1989). In his work, he demonstrated that during an economic downturn, companies experience a decline in revenues, an increase in costs and a drop in profitability. Fazzari et al. (1987) focused on the limitations of companies' ability to incur debt, which often leads to reduced investment spending and competitiveness, implying that access to capital is crucial for business survival. Similar conclusions were drawn from the analysis by Bernanke and Gertler (1986), who studied credit shocks and their impact on corporate decision-making, revealing significant problems in maintaining profitability during periods of restricted financing. Oliner and Rudebusch (1992) examined the relationship between business cycles and companies' investment expenditures. They found that companies invest in innovations during economic strength, improving efficiency. During crises, however, due to limited capital, companies struggle with declining profits and loss of liquidity. In their analysis of smaller companies, Bernanke et al. (1994) demonstrated that due to limited access to capital markets, smaller firms are more vulnerable to financial difficulties during downturns than corporations with more extensive reserves. Davis and Haltiwanger (1990) addressed the financial condition of companies from an employment perspective, confirming that in difficult times, businesses tend to reduce staff, which in the long run limits productivity and growth, as it is harder to return to pre-crisis employment levels. Campello et. (2010), analysing the impact of the 2008 financial crisis, found that restricted access to financing during a recession significantly hampers the ability to regain competitiveness during expansion periods.

There are also many analyses focusing on the financial condition of specific industries. Sun et al. (2019) analysed the cyclicality of the construction market and pointed out that companies experience reduced demand for housing and infrastructure investments during recessions. Similar phenomena have been observed in the automotive sector, which is sensitive to supply chain disruptions and decreased demand (Klepper & Graddy, 1990). Aikman et al. (2015), analysing the banking sector, indicated that banks with more diversified loan portfolios cope better with crises. However, systemically, the entire sector loses its ability to generate high margins.

Another popular research trend is analysing stock prices, macroeconomic factors and business cycles. Chen et al. (1986) set the direction for research on an-

alysing macroeconomic phenomena in the stock market. By analysing variables such as inflation, industrial production and interest rates, they demonstrated the relationship between these indicators and stock prices, especially in the construction and financial sectors, which are highly sensitive to changes in financing costs. Fama and French (2015) indicated in their five-factor analysis that inflation and unemployment significantly impact the performance of companies and investments. Rehmann et al. (2021) analysed the impact of the COVID-19 pandemic on stock prices, finding that the crisis had the most significant impact on companies in the service and transportation sectors due to the nature of the crisis. They also showed that companies dependent on individual consumption were more vulnerable to the crisis than high-tech companies. In a cross-sectional study, Bekaert and Harvey (1997) demonstrated that global stock market volatility is significantly related to global interest rates, commodity prices and public debt levels. They indicated that global crises destabilise markets and cause significant declines in stock prices.

In light of the above analysis, it is clear that negative economic conditions negatively affect companies' financial performance and stock prices. Despite their specific nature, debt collection companies also experience problems similar to those of other types of businesses, and these issues can be applied to the financial health of debt collection firms. However, due to the specific and sometimes surprising implications of the debt collection market, it is necessary to devote greater attention to this issue. Detailed qualitative analysis of external and internal determinants and the author's considerations regarding their potential impact on the debt collection sector are presented in section 3.

The debt collection industry is often said to be a counter-cyclical sector that performs well in both good and bad market conditions. However, there is a lack of scientific literature confirming this commonly repeated claim in the debt collection industry and trade press. Generally, the debt collection market is an under-researched financial industry sector. Most studies focus on the technical aspects of portfolio valuation or the public corporate debt market. It is challenging to find analyses that verify the financial condition of debt collection companies and their dependence on the economy.

The primary objective of this article is to verify the resilience of debt collection companies to economic slowdowns and crises. Therefore, an attempt was made to verify this impact by examining the resilience of financial performance to economic slowdowns. A qualitative analysis of internal and external determinants affecting financial results and efficiency was also conducted based on literature, market analysis and financial reports of debt collection entities. A broad case study analysis was carried out. Based on financial data from companies, an attempt was made to examine the relationship between the analysed financial results and the level of inflation and GDP dynamics. In addition to financial performance, companies' market valuations and resilience to economic slowdowns

were also examined – comparing the returns generated by a created weighted index of global debt collection companies with the S&P 500 and S&P 500 Finance indexes. Based on these analyses, an attempt was made to answer the question of how the business models of debt collection companies may may generate or prevent dependencies.

1. Debt collection market literature

The financial academic literature regarding debt collection companies is relatively limited. There are a few studies broadly describing the debt collection market and its selected aspects related to, for example, the collection process (Deville, 2015; Fedaseyeu & Hunt, 2015; Kreczmańska-Gigol, 2013, 2015). Much of the literature also focuses on the legal aspects of debt collection companies' activities (Goldberg, 2006; Hurt, 1964; Leonard, 1982; Stifler, 2017; Zywicki, 2016). The most well-researched area in the academic literature concerns the technical aspects of debt portfolio valuation and credit risk. The primary analyses involve credit risk and modelling credit losses for collection processes or determining the fair value of liabilities (Barbagli & Vrins, 2023; Bluhm & Wagner, 2011; Dos Santos, 2020; Duffie & Garleanu, 2001; Ermolova & Penikas, 2019; Han, 2017; Pineau, 2023).

Analyses related to the debt collection market and macroeconomics or corporate finance are limited. These typically address phenomena related to the banking sector (e.g. capital structure) or indicators concerning social issues (Fonesca et al., 2017; Fonesca, 2023). The relationships between debt collection company activity and the supply of consumer credit are also examined (Fedaseyeu, 2020).

Only a few publications analyse the company's financial condition. Karkuki (2011) verified that better receivables management influences the financial performance of companies in Nairobi. Kitonga (2017) studied the determinants of the effectiveness of collection activities on company performance and stock prices but focused on Kenyan banks rather than debt collection companies. However, there is a lack of studies centred on debt collection companies themselves, which researchers often overlook.

According to the author, the lack of analyses from the debt collection market can be explained by two primary arguments. First, the debt collection market is part of the financial sector, but its size is significantly smaller than that of the banking, leasing or investment sectors. Thus, it is often not analysed due to its lesser economic importance. Another reason is the atypical and non-standardised reporting – due to different regulations in various countries, debt collection investments are reported in different places and formats, creating analytical chal-

lenges and requiring many manual adjustments. Another problem is that many debt-collection companies operate within larger financial groups and do not have separate financial reporting.

Nevertheless, the debt collection industry remains an essential part of the sector, and its significance is growing. Therefore, examining the behaviour of this industry is crucial for researchers, investors, and the business World.

2. Debt collection agencies business characteristics

A debt collection company is an economic entity that professionally deals with recovering receivables and other activities supporting the management of a company's liquidity. The debt collection process is complex, requiring high competence and knowledge. Therefore, a debt collection company strives to acquire the appropriate know-how and maximise recoveries at each collection stage. Barowicz (2009, p. 160) defines debt collection as the totality of legal, procedural and factual activities to ensure the debtor fulfils their obligations to the creditor. The business models of debt collection companies are highly diversified and continue to evolve. The largest debt collection companies often offer comprehensive services, including preventive services, monitoring overdue receivables, amicable and court collection, as well as enforcement.

There are many differences in approaches to debt collection. However, from the perspective of this article, the most important is to highlight the distinction between commissioned collection and purchasing own portfolios. In the case of commissioned collection, there is no actual assignment of rights to the receivables to the entity conducting the collection activities. The collection is carried out on behalf of the client. Consequently, the recovered funds, less the collector's fees and the costs of the collection proceedings, go to the receivables' owner (the collection company's client). In this case, the debt collection company's revenue is usually a success fee defined in advance in the contract, representing a percentage of the recovered receivables and reimbursement of court, enforcement, as well as administrative fees (Fedaseyeu, 2020).

The business model is based on acquiring portfolios for the debt collection company's account, which involves the acquisition of individual receivables or portfolios from the original creditors. The nature of the receivables can vary depending on the strategy of the collection entity. The purchasing process (especially for debt portfolios) usually takes the form of a tender, to which several debt collection companies are invited. The companies receive basic information about the portfolio, based on which analysis departments create forecasts of possible cash

flows generated from the package. Ultimately, the buyer is selected based on the highest offered price.

Both commissioned collection and portfolio acquisition by debt collection companies can be conducted in two ways. The first is one-time contracts – under one agreement (tender), the client transfers a defined, closed catalogue of receivables to the collection company, which then handles them. These types of transactions usually cover more extensive portfolios of receivables, providing the debt collection company with a one-time influx of projects. However, there is no certainty about the future supply of projects. An alternative that allows for a more stable flow of projects is establishing a long-term cooperation agreement between the parties. The debt collection service transfers cases of a predetermined nature to the collection company for a specific period, as defined in the agreement.

Similarly, in the case of acquiring one's portfolio, there is the possibility of long-term cooperation. Although less popular than tenders for receivable packages, long-term contracts for purchasing receivables are becoming increasingly common in the Polish debt collection market. These agreements are most often referred to as forward flow contracts. They involve the regular sale of receivables by a given entity to the debt collection company, usually at specified time intervals (mainly monthly, though other arrangements are possible).

In recent times, the role of debt collectors has evolved, and they are no longer solely associated with the activities traditionally linked to debt collection companies, such as commissioned collection and recovering receivables, to increase

Table 1. Business implications for types of debt collection business models

Type of activity		Capital commitment	Automation potential	Scalability	Investment period
Type of portfolio	B2B collection	no impact	limited	limited	long-term
	B2C collection	no impact	high	high	medium-term
Type of collateral	secured claims	higher	limited	limited	long-term
	unsecured claims	lower	high	high	medium-term
Portfolio fragmentation	large individual claims	significant	limited	limited	long-term
	small mass claims	significant	high	high	medium-term
Type of investment in portfolio	commission-based collection	minimal	high	no differences	short-term
	acquisition of own portfolios	significant	high	no differences	medium/long-term

Source: own analysis.

liquidity for commissioning companies. Increasingly, this sector is seen as an essential part of the investment industry. The largest debt collection companies buy debt portfolios for their accounts to increase the profitability of their business. This is becoming an increasingly popular form of operation for such entities.

A key direction of investment in own portfolios by debt collection companies is the purchase of portfolios from banks, not only those in default – companies are also increasingly engaging in the securitisation of such receivables (Carlson, 1995). Debt collection companies conduct their operations in many ways, often combining various activities. A description of the basic types of debt collection activities, along with the described influence of business implications and significance for each type are presented in Table 1.

This article focuses on publicly traded companies, so the analysis mainly concerns those who base their business on collecting their own portfolios.

2.1. Determinants of debt collection business effectiveness

This subsection will present a qualitative analysis of the factors that may affect the business operations of debt collection companies. This analysis will be conducted qualitatively due to the need for more detailed data on specific areas of business activity, particularly in the context of acquired portfolios and the cash flows they generate. The quantitative analysis was conducted by examining the companies' financial results and basic indicators.

2.1.1. Internal determinants

Costs and management quality

Operational costs and management efficiency are crucial for the effectiveness of virtually all types of businesses (Barney & Hesterly, 2019). In the case of debt collection, the key component is the ability to manage variable costs, which arise as the business scales. Due to the nature of debt collection, many activities can be automated (e.g. sending letters, writing lawsuits, searching for debtor data) or improved through process optimisation. In the case of mass debt portfolios, the potential for optimisation is the greatest. Companies that can optimise their processes by utilising modern technologies and effective management methods achieve better financial results.

Another critical aspect is responding appropriately to market and legislative changes. A good example of responding to market shifts was Kruk S.A. halting purchases in the Polish market during increased portfolio prices caused by ineffi-

cient purchases from Getback. Additionally, skilled collection managers must respond in real time to changes in costs resulting from legislative adjustments, such as increased lawsuit fees, which can be mitigated by developing an appropriate collection strategy.

Economies of scale
Economies of scale increase the investment attractiveness of many types of businesses (Caves & Barton, 1990; Panzar & Willig, 1977). A high level of scalability characterises the debt collection business. The more significant the number of cases handled, the lower the unit costs of handling them, particularly for repetitive tasks like communicating with debtors or preparing lawsuits. Cost advantages are significantly influenced by the debt collection company's experience with similar cases. Different types of portfolios require different optimal collection strategies. A different approach is used for low-value debts compared to high-value nominal debts. The process will also differ for mortgage debts compared to lease debts. Large debt collection companies with experience handling various types of debt can leverage their historical experience and invest in solutions that allow for more universally planned and executed collection activities. This is more challenging for smaller companies, which is why many smaller debt collection firms specialise in a particular type of debt, such as telecommunications debt or fines, to maintain high operational leverage despite a smaller scale than market leaders.

Portfolio valuation accuracy and acquisition potential
Proper valuation of a debt portfolio is an essential aspect of determining the results collectors achieve (Kreczmańska-Gigol, 2015). Incorrectly estimating the recoverability potential of debts can lead to reduced profitability and even losses. Companies with advanced analytical models can better assess the recoverability potential and determine appropriate collection strategies and the associated service costs. The offered price must be the lowest among all bidders while providing a sufficient buffer to ensure profitability. Therefore, accurately estimating all variables is exceptionally challenging.

It is also important to note that due to economies of scale, more significant creditors can achieve better results thanks to their know-how and lower unit costs, giving them more pricing flexibility in portfolio acquisitions than their smaller competitors. Moreover, many types of debt portfolios, such as bank portfolios, are often entirely inaccessible to smaller entities due to capital requirements. Banks typically auction large portfolios, which are too expensive for smaller firms to acquire.

Type of debt financing
All industries utilising external capital can increase their business value through proper management (Harris & Raviv, 1991; Myers, 1984). The cost and type of fi-

nancing are most significant for the most capital-intensive, yet also the most profitable part of the debt collection business – collecting own portfolios. Properly adjusting the financing term (as returns on debt portfolios usually occur 1.5–2 years after acquisition) and its cost is critical to achieving profitability. For this reason, many debt collection companies use financing from their parent company, which is often a bank, allowing for low-cost financing. Most companies, however, have to obtain such financing from the market, e.g. in the form of corporate bonds.

Human capital, know-how and technology
Human capital, know-how and technology generally drive the efficiency of any business (Chen et al., 2012; Lepak & Snell, 1999). In debt collection, highly qualified employees, both in operational and managerial positions, are critical to the success of collection activities. The complex legal aspects of collection activities or the best-fit strategies for each type of debt are crucial for the overall process efficiency. Moreover, a proper history of debt collection and data helps train models for valuations and forecasts. Technology allows for better prediction of debtor behaviour and automation of specific processes. The efficiency of debt collection companies is expected to improve further with the implementation of AI solutions in their operations (Phillips & Moggridge, 2019).

2.1.2 External determinants

External factors also significantly impact debt collection activities, which will be discussed below.

Market competition
Market competition affects margins and shapes how businesses operate (Porter, 1998). Intense competition in the debt collection market often leads to pressure on margins, mainly when many companies compete for the same assets (portfolios). Among the largest firms, the most attractive portfolios, due to their scale, are bank portfolios, the supply of which is limited in some markets. As a result, many large enterprises focus on internationalising their operations to expand portfolio acquisition opportunities. However, this also comes with increased operational expenses and the need to learn or acquire expertise about the specifics of the given market (e.g. legal knowledge). Smaller, local entities try to mitigate this problem by focusing on niche markets that larger firms are not interested in (e.g. fines).

Inflation
High inflation negatively affects most businesses by destabilising their operations (Friedman, 1963). For debt collection companies, inflation increases operating costs

due to rising wages and service costs. However, it also has some benefits for collectors. Firstly, inflation increases the nominal recovery potential of portfolios. As prices rise, wages and the nominal value of debt securities (e.g. real estate) often increase, leading to higher recoverability of entire portfolios. Additionally, higher inflation often leads to an increased supply of debt portfolios on the market, as more significant financial burdens cause companies and consumers to miss payments more frequently.

Unemployment

Unemployment levels, like inflation, have positive and negative effects on the debt collection industry (Hassan & Nassar, 2015; Heer & Schubert, 2012). On the one hand, unemployment can lead to a more excellent supply of debt portfolios on the market, potentially resulting in lower prices at auctions. However, an increased number of unemployed individuals also increases the risk of lower recoverability from previously acquired portfolios and may prolong collection processes.

Social transfers

High levels of social transfers, such as benefits or aid programs, have historically been shown to significantly increase the recoverability of consumer portfolios (Lavinas et al., 2024; Leimer, 2016). A bailiff can immediately seize a one-time, significant cash inflow, especially when no exempt amounts are present, preventing the seizure of more significant sums. Additionally, the overall financial situation of debtors improves, leading to an increase in debt repayment rates.

Legal regulations

Changing regulations can significantly affect the debt collection market (Goldberg, 2006; Zywicki, 2016). Consumer protection regulations, restrictions on collection practices, or changes in the judicial system can substantially alter business operations and impact operating costs. These changes may increase administrative costs and limit the ability to pursue certain debts (e.g. changes in the statute of limitations). They often reduce the efficiency of the process by preventing or hindering specific collection procedures.

A crucial element of debt collection activities is the judicial recovery process, so any changes affecting these processes also reflect on the operations of such firms. Positive changes, like the introduction of electronic lawsuit submissions, can significantly speed up and reduce the cost of the process. However, negative changes, such as shortening the statute of limitations, can also occur.

Interest rates

Changes in interest rates can positively impact the supply of debt portfolios, as higher loan repayments on variable-interest loans increase the likelihood of debt

becoming overdue and entering the market (Fedaseyeu, 2020; Fedaseyeu & Hunt, 2015). However, debt collectors often finance their operations using bonds with variable interest rates, potentially reducing profitability due to rising interest costs.

Economic cycles

Economic cycles affect most businesses, though their impact varies – some sectors are less affected (e.g. the food industry), while others are more sensitive (e.g. construction) (Saviotti & Pyka, 2008). The business cycle also significantly affects the debt collection industry. During periods of economic growth, debt collection companies may see a decrease in the number of insolvent debtors, reducing the demand for their services. Conversely, during recessions or financial crises, the number of debtors increases, raising demand for collection services but potentially hindering the effectiveness of debt recovery efforts.

Thus, while it is commonly believed that the debt collection industry resists economic downturns, the author notes that this still needs to be empirically verified.

The next section of the article will attempt to assess the behaviour of debt collection companies' financial results and stock prices in response to deteriorating economic conditions.

3. Data, variables and method

Financial data for the companies was sourced from the Thomson Reuters Eikon database. The analysis includes information on the basic financial data of companies whose primary business activity was "debt collection" and that were publicly traded. Companies for which debt collection was a secondary activity were excluded from the analysis. Due to operational instability and greater susceptibility to microeconomic factors, companies with total assets less than $1 million in any of the analysed years were eliminated. A total of 13 companies were used for the final analysis. The time series covered 1996 to 2022, although data was unavailable for all companies over such an extended period. For the analysis, all debt collection companies included in the database were selected, provided that their data covered at least 5 years of observations. Table 2 presents primary data on the analysed companies:

For the purpose of this analysis, financial statements from the database were examined, and the following variables were prepared:

– total revenues,
– net profit,

Table 2. Companies included in the analysis

No.	Name of company	Country of incorporation	Timespan
1	Encore Capital Group, Inc	USA	1996–2022
2	Hoist Finance AB	Sweden	2012–2022
3	PRA Group, Inc.	USA	1999–2022
4	KRUK Spółka Akcyjna	Poland	2008–2022
5	Credit Corp Group Limited	Australia	2001–2022
6	Axactor ASA	Norway	2016–2022
7	BEST S.A.	Poland	1997–2022
8	B2 Impact ASA	France	2012–2022
9	JMT Network Services PCL	Thailand	2010–2022
10	Global Service Center PCL	Thailand	2018–2022
11	Kredyt Inkaso S.A.	Poland	2008–2022
12	Chayo Group PCL	Thailand	2014–2022
13	Intrum AB	Sweden	2001–2022

Source: own study based on Thomson Reuters Eikon database (https://eikon.refinitiv.com/).

- cash flows from operating activities,
- investment expenditures on debt portfolios,
- value of assets.

To reflect company behaviour against the backdrop of macroeconomic conditions, inflation rates and GDP growth indicators for the regions where the analysed companies operated were also obtained. This data were sourced from the International Monetary Fund. Additionally, stock prices of the selected companies and relevant stock market indices were obtained from the Thomson Reuters Eikon database to support the analysis.

The primary aim of this article is to verify the resilience of debt collection companies to economic slowdowns and crises. Accordingly, three approaches were adopted to assess this impact:

1. **Verification of the resilience of financial results to economic slowdowns**. This issue will be addressed in two ways:

   a) Case study analysis: Based on financial data, indicators of revenue dynamics, profitability and portfolio purchases were prepared and compared with average values for the industry during crisis periods of 2007–2009 and 2019–2021. This approach aimed to verify whether debt collection companies are internally resilient to crises or their performance deteriorates during more challenging economic times.

b) Statistical analysis: Using simple Pearson correlation, the relationships between the analysed financial results and both inflation and GDP growth levels were examined.

2. **Verification of stock prices' resilience to economic slowdowns**: The returns generated by a constructed balanced index of global debt collection companies were compared with the S&P 500 index and the S&P 500 Finance index.

Based on the above analyses, the article will also present analyses aimed at answering how the business models of debt collection companies can lead to the formation of relationships or their absence.

4. Results

The first issue to be examined in this article is the financial resilience of debt collection companies to challenging economic conditions. For this analysis, the following average financial indicators for the entities in the analysed group were selected for examination:

– revenue dynamics,
– net profit profitability,
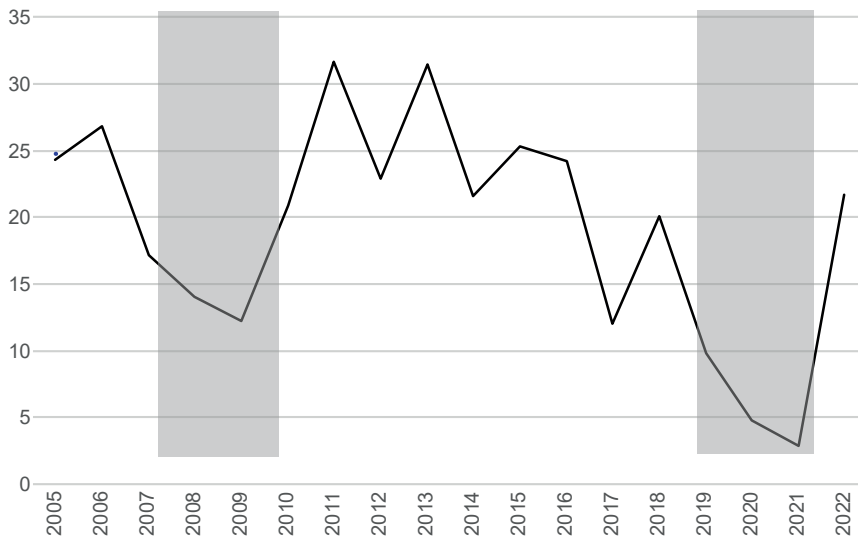– dynamics of portfolio purchases.

Figure 1. Cumulative revenue dynamics for debt collection companies (in %)

Source: own analysis.

The crisis years were defined as the period from 2007 to 2009 and the SaRS CoV2 pandemic from 2020 to 2021. Figure 1 presents the average revenue dynamics for the analysed entities.

Figure 1 shows that during the crisis years, revenue dynamics significantly declined in the years marked with a grey background indicating crises. Of course, the downward trend is partly due to the base effect and the overall expansion of the analysed companies, but it is evident that the crisis years performed significantly worse than the trend line. Therefore, it cannot be said that crises do not affect the current development of debt collection companies.

It is certainly positive that the analysed group did not report negative revenue dynamics, which can be considered a sign of resilience, as many in the financial sector did experience declines in this area.

However, revenue does not reflect a company's financial health alone; profitability is also a significant indicator of operational effectiveness. Therefore, while debt collection companies may be forced to limit their scale of operations and reduce risk, their margins remain high. Figure 2 presents the profitability of net income in the sector.

On average, debt collection companies in the analysed group exhibited a net profitability of around 20.0% from 2005 to 2022. During the 2007–2009 crisis, profitability dropped significantly, but it began to improve in subsequent years and stabilised between 20.0% and 25.0% for a long time. However, similar to rev-
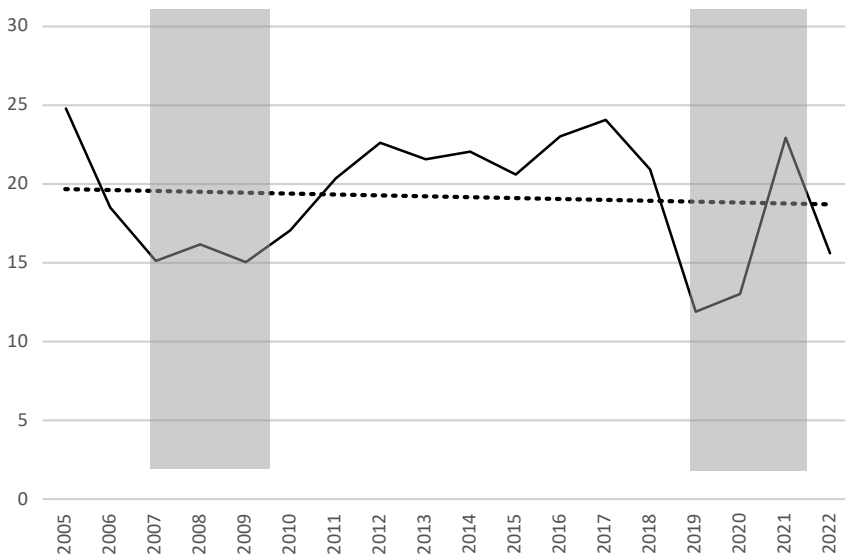

Figure 2. Cumulative net profit for debt collection companies (in %)

Source: own analysis.

enue, declines in business efficiency are also evident, though they are not as se-
vere as those seen in revenue dynamics.

The analysis of revenue dynamics and net profitability requires some context.
Both crises were somewhat different. The first was related to speculation in the fi-
nancial markets, leading to a general collapse of the financial sector and liquidity in
the market. Securing financing became difficult, and investors withdrew from the
markets. On the other hand, the COVID-19 crisis also had similar effects regarding
general market risk aversion. However, the most severe consequence for the debt
collection market was the significant hindrance to conducting collection activities.
In some countries, legal collections were completely frozen as courts were closed.

However, a notable rebound in profitability was observed in 2021, likely due
to increased portfolio recoveries driven by substantial social transfers. This trend
in 2021 is not visible in revenue dynamics, as many companies were forced to re-
duce their investment expenditures on portfolios. However, for those who already
had portfolios, business efficiency significantly improved. Figure 3 presents the
dynamics of expenditures on debt portfolios and cash flows from financial opera-
tions. Those who did not invest in portfolios during that period did not see corre-
sponding revenue dynamics, which only returned to normal in 2022.

The author's statement regarding the connection between the debt collection
sector and the entire financial market, as well as the performance of companies,
can be attributed to access to financing. The sector's revenues significantly de-

**Figure 3. Cumulative portfolio purchases to assets (left axis) and dynamics of cash
flows (right axis) of debt collection companies (in %)**

Source: own analysis.

pend on the ability to acquire new debt portfolios, which require substantial capital often raised through bond issuance or bank loans. In the absence of access to financing, acquiring portfolios becomes problematic, leading to challenges in maintaining average growth dynamics.

The response is different in terms of profitability. Fortunately, the presented analysis encompasses data concerning financial crises of entirely different natures. During the 2007–2009 crisis, profitability significantly declined throughout the crisis period due to a substantial deterioration in the financial situation of both companies and consumers. The ability to collect debts from portfolios could have been much improved.

In the case of the COVID-19 crisis, the initial situation was caused by restrictions on operational activities. However, there was a noticeable leap in profitability due to the significant role of social transfers, high inflation and improved financial conditions – especially for consumers. However, this was hindered by issues regarding access to financing for debt collection companies.

Another note is that debt collection companies are dependent on growth. The debt collection business exhibits significant economies of scale due to the automation of many processes and the standardisation of specific collection strategies. Thus, the lack of new portfolio purchases and consequently reduced utilisation of potential recoveries (as most recoveries from debt portfolios occur within 3–5 years of purchase) lead to a decrease in operational leverage.

A correlation analysis between the studied and macroeconomic indicators was conducted to verify further how economic conditions influence the financial results of debt collection companies. Due to the number of observations, the correlation analysis was limited to companies operating in the European market, using indicators for EU GDP and inflation in EU countries. The conclusions are presented in Table 3.

Table 3. Variables correlation

Var	GDP growth	CPI
Cumulative revenues	0.19	0.01
Cumulative net margin	0.57**	−0.01
Portfolio purchases dynamics	0.49**	0.30
Portfolio purchases to assets	0.23	−0.00

Note: * *p*-value < 0.1; ** *p*-value < 0.05.

Source: own analysis.

It is evident that the only statistically significant variables are the relationship between the dynamics of portfolio purchases and net profit margins. These are

not very strong correlations, but they exist. This suggests that inflation does not significantly impact debt collection companies; however, this may be because inflation did not change significantly in the analysed period (only towards the end). A significant correlation between margins and GDP is observed in the case of GDP dynamics. This aligns with expectations, as repayment issues are less prevalent during prosperous times, resulting in fewer potential portfolios for purchase, and those acquired tend to perform better. Additionally, access to financing is more accessible, allowing for the acquisition of new portfolios that can scale the business.

Stock market performance
In the next step of this analysis, the focus shifts to an additional issue – investor perception. Since the results show a specific positive correlation with the broader economy, might it be that investors view investments in debt collection companies favourably and seek them out as a haven?

Figure 4. S&P 500 and S&P 500 Financials compared with debt collection avg stock performance (in %)
Source: own analysis.

Unfortunately, the analysis of the chart in Figure 4 leads to entirely different conclusions. During the crisis years, the debt collection industry performed only slightly better than the broad S&P 500 index and the S&P 500 Financials index. This indicates that stock market investors, in a risk-off scenario, retreat from the shares of debt-collection companies to a similar extent as they do in other sectors of the economy. This aligns with the findings from previous analyses focusing

on financial results. In the analysed crisis years, debt collection companies faced problems similar to those encountered by businesses in other sectors: issues with obtaining financing, limitations on operational activities and worse financial situations for both firms and consumers. Therefore, it is not surprising to analyse the correlation between the returns of the examined stock indices and the created index of debt collection companies, the results of which are presented in Table 4.

Table 4. Variables correlation

Pair	GDP
S&P 500 vs S&P 500 Financials	0.95**
S&P 500 vs debt collection index	0.77**
S&P 500 Financials vs debt collection	0.85**

Note: * p-value < 0.1; ** p-value < 0.05.

Source: own analysis.

The correlation between the S&P 500 and S&P 500 Financials and the debt collection industry is statistically significant and strong or very strong. Therefore, this confirms that although the debt collection industry operates under a completely different business model than, for example, the banking sector, macroeconomic issues affect this sector to a very similar degree, both in good times and the bad ones.

Conclusions

The analyses presented in this article demonstrate that the debt collection industry cannot be considered acyclical or fully crisis-proof. Instead, its resilience depends both on the nature of the crisis and the internal characteristics of the companies themselves.

First, the results confirm that during both the global financial crisis of 2007–2009 and the COVID-19 pandemic, debt collection companies experienced a slowdown in revenue growth and a decline in profitability. The evidence shows that while these firms did not collapse as severely as some other financial institutions, they were nevertheless significantly affected by adverse macroeconomic conditions. This finding challenges the popular belief that debt collection is entirely counter-cyclical.

Second, the type of crisis matters. The 2007–2009 financial crisis primarily undermined debt collection through restricted access to financing and weaker recoveries from portfolios, leading to lower profitability. By contrast, the COVID-19

crisis was characterised less by financial market disfunction and more by operational disruptions, such as court closures, which directly limited the ability to conduct enforcement proceedings. At the same time, unprecedented fiscal transfers and inflation created a temporary boost in recoverability. These differences illustrate that resilience is contingent on whether the crisis originates in the financial system or is rooted in broader social and institutional disruptions.

Third, the correlation analysis confirms that debt collection companies' performance is significantly related to GDP dynamics, while the role of inflation appears more nuanced. This suggests that resilience is not absolute but conditional: in times of growth, companies benefit from more efficient recoveries and easier access to financing, whereas in downturns, both revenue generation and portfolio acquisition are constrained.

Finally, the stock market evidence shows that investors perceive debt collection companies similarly to other financial institutions: in periods of heightened risk aversion, their shares decline in line with the broader market. This further undermines the thesis of exceptional counter-cyclicality.

Taken together, the findings lead to three key conclusions. (1) Debt collection companies are partially resilient but not immune to crises. (2) The impact depends strongly on the type of crisis – financial crises weaken profitability through capital access and portfolio performance, while systemic shocks like the pandemic disrupt operations but may create offsetting effects via policy support. (3) Future resilience will depend on the sector's ability to diversify financing sources, adapt to legal and operational disruptions, and leverage technology to sustain efficiency in volatile environments.

Further research should explore how different business models – particularly smaller firms relying on commissioned collection rather than portfolio investment – respond to various crisis types. This would provide a more granular understanding of resilience across the industry and help determine whether certain models are better suited to withstand shocks than others.

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Exploring the relationship between R&D investment and the labour market outcomes in the OECD countries

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Abstract

This paper examines the relationship between labour market outcomes, labour market policies and investment in R&D in OECD countries from 2011 to 2021. Firstly, the relationships between labour market variables and R&D investment variables were estimated using Pearson correlation. Subsequently, predictive models were developed using eight algorithms to assess their performance in explaining labour market outcomes. K-fold cross-validation was employed to average results over multiple train/test splits. Initial findings indicate that R&D investment was positively associated with the employment rate and labour force participation rate, and negatively associated with the unemployment rate. Furthermore, public spending on active labour market policies showed a significant association with R&D investment variables. Additionally, findings based on the performance of predictive models revealed that data on R&D investment and labour market outcomes exhibit complex interactions best captured by ensemble techniques – Random Forest and Gradient Boosting. Regardless of the model used, the strictness of employment protection for temporary contracts consistently emerged as an important predictor for all labour market outcomes. Moreover, indicators

Keywords

- Industry 4.0
- innovation
- labour market
- labour market institutions
- OECD countries
- research and development

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related to R&D investment demonstrated relatively strong predictive power, suggesting a meaningful contribution of such investment to employment outcomes. Innovation-related measures also emerged as relevant factors influencing labour market outcomes in OECD countries.

Introduction

The recent advances in technology make governments become increasingly aware of the importance of using the digital economy for innovation, social and economic growth and social prosperity. Innovations and new technologies within the digital economy can enhance goods and services and address policy challenges across various sectors, including labour market, education, health, the environment, public governance and transport, as well as influencing employment, productivity and overall well-being. What is more, innovations are essential for future job creation, economic growth and competitiveness. Even though, innovations and new technologies create opportunities for firms, employees and society to engage in economic activities, these technologies may also displace workers in some occupations, increasing existing gaps in labour markets, resulting in greater inequality and new digital divides (OECD, 2016).

These innovations are primarily driven by investments in research and development, which are a key factor in driving technological progress and contributing to increased prosperity, improved labour productivity, and more (Diebolt & Hippe, 2019; Sun et al., 2016). Investments in research and development also play an important role in promoting innovation within the economy, as the availability of funds for research and development determines entrepreneurs' and communities' access to new technologies and innovations (Schmidt et al., 2016). Recent economic advances, known as Industry 4.0 or the fourth industrial revolution, have led to many fundamental changes in the labour market. New technologies and innovations continuously reshape labour markets, impacting labour demand and supply, wages, work environments and workplace structures (Acemoglu & Restrepo, 2020; Flores et al., 2019; Pereira & Romero, 2017; Schroeder et al., 2017). Given the development of new digital technologies, a thorough understanding of labour markets changes remains crucial for policymakers, employers, employees and society at large. This necessitates the development of customised labour market institutions and policies (Goos et al., 2019).

This paper examines the relationship between labour market outcomes, labour market policies and investments in research and development in OECD countries from 2011 to 2021. Given that both labour market performance and R&D investment are shaped by the broader economic context, it is important to consider the socio-economic conditions prevailing during the analysed period. Generally, the socio-economic situation of OECD countries varied between 2011 and 2021. In 2011, OECD countries recorded real GDP growth of 2.1%, although some countries experienced negative economic growth, including Greece (–9.9%). By 2021, the economic situation had improved significantly, with the average growth rate for the OECD reaching 6.3%, and all OECD countries recording positive growth. This represented a marked improvement compared to the previous year, in which almost all OECD countries experienced negative growth due to the COVID-19 pandemic (OECD, 2025c). Regarding GDP per capita growth, it was 1.4% in 2011 and increased to 5.8% in 2021 in OECD countries. However, in 2020, OECD members on average reported –4.3% GDP per capita growth due to the COVID-19 pandemic (World Bank, 2025a). Inflation (CPI) in OECD countries was 3% in 2011, with most countries recording higher inflation than the OECD average. By 2021, inflation in OECD countries had risen to 4%, mainly due to the COVID-19 pandemic (OECD, 2025a). Government expenditure on education in OECD countries remained at 5.1% of GDP in both 2011 and 2021. For most years of the analysed period, government spending on education was below 5% on average among OECD members. However, substantial differences exist between countries. In 2021, Scandinavian countries allocated the highest share of GDP to education (around 7%), while countries such as Ireland, Turkey and Greece devoted the least (World Bank, 2025b). Furthermore, by the end of the analysed period, OECD countries were recovering from the effects of the COVID-19 pandemic. Importantly, this period was also marked by a growing prevalence of working from home and increased flexibility in employment arrangements across OECD countries (OECD, 2021).

Therefore, combining data on labour market characteristics across OECD countries with data on investment in research and development allowed for an assessment of the relationships between employment rates, unemployment rates and labour force participation rates with R&D investment variables in these countries. Firstly, the relationships between labour market variables and R&D investment variables were estimated using Pearson correlation. Subsequently, predictive models were developed using eight algorithms to assess their performance in explaining labour market outcomes. The importance of individual variables, measured in terms of predictive power, was also evaluated within the best-performing models. K-fold cross-validation was employed to average results over multiple train/test splits, providing more reliable and less biased estimates of model performance.

This study contributes to the literature by assessing the relationships between labour market outcomes, labour market policies and investments in research and

development financed from different sources. Furthermore, this paper discusses the benefits and challenges of new technologies and innovations for labour market participants. It also highlights the importance of investments in research and development and innovation for socio-economic growth and job creation in the evolving labour market.

The paper is structured as follows. The next section provides a literature review on the labour market in the face of new technologies and R&D investments. This is followed by the methodology section, which outlines the time and geographical scope, methods used and the selection of variables. The third section presents and discusses the results of the empirical analysis. Finally, the paper concludes with a summary of limitations and suggestions for future research.

1. The labour market in the face of new technologies and R&D investments: an overview

The growing focus on Industry 4.0 has raised numerous inquiries regarding the significance and impact of these changes on labour markets. Previous studies suggest that the influence of the fourth industrial revolution is expected to have a more positive effect on labour markets in developed countries due to their competitive advantage and higher wage rates (Nafchi & Mohelská, 2018). However, the risk of job automation and associated technological unemployment may still manifest in developed labour markets. For instance, an analysis by Acemoglu & Restrepo (2020) indicates a negative impact of industrial robots on wages and labour demand in the USA, along with a positive impact on productivity. Furthermore, an analysis by Frey and Osborne (2017) reveals that about 47% of employment in the USA is at risk of computerisation in the next decade or two. In contrast, Klenert et al. (2023) indicate that industrial robots do not reduce the share of low-skill employment, which contrasts with the popular view that robots reduce employment. However, they demonstrate that countries and sectors with relatively high levels of automation are more resilient to the decline in manufacturing, especially in terms of employment. The literature also indicates that the main solutions for reducing technological unemployment include reducing the working week, rethinking higher education, creating minimum income guarantees and reforming tax systems (Lima et al., 2021).

Another challenge of Industry 4.0 is the labour market polarisation, as middle-skilled jobs involving routine tasks are at a high risk of being replaced by automation (Sumer, 2018). Additionally, the development of new technologies has led to

the rapid transformation of workers' tasks. On the one hand, there will be an increased demand for employees who perform innovative and creative tasks (Flores et al., 2019). On the other hand, routine tasks will be partially or entirely replaced by robots and machines (Sumer, 2018).

Moreover, benefits and challenges in the labour market related to recent technological changes mean that labour market institutions, including labour market policies still play a crucial role in the digital economy. Previous studies (e.g. Fernández-Macías, 2015; Fernández-Macías & Hurley, 2017) indicate that the majority of structural employment changes across European countries result from country-specific institutions and policies that mediate the consequences of technological changes in labour markets. For instance, in Germany, employment polarisation began as wage compression markedly declined since the millennium. This change is probably linked to both the reduced influence of trade unions and the "Hartz" labour market reforms (Dustmann et al., 2014). This suggests that labour market institutions play a crucial mediating role in how technological advancements affect the labour market. In addition, Rendall and Weiss (2016) state that labour market polarisation in Germany was slower due to the apprenticeship system and the fact that firms had lower incentives to replace these skilled workers compared to countries with less structured training programs. Consequently, labour market institutions that provide workers with broad protections or relatively high benefits may be more inclined to invest in training to equip workers with digital skills, helping them adapt to the technological change.

Therefore, technological progress and emerging new technologies pose numerous challenges for the labour market. On the one hand, new technologies may result in some employees losing their jobs or needing to change careers in response to the broad impact of digitalisation and technological advancements. On the other hand, the recent advance in technology requires that workers adapt their skills to the evolving labour market, where digitalisation and new technologies play a crucial role. Therefore, it is essential to provide training and appropriate education, as well as implement organisational management strategies to meet the new market requirements (Arntz et al., 2016; Ing et al., 2019; Maresova et al., 2018; Ninan et al., 2019; Petrillo et al., 2018; Sumer, 2018). These changes may require organisations and governments to invest in infrastructure and training to fully capitalise on the opportunities arising from Industry 4.0 advancements. Investments in research and development play a fundamental role in preparing the labour market for the challenges associated with digitalisation and technological progress. Thus, both governments and organisations will play a fundamental role in educating the workforce while their engagement in efforts on investments in research and development, innovations and developing the digital economy will influence labour market outcomes as well (Burgess & Connell 2020; Ing et al., 2019; Schroeder et al., 2017).

Investment in research and development is a key driver of technological progress, stimulating education, labour productivity and contributing to higher levels of GDP per capita (Diebolt & Hippe, 2019; Sun et al., 2016). Moreover, investments in research and development play a significant role in fostering innovation in the economy, as the availability of R&D funding largely determines entrepreneurs' and communities' access to innovations (Schmidt et al., 2016). Furthermore, considering the ageing population in highly developed countries and the resulting decline in the labour force, both R&D and innovation investments are crucial for ensuring future growth. It is also emphasised that R&D and innovation investments are necessary not only from economic and social perspectives but also from an environmental one (Steeman et al., 2024).

Government financial support for research and development is crucial for sustaining and ensuring socio-economic progress, as well as fostering innovation, particularly when private initiatives alone are not sufficient. Businesses are also key players in financing research and development and, consequently, in driving innovation. However, companies' willingness to invest depends largely on economic opportunities, including the overall economic situation in a given country. The COVID-19 pandemic has demonstrated that, especially during periods of economic downturn, government support may be necessary to address social and economic challenges, particularly those related to the labour market (OECD, 2024b, 2024f). Importantly, the development of a knowledge-based economy can be stimulated not only by government and business investments in R&D but also by investments made by higher education institutions. These institutions play a crucial role in fostering innovation through scientific research and human capital development. Strengthening the mutual links between higher education institutions and enterprises is also essential (Hunady et al., 2019). Given these implications, as well as recent changes resulting from the increasing role of new technologies and digitalisation in the labour market, and the significant role of R&D investments in implementing new technologies and innovations – including those in the labour market – it is worth conducting an empirical assessment of the relationship between labour market outcomes, labour market policies and investments in research and development.

2. Methodology

This paper empirically assesses the relationship between labour market outcomes, labour market policies and investments in research and development in OECD countries. The empirical analysis includes countries that belong to the

Organisation for Economic Co-Operation and Development in the years 2011–2021. Based on the literature review, the following research questions have been formulated:

– What were the level and growth rate of R&D expenditure in OECD countries from 2011 to 2021?
– Are investments in research and development (financed by the government, business and higher education) related to labour market outcomes and policies?

The research methodology consists of five steps. Firstly, data on labour market and investment in research and development in the OECD countries were collected and the database was created. Next, the descriptive statistics of the used variables were calculated. In the next step, the relationships between labour market variables and investment in research and development variables in the OECD countries were estimated using the Pearson correlation. After that, we built predictive models to assess their performance in explaining labour market outcomes, including the employment rate, unemployment rate and labour force participation rate in OECD countries. In order to build the models, we chose 8 algorithms:

– Linear Regression – fits a straight line by minimising squared errors;
– Ridge – extend linear regression with L2 regularisation to control overfitting;
– Lasso – extend linear regression with L1 regularisation to control overfitting;
– Decision Tree – recursively splits data into homogeneous regions;
– Random Forest – averages predictions over many bootstrapped trees;
– Gradient Boosting – sequentially builds trees to correct prior errors;
– K-Nearest Neighbors (KNeighbors) – predicts by averaging nearby training points;
– Support Vector Regression (SVR) – fits a margin-maximising regression function within an ε-insensitive tube.

We also estimated the importance of variables (in terms of predictive power) within the best-performing models. The independent variables included: LMP, ALMP, PLMP, TRAINING, Strictness_temporary, Trade_Union, Strictness_regular, B_GERD, GOV_GERD, GERD_PC, GERD_GROWTH, HERD, Share_patent, Start-up, ICT_invest, Top_doc, and VC_invest (see Table 1). It should be emphasised that, in the case of missing individual values, zeros were imputed to avoid deleting entire records from the dataset. In order to have more reliable and less biased estimations of models we used k-fold cross-validation, which averages results over multiple train/test splits. All calculations were conducted using STATA and Python. Finally, the results were presented and discussed with the previous research.

The factors included in the study were chosen to capture the nature of labour market dynamics and research and development and innovation-related factors from both theoretical considerations and empirical relevance. Investment in re-

search and development is key to innovation in the digital economy (OECD, 2018, 2024b). Additionally, research and development are also among the most important factors in preparing an economy to face the challenges of the fourth industrial revolution, particularly in the context of the labour market (Anbumozhi et al., 2020; ILO, 2019). R&D includes basic research (aimed at building new knowledge with no specific practical purpose), applied research (creating new knowledge with a specific

Table 1. Description and sources of used variables

Variable	Description	Source
Labour market variables		
UNEMPL	Unemployment rate (% of total labour force)	OECD (2024g)
EMPL	Employment rate (% of total working age population)	OECD (2024a)
LABOUR	Labour force participation rate (% of total 25-64 years old)	OECD (2024c)
LMP	Public spending on labour markets (% of GDP)	OECD (2024e)
ALMP	Public spending on active labour market (% of GDP)	
PLMP	Public spending on passive labour market (% of GDP)	
TRAINING	Public spending on training (% of GDP)	
Strictness_regular	Strictness of employment protection, individual dismissals (regular contracts)	OECD.Stat (2025a)
Strictness_temporary	Strictness of employment protection (temporary contracts)	
Trade_Union	Trade union density (% of employees)	OECD.Stat (2025b)
Investment in research and development variables		
GERD_PC	Gross domestic spending on R&D per capita (current PPP $)	OECD (2024d)
GERD_GROWTH	Compound annual growth rate of gross domestic spending on R&D (constant prices)	
GOV_GERD	Government-financed GERD (as a percentage of GDP)	
B_GERD	Business-financed GERD (as a percentage of GDP)	
HERD	Higher education expenditure on R&D (as a percentage of GDP)	
Share_patent	Share of countries in "triadic" patent families	
ICT_invest	ICT investment (total; as a share of GDP)	OECD (2025b)
VC_invest	Venture capital investment in the ICT sector (as a share of GDP)	
Start-up	Share of start-up firms (up to 2 years old) in the business population (Information industries (ISIC 26+58-63))	
Top_doc	Top 10% most-cited documents in computer science (as a share of the top 10% ranked documents in all fields)	

Source: own elaboration.

application) and experimental development (to create new products or processes) (OECD, 2015). Moreover, considering the importance of information industries in overall business R&D spending, these sectors may be key beneficiaries from public spending on R&D. Additionally, government support for business R&D aims to encourage businesses to invest in developing new knowledge that transforms industries and markets and results in benefits to society, as well as is commonly justified as a strategy to address various market and institutional failures (OECD, 2018).

Based on these circumstances, the empirical analysis includes the following measures: gross domestic spending on R&D; government-financed spending on R&D; business-financed spending on R&D; higher education spending on R&D, gross domestic spending on R&D per capita (current PPP $) and annual growth rate of gross domestic spending on R&D. Additionally, ICT investment (total; as a share of GDP), Venture capital investment in the ICT sector (as a share of GDP), Share of start-up firms (up to 2 years old) in the business population (Information industries (ISIC 26+58-63), share of countries in "triadic" patent families, and Top 10% most-cited documents in computer science (as a share of the top 10% ranked documents in all fields) were also involved in the empirical analysis. The empirical analysis also includes the following labour market variables: employment rate, unemployment rate, labour force participation rate and public spending on labour market policies (Table 1)[3].

3. Results and discussion

Table 2 provides an overview of the descriptive statistics on labour market characteristics, investment in R&D and innovation in OECD countries from 2011 to 2021. The average employment rate over the analysed period was 68.45%, while the unemployment rate and labour force participation rate were 7.7% and 75.36%, respectively. However, the standard deviation of the unemployment rate, at 4.47%, indicates significant variability in unemployment rates across different countries. Furthermore, on average, during this period, OECD countries allocated 1.47% of GDP to labour market policies. Notably, they allocated more to passive labour market policies (0.89% of GDP) than to active labour market policies (0.57% of GDP). This was likely due to the challenges in the labour market related to the COVID-19 pandemic. Moreover, the descriptive statistics on investment in

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[3] However, some variables were included only in the predictive models due to the fact that correlation analysis explores only linear relationships while predictive models may also capture nonlinear relationships and complex interactions between variables.

R&D indicate that the average gross domestic spending on R&D per capita was 958.92$, with a standard deviation of 577.9$, suggesting significant variability. Considering government, business and higher education spending on R&D, the data show that the business enterprise sector allocated, on average, 1.1% of GDP, while the government allocated 0.59%, and the higher education sector allocated 0.47% of GDP. As the data presented in the table indicate, most R&D work in OECD countries is conducted by higher education and enterprises, which is why the role of the state is crucial in this regard. In particular, public policies supporting innovation play a key role in directing enterprises' investment efforts toward the most pressing socio-economic areas (OECD, 2024b).

Table 2. Descriptive statistics of used variables

Variable	Min	Q_1	Q_2	Mean	Q_3	Max	Standard deviation	Countries	Observations
UNEMPL	2.02	4.84	6.59	7.70	8.80	27.83	4.47	32	352
EMPL	48.48	64.37	69.08	68.45	73.37	80.48	6.45	32	352
LABOUR	62.05	71.39	75.48	75.36	79.17	89.20	5.59	32	352
LMP	0.24	0.66	1.18	1.47	2.15	4.80	0.97	31	335
ALMP	0.08	0.24	0.49	0.57	0.76	4.14	0.48	31	336
PLMP	0.12	0.37	0.62	0.89	1.35	3.36	0.67	31	336
TRAINING	0.00	0.04	0.08	0.13	0.16	0.64	0.14	30	338
Strictness_regular	0.09	1.64	2.33	2.15	2.55	4.13	0.73	25	276
Strictness_temporary	0.21	1.58	2.13	2.08	2.54	3.83	0.83	25	275
Trade_Union	4.50	13.20	17.85	26.12	32.55	69.60	18.46	21	237
GERD_PC	71.41	442.15	894.47	958.92	1388.98	2551.96	577.90	30	340
GERD_GROWTH	−30.53	0.56	3.22	3.81	6.76	56.60	7.62	29	321
GOV_GERD	0.12	0.46	0.55	0.59	0.74	1.12	0.22	28	313
B_GERD	0.09	0.58	0.80	1.10	1.64	3.75	0.76	28	314
HERD	0.11	0.33	0.43	0.47	0.43	1.04	0.20	31	341
Share_patent	0.00	0.04	0.51	2.81	1.54	35.56	6.91	32	320
ICT_invest	0.73	1.82	2.45	2.60	3.23	8.69	1.06	31	310
VC_invest	0.00	0.02	0.03	0.09	0.07	2.27	0.23	31	336
Start-up	8.50	24.80	30.20	30.10	35.05	60.30	8.46	29	248
Top_doc	2.45	6.23	7.91	8.50	9.50	27.40	3.61	32	352

Note: the table involves values of the indicators in the years 2011–2021.

Source: own calculations based on the data collected from the sources listed in Table 1.

Figure 1 shows compound annual growth rate of gross domestic spending on R&D (GERD_GROWTH) in the OECD countries from 2011 to 2021. The countries

exhibited variation in terms of the growth rate of government expenditure on R&D. In 2011, the highest GERD growth rate was observed in European countries, such as Estonia, Lithuania, Latvia and the Czech Republic (56.6%, 22.2%, 21.2% and 18.5%, respectively). However, in 2011, some OECD countries recorded a negative growth rate, specifically Portugal, Spain, Ireland and Italy (−6.7%, −2.8%, −1.5%, and −0.7%, respectively). Interestingly, in 2021, the annual GERD growth rate showed reduced diversity, and the differences among countries were less pronounced. The highest GERD growth rate in 2021 was observed in Hungary, Poland (10.5%, respectively), and in Portugal (9.9%). In contrast, negative growth rates in 2021 were observed in Chile (−8.1%), Canada (−2.0%) and Denmark (−0.7%).

Figure 1. GERD growth rate in OECD countries

Note: due to insufficient data, the values of the indicator in Slovenia and Switzerland in 2011 were replaced by the values for 2012; the value of the indicator in the Netherlands in 2011 was replaced by the value for 2014; and the values of the indicator in Chile and Ireland in 2021 were replaced by the values for 2020.

Source: own elaboration based on: (OECD, 2024d).

Table 3 presents the correlation between labour market variables and R&D investment variables. First, R&D investment variables were positively associated with the employment rate and labour force participation rate in OECD countries, and negatively associated with the unemployment rate. Furthermore, a positive and statistically significant association was found between R&D investment variables and labour market policies (both overall and active policies). However, this relationship was statistically significant only for higher education spending on R&D. Moreover, a positive and statistically significant correlation was observed between higher education and government-financed R&D spending and public spending on training. In contrast, the correlation between R&D investment variables and passive labour market policy was not statistically significant.

Table 3. Correlation between labour market variables and R&D investment variables

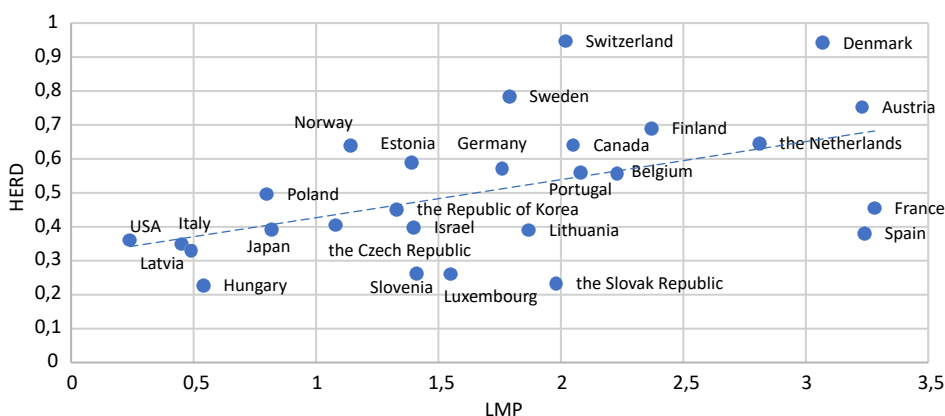|	LMP	ALMP	PLMP	TRAINING	UNEMPL	EMPL	LABOUR	GERD_PC	GOV_GERD	B_GERD
ALMP	0.68*									
PLMP	−0.34	−0.07								
TRAINING	0.67*	0.61*	−0.18							
UNEMPL	0.22*	−0.04	0.35*	0.05						
EMPL	−0.02	0.20*	−0.19*	0.08	−0.72*					
LABOUR	0.23*	0.27*	0.13*	0.13*	−0.44*	0.88*				
GERD_PC	0.13	0.24	−0.00	0.30	−0.49*	0.50*	0.38*			
GOV_GERD	0.23	0.37	0.18	0.43*	−0.28*	0.35*	0.28*	0.70*		
B_GERD	0.02	0.30	−0.01	0.18	−0.44*	0.35*	0.19*	0.84*	0.70*	
HERD	0.50*	0.67*	−0.05	0.52*	−0.05	0.36*	0.26	0.50*	0.67*	0.41*

Note: * Significant at level 10%; ** Significant at level 5%; ***Significant at level 1%. Due to space limitations, the figures are restricted to presenting only relatively strong correlations (i.e. > 0.5).

Source: own calculations based on: (OECD, 2024a, 2024c, 2024d, 2024e, 2024g).

Figure 2 presents the correlation between labour market policy (LMP) and higher education spending on R&D. The findings show that countries with relatively high R&D investment also tend to have high levels of public spending on labour market policies (e.g. Denmark, Austria, Finland, the Netherlands and Sweden).

Figure 2. Correlations between LMP and HERD (0.50*)

Note: * Significant at level 10%; ** Significant at level 5%; ***Significant at level 1%. The values of correlation and their significance were shown in parentheses. Figures 2–4 show the results for 30 OECD countries in 2021 (due to insufficient data the following countries were excluded: Australia, Chile, Colombia, Costa Rica, the United Kingdom, Iceland, Mexico, Turkey).

Source: own calculations based on: (OECD, 2024d, 2024e).

This implies that both elements are important for economic prosperity. Given that investments in research and development lead to significant economic and social changes, implementing such changes may also require broad-based political and socio-economic initiatives, including labour market institutions (Sheehan & Wyckoff, 2003). The results further indicate that most Central and Eastern European countries tend to have lower R&D expenditure compared to other OECD countries.

A positive and statistically significant relationship was observed between public spending on labour market policy (LMP) and gross domestic expenditure on R&D (GOV_GERD) (Table 3, Figure 3). Furthermore, the results indicate a positive relationship between public spending on training and higher education expenditure on R&D. Figure 4 examines the bivariate associations between public spending on training and higher education expenditure on R&D. This relationship provides some indication that training may enhance the skills and competencies of employees, enabling them to engage more in innovative activities. This result is also consistent with the study by Ninan et al. (2019), who indicate that training must be provided to adapt employees' skills to the requirements of the new labour market.

Moreover, as employees become more involved in technology-driven processes and better equipped to contribute to R&D initiatives, this may lead to an increase in R&D spending. Additionally, this may be related to collaborative efforts in fostering education and technological development, thereby stimulating research and development activities. Furthermore, public spending on labour market policies supports the growth of employees' skills and competencies, resulting in higher human capital. This increased human capital also fosters a greater potential for re-
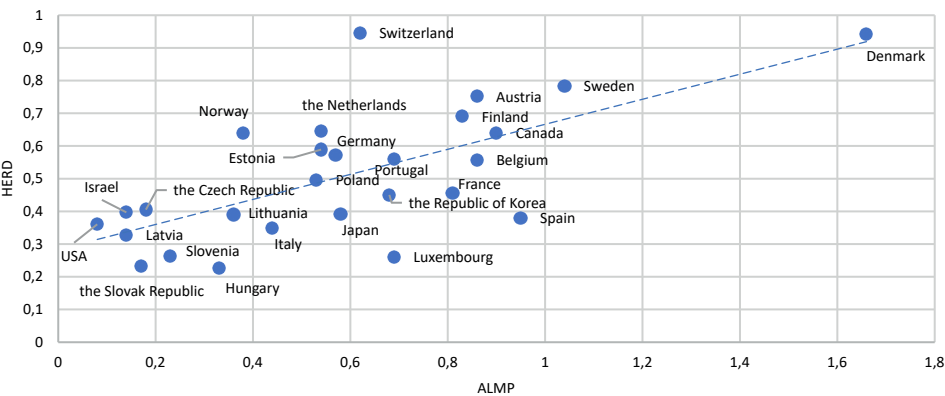

Figure 3. Correlations between ALMP and HERD (0.67*)

Note: as in Figure 2.

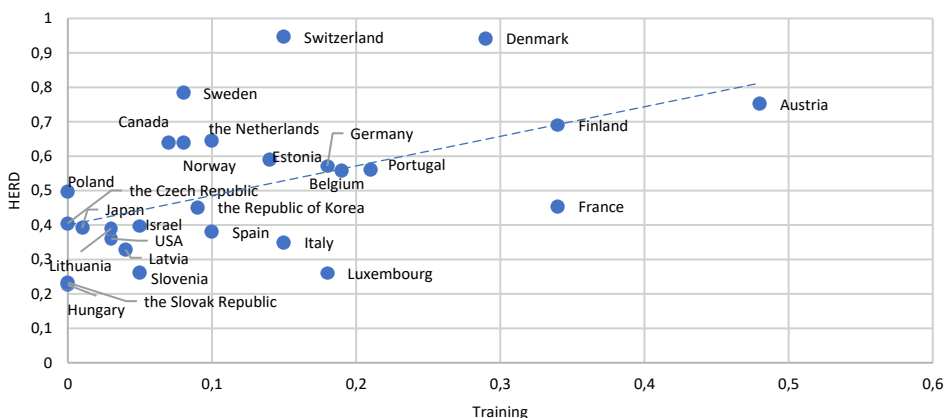Source: own calculations based on: (OECD, 2024d, 2024e).

Figure 4. Correlations between TRAINING and HERD (0.52*)

Note: as in Figure 2.

Source: own calculations based on: (OECD, 2024d, 2024e).

search and developmental activities in educational institutions, and in the overall economy. Active labour market policies aimed at improving employment and supporting the development of workers' skills and knowledge can also increase the potential for research in educational institutions. What is more, this may also result from the conditions accompanying cooperation between educational institutions.

Overall, the correlation values for labour market outcomes and investment in research and development indicate a positive relationship between the employment rate and labour force participation rate and investment in R&D in the OECD countries (Table 3, Figure 5). Conversely, the results indicate a negative relationship between the unemployment rate and investment in R&D in each country. While these findings are not surprising, they establish significant connections between these indicators. Firstly, labour market outcomes remained better in developed countries, which were also more technologically advanced. Additionally, a developed and stable economic environment may encourage educational institutions to increase their efforts in science and technology. Furthermore, higher employment (or lower unemployment) may lead to a greater demand for research and development to support employees in the evolving digital labour markets.

In the next step of our analysis, predictive models for employment rate, unemployment rate and labour force participation rate were estimated. Tables 4, 5 and 6 present the performance of the predictive models for employment rate, unemployment rate and labour force participation rate, respectively. Using 5-fold cross-validation, Random Forest and Gradient Boosting achieved the highest predictive performance among all models tested. Specifically, these models demonstrated relatively high R^2 values for the each of three considered dependent variables:
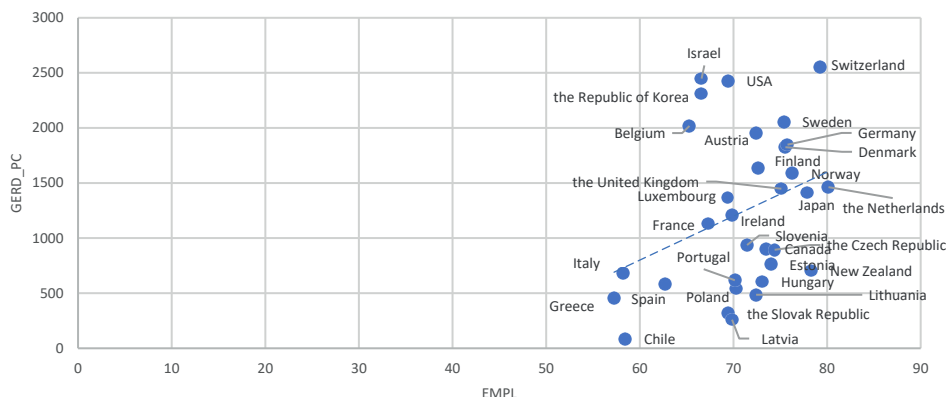
Figure 5. Correlations between GERD_PC and EMPL (0.50*)

Note: * Significant at level 10%; ** Significant at level 5%; ***Significant at level 1%. Figure 5 presents the results for 32 OECD countries (due to insufficient data the following countries were excluded: Australia, Colombia, Costa Rica, the United Kingdom, Iceland, Mexico, Turkey).

Source: own calculations based on: (OECD, 2024a, 2024d).

- 0.76 for employment rate;
- 0.82 for labour force participation rate;
- 0.75 and 0.77 for unemployment rate.

These models also produced relatively low error rates: mean absolute error (MAE) ranged from 1.39 to 2.17, while root mean square error (RMSE) ranged from 2.07 to 3.72 for all Random Forest and Gradient Boosting models.

Furthermore, the Random Forest and Gradient Boosting models exhibits relatively high stability, as indicated by low values of standard deviation of the R^2. This indicates that the models' performance was stable and reliable, as well as consistent across different data splits. In contrast, other models (e.g. K-Nearest Neighbors algorithm (KNeighbors) or Support Vector Regression (SVR)) showed lower predictive performance. Their explanatory power was significantly weaker, with R^2 values ranging from 0.05 to 0.23; they also exhibited higher prediction errors (e.g. MAE ranging from 4.85 to 2.52). Thus, the data exhibit complex interactions that are most effectively captured by ensemble techniques such as Random Forest and Gradient Boosting. Therefore, in the next step, we focus on these two models to explore the predictive power of the independent variables for the dependent variables.

Figure 6 presents the influence of individual variables on the prediction of the employment rate (EMPL variable), labour force participation rate (LABOUR variable), and unemployment rate (UNEMPL variable) in Random Forest and Gradient Boosting models. Firstly, regardless of the model used, the strictness of employment protection for temporary contracts (Strictness_temporary variable) emerged

Table 4. Performance of predictive models (dependent variable: EMPL)

Model	R²	MAE	RMSE	MSE	Standardized *R*-squared
LinearRegression	0.43	3.58	4.72	22.86	0.11
Ridge	0.47	3.54	4.58	21.37	0.07
Lasso	0.29	4.29	5.3	28.83	0.05
DecisionTree	0.48	2.71	4.4	19.46	0.16
RandomForest	0.76	2.15	3.08	9.74	0.06
GradientBoosting	0.76	2.17	3.01	9.17	0.06
KNeighbors	0.15	4.57	5.71	32.78	0.16
SVR	0.14	4.85	5.86	35.19	0.04

Source: own calculations in Python based on the results of 5-fold cross-validation of the models on the dataset, which contained data from: (OECD, 2024a, 2024c, 2024d, 2024e, 2024g, 2025b; OECD.Stat, 2025a, 2025b).

Table 5. Performance of predictive models (dependent variable: LABOUR)

Model	R²	MAE	RMSE	MSE	Standardized *R*-squared
LinearRegression	0.53	2.99	3.77	14.36	0.11
Ridge	0.55	2.95	3.71	13.82	0.09
Lasso	0.43	3.47	4.19	17.58	0.06
DecisionTree	0.53	2.12	3.72	14.27	0.18
RandomForest	0.82	1.53	2.32	5.56	0.07
GradientBoosting	0.82	1.55	2.28	5.32	0.07
KNeighbors	0.14	4.06	5.13	26.44	0.04
SVR	0.05	4.41	5.39	29.24	0.03

Source: own calculations in Python based on: (OECD, 2024a, 2024c, 2024d, 2024e, 2024g, 2025b; OECD.Stat, 2025a, 2025b).

Table 6. Performance of predictive models (dependent variable: UNEMPL)

Model	R²	MAE	RMSE	MSE	Standardized *R*-squared
LinearRegression	0.34	2.50	3.45	12.38	0.06
Ridge	0.36	2.47	3.41	12.18	0.07
Lasso	0.19	2.70	3.85	15.75	0.05
DecisionTree	0.67	1.47	2.36	5.62	0.08
RandomForest	0.75	1.40	2.11	4.68	0.03
GradientBoosting	0.77	1.39	2.07	4.61	0.04
KNeighbors	0.23	2.52	3.67	14.04	0.20
SVR	0.13	2.68	4.02	17.48	0.08

Source: own calculations in Python based on the results of 5-fold cross-validation of the models on the dataset, which contained data from: (OECD, 2024a, 2024c, 2024d, 2024e, 2024g, 2025b; OECD.Stat, 2025a, 2025b).

as an important predictor for both the employment rate and the labour force par-
ticipation rate. In addition, this variable was also a significant predictor for the un-
employment rate. These results indicate a significant and strong association be-
tween labour market flexibility and labour market outcomes. Thus, the findings
suggest that legal employment protection – particularly regarding temporary con-
tracts, plays a crucial role in shaping labour market outcomes in OECD countries.

Furthermore, indicators related to investment in research and development,
such as higher education expenditure on R&D, as a percentage of GDP (HERD
variable) or gross domestic spending on R&D per capita (GERD_PC variable), also
demonstrated relatively strong predictive power. These findings suggest that in-
vestment in research and development contributes meaningfully to employment
outcomes in the analysed countries. Additionally, the results underline the im-
portance of higher education and R&D investment for the functioning of labour
markets in OECD countries.

The data presented in Figure 6 also show that public spending on passive la-
bour market (% of GDP, PLMP variable) has relatively high predictive power for
the unemployment rate. This relationship is not surprising, and highlights the role
of such spending in mitigating the negative effects of unemployment, assuming it
is balanced with active labour market policies. Finally, innovations-related mea-
sures, such as ICT investment (ICT_invest variable) and the share of the top 10%
most-cited documents in computer science relative to all fields (Top_doc vari-
able) also emerged as the relevant factors influencing the employment rate, la-

Figure 6. Ranking of variables by predictive importance

Note: interactive version is available at https://data.lewoniewski.info/oecd/.

Source: own calculations in Python based on the results of 5-fold cross-validation of the models
on the dataset, which contained data from: (OECD, 2024a, 2024c, 2024d, 2024e, 2024g).

bour force participation rate, and in the case of Top_doc, the unemployment rate in the OECD countries. Therefore, factors that promote and support the development of digital innovations, as well as those that advance knowledge on innovation, are important predictors of labour-market outcomes in OECD countries. In conclusion, the findings underline a robust set of factors across all models, supporting the stability of our results.

Conclusions

In conclusion, the growth rate of gross domestic spending on R&D rate in 2011 was significantly higher in individual countries (when the term "Industry 4.0" was coined) compared to the growth rate in 2021. Undoubtedly, the origins of this phenomenon can be attributed to the crisis caused by the COVID-19 pandemic. Despite this, the GERD growth rate remained positive in most OECD countries. The findings indicate that investment in research and development was positively associated with the employment rate and labour force participation rate in OECD countries, while it was negatively related to the unemployment rate. Moreover, public spending on active labour market policies was found to be significantly correlated with R&D investment variables. Conversely, the relationship between R&D investment variables and passive labour market policies was not statistically significant.

The findings also reveal that OECD countries with relatively high R&D investment tend to have high levels of public spending on labour market policies. This highlights the fact that although investments in research and development bring many positive changes to socio-economic life, they also require extensive institutional changes. The results indicate a positive relationship between public spending on training and higher education expenditure on R&D. This suggests that training may enhance employees' skills and competencies, enabling them to participate more actively in innovative activities. This finding is also consistent with the previous studies, which emphasise that training must be provided to adapt employees' skills to the changing labour market requirements.

Furthermore, based on the performance of the predictive models using 5-fold cross-validation, Random Forest and Gradient Boosting achieved the highest predictive accuracy among all models tested for employment rate, unemployment rate and labour force participation rate, respectively. The Random Forest and Gradient Boosting models also exhibits relatively high stability, as indicated by low values of standard deviation of the R^2. These findings show that the data on the R&D investment and the labour market in the OECD countries exhibit complex interactions that are most effectively captured by ensemble techniques such as Random Forest

and Gradient Boosting. Regardless of the model used, the strictness of employment protection for temporary contracts emerged as an important predictor for both the employment rate and the labour force participation rate. In addition, this variable was also a significant predictor for the unemployment rate. These findings indicate a significant and strong relationship between labour market flexibility and labour market outcomes. Furthermore, indicators related to investment in research and development also demonstrated relatively strong predictive power, suggesting that investment in research and development contributes meaningfully to employment outcomes in the analysed countries. Moreover, public spending on passive labour market has relatively high predictive power for the unemployment rate, highlighting the role of such spending in mitigating the negative effects of unemployment. Finally, innovations-related measures also emerged as the relevant factors influencing the labour market outcomes in the OECD countries.

This research contributes to the existing knowledge from both theoretical and practical perspectives. First, it examines the relationships between labour market outcomes, labour market institutions, as well as investments in research and development financed from different sources. Specifically, it discusses the significance of R&D expenditure by the government, business sector and higher education. Moreover, it explores the benefits and challenges of new technologies and innovations for labour market participants. Finally, the implications of this study may be relevant for supporting the benefits and addressing the challenges in the labour market resulting from technological progress through appropriate investments in research and development. Despite these contributions, this study has certain limitations. It was constrained by limited access to up-to-date data sources for labour market policies. However, the data were collected carefully from official international databases. Additionally, the study is limited to OECD countries for which statistical data were available, and is based on a static approach to inputs and outcomes. Furthermore, conducting a cluster analysis in order to group OECD countries in terms of labour market outcomes and reveal potential differences in studied relationships could be considered for further studies. In addition, the present study could be extended to include non-OECD countries, and examining investments in research and development may reveal their effects on the labour market over a longer time horizon.

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Do agency costs matter? Evidence from Egypt on the capital structure-performance nexus

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Abstract

This study has two main objectives: (i) to explore the relationship between capital structure (CS) and firm performance (FP) among non-financial firms listed on the Egyptian Exchange (EGX30), and (ii) to analyse how agency costs (AC) influence this relationship as a moderator. The research uses panel least squares (PLS) to examine how AC affects the association between CS and FP. The sample includes 200 firm observations annually from 20 non-financial firms listed on the Egyptian Stock Exchange (EGX30) from 2014 to 2023. The debt-to-equity ratio (D/E) measures CS, while return on equity (ROE) assesses FP. The asset utilisation ratio (AUR) gauges AC. Results indicate that CS positively affects FP. Additionally, AC demonstrate a positive moderating effect on the relationship between CS and FP. To the best of the authors' knowledge, this is the first study to examine the moderating influence of AC on the association between CS and FP in Egypt.

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Introduction

The need for financing in any enterprise is not dependent on the firm's age. Capital is a vital element for a company at any stage of its growth. This funding is known as capital structure (CS) (Chechet & Olayiwola, 2014). CS refers to the ratio of debt to equity that a company chooses to fund its growth, operations and future projects. It plays a crucial role in determining a company's market position concerning risk and return. Finding the best CS is a continuous process where companies must regularly evaluate the costs and benefits of various funding options. An ideal CS maximises the firm's value while minimising costs (Chadha & Sharma, 2015). Reaching the right CS requires a cautious balance between the advantages and disadvantages of debt and equity. Although previous studies (Ayaz et al., 2021; Ogebe et al., 2013) suggest that organisations can find an optimal CS, decades of research have yet to produce a clear framework for achieving it.

The Financial Regulatory Authority (FRA) in Egypt has set standards for the CS of non-financial companies. These guidelines include details on minimum capital requirements and transparency rules. The FRA Decree No. 91 of 2023 states that the minimum capital requirement for leasing and factoring companies is EGP 75 million. The FRA Decree No. 196 of 2024 outlines the minimum capital requirements for insurance businesses, which vary depending on the type of insurance license. Disclosure regulations require regular reporting of information about CS, debt issuance and any changes in a firm's paid-in capital.

The relationship between CS and firm performance (FP) has been a subject of debate since Modigliani and Miller proposed in 1958 that a firm's value is unaffected by its CS; however, the assumptions behind this theory are impractical (Iavorskyi, 2013). In 1963, the two authors revisited their work and took into account the impact of corporate tax, highlighting the importance of interest payments that are tax-deductible.

Since then, other theories have been developed, including the Tradeoff Theory, which suggests that firms try to reach a target debt ratio, the Pecking Order Theory, which highlights the best hierarchy for obtaining financing from the cheapest to the most expensive choice, as well as the Agency Theory, which states that the use of leverage keeps managers from making decisions that will primarily benefit them resulting in lower agency costs (AC) (Tudose, 2012). All of these theories are meant to further clarify the association among CS, FP, and AC.

Previous research has identified various factors that influence CS and alter the debt-to-equity ratio (D/E). The primary factor is firm size (FS), a key determinant of CS, because larger firms generally use a higher proportion of debt in their financing due to their ability to reduce risk, in line with the trade-off theory (Ahmed Sheikh & Wang, 2013; Chen et al., 2014; Ghosh, 2017). The second factor is liquidity

(LQ), which refers to a firm's ability to convert assets into cash quickly. It is generally easier for more liquid companies to obtain external financing (Ghasemi et al., 2016). The third factor is tangibility (TG), since physical assets make it more economical to acquire debt due to their potential as collateral. The higher the value of tangible assets, the more confidence lenders have regarding the recovery of their outstanding amounts (Ernawati & Murhadi, 2013). The last factor is business risk (BR), as higher-risk firms should rely more on equity financing, whereas firms with lower risk and financial distress should rely more on debt financing (Chen et al., 2014). BR also tends to increase then decrease as it has a quadratic relationship with leverage (Ghosh, 2017).

While CS can support a firm's optimal performance, it can also lead to its downfall. Evidence of this is witnessed in companies that were once among the largest globally. Kmart was once one of the leading bargain retailers in the United States. The problem stemmed from increased competition from rivals like Target and Walmart, which were establishing themselves as market leaders. Kmart filed for bankruptcy on January 22, 2002, due to intensified price cuts, declining sales and numerous defaulted bonds (Stowell & Stowell, 2017). Toys R Us was once among the top toy retailers worldwide. After its share price fell from $45 to about $23–$24, and following a $6.6 billion leveraged buyout with roughly $450 million in annual interest payments, the company was forced to declare bankruptcy in 2017 (Morgan & Nasir, 2021).

The contributions of previous literature on this topic are significant; however, they have consistently yielded conflicting results. Several studies indicated that in Bangladesh, Ukraine and Vietnam, CS negatively impacted FP, regardless of the measurement methods used (Iavorskyi, 2013; Nguyen & Nguyen, 2020; Rouf, 2015). Conversely, many studies in Malaysia, Jordan, India, Egypt, Pakistan and Sri Lanka yielded inconclusive results (Al-Taani, 2013; Ayaz et al., 2021; Chadha & Sharma, 2015; Muhammed & Shah, 2014; Sakr & Bedeir, 2019; Salim & Yadav, 2012). Despite decades of debate about the relationship between CS and FP, finding a definitive answer on how CS influences FP remains challenging. Furthermore, few studies have examined this topic in Egypt. This research will analyse the influence of CS on FP, considering the moderating effect of AC in Egypt.

This research advances the existing literature by providing valuable insights into corporate behaviour where significant economic reforms and macroeconomic changes occurred throughout the study period. Ultimately, by using AC as a moderating variable, the study sheds light on how conflicts between managers and shareholders may impact financing decisions and FP.

This research includes the following sections: Section 1 covers the literature review and hypothesis development. Section 2 describes the sample used and the specification of the model. Section 3 explains and discusses the statistical results. Finally, there are conclusions, implications, limitations and recommendations for future research.

1. Literature review

This section offers a thorough examination of the conceptual foundations and theoretical frameworks supporting this investigation. It specifically addresses the independent variable (CS), the dependent variable (FP) and the moderating variable (AC), subsequently reviewing the relevant theories that clarify their interconnections.

1.1. Capital structure

CS, which explains how a corporation finances its operations, investments and growth through a mix of debt and equity, is crucial in determining firm value (Muhammad & Shah, 2014; Salim & Yadav, 2012). These financing options have significant effects, directly influencing the interests of various stakeholders, including shareholders, creditors and management (Sakr & Bedeir, 2019). Debt typically includes instruments like loans, bonds, debentures and notes payable, while equity covers common and preferred shares (Chadha & Sharma, 2015; Dada & Ghazali, 2016). Poor CS decisions can lead to higher costs of capital, which reduces the net present value (NPV) of investment opportunities and makes them less attractive financially. A properly balanced CS lowers the cost of capital, increases project NPV, and ultimately helps maximise firm value (Rouf, 2015).

1.2. Firm performance

The primary reason for establishing a firm is to maximise shareholder wealth and overall firm value. To reach these goals, companies consistently strive to enhance their performance. Evaluating FP is vital for ensuring continuous progress by providing insights into operational efficiency and financial health. This evaluation ultimately helps identify areas where the company needs improvement and enhances the decision-making process. Regular assessment of performance is essential because it allows companies to adapt to market changes, allocate resources effectively and improve business operations. These efforts ultimately lead to sustainable corporate growth (Rohim et al., 2024). To assess FP, financial reports are carefully analysed, as they contain comprehensive information about FPs across various financial aspects, which can be examined through different financial ratios. These ratios reveal the company's liquidity, solvency, profitability and market value (Maysuri & Dalimunthe, 2018).

1.3. Agency costs

AC arises because of a conflict of interest between managers and shareholders due to the separation of ownership and management (Pranata & Nugroho, 2025). This separation leads managers to diverge from the ultimate objective of maximising the value of the firm, as they are more prone to act in their interest (Rohim et al., 2024). Monitoring expenses, bonding costs and residual losses are different types of AC. Monitoring costs are the expenses related to making sure management acts in the best interests of investors, such as hiring an external auditor. Bonding costs are expenses incurred to prevent managers from engaging in certain behaviours. A bond covenant, which is part of the bonding costs, restricts the corporation from taking specific actions. Lastly, residual losses are the costs paid when a conflict of interest between managers and investors arises, even when monitoring and bonding measures are in place (Sapuan et al., 2021).

1.4. Theoretical framework

This section discusses three theories about the relationship between CS and FP: the Modigliani-Miller theory, the trade-off theory and the dynamic trade-off theory. It also covers two theories about the moderating effect of AC on the relationship between CS and FP: the pecking order theory and agency theory.

1.4.1. CS and FP theories

The relationship between CS and FP has long been a central topic in corporate finance. Three primary theories explain this relationship: the Modigliani-Miller theorem, the trade-off theory and the dynamic trade-off theory. The Modigliani-Miller hypothesis, first introduced by Modigliani and Miller in 1958, marks the initial formal analysis of how CS influences a firm's value. Based on a set of idealised assumptions, such as excluding taxes, transaction costs and information asymmetry, the theory states that a firm's value is unaffected by its CS and is instead determined by its earning potential and risk profile (Dao & Ta, 2020). However, these assumptions greatly limit the theory's practical applicability. In 1963, Modigliani and Miller adjusted their framework to include corporate taxes, arguing that companies can increase their value by using debt to benefit from tax-deductible interest payments. However, implementing this revised theory in practice remains limited, especially for smaller businesses (Magoro & Abeywardhana, 2017).

The trade-off approach, developed by Kraus and Litzenberger in 1973, challenges the Modigliani-Miller assumptions by recognising that firms weigh the benefits

of debt, such as the tax shield, against its costs, including financial hardship. This viewpoint suggests that each firm has an optimal CS, and deviations from this target require adjustments to restore balance (Singh & Kumar, 2008).

The dynamic trade-off theory incorporates time as a key factor in CS decisions. It emphasises the speed of adjustment (SOA), a metric indicating how quickly firms return to their target leverage after fluctuations. This approach captures the complex realities of corporate financing behaviour, recognising that firms do not instantly achieve or maintain optimal capital structures (Abdeljawad et al., 2013).

1.4.2. CS, FP and AC theories

The Pecking Order Theory was developed by Stewart Myers and Nicolas Majlouf in 1984 (Singh & Kumar, 2008). This theory suggests that companies prefer specific funding sources. The order of financing preference starts with internal funds, then debt, and finally equity, with short-term debt preferred over long-term debt. This preference arises from the information asymmetry between managers and investors, which increases the cost of capital, making retained earnings the most cost-effective source of financing (Chen & Chen, 2011).

The Agency Theory was introduced by Jensen and Meckling in 1976. The researchers argued that eliminating costs arising from conflicts between managers and shareholders allows a firm to achieve an optimal CS. This can be accomplished by holding a level of debt that encourages managers to act in the company's best interests, since taking on debt requires meeting those debt obligations (Chechet & Olayiwola, 2014).

1.5. Empirical review

This section indicates empirical studies investigating the impact of CS on FP, as well as the moderating influence of AC within this context. The examined studies (Ayaz et al., 2021; Chadha & Sharma, 2015; Do et al., 2022; Iavorskyi, 2013; Mathur et al., 2021; Nguyen & Nguyen, 2020; Pandey & Sahu, 2017; Rouf, 2015; Sakr & Bedeir, 2019) encompass numerous countries and sectors, demonstrating inconsistent outcomes, hence highlighting the necessity for additional research, especially in developing markets like Egypt.

1.5.1. Capital structure and firm performance

Nguyen and Nguyen (2020) examined the influence of CS on FP in Vietnam. The data was obtained from 488 non-financial firms spanning the years 2013 to

2018. Short-term obligations, long-term liabilities and the ratio of total liabilities to total assets were utilised to assess CS. Return on assets (ROA), return on equity (ROE) and earnings per share (EPS) were used to assess FP. The findings indicated that CS negatively impacts FP. This is attributed to high loan rates that lead to low business results. Additionally, Rouf (2015) examined the impact of CS on FP in Bangladesh, utilising data from 106 manufacturing firms between 2008 and 2011. The indicators for CS were the debt ratio, current debt ratio, debt-to-equity ratio, proprietary equity ratio, as well as the ratio of current assets to proprietors' funds. The indicators for FP were ROA and return on sales (ROS). The findings indicated that FP was negatively affected by its CS. This could be attributed to a higher reliance on equity rather than debt which results in a higher cost of capital and reduced profitability. Iavorskyi (2013) examined the influence of CS on FP in Ukraine, utilising a sample of 16,500 firms from 2001 to 2010. CS was assessed using total leverage, while FP was evaluated through ROA, EBIT margin and total factor productivity. The findings indicated that CS negatively impacts FP, with the researcher asserting that leverage has a more positive influence on low-growth firms compared to high-growth firms.

Conversely, Ayaz et al. (2021) examined the impact of CS on FP in Malaysia. From 2005 to 2016, five hundred twenty-eight non-financial firms were analysed. CS was measured using market leverage and total leverage. At the same time, FP was assessed through ROA, ROE, gross margin and Tobin's Q. The findings showed that CS positively affected FP as indicated by Tobin's Q, ROA and ROE. This could be attributed to firms having moderate levels of debt and an optimal capital structure which enhance FP. Sakr and Bedeir (2019) studied the influence of CS on FP by analysing sixty-two non-financial companies in Egypt from 2003 to 2016. CS was assessed using ratios of total debt to total assets, short-term debt to total assets (STDA) and long-term debt to total assets (LTDA). ROA and ROE were used to measure FP. The results revealed that when ROA measured FP, CS had a negative impact. Conversely, a positive effect was observed when CS was measured using STDA and when ROE was utilised to FP. Mathur et al. (2021) investigated this relationship in Indian pharmaceutical companies from 2000 to 2018. Total debt ratio, long-term debt ratio and short-term debt ratio were proxies for CS. ROA and ROE were proxies for FP. The results showed that CS had a negative impact on FP regardless of the proxies used. This is due to the fact that debt repayment is a mandatory obligation. High reliance on debt can also lead to financial distress and operational risk. In the same vein, Do et al. (2022) studied the association between CS and FP in Vietnam from 2015 to 2020. CS was assessed by STDA and LTDA. FP was assessed using ROA and Tobin's Q. The results showed that when ROA measured FP, CS had a negative impact. This is due to the fact that interest payments on debt have to be paid regardless of whether the company was profitable or not, reducing cash inflows. Failure to fulfil those obligations can lead to

bankruptcy. Conversely, when Tobin's Q measured FP, STDA did not affect FP, but was negatively affected by LTDA. Additionally, Pandey and Sahu (2017) measured CS by D/E, while ROA measured FP and return on net worth in India from 2009 to 2016. Results indicated that there is a negative association between CS and FP. Finally, Chadha and Sharma (2015) investigated this relationship in India by analysing four hundred twenty-two firms from 2003 to 2013. CS was assessed using the debt-to-equity ratio, while FP was measured through ROE, ROA and Tobin's Q. The findings showed that when ROE was used to measure FP, CS had a significant negative effect which can be attributed to a high cost of capital when relying more on equity which negatively affects the value of the firm. Conversely, when FP was assessed by Tobin's Q and ROA, it was unaffected by CS.

Due to the fact that higher financial risk is associated with higher leverage, especially in a volatile economic environment like Egypt, and due to the fact that most of the aforementioned findings indicated a negative impact of CS on FP, we have decided to formulate our main research hypothesis as follows – H1: CS negatively and significantly impacts FP.

1.5.2. Capital structure, firm performance and agency costs nexus

Ahmed et al. (2023) explored how AC influences the relationship between CS and FP in Iranian manufacturing companies. The study analysed a sample of 165 firms from 2011 to 2019. CS was measured using the debt-to-asset ratio and the debt-to-market capitalisation ratio. FP was assessed through EPS, ROA and Tobin's Q. The asset utilisation ratio (AUR) and the operational expense ratio indicated AC. The findings showed that, when measuring FP with Tobin's Q, AC had a negative moderating effect. However, when using EPS and ROA, and the AUR measured AC, a significant positive moderating effect of AC on FP was observed. This is due to the fact that when assets are utilised efficiently, agency costs can be mitigated which positively affects performance. However, when asset utilisation goes beyond a certain threshold, it may discourage further investing in the company as it becomes harder to enhance performance.

Pranata and Nugroho (2025) studied how AC moderates the relationship between CS and FP in non-financial firms listed on the Indonesia Stock Exchange (IDX) from 2020 to 2022. CS was measured using the debt-to-asset ratio and debt-to-market capitalisation, while FP was evaluated through Tobin's Q, EPS and ROA. Lastly, AC was assessed using AUR. The findings showed that AC positively moderates the relationship described earlier. This indicates that utilising assets efficiently can reduce a firm's losses that result from relying on higher levels of debt.

Due to the fact that agency costs can enforce control mechanisms to enhance the benefits of debt and mitigate its adverse effects, and due to the fact that most

of the aforementioned findings indicated a positive moderation effect of AC on the relationship between CS and FP, we have decided to formulate our main research hypothesis as follows – H2: AC positively and significantly moderates the relationship between CS and FP.

2. Methodology

2.1. Data description

This research uses panel data, consisting of a sample frame of twenty non-financial firms over ten years from 2014 to 2023, which is due to the fact that markets stabilised in 2014 after the political and economic turmoil from 2011 to 2013. This research employed a judgmental sampling scheme where the initial sample included all thirty firms in the Egyptian Exchange (EGX30); however, banks and financial institutions were excluded due to their unique nature. Additionally, any companies with missing data were removed as shown in Table 1. This study uses a balanced panel with two hundred observations. The data for this research were exclusively collected from the DataStream database, which provides extensive financial information, including annual reports, financial statements and relevant firm-level metrics for firms listed on EGX30.

Table 1. Sample selection

Description	Number of observations
Initial sample (over 10 years)	300
Less: banks and financial firms	90
Less: firms with unavailable data	10
Final sample	200

Source: authors' compilation.

2.2. Description and measurement of variables

The dependent variable, FP, is measured by ROE which gauges a firm's profitability and efficiency (Ayaz et al., 2021). The independent variable, CS, is measured by the debt-to-equity ratio in order to understand how much debt a firm is

utilising compared to equity (Ayaz et al., 2021). The moderating variable, AC, was assessed using AUR which assesses how a firm generates revenue by using its assets efficiently (Ahmed et al., 2023; Pranata & Nugroho, 2025). Measures, sources, and references for each variable are presented in Table 2.

Table 2. Variables, abbreviation, measure and source

Variable	Abbre-viation	Measure	Source	Reference
Dependent variable				
Firm performance (return on equity)	ROE	Earnings before interest and taxes divided by total equity.	DataStream	Ayaz et al., 2021
Independent variable				
Capital structure (debt to equity ratio)	D/E	Total debt divided by total equity.	DataStream	Ayaz et al., 2021
Moderator variable				
Agency costs (asset utilization ratio)	AUR	Annual sales divided by total assets.	DataStream	Ahmed et al., 2023; Pranata & Nugroho, 2025
Control variables				
Liquidity	LQ	Current assets divided by current liabilities.	DataStream	Ayaz et al., 2021; Rouf, 2015
Tangibility	TG	Net fixed tangible assets divided by total assets.	DataStream	Ayaz et al., 2021 Nguyen & Nguyen, 2020
Firm size	FS	Natural logarithm of total assets.	DataStream	Ayaz et al., 2021; Nguyen & Nguyen, 2020; Javed et al., 2014
Business risk	BR	Standard deviation of earnings before interest and taxes divided by total assets.	DataStream	Ayaz et al., 2021

Source: authors' compilation.

2.3. Model specification

This empirical analysis was conducted using panel least squares (PLS). The research incorporated control variables alongside the moderating variable of AC. Control variables were used to minimise the influence of external factors on the analysis. This study utilises two models: (i) one that examines the relationship

between CS and FP, and (ii) one that includes AC as a moderating variable in the previously described relationship.

No-AUR regression model:

$$\text{ROE}_{it} = \alpha i + \beta_1 \text{D/E}_{it} + \beta_2 \text{LQ}_{it} + \beta_3 \text{TG}_{it} + \beta_4 \text{FS}_{it} + \beta_5 \text{BR}_{it} + \lambda_{it} + \varepsilon_{it} \tag{1}$$

AUR regression model:

$$\text{ROE}_{it} = \alpha i + \beta_1 \text{D/E}_{it} + \beta_2 \text{LQ}_{it} + \beta_3 \text{TG}_{it} + \beta_4 \text{FS}_{it} + \beta_5 \text{BR}_{it} + \beta_6 \text{AC}_{it} + \\ + \beta_7 (\text{D/E}_{it} \cdot \text{AUR}_{it}) + \lambda_{it} + \varepsilon_{it} \tag{2}$$

where:

ROE_{it}	– return on equity of firm i in year t,
D/E_{it}	– debt-to-equity ratio of firm i in year t,
LQ_{it}	– liquidity of firm i in year t,
TG_{it}	– tangibility of firm i in year t,
FS_{it}	– firm size of firm i in year t,
BR_{it}	– business risk of firm i in year t,
AUR_{it}	– asset utilisation ratio of firm i in year t,
$(\text{D/E}_{it} \cdot \text{AUR}_{it})$	– impact of CS and AUR on FP,
λ_{it}	– coefficient of variation,
ε_{it}	– random error.

3. Results and discussion

3.1. Descriptive statistics

The descriptive data in Table 3 show that the average ROE for the sample is 0.215, whereas a good ROE ratio is between 0.15 and 0.2, indicating that companies efficiently utilise the equity invested by shareholders, which leads to high profitability. Ezz Steel recorded the lowest ROE of –8.053 in 2023, mainly due to a significant drop in earnings before interest and taxes (EBIT), caused primarily by higher manufacturing costs due to exchange rate differences. In contrast, Ezz Steel reached the highest ROE of 1.09 in 2018. This increase was attributable to a rise in production volumes, higher sales and a decrease in the cost of goods sold, which led to a 27% increase in gross profit compared to the previous year which was the result of better pricing power. A good D/E ratio is between 1 and 1.5. Since the average D/E is 0.656, it indicates a higher dependence on equity financing compared

to debt financing. The lowest D/E ratio was −8.56, recorded by Ezz Steel in 2022, likely reflecting fluctuations in raw material prices and a shift to equity financing. On the other hand, the highest D/E ratio of 8.08 was also recorded by the same company in 2018, indicating greater reliance on debt to support expansion. The average AUR is 0.994, whereas a good AUR is between 1 and 2, suggesting inefficient asset utilisation in sales generation and possibly reflecting increased managerial opportunism or agency conflicts. The lowest value of AUR 0.108 for TMG Holding was recorded in 2016, highlighting effective resource use and improved sales performance. Conversely, the highest AUR value of 3.747 was documented by Alexandria Mineral Oils Company in 2022, indicating efficient asset utilisation to generate sales and resulting in low AC. All the variables had low standard deviations which indicates that the data is closely clustered to the mean.

Table 3. Descriptive analysis of variables

Variables	Mean	Min	Max	Standard
Panel A: dependent variable				
ROE	0.215	−8.053	1.09	0.691
Panel B: independent and moderator variables				
D/E	0.656	−8.56	8.08	1.418
AC	0.994	0.108	3.747	0.738
Panel C: control variables				
LQ	1.589	0.232	6.842	0.974
TG	0.408	0.006	1.378	0.262
FS	23.217	21.142	25.815	1.149
BR	0.24	0.008	2.182	0.41

Source: authors' calculations.

3.2. Pearson coefficient correlation matrix

Table 4 shows a weak positive correlation, with a coefficient of 0.307, between D/E and ROE, indicating that moderate debt use may signal growth potential to investors, thereby boosting ROE. On the other hand, there is a weak negative correlation with a coefficient of −0.193 between FS and ROE, because when firms expand, operational costs increase, causing diseconomies of scale and lower profitability, which reduces ROE. A weak negative correlation exists between D/E and LQ, with a coefficient of −0.145, since firms relying heavily on debt must meet debt obligations through interest payments, reducing LQ. A weak positive correlation exists between TG and BR, with a coefficient of 0.295, because industries that depend

heavily on tangible assets tend to need more debt, raising the chance of default. Conversely, there is a weak negative correlation between TG and LQ, with a coefficient of −0.258, due to the difficulty of quickly converting tangible assets to cover short-term needs, which lowers LQ. A weak positive correlation exists between AC and BR, with a coefficient of 0.168, as AC arises from conflicts between managers and shareholders, potentially increasing a firm's BR when managers select higher-risk projects for personal gain. Conversely, a weak negative correlation exists between AC and FS, with a coefficient of −0.488, because larger firms tend to reduce AC through better governance. A weak negative correlation exists between FS and BR, with a coefficient of −0.306, as larger firms can utilise multiple income streams to mitigate unexpected risks. Finally, a weak negative correlation exists between FS and LQ, with a value of −0.268, since larger firms can more easily access capital markets to raise funds while maintaining low LQ. Moreover, the variance inflation factor (VIF) shows that all variables have a VIF below 5, indicating the absence of multicollinearity among the independent variables, so none need to be removed.

Table 4. Pearson coefficient correlation matrix

Variables	ROE	D/E	TG	AC	BR	FS	LQ
ROE	1.000						
D/E	0.307**	1.000					
TG	−0.071	0.025	1.000				
AC	−0.037	0.029	0.008	1.000			
BR	0.008	−0.015	0.295**	0.168*	1.000		
FS	−0.193**	−0.002	−0.068	−0.488**	−0.306**	1.000	
LQ	0.100	−0.145*	−0.258**	0.101	−0.064	−0.268**	1.000
Multicollinearity diagnostics							
VIF	−	1.04	1.258	1.514	1.238	1.688	1.458

Note: * Significant at level 10%; ** Significant at level 5%; *** Significant at level 1%.

Source: author's calculations.

3.3. Regression analysis

PLS were utilised in order to determine whether there is a significant relationship between CS and FP or not. The fixed effects model takes into account the different years that are included in the sample. However, the random effects model acknowledges the fact that there are different companies included in the sample. The Hausman test was utilised in order to determine which of the previously mentioned models is a better fit for the analysis. Since the p-value was greater than 0.05

as demonstrated in Table 5, the analysis relied on the results of the random effects model. Table 5 also shows that an increase of 1 unit in D/E results in a 0.154 unit increase in ROE, indicating that ROE rises when firms acquire debt at a lower cost and pursue high-yield projects. Finally, a 1-unit increase in FS causes a 0.097 decrease in ROE. This occurs because larger firms, once they reach maturity, have fewer incentives for growth as they have achieved their objectives. This prompts investors to seek alternative opportunities in the market with firms that may offer higher profits. The findings are supported by the pecking order theory, which suggests that a hierarchy should be followed in the finance acquisition process. This hierarchy starts with retained earnings, then debt, and finally equity. The rationale is that each funding source has a cost, and the ideal CS maximises the firm's value while minimising capital costs. Retained earnings and debt are more economical sources of funding than equity because, in cases of liquidation or bankruptcy, debt creditors are paid before equity investors. As a result, equity investors expect higher returns to compensate for the increased risk. This hierarchy guides firms toward an optimal CS with minimal trade-offs, ultimately improving FP. Additionally, the *R*-squared value is 0.141, which means that the model explains 14.1% of the variation in ROE. The findings show that H1 is rejected, as CS has a positive effect on FP.

Table 5. Relationship between CS and FP

Estimates of PLS	Fixed effects model		Random effects model	
	coefficient	*t*-statistic	coefficient	*t*-statistic
Constant	0.663	0.28	2.307	1.69
D/E	**0.148*****	4.32	**0.154*****	4.74
Control variables				
LQ	0.028	0.42	0.053	0.93
TG	0.431	1.33	0.001	0.01
FS	−0.032	−0.32	**−0.097***	−1.72
BR	−0.095	−0.27	−0.061	−0.36
Other statistics				
R-squared	0.115		0.141	
Number of observations	200		200	
Hausman test (*p*-value)	0.557			

Note: * Significant at level 10%; ** Significant at level 5%; *** Significant at level 1%.

Source: author's calculations.

PLS were utilised in order to determine whether AC had a significant moderation effect on the relationship between CS and FP or not. The random effects model was the better fit as the Hausman test had a *p*-value greater than 0.05 as demon-

strated in Table 6. Table 6 also shows that a 1-unit rise in AC leads to a 0.219 decrease in ROE, as AC is typically reduced by incentives that lower profitability and ROE. The interaction test results reveal that AC positively moderates the relationship between CS and FP, due to the significant reliance on debt in firms with high AC. This is because incurring debt entails servicing costs, which compel managers to prioritise the firm's best interests, thereby enhancing profitability and overall performance. Agency theory supports these findings, claiming that AC decreases as debt is used, aligning the interests of managers and shareholders. Increasing debt reduces managers' free cash flow, limiting any discretionary behaviour they might display. Additionally, the *R*-squared value for this model is 0.152, meaning that the model explains 15.2% of the variation in ROE. The findings confirm that H2 is supported, as AC positively influences the association between CS and FP.

Table 6. Impact of AC on the relationship between CS and FP

Estimates of PLS	Fixed effects model		Random effects model	
	coefficient	*t*-statistic	coefficient	*t*-statistic
Constant	2.319	1.0.98	3.925	2.58
D/E	**0.136*****	4.06	**0.152*****	4.72
AC	**−0.4*****	−3.10	**−0.219****	−2.43
Moderating effect				
D/E x AC	**0.103*****	4.19	**0.111*****	4.84
Control variables				
LQ	0.024	0.35	0.05	0.88
TG	0.412	1.27	0.015	0.07
FS	−0.023	−0.23	−0.077	−1.39
BR	−0.09	−0.25	−0.057	0.166
Other statistics				
R-squared	0.110		0.152	
Number of observations	200		200	
Hausman test (*p*-value)	0.67			

Note: * Significant at level 10%; ** Significant at level 5%; *** Significant at level 1%.

Source: author's calculations.

3.4. Discussion of results

The statistical research shows that CS has a positive effect on FP measured by ROE. These findings are supported by the findings of Ayaz et al. (2021) who stud-

ied this relationship on Malaysian firms. On the other hand, these findings contradict earlier studies, including Rouf (2015), which analysed firms listed on the Dhaka Stock Exchange from 2008 to 2011; Pandey and Sahu (2017), which examined Indian manufacturing firms from 2009 to 2016; Muhammad and Shah (2014), which focused on firms listed on the Karachi Stock Exchange from 2009 to 2013; Al-Taani (2013), which studied a sample of 45 manufacturing companies in Jordan from 2005 to 2009; and Chadha and Sharma (2015), which examined 422 Indian companies from 2003 to 2013. All of these studies found that, when ROE measures FP, FP was negatively and significantly affected by CS. Differences in results between this research and previous studies can be attributed to the use of different contexts and periods during which countries face varying economic and political conditions that may affect the analysis.

The findings showed that AC positively influences the relationship between CS and FP, as managers tend to make unbiased decisions regarding the efficient use of assets when the firm takes on additional debt to cover interest payments. The findings of Ronoowah and Seetanah (2024) support this, since they examined the relationship between CS, FP and AC in Mauritian firms from 2009 to 2019. Proper asset utilisation reduces the negative impact of leverage on FP and lowers AC. These results were confirmed by Pranata and Nugroho (2025), who conducted similar research on Indonesian companies from 2020 to 2022. When organisations manage their assets effectively, valuation issues and profitability losses caused by high debt levels are addressed. Among the control variables, only FS showed statistically significant results, indicating a negative effect on FP. This happens because, over time, larger organisations often experience reduced profitability as the benefits of size no longer outweigh the costs (Yadav et al., 2022). In contrast, TG, LQ and BR showed statistically insignificant effects.

3.5. Robustness test

To verify the validity of the results obtained from the PLS and determine whether the relationship between CS and FP is both positive and significant, equity-to-assets (E/A) was used as an additional measure for CS. Both the fixed effects model and the random effects model were utilised with the Hausman Test suggesting that the random effects model was a better fit.

Table 7 indicates that an increase of 1 unit in E/A leads to a 0.551 increase in ROE, which can be an indicator that firms are relying more on equity, leading to reduced interest expenses. This leads to an improvement in net income compared to the firm's equity base, resulting in an improved ROE. Lastly, a 1-unit increase in FS results in a 0.092 decrease in ROE, because as firms grow, they may have fewer

investment opportunities with high returns. It can also be attributed to the fact that firms tend to become less efficient as they grow, which also reduces ROE. Additionally, the *R*-squared is 0.071, which means that the model explains 7.1% of the variation in ROE.

Table 7. Additional analysis: equity-to-assets

Estimates of PLS	Fixed effects model		Random effects model	
	coefficient	*t*-statistic	coefficient	*t*-statistic
Constant	−0.193	−0.08	**2.244***	1.70
E/A	0.363	0.85	**0.551***	1.88
Control variables				
LQ	−0.018	−0.24	−0.033	−0.51
TG	0.547	1.61	−0.181	−0.78
FS	0.002	0.02	**−0.092***	−1.70
BR	−0.041	−0.11	−0.066	−0.42
Other statistics				
R-squared	0.025		**0.071**	
Number of observations	200		200	
Hausman test (*p*-value)	0.068			

Note: * Significant at level 10%; ** Significant at level 5%; *** Significant at level 1%.

Source: author's calculations.

Conclusions and remarks

This research aims to examine the impact of CS on FP, considering the moderating effect of AC. A sample of 20 non-financial companies from the EGX30 was used from 2014 to 2023. The analysis employed three different panel least squares methods, with the Hausman test indicating that the random effects model was the most suitable choice. The results showed a significant and positive relationship between CS and FP, as effective use of debt and strategic investments can significantly enhance FP. AC has a positive influence on the relationship between CS and FP. Managers are less likely to prioritise their interests over those of the firm and shareholders when there is heavy reliance on debt for projects. Regarding control variables, only company size showed a negative effect on FP, while LQ, TG and BR were found to be insignificant.

This research has important implications for stakeholders. Firstly, firms need to evaluate the costs and benefits of different financing sources before choosing

the most appropriate option, as the ideal CS is heavily influenced by factors such as industry, firm size, cash flow predictability, corporate goals and shareholder expectations. Secondly, companies in the maturity phase of their lifecycle should pursue projects that promote growth beyond their initial objectives to attract investors who may be drawn to smaller firms offering higher returns. Thirdly, governments should implement initiatives to improve entrepreneurs' financial literacy, thereby fostering a better understanding of how various financing sources can impact the organisation as a whole.

Some limitations encountered during data collection and analysis may have affected the generalisability and depth of the results. Initially, financial statements for 2013 were unavailable and thus excluded from the dataset. This could have impacted the continuity and accuracy of the time series analysis. Additionally, although the original research design aimed to include market-based indicators of CS (e.g. market leverage) and FP (e.g. Tobin's Q), the limited availability of published market data restricted the precise calculation of these variables. As a result, the analysis mainly relied on accounting-based proxies, which might not adequately reflect market opinions or external assessments of FP and leverage. Finally, the literature review revealed a significant gap as no previous studies established a meaningful relationship between CS, as indicated by D/E, and FP, measured by ROE. This posed a challenge during the discussion phase, as it limited the amount of prior empirical evidence available to benchmark or validate the current findings.

Future research should extend the study period beyond ten years to better detect long-term trends and cyclical effects that may influence the relationship between CS and performance. Additionally, expanding the geographic scope to include various countries could enhance the findings by accounting for differences in political, regulatory and economic environments. Lastly, due to the fact that the *R*-squared values are low as is acceptable in social sciences considering that it deals with complex human behaviour which is everchanging and hard to predict (Ozili, 2023), other independent variables should be used to better explain the variation in ROE.

Appendix

All firms in EGX30 as of 2024

Abou Kir Fertilizers	EGS38191C010	ABUK.CA	Basic Resources
Alexandria Mineral Oils Company	EGS380P1C010	AMOC.CA	Basic Resources
Delta Sugar	EGS30201C015	SUGR.CA	Food, Beverages and Tobacco
Eastern Company	EGS37091C013	EAST.CA	Food, Beverages and Tobacco
Edita Food Industries	EGS305I1C011	EFID.CA	Food, Beverages and Tobacco
Egyptian International Pharmaceuticals	EGS38081C013	PHAR.CA	Healthcare and Pharmaceuticals
El Sewedy Electric	EGS3G0Z1C014	SWDY.CA	Industrial Goods, Services and Automobiles
Emaar Misr for Development	EGS673Y1C015	EMFD.CA	Real Estate
Ezz Steel	EGS3C251C013	ESRS.CA	Industrial, Construction and Materials
GB Auto	EGS673T1C012	GBCO.CA	Industrial Goods, Services and Automobiles
Ibnsina Pharma	EGS512O1C012	ISPH.CA	Healthcare and Pharmaceuticals
Juhayna Food Industries	EGS30901C010	JUFO.CA	Food, Beverages and Tobacco
Madinet Masr for Housing and Development	EGS65571C019	MASR.CA	Real Estate
Misr Fertilizers Production Co	EGS39061C014	MFPC.CA	Basic Resources
Orascom Development Egypt	EGS70321C012	ORHD.CA	Real Estate
Oriental Weavers	EGS33041C012	ORWE.CA	Textile and Durables
Palm Hills Development Company	EGS655L1C012	PHDC.CA	Real Estate
Sidi Kerir Petrochemicals	EGS380S1C017	SKPC.CA	Basic Resources
Telecom Egypt	EGS48031C016	ETEL.CA	IT, Media and Communication Services
TMG Holding	EGS691S1C011	TMGH.CA	Real Estate
Abu-Dhabi Islamic Bank (ADIB-Egypt)	EGS60111C019	ADIB.CA	Banking
Beltone Holding	EGS691G1C015	BTFH.CA	Non-bank Financial Services
Credit Agricole Egypt	EGS60041C018	CIEB.CA	Banking
EFG Holding	EGS69101C011	HRHO.CA	Non-bank Financial Services
E-finance for Digital and Financial Investments	EGS743O1C013	EFIH.CA	IT, Media and Communication Services
Fawry for Banking Technology and Electronic Payment	EGS745L1C014	FWRY.CA	Non-bank Financial Services

Qalaa for Financial Investments	EGS73541C012	CCAP.CA	Non-bank Financial Services
Raya Holding for Financial Investments	EGS690C1C010	RAYA.CA	Non-bank Financial Services
Non-financial firms with incomplete data			
Alexandria Containers and Goods	EGS42111C012	ALCN.CA	Shipping and Transportation Services Sector

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CBDC as an element of the fight against financial exclusion on the example of Nigeria

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Abstract

The article examines the potential of central bank digital currency (CBDC) as a policy tool to reduce financial exclusion, with particular reference to Nigeria's eNaira project. The study investigates whether implementing a CBDC can facilitate access to financial services and contribute to improving inclusion levels, especially in regions affected by persistent economic and technological disparities. Nigeria serves as a representative case due to its pioneering role among developing economies in introducing a national digital currency aimed at enhancing financial inclusion. The methodological framework is based on a critical literature review supported by both quantitative and qualitative evidence. The literature search covered 2018–2025 and included databases and sources such as Google Scholar, World Bank publications, central bank repositories, and peer-reviewed academic journals. The inclusion criteria encompassed studies addressing CBDC implementation, financial inclusion indicators, and digital infrastructure in Nigeria. The findings suggest that while CBDCs can enhance accessibility to financial services, their effectiveness depends on factors such as digital literacy, infrastructure quality, and public trust in digital financial systems. The case of the eNaira highlights both the opportunities and limitations of CBDC deployment in developing countries, offering valuable implications for policy design and financial innovation strategies.

Keywords

- CBDC
- eNaira
- financial exclusion
- Industry 4.0

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Introduction

New technologies are becoming more and more present in our lives. Lack of access to them, can hinder a country's economic development, as well as exacerbate social inequality and financial exclusion. Cellary (2019) points to the great importance of information in the modern economy and defines Economy 4.0 as including Industry 4.0 with collaborative smart factories, environments from many sectors such as energy, transport, healthcare and agriculture. An indispensable part of the modern economy is also the financial sector, which also needs to adapt technologically to the realities of Economy 4.0, and to find solutions to contemporary problems such as the financial exclusion of a significant number of people around the world. This is a serious problem, as this de facto phenomenon makes the daily lives of the financially excluded much more difficult, but also limits the potential profits of banks and financial sector companies due to the lack of deposits and revenues from the services offered to them. Therefore, the authors, through this article, will try to answer the following question: can a central bank digital currency (CBDC) be a solution to the problem of financial exclusion, especially in developing countries. As Warchlewska (2022, pp. 7–10) notes, the development of financial technology creates opportunities for facilitated and universal access to banking services. On the other hand, it may contribute to the technological and financial exclusion of groups that are less familiar with new technologies, such as the elderly, the poorly educated or people with disabilities[3]. The response of some central banks whose countries are facing the problem of financial exclusion is the implementation of CBDCs. These have been introduced by central banks in, among others: Nigeria, Jamaica and the Bahamas. It is currently being piloted in many countries, such as Russia, the People's Republic of China (PRC) India, Iran, Australia (Denecker et al., 2023).

The purpose of the central bank is, among other things, to fight inflation (maintaining stable prices), to reduce the risk of financial crisis (Kiedrowska & Marszałek, 2003). However, increasingly, there growing discussion about new tasks for central banks, which so far have not been part of the traditional central bank responsibilities. As Kliber (2022) notes, the goals of central banks are changing and evolving. The author points out that there are ongoing discussions about a different approach of the central bank to its policy (taking climate change into account), as well as about the use of CBDC to support climate policy.

In the context of the dynamic development of the banking sector and new technologies, the central bank can effectively combat financial exclusion. However, in the authors' opinion, CBDC may not be an appropriate tool for financial inclusion in areas characterised by low development of mobile communication technolo-

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[3] The issue of financial education that may contribute to financial inclusion of people with disabilities is analysed by, for example, Banaś (2024).

gies, underdeveloped economies and low levels of education. An illustrative example is Nigeria – a country where limited access to banking service and mobile internet (Ozili, 2023; Statista, 2022) would suggest significant challenges for digital financial inclusion through CBDC. Nevertheless, the Central Bank of Nigeria decided to launch a central bank digital currency despite these adverse conditions. In this article, we present statistical data on the socio-economic and technological environment in Nigeria and examine how these factors interact with CBDC adoption and the prospects for financial inclusion.

This study aims to evaluate the role of CBDC as a tool in reducing financial exclusion, with a specific focus on Nigeria. We assess whether the introduction of eNaira has led to measurable improvements in financial accessibility and inclusion. In academic discussions, CBDC is considered as an example of technology which is increasingly used as a tool for financial inclusion (Auer et al., 2020; Inder, 2024; Tan, 2024). The first part of this article outlines what the phenomenon of financial exclusion is. CBDC is then defined, and the characteristics and potential applications in the context of the financial inclusion process are demonstrated. This is followed by a discussion of the implications and reasons for the introduction of CBDC in Nigeria, and the opportunities it presents. The study area, its specifics and its key economic and social features are also described. The discussion concludes with an analysis of the findings and their implications for financial inclusion.

The methodological approach in this article is based on a case study of Nigeria, supplemented with a selective literature review. Instead of a systematic literature review, the study focuses on sources directly relevant to financial exclusion and the implementation of eNaira. Comparative analysis centres on changes in financial inclusion before and after the launch of eNaira, alongside evaluation of technological and infrastructural conditions that influence CBDC adoption in a developing country. Data sources include reports from the World Bank, Central Bank of Nigeria and EFInA (Enhancement of Financial Innovation and Access), which provide reliable measures of Nigeria's financial exclusion. The analysis compares financial inclusion rates before and after the introduction of eNaira – 45% in 2021 (launch year) and 52% in 2023 – while total financial inclusion (formal and informal channels) reached 74% (Demirgüç-Kunt et al., 2022; EFInA, 2023).

1. Financial exclusion – defining the concept

The issue of financial exclusion is directly linked to functioning in society and its economic consequences. It is possible to consider it on many levels and as an effect or cause of other types of exclusion, e.g. social exclusion (Warchlewska, 2020) or digital exclusion (Banaś, 2024).

The term financial exclusion was first defined by Leyshon and Thrift (1995) as processes that serve to limit access to the financial system for specific social groups. They also pointed out that it mainly affects people with limited income. In subsequent years, the perception of the problem has evolved to take into account changing circumstances. An example of an attempt at a new definition is presented in the 2008 EC report on financial exclusion (Leyshon & Thrift, 1995, p. 10). There, more attention was paid to the general population, and the focus was on problems in accessing or using financial services and the resulting impediments to the individual's functioning in society. Szopa and Szopa (2011), returning to the first definition of the concept, again pay more attention to the limitation of financial resources preventing the use of any services.

Due to the wide-ranging phenomenon and the lack of an unambiguous definition of this issue, new attempts to standardise the understanding of financial exclusion are still emerging. In reviewing the literature, it is important to point out that both the definition and assumptions relating to financial exclusion have evolved over time and continue to do so. These changes can be observed in Table 1, which presents selected definitions. For this reason, it currently seems impossible to adopt a single, irrefutable definition that addresses all aspects of such a complex problem. For the purposes of this article, the authors rely on the definition proposed by Warchlewska (2022), as financial exclusion was mainly considered to be an example of the lack of access, or impeded access, of the population to banking services in the broadest sense, particularly electronic and internet banking, which play an increasingly important role in modern society.

Table 1. Selected definitions of the term "Financial Exclusion"

Definition	Author and year of publication
Financial exclusion is the processes that serve to restrict access to the financial system for specific social groups. It most often affects groups with limited income.	Leyshon & Thrift, 1995
A process in which citizens experience problems in accessing and/or using financial products and services in the mainstream market that are appropriate to their needs and enable them to lead a normal life in society.	European Commission, 2008
Financial exclusion refers to the state of limitation or lack of financial resources available to the subjects, which does not allow them to make effective use of financial services, banking, insurance, business advice, legal services or even health, education, culture, prevents the activity of investing in the stock market, in investment funds or having a bank account.	Szopa & Szopa, 2011
The totality of difficulties faced by financial services actors in the sphere of their consumption, production and social cohesion is defined as financial exclusion.	Warchlewska, 2022

Source: own elaboration.

2. The dimension of financial exclusion

A broad look at this phenomenon allows us to see the complexity and heterogeneity of this problem. By treating financial exclusion as, on the one hand, a difficulty in accessing services and, on the other hand, as an inability to use the services and products offered, we can conclude that this problem is the result of the consequences of exclusion not only in this, but also in other areas (Warchlewska, 2022, pp. 18–19).

Problems of accessibility to financial products can have two substrates: demand and supply. The former is mainly the result of self-exclusion caused by the public's reluctance or distrust of the banking sector and, to a lesser extent, due to a lack of need for banking services (Solarz & Swacha-Lech, 2011). The supply-side substrate refers to the banking sector providing services, and we can decompose it into direct and indirect factors. The former consists in the accessibility not so much of the services but of the banking facilities themselves. This is a particularly significant problem in societies where there is a preponderance of older people, who are usually more reluctant to bank electronically (Mei, 2024; Msweli & Mawela, 2020; "You can't bank…", 2023). Direct factors consist of a bank denying a customer access to certain services, where the decision to do so is made on the basis of risk, customer profile and bank policy (Czarnecka, 2018).

Access to financial services is a fundamental prerequisite for effective financial inclusion and the widespread adoption of digital payment solutions. The physical presence of branches and payment service outlets remains important, especially for vulnerable groups and individuals less able to access or use digital channels. Monitoring trends in the availability of these physical points helps illustrate the challenges, as well as the progress, in adapting traditional banking infrastructure to the evolving financial landscape.

Physical financial infrastructure remains deeply important for financial inclusion strategies in developing economies. While advanced economies have reduced the number of bank outlets in favour of digital channels, developing economies like Nigeria still rely on physical branches and agents to reach excluded populations. Studies show that limited digital penetration and concentrated banking networks in urban areas create barriers, especially in rural Nigeria. The eNaira's distribution model relies on both central and commercial bank infrastructure – which remains insufficiently developed outside large cities (Central Bank of Nigeria, 2021; Demirgüç-Kunt et al., 2022).

According to the 2011–2021 data for the world, we can observe an average increase in the percentage of the population with accounts in financial institutions or their mobile equivalents of around 2.5% per year. The increase from 50.6% to 76.2% in account ownership among the global population over the age of 15 clear-

ly indicates a significant reduction in financial self-exclusion. More adults having access to an account – whether at a bank or through a mobile money provider – directly translates to increased opportunities for using financial services, saving securely, accessing credit and participating in the digital economy. This suggests that fewer people are left outside the formal financial system, and barriers such as lack of documentation, high costs or distance are being more widely overcome. It should be noted that in 2021, as many as 74% of these people have accounts with financial institutions. In contrast, only 10% have a mobile version (Demirgüç-Kunt et al., 2022, p. 2).

One can see a huge disparity in the use of mobile and traditional services. It is possible that this is a result of mobile services not being sufficiently disseminated to the general population. Also, the large proportion of people who prefer traditional solutions and do not intend to use mobile solutions as long as the ones they use are still operational may have a significant impact on this distribution.

3. CBDC – definition of the concept

The central bank digital currency (CBDC) concept was launched by the European Banking Authority in 2013. Due to the fact that it is a new form of money, work is ongoing all the time to implement the concept effectively for public use, and in some regions it is already being implemented. In May 2023, the digital currency was fully introduced by 11 countries (Atlantic Council, n.d.). These are mainly less developed countries, with the three largest being the Bahamas, Jamaica and Nigeria. However, it should be noted that research and pilot implementations of

Table 2. Selected CBDC definitions

Definition	Author and year of publication
A digital form of fiat money that is issued and regulated by a country's monetary authority.	European Parliament, 2019
A new form of money, issued in digital form by the central bank, to be used as legal tender.	Griffoli, 2018
A liability of the central bank, expressed in the prevailing unit of account, which serves as a medium of exchange and a means of holding value.	BIS, 2018
A liability denominated in an existing unit of account that serves as both a medium of exchange and a store of value and has no physical form.	Iwańczuk-Kaliska, 2018

Source: own elaboration.

CBDC are also underway in more developed economies, including China and India, where authorities treat the digital currency as a tool for upgrading payment infrastructure, digital innovation and – in certain cases – financial inclusion (Turrin, 2022). During the existence of the concept, researchers have repeatedly attempted to come up with the best possible definition (Table 2).

It can be argued that this is a new form of publicly available central bank money. It represents an innovation for entities that, in most functioning monetary systems, do not have access to reserves in accounts held by the central bank (BIS, 2018). At the same time, Iwańczuk-Kaliska (2018) points out that the initiation of CBDC research by banks has been triggered, among other things, by the growing importance and market value of cryptocurrencies, which, due to their lack of connection to any central bank, can create a kind of threat to the currently existing financial system.

4. CBDC – conception and possibilities

The CBDC is thus the digital equivalent of a country's currency, and the start of the conceptual work, as already mentioned, was due, among other things, to the empowerment of cryptocurrencies. Some models for implementing this instrument are currently being considered. Bech and Garrat (2017) proposed three main models for the implementation of CBDCs for public use:

– a model based on central bank accounts,
– a model based on token issuance for retail payments,
– a model based on token issuance for high-value payments.

The first model assumes universal acceptance of CBDCs and that the payer and the payee have accounts at the central bank. Payments would be initiated by users via terminals, apps or on a website, and then processed in real time by a closed system administered by the central bank (this would be done in a similar way to how payments are settled in terms of a single bank). Users' CBDC accounts would be credited by transfer from a payment account at a commercial bank. There would also be the possibility of reversing this process to settle debts with entities without a CBDC account. The incredible advantage of this model would be the ability to make payments without internet access. However, it should not be overlooked that these payments would have a certain amount or quantity limit, thus guaranteeing relative security (Bindseil, 2020; BIS, 2023). Should this model be introduced, the central bank would gain another instrument in conducting a more effective monetary policy, and the accounts themselves could earn interest directly at the central bank (Bindseil, 2020; Kiff et al., 2020). In addition, if the

underlying architecture of the solution (API) were made available, third parties would be able to expand the range of services and capabilities in the implementation of CBDC as a monetary measure (Auer & Böhme, 2020). In this case, the central bank would be limited to account management and monetary policy, and all additional functionality and payment solutions developed would be provided by others (Auer & Böhme, 2020; BIS, 2023).

The model for retail payments reduces the role of the central bank to the issuer of CBDC tokens as digital representatives of value. It would be the entity responsible for setting and implementing the standard and for keeping a record of the volume of token issuance (it could delegate these competences to another entity under its supervision). Issuance would be made by accepting funds deposited with the central bank and assigning the appropriate number of tokens to the holder's account. These, in turn, could be stored in a digital wallet (offline or online, accessible, for example, via apps). Payments would be made via an appropriate interface having access to the digital wallet and would be settled in real time. Authentication of transactions would take place using a private and public key, and funds would be transferred from the payer's account directly to the recipient's account stored in the decentralised register. On the other hand, commercial banks become the distributors following this assumption (NBP, 2021). It should also be noted that it would be possible to use tokens as an alternative to cash. This would be done using a local recording of the CBDC on a data carrier, for example: an app, a SIM card in a phone or some kind of payment card. Payments would be made via an adapted terminal or application of the payee. The settlement of payments within the specified security limits would not need to communicate with the system (they would be possible offline) and the funds would be transcribed from the payer's carrier to the payee's carrier. Such a solution would enable the issuing of virtually anonymous digital money operating on the same principles as current cash. Losing or becoming a victim of theft of the token carrier would be tantamount to losing access to the funds stored there without the possibility of recovering them. In the model described, the National Bank of Poland (NBP) states that it does not envisage any interest on the tokens and that data collection will be limited to the amount of CBDC issued as well as transactions made with it.

The last model assumes the implementation of CBDCs for high-value payments, international settlements or securities settlement. Additionally, what is also under consideration is the use of this model for cross-border payments. The main demands are:

– achieving a shorter time to credit the payee's account (in the case of securities, also assigning the corresponding ownership rights to the payer),
– reducing the costs associated with the maintenance and administration of the system.

The process of issuing CBDC tokens would be virtually identical to the previous model. Namely, in exchange for funds deposited in an account at the central bank by commercial banks, the latter would grant tokens and register them in the system. In view of the well-developed Real-Time Gross Settlement (RTGS) interbank settlement system, this model would not be applicable, as the potential benefits of implementing this solution would be marginal or non-existent. The implementation of this solution would only be beneficial for older, less efficient versions of RTGS systems, or as an alternative to National Electronic Funds Transfer (NEFT) systems, where there is a delay of approximately two hours in the execution of transactions. However, the model would find application in payment settlement and securities market transactions, where there would be a significant improvement in the time to settle payments and to recognise the instrument purchased (linked to immediate execution of the order). In the long term, it is also estimated that transaction and system costs would be reduced and the payment method itself would not change (NBP, 2021).

Just as Kliber (2022) points out, the CBDC implementation models presented for use will force central banks to make decisions. Introducing a model for high-value payments will be tantamount to introducing a new monetary order, shattering the current one put in place after Bretton Woods (Twarowska, 2014), and cutting individual customers out of the system, with potentially adverse consequences for both banks and consumers.

Dyson and Hodgson (2016) believe that CBDCs can counter financial exclusion by bringing into the financial system individuals and communities that it may not be profitable for conventional commercial banks to serve. This may be because, for example, the cost of acquiring such a customer is too high and the revenue generated from serving them is low. The central bank transcends one of its traditional functions of a so-called 'bank of banks' and takes on the role of a commercial bank, which is atypical for central banks. In sectors where, for various reasons, commercial banks are unwilling or unable to offer their services to potential customers. As an example of such a country, Dyson and Hodgson (2016) cite, among others, Ecuador, where citizens have the right to open an account with the country's central bank. It is also worth noting that it will only be possible to counter financial exclusion if digital exclusion does not occur or is reduced.

5. Nigeria – pioneer of CBDC implementation

Nigeria became a global pioneer by launching its own central bank digital currency, the eNaira, in October 2021. The introduction of the eNaira was motivated

by the need to promote financial inclusion, modernise the country's payment system, reduce costs and increase transparency in financial transactions. However, as Statista (2022) shows, in 2022, only 37.34% of Nigeria's population had mobile internet access (Figure 1), a critical requirement for using the eNaira wallet application. This illustrates both the ambitions and the significant practical limitations associated with deploying a CBDC in an environment with relatively low digital penetration.

According to Ozili's (2023) research, the states with the highest interest in the eNaira project were Yobe, Jigawa, Adamawa and Gombe (with the exception of Jigawa state, these are the states with GDP per capita below the median). Recent evidence demonstrates the persistence of elevated banking costs (Adeyinka et al., 2023). This shows that the Central Bank of Nigeria has not reached all states with potentially the highest proportion of financially excluded people. As Itah and Emmanuel's (2014) study shows, the margins of Nigerian commercial banks are relatively high compared to Western banks. Recent evidence demonstrates the persistence of elevated banking costs. In 2024, the five largest Nigerian banks (Zenith Bank, Access Bank, GTB, UBA and FCMB) generated net fees and commissions totalling approximately ₦1.2 trillion ($748.2 million), representing an 82% increase from 2023 (Orjiude-Ndibe, 2025). Electronic banking charges alone accounted for $147.3 million in 2024, up from $78.2 million in 2023, underscoring the substantial commission structure within Nigerian banks (Orjiude-Ndibe, 2025). Additionally, as of 2024, Nigerian banks charge account maintenance fees ranging
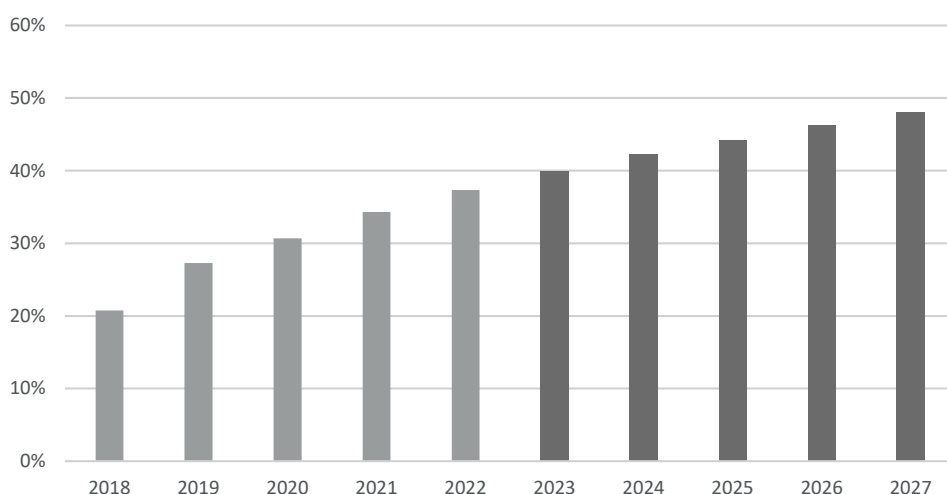

Figure 1. Percentage of mobile internet users in Nigeria

Note: grey – real data, dark grey – projected data.

Source: own elaboration based on data from: (Statista, 2022).

from ₦1 per mille of customer-induced debit transactions to fixed monthly fees of up to ₦2,500 for premium accounts, with card issuance and replacement fees reaching ₦1,075 per transaction (Stanbic IBTC Bank, 2024). Such cost structures cause many Nigerians to opt out of banking services, with the indigent, the most vulnerable to financial exclusion, being most affected.

To assess eNaira's impact on financial exclusion, it is essential to compare inclusion metrics before and after its launch. eNaira was officially introduced in September 2021. Before its launch, only 45% of adults had an account in a financial institution or with a mobile money provider (Demirgüç-Kunt et al., 2022). By 2023 – after over two years of operation – bank-based inclusion rose to 52%, formal inclusion reached 64%, and total inclusion (formal + informal) reached 74% (EFInA, 2023). While inclusion grew 7 percentage points, much of this increase reflects mobile service and informal channels – eNaira itself remained marginal at just 0.36% of circulating currency (Ojukwu, 2024).

In Nigeria, the percentage of adults (aged 15 and over) who owned an account at a financial institution or through a mobile money provider increased from less than 30% in 2011 to 45% in 2021, according to World Bank data (Klapper et al., 2022, pp. 2, 12, 99). Although this demonstrates a clear upward trend, progress has not been uniform, with growth rates fluctuating across the period. Despite these gains, Nigeria still lags behind the global average: in 2021, the global percentage of adults with an account was 76%, marking a 31 percentage point gap (Table 3).

However, when comparing Nigeria to other countries at a similar stage of economic development – specifically, those with a gross national income per capita between $1,046 and $4,095 – the divergence is less pronounced. In 2021, this group's average was 62%, meaning Nigeria trailed by 17 percentage points. For additional perspective, the average across low and middle-income countries was 57%. Table 3 below summarises these figures.

Table 3. Percentage of adults (15+) with an account at a financial institution or through a mobile money provider in Nigeria, selected country groups and the world

Region/country	2011 (% adults with account)	2021 (% adults with account)	Global average 2021 (%)	Deviation from global average (pp)
Nigeria	< 30	45	76	−31
Low & middle-income group	~31	57	76	−19
Countries with GNI per capita $1046–$4095	~28	62	76	−14
World	51	76	76	0

Source: based on: (Demirgüç-Kunt et al., 2022, pp. 2, 12, 99).

In Nigeria, the eNaira wallet app had more than half a million downloads in the Google Play shop (as of 1/05/2023), with a Nigerian population of 213.4 million. Indeed, eNaira is a tool for fast payments without consumers having to pay commissions (Abiodun, 2023). In November 2022, the Central Bank of Nigeria celebrated 700,000 payments through eNaira with a volume of about $17.4 million. According to news articles, this may be due to the fact that the Central Bank of Nigeria has chosen not to partner with commercial entities, practically making eNaira not solve the problems the project was intended to solve. The project currently does not introduce new solutions that commercial banks could not offer, for whom this introduction of CBDC could be highly disadvantageous as it takes commissions away from commercial banks on payments through electronic banking as a mode of payment. Indeed, eNaira is a tool for fast payments without consumers having to pay commissions.

Nevertheless, eNaira has been successively, albeit rather slowly, making an increase in recorded payments and users. This may suggest that financially excluded individuals are either not sufficiently informed about the availability of the CBDC, unable to use it because they cannot meet the requirements of the CBDC wallet application, or that financial exclusion in Nigeria stems from factors beyond limited access to formal banking services. Mobile financial services are highly developed in Africa, particularly in Sub-Saharan African countries, where millions of adults use mobile money accounts and, in numerous markets, it is possible to open a financial account entirely via a smartphone app (Demirgüç-Kunt et al., 2022; GSMA, 2023).

Recent studies highlight a significant gap between eNaira's ambitious goals and actual adoption. By March 2024, total eNaira in circulation was only ₦13.98 billion, accounting for just 0.36% of all circulating currency (Ojukwu, 2024). With Nigeria's population at 213.4 million, the number of active eNaira users was about 700,000 – just 1.3% out of ~55 million financial accounts (Usman et al., 2025). Comparable challenges occurred with Jamaica's JAM-DEX and the Bahamian Sand Dollar: in both cases, usage has been minor versus conventional cash, with most transactions tied to government transfers instead of organic consumer demand (Anthony, 2025).

Discussion and conclusions

Our findings suggest that while CBDC can address some aspects of financial exclusion – such as accessibility and transaction costs – its impact is significantly constrained by digital infrastructure limitations. The analysis suggests that digital exclusion is one of the major obstacles limiting financial inclusion in Nigeria;

however, the limited reach and diversity of formal financial services offered by the banking sector may also significantly contribute to this issue. This limitation is visible in infrastructure gaps and service diversity. World Bank Findex data show that, while globally 76% of adults held an account in 2021, only 45% did so in Nigeria – reflecting limited service outreach especially beyond urban centres (Demirgüç-Kunt et al., 2022). EFInA's 2023 survey reports financial exclusion rates above the national average in northern regions, such as Borno State (75% exclusion), where banking infrastructure is particularly sparse (EFInA, 2023).

In the authors' opinion, a solution to this problem could be introducing a token-based CBDC rather than the current account-based CBDC in Nigeria. However, this is an unlikely solution as it would require the development of a new CBDC system, which would be both time-consuming and costly. The first step toward reducing financial exclusion in Nigeria should therefore be not the introduction of a CBDC, but the expansion of mobile telephony and mobile internet infrastructure. CBDC does not seem to solve the problem of financial exclusion in Nigeria, as it is directly caused not by the lack of accessibility to banking services, but by the lack of access to mobile connectivity, which results in the inability to use the e-banking services of Nigerian commercial banks. The CBDC could therefore be effective in combating financial exclusion, provided digital inclusion is carried out in Nigeria, allowing Nigerians to enjoy the benefits of the Internet.

On the other hand, in the event of reducing digital exclusion, Nigerians would likely have access to financial services from outside Nigeria, offered by foreign banks and fintechs. This would increase competition in the Nigerian financial market and force Nigerian banks to lower their existing margins. Net interest margins for major Nigerian banks have remained high, averaging 10–12% in 2024, compared to 3–5% in developed economies. Fidelity Bank, for example, raised its net interest margin from 8.1% (2023) to 12.0% (2024), benefiting from elevated interest spreads (Fidelity Bank, 2025). The Central Bank of Nigeria's policy rate reached 27.50% in November 2024 before dropping slightly to 27% in September 2025 ("Nigeria interest...", n.d.).

Another option would be to introduce top-down regulation to force a reduction in bank rates, or to introduce EU-like solutions similar to the Basic Payment Account offered in the EU. The role of the CBDC as a tool for financial inclusion therefore seems superfluous. The introduction of CBDC may both reduce costs for consumers by introducing real competition in the payment services market, but paradoxically it may also increase the prices of other banking services. Commercial banks may then reduce the cost of credit transfers and basic banking services, as competition from the central bank will somehow force them to do so. This is likely to increase the prices of services not offered by the central bank, such as loans. A factor in favour of such a scenario is the willingness of commercial banks to compensate not only for lost profits from intermediation of transactions, but also for lost bank deposits to the Central Bank of Nigeria.

Those affected by financial exclusion may not be aware of the specific ways in which they could benefit from using eNaira for payments. The project seems to ignore the fact that a large proportion of the financially excluded are people who are excluded not by their own choice (known as self-exclusion), but because they lack the knowledge or resources to be able to use the technology.

Thus, the introduction of CBDCs does not appear to have had much impact on the eradication of financial exclusion in Nigeria. However, this is a relatively young project and further conclusions will only be possible in about 2–3 years. At present, it is difficult to say whether eNaira is a failed project or whether it is going through the initial difficulties characteristic of any innovative project. This uncertainty is well illustrated by the concept of the product life cycle, which highlights that new products and technologies typically begin with an introductory phase marked by low adoption, limited public awareness, technical and operational challenges, as well as a need for ongoing user education. The issues currently observed with eNaira, such as slow uptake, technological barriers and scepticism among users, are common in the early stages of many innovative financial products, especially in environments facing infrastructural and educational challenges. Therefore, these initial struggles do not necessarily signal failure, but may rather be an inherent part of the adoption and development process. The long-term outcome for eNaira will depend on how effectively these challenges are addressed and whether the project can successfully transition into the next phases of growth and broader acceptance. In the context of Nigeria, the eNaira and the CBDC initiative overall are primarily intended to complement, rather than substitute, the existing banking system. The architecture adopted by the Central Bank of Nigeria follows a two-tier model in which the central bank issues the digital currency, but private banks and financial institutions are responsible for customer relationships and the provision of related services. This approach aims to enrich and modernise the payments ecosystem by adding a digital alternative to cash, as well as supporting everyday transactions and remittances, rather than replacing traditional bank accounts or banking services. The growing cooperation between the central bank and private sector entities can broaden the range of available digital services, but this expansion will mostly benefit people who are already integrated into the digital financial system. For the moment, technological and educational barriers prevent the eNaira from significantly reaching or replacing solutions for the digitally excluded. In 2022, only 37.34% of Nigerians had mobile internet access, restricting eNaira's reach (Statista, 2022). EFInA's 2023 data indicate that financial inclusion rates are 68% among adults with formal education, but only 16% without. Adoption studies stress that social influence, awareness, and perceived usefulness are crucial factors, with information on eNaira limited outside major cities (Ozili, 2023).

In the absence of the technical background required by CBDC, it is not capable of eradicating financial exclusion. It is worth noting that this is a relatively new

economic concept that is very flexible and adaptable to local realities. In the case of Nigeria, the potential of CBDC has not been fully realised. The people to whom CBDC was mainly targeted are probably not aware of its existence at all, or even if they are aware of it, they have no opportunity to take advantage of it, as the cited data on digital exclusion indicate.

Using Nigeria as an example, it is not possible to make a clear judgment on the role of CBDCs in combating digital exclusion. On the one hand, it does not appear from the cited data that CBDC has received much attention in Nigeria. On the other hand, it may not be the fault of CBDC per se, but of inadequate promotion, the inadequacy of this tool to the realities of Nigeria, digital exclusion or lack of knowledge about how to use eNaira. It is important to ask whether, if the problems by which CBDC has currently failed in Nigeria are addressed, commercial solutions would succeed. In the authors' view, this is possible, which calls into question the idea of using CBDC to combat financial exclusion. It is certainly a cost-effective solution for the state, as it reduces, or in the case of complete substitution, eliminates the costs associated with the production of new banknotes and coins. According to Dyson and Hodgson (2016, pp. 1–2), the benefit of issuing CBDCs can be maintaining mint annuity income while reducing cash issuance. Thus, from a state budget perspective, it is a worthwhile solution that could generate additional revenue and reduce state budget losses. Moreover, such a transformation of money circulation may bring tangible benefits, as a complete shift to electronic forms of payment in a country has the potential to generate annual savings approaching 1% of GDP (Humphrey et al., 2003). However, it appears that the CBDC project is premature at this stage of Nigeria's development, and that the money spent on its development and implementation would yield better results both economically and socially when spent on combating the digital exclusion.

CBDC is not a one-size-fits-all concept and developed countries have different objectives and applications for it than developing countries. Developed countries, in addition to the use of CBDCs within their own countries, hope to expand this means of payment to developing countries and derive economic benefits from it. Developing countries, on the other hand, see it as a panacea for the economic problems they face. Unlike the digital currency projects of the central banks of developed countries, eNaira is in current use. The highest stage of CBDC development in the developed countries is currently piloting; countries such as Nigeria and Jamaica are in the vanguard here. This raises the question of whether a developing country with less economic and scientific potential can create such a tool faster than countries and communities much more advanced, like the United States, China or the European Union.

Experience from other developing economies provides crucial context. Jamaica's JAM-DEX, launched in July 2022, suffered minimal uptake beyond government transfer programs. Initial transaction volume came mainly from government em-

ployment program payments, not consumer-driven demand (Anthony, 2025). Similarly, The Bahamas' Sand Dollar, launched in October 2020, has had little organic use, with government promotions and giveaways driving most activity. These cases suggest that adoption challenges – low awareness, poor infrastructure, competition from other digital methods – reflect broader innovation obstacles and are not unique to Nigeria's CBDC.

In the future, according to the Copernicus-Gresham law inferior money drives out superior money (Investopedia, 2025), CBDC may be the dominant form of payment. It is an easy to use, convenient and secure form. The state, as the dominant entity, can top-down impose its use, which commercial banks cannot afford to do. Such a scenario is likely, as a lot of resources have already been invested in the Nigerian eNaira project. Nigeria will probably want to develop the concept in the future, especially as the project is already being developed, including the Central Bank of Nigeria entering into partnerships with commercial entities, the lack of which has been criticised in the press.

Our analysis indicates that CBDC, in its current form, has not significantly contributed to reducing financial exclusion in Nigeria. While some positive effects, such as improved access to digital financial services and lower transaction costs, can be observed, the overall impact has so far been limited, particularly among rural and unbanked populations, due to barriers like insufficient digital infrastructure and low levels of digital literacy. Future research should therefore explore whether infrastructure improvements and targeted financial education initiatives could enhance the effectiveness of the eNaira in reaching the unbanked population. It would also be valuable to extend comparative research to other countries that have implemented or piloted retail CBDCs, such as Jamaica and the Bahamas, to assess whether similar patterns and challenges are observed in other developing economies. Additionally, analyses of more advanced economies – for example, China, where mobile internet access is far more widespread – could provide insights into whether greater technological readiness translates into broader CBDC adoption and more substantial progress in financial inclusion. Such comparative studies would deepen our understanding of the contextual factors shaping the effectiveness of CBDCs as tools for reducing financial exclusion.

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Informal earnings and domestic production – the size of the shadow economy of the household: Case of Turkey

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Abstract

We performed our calculations to find out the value of domestic production and the size of the informal economy of the households. The dataset used in this estimation was obtained by matching the Turkey Time Use Survey of 2006 with the Household Budget Survey for the years 2007–2011. Informal earnings were measured using household budgetary declarations and the concept of full income (including monetary values of time use on non-market activities). In our analysis, we use terms of extended incomes (i.e. monetary incomes with the informal earnings of households) and extended full incomes (i.e. monetary incomes and monetary time values including informal earnings). An important finding is that higher domestic production reduces the size of the informal economy among the self-employed, yet it has the opposite effect for wage earners. The average estimation of

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the size of the informal economy in Turkey decreased on average from 73.59% to 70.89% of GDP respectively for monetary and full expenditure for the years 2007–2011. Further, deeper analysis is needed to analyse income inequality among wage earners and self-employed workers participating in informal activities.

Introduction

It is crucial for governments to be specific in their policies and programmatic interventions in order to avoid any undesired economic and social costs arising from poverty and informal markets. Some researchers have examined the effect of time allocation decisions (as a substitution between working in informal and domestic activities) on income inequality. A reasonable hypothesis is that the monetary value of time spent on domestic activities is highly correlated with the socioeconomic characters of the households. The unit monetary value of time spent (i.e. the opportunity cost of time) varies depending on elastic market structures, family types, professional activities, etc. Aktuna-Gunes et al. (2014) demonstrate that participation in informal activity at the micro-decision level necessitates integrating the conditions of shortage relating to the resources used in domestic production. Especially for developing economies, insufficient monetary incomes along with lower opportunity costs of time for households result in an increase in the rate of participation in informal activities to obtain the necessary goods and services. As a complementary study, Aktuna-Gunes et al. (2017) investigated the behaviour of households through price, time use and income elasticities. According to their findings, time-cost elasticities are shown to be larger in absolute value than their monetary price counterparts. While for income effects, the time-resource elasticities are lower in absolute value than the monetary income ones. These results show a large difference in the substitution effect between time and money among households participating or not participating in informal activities.

As far as the organisation of this article is concerned, we first get cross-sectional data by matching the classic Household Budget and Time Use surveys for Turkey for the years 2007–2011. Secondly, we use cross-sectional data within a complete demand system framework but estimated on full prices and full expenditures (i.e. monetary expenditures plus the monetary time values of domestic activities). Next, we measure the size of informal earning of both the self-employed and wage earner population.

The remainder of the paper proceeds as follows: Section 1 presents the full price concept and the theoretical model of the complete demand system in the context of the under-reporting of income from various sources with the model of full prices. Section 2 derives the econometric specification of the complete demand model. Section 3 introduces the combined datasets of the Household Budget and Time Use surveys used in the estimations with a short description of the matching procedure in Section 4. Section 5 reports the empirical results, and the last part concludes the paper[5].

1. Domestic production

Full price values and estimations of the size of the informal economy are computations that are both necessary to obtain the full incomes of households. Briefly speaking, the full price approach is used to define the cost of the final goods produced in domestic production. This is a new method used to estimate the opportunity cost of time (OCT) and price elasticities at the micro level (see Aktuna-Gunes et al., 2017; Gardes, 2019). The methodology that was mainly used so far assumed that OCT is equal to the market wage rate for a person working in a given profession, or for people with irregular work – "reservation wage" – the minimum wage for which one is willing to work (Cornet et al., 2022; Hecman, 2015; Jara-Díaz et al., 2008). We suppose that full prices (as the cost of final goods production) also play a role in participation decisions regarding informal activities.

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[5] An earlier working-paper version of this research, which focused primarily on income inequality, was presented by O. Gunes (2017) at the 18th Annual Meeting of the Association for Public Economic Theory (APET), held at Université Paris-Panthéon-Assas in Paris, France, on July 10–13, 2017. In the current version of the paper, the section on income inequality has been completely removed, resulting in a more coherent article. Neither this version nor any earlier versions of the paper have been published previously.

1.1. The full price concept

The full price approach is explained in Aktuna-Gunes et al. (2017). Becker (1965) considers a set of final goods, Z_i for $i = 1$ to m, whose quantities enter the direct utility function of the consumer $u(Z_1, Z_2, \ldots , Z_m)$. In order to simplify the analysis, Becker states that a separate activity i produces the final good i in quantity Z_i using a unique market good in quantity x_i and unit time t_i per unit of activity i. Finally, the time to produce activity i is supposed to be proportional to the quantity of the market factor: $t_i = \tau_i x_i$[6]. Thus, the final goods are produced by a set of domestic production functions f_i: $Z_i = f_i(x_i, \tau_i; W)$; with all other (socio-economic) characteristics of the household in the vector W. This assumption allows Becker to create the consumer theory: Max $u(Z_1, Z_2, \ldots , Z_m)$ such that $Z_i = f_i(x_i, \tau_i; W)$, $\Sigma_i p_i x_i = y$ and $\Sigma_i \tau_i x_i + t_w = T$, with $y = wt_w + V$ being monetary income which incorporates labour and other incomes, t_w the labour time on the market and T the total disposable time for one period. In the case of multiple market goods used in activity i, a generalisation for the bundle of market goods used to produce the activity can be performed by defining the aggregate commodities of these market goods for i: the monetary price p_i can be defined as a price index for the bundle of corresponding goods coherent with the monetary budget constraint.

The sum of these three constraints gives the full budget constraint, which depends on full income y^f, defined as the maximum monetary income which could be earned if all available time T were supplied to the market at the net wage rate w: $y^f = wT$. The full price for each final good i expressed as $p_i x_i + \omega t_i$, where ω represents the opportunity cost of time, which can eventually be taken as the agent's market wage rate. If the agent's opportunity cost ω differs from the net wage, the full budget constraint is written as:

$$\sum_i (p_i x_i + \omega t_i) = y^f + (\omega - w)(T - t_w) = y^f + (\omega - w)\sum_i \tau_i x_i \qquad (1)$$

In this case, the full income is corrected by means of a function of the domestic production time which represents the difference between the market and the personal valuation of that time – the agent substrates from their full income the transaction cost between their leisure and market labour opportunity cost of time (this correction applies whence the market labour supply t_w is predetermined, which defines the monetary income).

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[6] For a description of complementarity between market goods and time use in domestic production see Table A1 in the Appendix.

$$\pi_{ih} = \frac{(p_{it} + \omega_{ht}\tau_{ht})x_{ih}}{p_i x_{ih}} = \frac{p_{it} + \omega_{ht}\tau_{ht}}{p_i} = 1 + \frac{\omega_{ht}\tau_{ht}}{p_i} = \frac{1}{p_i}p_{ih}^f \qquad (2)$$

Under the assumption of a common monetary price p_i for all households in a survey during the same period, this ratio contains all the information on the differences of full prices between households derived from their opportunity cost of time ω_h and the coefficient of production τ_{ih}. If the monetary price changes between households or periods, the full price can be computed as the product of this proxy π_{ih} with p_{ih}: $p_{ih}^f = p_{iht}\pi_{ih}$. With these definitions, it is possible to measure the full prices, observing only monetary and full expenditures by Equation (1). The market wage net of taxes has been used to calibrate the opportunity cost of time (for a discussion on this subject, see, for example, Gardes & Starzec, 2015).

1.2. Informal production

The lack of reliable direct statistics on the informal economy requires both a specific methodological solution and appropriate databases to indirectly evaluate the size of unreported incomes. The most frequently used methods are based on a macroeconomic approach, very often giving disparate evaluations (Schneider & Enste, 2000)[7]. The background of these various macroeconomic methods is frequently discussed and criticised. For instance, Thomas (1999) points out that they are not based on any theory.

In our study, we use the complete demand system approach developed by Lyssiotou et al. (2004) (see also Aktuna-Gunes et al., 2014; Fortin et al., 2009), for an estimation of the size of the shadow economy in Turkey. The model will be estimated on individual cross-section household data covering the period 2007–2011. The basic idea of this approach is to estimate the individual Engel curves and compare the observed expenditures and income. Underreported income is described as the difference between the level of reported income and its theoretical level

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[7] The large differences between the estimates are essentially due to the method used. These differences prevent policy makers from evaluating the gravity of the problem so as to adopt appropriate policies. This is also the case in Turkey. Many methods have been used in the past such as the money demand method by Ögunç and Yılmaz (2000) as well as by Cetintas and Vergil (2003), the tax collection method by Ilgın (2002), the electricity usage method by Us (2004), and the Dynamic Multiple Indicators Multiple Causes Method (DYMIMIC) by Schneider and Savaşan (2007), which creates a discussion about the reliability of the estimated size of the Turkish informal sector (see Ülgen & Öztürk, 2006). Indeed, these studies give very different estimations of the informal economy in Turkey, from 3.61% (Temel et al., 1994) to 139% (Akalin & Kesikoğlu, 2007), depending on the method used for relatively recent and comparable periods.

corresponding to the observed expenditures which are supposed to be exactly as reported. We propose a complete demand system approach for the estimation of the under-reported part of incomes both for self-employed and wage-earners[8]. This approach allows us to identify more accurate coefficients for under-reporting due to self-employed incomes and to wages by assuming that the consumption of each good, related to its marginal propensity of consumption, is the same as in the case of the revenue actually observed. Thus, it is possible to compute the size of the black economy on the basis of the information regarding the relative amount of self-employment and wage incomes in GDP. In this model, we compare all goods, services and full incomes with the full price values proposed by Alpman and Gardes (2016) (see also Aktuna-Gunes et al., 2017) in a quadratic demand system in order to better identify the influences of domestic activities on informal earnings. "Full" values are obtained by integrating monetary time use values in income and in price.

A widely accepted approach for quantifying the extent of underreported income among the self-employed is the method introduced by Pissarides and Weber. In their seminal study, Pissarides and Weber (1989) were the first to provide an empirical estimate of concealed income in this population. Their framework rests on two key assumptions: (i) household food expenditure is accurately reported in survey data, and (ii) wage and salary workers disclose their earnings fully. Using these premises, the authors inferred the magnitude of unreported income by comparing discrepancies between reported income and food expenditure across households headed by employees and the self-employed. This methodology has since been refined and applied extensively in subsequent research examining informal income or tax evasion.

The study by Pissarides and Weber focused on household expenditure on food. A similar approach, examining food expenditure shares among the self-employed and wage employees, was presented, among others, by Kim et al. (2009). In turn, the works of Lyssiotou et al. (2004) and Fortin et al. (2009) introduced the AIDS model (including its quadratic extension, QAIDS) for modelling expenditure shares across various goods. The approach proposed by Lyssiotou et al. (2004) initially attracted criticism regarding the plausibility of the Engel curve assumptions employed in the model-building procedure. An example of such critique is Tedds (2010), who, while also drawing on the Pissarides-Weber framework, proposed nonparametric estimation methods. However, advances in numerical techniques have led to a growing body of research building on ideas similar to those of Lyssiotou et al. (2004). More recent contributions include Aktuna-Gunes et

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[8] According to research conducted by the Republic of Turkey Social Security Institution in 2011, 75% of wage-earners declared a minimum wage lower than their real wage-rate. Undeclared wage earners represent 45.63% of total wage earners.

al. (2014), Cabral et al. (2018, 2019). In Cabral et al. (2018), the authors applied a demand system to two categories of expenditure (food and durable goods), whereas Cabral et al. (2019) extended the analysis to a broader set of expenditure categories. The previously cited study by Kim et al. (2009) was recalculated using more recent data and subsequently published as Kim et al. (2017). This demonstrates the substantial potential of this approach for estimating the scale of the black economy.

Following Lyssiotou et al. (2004), Fortin et al. (2009) and Aktuna-Gunes et al. (2014), we consider households with separable preferences in durable and nondurable goods represented by a cost function: $C(p, U) = F(c(p, U), d(r, U), U)$, where p, r and U correspond to the price vector of nondurable and durable goods, and to the household utility level. The $c(.)$ and $d(.)$ functions represent aggregate price indexes for nondurable and durable goods, respectively. In other words, they are the sub-cost functions which reflect the prices of unit costs paid by households for each type of good. Each of these functions increases in U and is linearly homogeneous in price. This structure implies that household consumption decisions can be decomposed into two-stage budgeting.

1. The household begins with allocating its total revenue Y^* to the expenditure of durable and nondurable goods according to the cost minimising rule (with the help of $c(.)$ and $d(.)$).

    For example, demand for the ith good in the nondurable group is defined as:

$$q_i = \frac{\partial F(.)}{\partial c(.)} \cdot \frac{\partial c(.)}{\partial p_i} \tag{3}$$

    Therefore, we can aggregate the demand of q_i to obtain the household total expenditure of nondurable goods by using Shephard's lemma and the first-degree homogeneity property on p of the $c(.)$ function.

$$y = \sum_i p_i q_i = \frac{\partial F(.)}{\partial c(.)} \sum_i p_i \frac{\partial c(.)}{\partial p_i} = \frac{\partial F(.)}{\partial c(.)} c(.) \tag{4}$$

2. In the second step, the household chooses the part of the expenditure for each good which belongs to a given group (durable, nondurable) within the total expenditure of each group according to the price vector of this group and to the total utility level.

    More precisely, the share of nondurable expenditures w_i within the total expenditure (y) is given by:

$$w_i = \frac{p_i q_i}{y} = \frac{p_i \dfrac{\partial F(.)}{\partial c(.)} \cdot \dfrac{\partial c(.)}{\partial p_i}}{\dfrac{\partial F(.)}{\partial c(.)} c(.)} = \frac{p_i \dfrac{\partial c(.)}{\partial p_i}}{c(.)} = \frac{p_i}{c(.)} \cdot \frac{\partial c(.)}{\partial p_i} = \frac{\partial \ln c(.)}{\partial \ln p_i} \qquad (5)$$

Following Banks et al. (1997), $c(.)$ and $d(.)$ are specified as Pig-log cost functions, and Equation (5) can thus be written as a Quadratic Almost Ideal Demand System (see Section 2).

2. Complete demand system estimation using full prices

It can be assumed that the unit cost of goods has the following quadratic logarithmic form (Lewbel, 1990):

$$\ln c(p, U) = a(p) + b(p) \left[\frac{U}{1 - g(p)U} \right] \qquad (6)$$

where $a(p)$, $b(p)$ and $g(p)$ are some functions homogeneous in p. Hicksian shares are budget shares:

$$w_i = a(p) + b(p) \left[\frac{U}{1 - g(p)U} \right] + \lambda_i(p) \left[\frac{U}{1 - g(p)U} \right]^2 \qquad (7)$$

where $a_i(p) = \partial \ln a(p)/\partial \ln p_i$, $b_i(p) = \partial \ln b(p)/\partial \ln p_i$ and $\lambda_i(p) = b_i(p)\partial \ln g(p)/\partial \ln p_i$, and U is the households utility level. In order to calculate the budget share within the system of Engel Curves, the base period prices can be assumed to be equal to 1, such as $p = r = 1$, by introducing the h subscript which denotes the individual households:

$$w_{ih} = \alpha_i + \beta_i \left[\ln Y_h^* \right] + \delta_i \left[\ln Y_h^* \right]^2 \qquad (8)$$

where Y^* is the total (true) income and using Equation (7), $U/(1 - g_0 U) = (\ln Y^* - a_0)/b_0$, where a_0, b_0 with g_0 are the values corresponding functions at $p_i = r_i = 1$. The parameters are α, β, δ. This equation represents the quadratic Engel curve derived from the Pig-log cost function.

We assume in our model that Y^* is separated into three sources denoted a, s, r, which respectively correspond to other income sources, wages and self-employ-

ment income. Thus, the total reported (true) income is supposed to be a weighted sum of these three sources.

$$Y_h^\star = \sum_{m=a,s,r} \theta_m Y_{mh} \qquad (9)$$

This equation implies that the true income must be equal to the sum of the observed incomes (Y_a, Y_s, Y_r) multiplied by their corresponding factors (θ_a, θ_s, θ_r), where we suppose θ_r, $\theta_s \geq 1$ (i.e. underreporting) and $\theta_a = 1$ (correct observation of the other incomes). It allows us to calculate the size of the underground economy and the saving tendencies with respect to the underreporting part of declared incomes by an estimation of θ_r and θ_s.

Finally, the sum of each source of income can be determined as a ratio of the reported total income: $y_m = Y_m/Y$, where Y is the sum of the other sources such as fees, government transfers, etc., as well as wages and self-employment incomes. Following the model proposed by Aktuna-Gunes et al. (2014, based on Banks et al., 1997), we consider all goods and services with full price values in a quadratic demand system:

$$w_{ih} = \alpha_i + \sum_j \alpha_{ij} Z_{jh} + \beta_{1i} \left[\ln Y_h + \ln\left(\sum_{m=a,s,r} \theta_m y_m \right) \right] +$$

$$+ \beta_{2i} \left[\ln Y_h + \ln\left(\sum_{m=a,s,r} \theta_m y_m \right) \right]^2 + \sum_j \gamma_{ij} \log \pi_{jh} + e_{ih} \qquad (10)$$

where w, π, Z, represent respectively budget share, full prices and the household characteristics vector (which allows us to take into account the heterogeneity of preferences), and y_m the tree components of income. We cannot expect individuals from different social groups to have the same reaction in terms of consumption and saving choices with respect to different types of incomes especially when there is uncertainty about these revenues.

3. Micro data, matching statistics

We use two household surveys from the Turkish Statistical Institute (TURKSTAT): the 2006 Time Use Survey (TUS) and the Household Budget Survey (HBS) covering the years 2007–2011. The HBS was conducted with 720 households each month, totalling 8,640 households per year. Three basic groups of variables were obtained from these surveys: 1) variables of the socio-economic status of the households,

such as the status of the property or house, living in a village or rural area, etc., 2) variables related to the individuals (age, gender, academic background), and 3) consumption expenditure variables (food and non-alcoholic beverages, alcoholic beverages along with cigarettes and tobacco, clothing, health, transportation, education services, etc.). In the 2006 TUS, approximately 390 households were selected each month giving a total of 5,070 households during the whole year. Within these households, 11,815 members aged 15 and over were interviewed and asked to complete two diaries – one for a weekday and one for a weekend day – in which they recorded all their activities over a 24-hour period in ten-minute intervals. The 2006 Time Use Survey is matched independently with the Household Budget Survey in terms of monetary and time expenditure data. In this application, we do not take into account the possible spatial autocorrelation within regions.

We combine the monetary and time expenditures into a unique consumption activity at the individual level. We proceed with the matching of these surveys by using similar exogenous characteristics in both datasets, such as age, household size (based on OECD equivalence scales), the share of children, marital status, home ownership, number of household members and geographical location, applied separately for household heads and women. The selection equation focuses on households that report a positive time use in terms of their activities. More precisely, we estimate 8 categories of time use in the TUS which are also compatible with the data available from the HBS, defined as follows:

1. Food Time (TUS) – Food Expenditures (HBS);
2. Personal Care and Health Time (TUS) – Personal Care and Health Expenditures (HBS);
3. Housing Time (TUS) – Dwelling Expenditures (HBS);
4. Clothing Time (TUS) – Clothing Expenditures (HBS);
5. Education Time (TUS) – Education Expenditures (HBS);
6. Transport Time (TUS) – Transport Expenditures (HBS);
7. Leisure Time (TUS) – Leisure Expenditures (HBS);
8. Other Time (TUS) – Other Expenditures (HBS).

Food Time includes household and family care activities related to food preparation and management. Personal Care Time covers personal care, commercial-managerial-personal services, and caring for a sick or elderly household member. Housing Time corresponds to household and family care activities such as home maintenance, gardening, pet and animal care, construction or repair work, and tasks related to managing the household. Clothing Time consists of washing clothes and ironing clothes. Education Time includes study-related activities (education) and childcare. Transport Time consists of travel and periods of unspecified time use. Leisure Time encompasses voluntary work and meetings, social and entertainment activities, cultural events, rest and holidays, sports and physical exer-

cise, including hunting, fishing, etc., along with hobbies, games and mass-media consumption such as reading, watching television or listening to radio and music. Other Time includes time spent in employment and in searching for work.

4. Matching procedure

The high level of domestic production in developing countries[9] increases the possibility of substitution between formal and informal incomes via, among other things, domestic activities. In this respect, in the estimation, we combined the Household Budget Surveys for the years from 2007 to 2011 with the Time Use Survey for 2006.

However, time use surveys are often conducted only periodically and the variables available for imputation are not the same between surveys. It is rare to find datasets with both budget and time use data. The most common approach is to impute the value of household production income to individuals in the budget dataset. First, the time spent in household production is predicted from the time-use data in a regression framework using covariates that are common to both datasets. The predicted values are converted to the same time period as the income variables and then merged into the income dataset using a set of common variables.

In this study, we use Rubin's (1986) matching approach, which is considered to be distinct from almost all other work on this topic (Moriarity & Scheuren, 2003). The matching procedure proposed by Rubin allows us to overcome two major problems relating to traditional matching methods. When imputing the monetary expenditure allocated to activity i, denoted x_i, into the time use survey, traditional procedures use the regression coefficients of x_i for the whole dataset (where Z is a set of variables such as age and education common to both datasets). Traditional procedures assume that monetary and time expenditures t_i allocated to activity i are conditionally independent given Z, disregarding as a consequence, the possible substitution between monetary and time inputs. Rubin (1986) showed that this assumption may considerably bias the regression coefficients. Rubin's concatenation methodology allows the regression coefficients of x_i on $(1, Z, t_i)$ and t_i on $(1, Z, x_i)$ to be obtained by assuming a partial correlation value between x_i and t_i given Z (where t_i is time allocated to activity i). Thus, x_i is predicted as a function of t_i and Z, while t_i is predicted as a function of x_i and Z for the whole dataset.

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[9] Domestic production takes up the largest share of daily life in Turkish households. According to İlkkaracan and Gunduz (2009), this production represented values between 25% and 45% of GDP in 2006.

The second problem concerns the decrease in variance of the imputed values since traditional matching procedures smooth the variations in individual's expenditure data. As a consequence, inequalities in full income decrease, which is a major concern when seeking to address income inequalities. Rubin's approach matches each unit of the time survey to the observation with the closest predicted values of x_i in the consumer expenditure survey, conditional on identical characteristics as informed by Z. It follows that the observed value of the match is imputed to the missing values.

In order to overcome the two aforementioned problems, we take into account the concatenation between imputed variables in the time dataset[10]. To summarise the concatenation methodology proposed by Rubin (1986, 1987), the variable Y in survey A is imputed in survey B and the variable Z in survey B is imputed in survey A. The software used for this matching was developed by Alpman (2016). The details of the matching procedure are as follows:

1. We consider three different kinds of variable sets: the first group of variables (Y) include the above-explained time use categories in the TUS. The second group (Z) represents the expenditure variables in the HBS corresponding to (Y) in the TUS. The third set is the common variables (X) such as sex, age, marital status, education level, geographic location, employment status, sector of work and type of firm in both surveys. The main hypothesis is that the partial correlation between Y and Z given X is supposed to be other than zero, and is thus denoted: $\rho_{Y, Z|X \neq 0}$.

2. Therefore, the partial variance of Y and Z given X, respectively $\rho_{Y|X}$ and $\rho_{Z|X}$, can be obtained by linear regressions of Y and Z on X. We begin with a linear regression model, where Y and Z are successively regressed on X:

$$Y = a_0 + aX + \epsilon \qquad (11)$$

$$Z = b_0 + bX + \mu \qquad (12)$$

3. The partial covariance of (Y, Z) given X, denoted $\sigma_{Y, Z|X}$, can be deduced from $\rho_{Y, Z|X} (\rho_{Y|X} \cdot \rho_{Z|X})^{1/2}$.

4. Supposing that α and β are the column vectors of the regression coefficients of Y on $(1, X)$ and Z on $(1, X)$ respectively, Y and Z values may be generated for the dataset formed by A and B by using these regression coefficients. In this prediction, it is assumed that Y and Z values are conditionally independent for a given X. Rubin (1986) applies the sweep matrix operator: sweeping on Y gives the regression coefficients of Z on $(1, X, Y)$ while sweeping on Z gives the re-

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[10] We would like to thank A. Alpman for his help in the application of this matching procedure. See a discussion of matching procedure in Alpman and Gardes (2016).

gression coefficients of Y on $(1, X, Z)$. The new regression coefficients are used to create new predicted Y and Z values for the dataset formed by A and B.

5. Thus, the predicted Y and Z are used in the prediction equation for Y given X and Z and in the prediction equation for Z given X and Y. These are the new prediction coefficients used to create new Y and Z values for the dataset formed by A and B: each missing unit of Z in A (and Y in B) is matched with the closest new predicted Z value in B (and Y in A), dependent on identical characteristics informed by X.

5. Empirical results

We estimate a complete demand expenditure system (Equation 10) using the Generalized Method of Moments (GMM) for both full expenditure (time plus money) and for monetary expenditure alone. We integrate prices in the equation and the income variables are taken as endogenous. The same estimation is found in by Aktuna-Gunes et al. (2017), which measures the size of the informal economy for the years from 2003 to 2006 inclusive. The control variables included in the model are the OECD equivalence scale, home ownership, indicators for men and women in white-collar occupations, and the natural logarithm of household members' ages. We also account for two interaction terms: self-employed men and male wage earners in white-collar occupations with permanent contracts, along with fixed-term contracts for both men and women. Additional controls include household type – classified as single, single with children, couple, couple with children, and other family types – educational attainment dummies for men and women, and durable-goods indicators such as computer ownership and the presence of an effective heating system. We further control for the number of rooms in the dwelling and the number of mobile phones. After several trials to identify suitable instruments, we selected the following: the logarithm of the OECD equivalence scale, sex, the natural logarithm of age for men and women, its squared term for each, and the ratio of children to adults within the household's characteristics vector (see Lyssiotou et al., 2004; Aktuna-Gunes et al., 2014).

The estimation of the model for full expenditures and exclusively monetary expenditures from the pooled cross-sectional data covering the 2007–2011 period of investigation is presented in Table A2 and Table A3 respectively in the Appendix[11].

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[11] Based on the 2007 variables, the over-identifying restriction in the estimation is 6.56. The Chi-square *p*-value for monetary estimations is 0.83, which is bigger than 0.05, so the null hypotheses and the validity of the identifying instruments cannot be rejected for the chosen control variables.

The size of the pooled sample increased to 33,765 households. The parameters of the estimates of only seven budget share equations are reported in these tables since the parameters of Equation 8 (other goods/services) are redundant due to the adding up condition.

We obtain the size of the informal economy for each year (Table 1) by scaling up the under-reported parameters k and l (estimated by monetary and full expenditure) with the income part of self-employed and wage earners in GDP (Table A4 in Appendix). The corresponding size of the informal economy between 2007 and 2011 for self-employed workers varies between 32.12% and 29.52%, and from 25.34% to 23.30% of GDP for the monetary and the full expenditure estimations. The size of the informal economy decreases on average by 6.53% (= 30.96% to 24.43%) due to the time use intensive domestic production of self-employed households.

Table 1. The size of informal economy in Turkey for the years between 2007 and 2011 (in %)

Data range	Type of employment	2007	2008	2009	2010	2011	Avg.	Total
Monetary expenditure	Wage earners	39.21	41.63	39.64	46.04	46.61	42.63	73.59
	Self employed	32.12	30.98	31.61	30.57	29.52	30.96	
Full expenditure*	Wage earners	42.74	45.38	43.21	50.18	50.81	46.46	70.89
	Self employed	25.34	24.45	24.94	24.12	23.30	24.43	

Note: * Full expenditure = monetary expenditures + monetary time use values.

Source: own calculations.

Conversely, however, this estimation points out inverse results for wage earners. The corresponding size of the informal economy between 2007 and 2011 for wage earners varies between 46.61% and 39.21% and from 50.81% to 42.74% of GDP for the monetary and the full expenditure estimations, respectively. This indicates that the size of the informal economy increases on average by 3.83% (= 42.63% to 46.46%) due to the commodity intensive domestic production of wage-earning households. The last column in Table 1 shows the total effect domestic activities have on the under-reporting of income. When domestic activities are included, the size of the informal sector decreases by 2.7 points (from 73.59% to 70.89%).

We keep the same control variables and do not add new ones in order to compare the results obtained from both estimations.

Conclusions

In this paper, we show how the time use values of households may determine the size of the informal economy in Turkey between 2007 and 2011. The model is well estimated with almost all significant parameters in place. The informal economy results are three-fold:

1. An increase in domestic production yields a decrease in the size of the informal economy for the self-employed (on average from 30.96% to 24.43% when we consider domestic production). The main argument underpinning this result is that the time use substitution elasticity of final goods production for self-employed workers would be elastic, implying that they have more time-intensive domestic production technology than other workers.
2. An increase in domestic production yields an increase in the average size of the informal economy among wage earners, which rose from 42.63% to 46.46% in Turkey. When we look at the national statistics[12], the average weekly hours worked by wage earners are high while they consume less. Wage earners participated in informal activities in order to compensate for a lack of monetary resources to use in domestic production.
3. We consider all goods taking into account domestic production in a complete demand system framework by adding the monetary value of time use to the monetary expenditures. The average estimation of the size of the informal economy in Turkey decreased on average from 73.59% to 70.89% of GDP, respectively, for monetary and full expenditure for the years 2007–2011. Comparing our results for a developing country such as Turkey with findings for the Quebec region (Fortin et al., 2009), using the same methodology, reveals a striking contrast. The informal sector accounted for about 6% in Quebec in 2002, whereas for Turkey it reached 65.6% when measured with monetary income and 79.28% when measured with full income for the years 2003–2006 (Aktuna-Gunes et al., 2017).
4. The results obtained should also rise specific actions within the framework of socio-economic policy. The significant size of the informal economy demonstrates that Turkey requires a multi-dimensional strategy that would combine tax, insurance, institutional and social reforms. Specific actions that could improve the situation include reducing the costs of legality, especially for small

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[12] According to the Turkish Statistical Institute, during these years the average inflation rate was 8.66 and the unemployment rate was 14.14 with an increasing tendency. The average weekly hours worked on the main job was 51.12 hours, while it was 36.82 for OECD countries. According to the OECD statistics, purchasing power parities in Turkey are an average of 0.9, while this is 0.77 for European Countries.

businesses and the self-employed, administrative simplification, increasing the transparency of trade through the digitalisation of economic activity, combating informal employment through inspections and various incentives (strengthening labour inspections, rewarding legal employment with a temporary tax reductions).

Taken together, these findings highlight the importance of accounting for households' time-allocation decisions between domestic and informal activities when measuring inequality and poverty. The Gini Index may be useful for measuring and explaining income inequality across the entire distribution of informal earnings and socioeconomic status. However, an additional methodology could be useful to demonstrate how informal earnings can be decomposed into the contributions of individual socioeconomic factors to income-related inequality. Finally, additional analysis is required for the poverty computation. It is reasonable to assume that the elasticity of substitution and complementarity between time use in domestic activities can be used to explain the reasons for the decrease in poverty for different sub-populations and countries. These analyses are left for future work.

Appendix

Full prices proxies for complementary factors

In the case of complementary factors (market goods and time) used for domestic commodities, Becker's full price for commodity *i* can be written as follows:

$$p_{ih}^{f} = p_i + \omega_h\, \tau_{ih}$$

with τ_{ih} being the time use necessary to produce one unit of that activity and p_i the monetary price. Suppose that a Leontief technology allows the quantities of the two factors to be proportional to the activity:

$$x_{ih} = \xi_{ih}\, z_{ih}$$
$$t_{ih} = \theta_{ih}\, z_{ih} \text{ so that } t_{ih} = \tau_{ih}\, x_{ih} \text{ yields } \tau_{ih} = \frac{\theta_{ih}}{\xi_{ih}}$$

This case corresponds to an assumption of complementarity between the two factors in domestic technology[13], which allows calculating a proxy for the full price of activity *i* by the ratio of full expenditure (monetary expenditure and the value of time defined as time use per unit of the commodity multiplied by the opportunity cost of time ω) over its monetary component.

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[13] An alternative hypothesis based on the substitutability between the two factors is discussed in Alpman and Gardes (2016).

Table A1. Descriptive statistics

Budget Shares	Variable	Mean	Std Dev	Minimum	Maximum
Monetary expenditures	Food	0.2953	0.1481	0	0.9930
	Personal Care (with Health)	0.0823	0.0835	0	1.0000
	Housing	0.3995	0.1590	0	1.0000
	Clothing	0.0529	0.0637	0	0.8424
	Education	0.0157	0.0455	0	0.8726
	Transport	0.1166	0.1347	0	0.9284
	Leisure	0.0251	0.0497	0	0.7868
	Other	0.0127	0.0370	0	0.7920
Full expenditures	Food	0.1328	0.0800	0	0.9264
	Personal Care (with Health)	0.1509	0.0435	0	0.8018
	Housing	0.1741	0.1077	0.01	1.0000
	Clothing	0.0273	0.0328	0	0.5578
	Education	0.0222	0.0288	0	0.8190
	Transport	0.1110	0.0729	0	0.8460
	Leisure	0.2210	0.0918	0	0.6910
	Other	0.1608	0.1200	0	0.6697
Occupation dummies	Men in white collar occupation	0.1459	0.3530	0	1
	Women in white collar occupation	0.0463	0.2102	0	1
	Men wage worker	0.3079	0.4616	0	1
	Women wage worker	0.0703	0.2556	0	1
	Men self-employed	0.1750	0.3800	0	1
	Women self-employed	0.0378	0.1908	0	1
	Men with permanent contract	0.3082	0.4617	0	1
	Women with permanent contract	0.0707	0.2563	0	1
	Men with fixed-term contract	0.0222	0.1475	0	1
	Women with fixed-term contract	0.0150	0.1216	0	1
	Men without a diploma	0.1868	0.3897	0	1
	Men primary education	0.1048	0.3063	0	1
	Men secondary education	0.4745	0.4994	0	1
	Men superior education	0.1383	0.3452	0	1
	Men other eduaction	0.0957	0.2941	0	1
	Women without a diploma	0.8132	0.3897	0	1
	Women primary education	0.0295	0.1693	0	1
	Women secondary education	0.0917	0.2886	0	1
	Women superior education	0.0307	0.1724	0	1
	Women other eduaction	0.0349	0.1835	0	1

cont. Table A1

Budget Shares	Variable	Mean	Std Dev	Minimum	Maximum
Household income share	ln(Total Income)	6.8961	0.9378	0.6931	11.5179
	Other income / Total Income	0.0752	0.1284	0	0.9747
	Self employment / Total Income	0.3117	0.4632	0	1
	Extended (Self employment / Total Income)	0.3937	0.5868	0	1.5940
	Full extended (Self employment / Total Income)	0.3820	0.5721	0	1.6541
	Wage income / Total Income	0.6131	0.4292	0	1
	Extended (Wage income/ Total Income)	0.7423	0.5069	0	1.2918
	Full extended (Wage income/ Total Income)	0.7460	0.5220	0	1.4812
	ln(Total Income) instrumented	6.8423	0.6817	4	9.0783
	ln(Total full Income) instrumented	6.7708	0.6786	4	8.8271
Demographic and regional character-istics	ln(age)	3.7933	0.2922	2.8904	4.5326
	Household type	2.4743	1.2993	1	5
	OECD equivalence scale	2.2141	0.7613	1	11.3
	City	0.6946	0.4606	0	1
Durables and luxury goods	Home ownership	0.6353	0.4814	0	1
	Number of rooms in the house	3.4991	0.8181	1	10
	Computer	0.3738	0.4838	0	1
	Good heating system	0.2995	0.4581	0	1
	Number of cell phone	2.0024	1.1325	0	9

Note: N = 33,765.

Source: own calculations.

Table A2. Results for monetary expenditures based on the complete demand system: all populations (GMM), 2007–2011

Variables	Food	t-ratio	Pc& Health	t-ratio	Housing	t-ratio	Clothing	t-ratio	Other	t-ratio	Trans-port	t-ratio	Leisure	t-ratio
Constant	0.921	1.690	2.621	2.680	−8.114	−4.490	0.030	0.030	0.119	0.120	3.606	5.200	0.628	1.210
2007	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2008	0.005	2.190	−3.950	0.001	0.017	7.420	−0.006	−4.700	−0.003	−5.390	−0.002	−0.850	−0.002	−2.770
2009	0.000	0.020	4.080	0.001	0.013	5.430	−0.013	−10.220	−0.002	−3.140	−0.001	−0.450	0.002	2.810
2010	0.000	0.150	2.260	0.001	0.016	6.830	−0.013	−10.680	0.000	−0.320	−0.001	−0.470	0.001	1.350
2011	0.001	0.420	5.150	0.001	0.015	6.460	−0.016	−12.080	−0.001	−2.340	0.000	−0.060	0.000	0.020
OECD equivalence scale	0.019	14.500	−0.005	−7.890	−0.033	−27.020	0.011	14.510	0.000	0.420	0.003	2.660	−0.001	−1.780
Home ownership	0.012	7.410	−0.004	−5.110	0.008	4.900	−0.002	−1.930	−0.001	−2.380	−0.011	−7.810	−0.001	−2.660
Men in white collar occupation	−1.026	−2.960	−2.530	0.044	0.559	3.080	−0.030	−0.820	0.150	2.690	0.494	2.790	0.031	0.750
Female in white collar occupation	0.020	5.020	−0.003	−1.250	−0.019	−3.270	0.015	5.960	0.000	−0.130	−0.005	−1.040	−0.008	−4.550
ln(age)	0.041	8.760	0.019	8.550	0.063	14.190	−0.033	−15.890	−0.008	−6.720	−0.034	−9.400	0.014	11.020
Men self employed × Male in white collar occupation	0.906	2.850	0.169	4.040	−0.499	−3.070	−0.072	−2.000	−0.117	−2.300	−0.413	−2.500	−0.007	−0.190
Men wage worker × Male in white collar occupation	1.132	3.030	1.570	0.047	−0.591	−2.990	0.093	2.330	−0.169	−2.810	−0.568	−3.000	−0.051	−1.140
Men having permerent contract	−0.113	−6.140	0.028	7.070	0.031	2.710	−0.032	−10.130	0.015	4.710	0.063	6.530	0.013	4.930
Women having permerent contract	0.002	0.370	0.006	2.170	−0.022	−4.910	0.009	4.600	−0.002	−1.450	0.011	2.680	−0.005	−3.860
Men having fixed-term contract	−0.023	−1.960	0.020	6.720	−0.013	−1.870	−0.011	−4.290	0.000	0.090	0.022	3.390	0.003	1.960
Women having fixed-term contract	0.005	1.090	−0.003	−1.130	−0.018	−3.580	0.013	5.830	0.000	−0.040	0.011	2.270	−0.006	−3.700
Men don't have education	−3.175	−1.870	−0.891	−1.510	5.816	2.770	−0.478	−0.470	−0.032	−0.020	−0.643	−0.600	0.000	0.000
Men having primary education	−0.027	−2.260	−0.017	−4.300	−0.090	−9.020	0.054	14.720	−0.002	−1.070	0.056	7.670	0.006	2.820
Men having secondary education	−0.019	−1.250	−0.005	−1.270	−0.073	−6.550	0.037	10.530	−0.004	−1.770	0.039	4.980	0.005	2.330
Men having superior education	−0.017	−1.450	0.000	−0.100	−0.044	−4.980	0.024	8.400	−0.006	−2.780	0.028	4.260	0.003	1.640
Women don't have education	−3.182	−1.880	−0.886	−1.500	5.874	2.790	−0.493	−0.490	−0.028	−0.020	−0.669	−0.620	−0.002	−0.730
Women having primary education	0.085	6.390	−0.105	−12.660	0.008	0.560	0.110	18.780	0.000	0.090	−0.071	−5.600	−0.026	−6.120
Women having secondary education	0.029	3.220	−0.069	−12.500	−0.040	−4.000	0.087	20.270	0.003	1.060	−0.008	−0.880	−0.015	−5.100

Variables	Food	t-ratio	Pc& Health	t-ratio	Housing	t-ratio	Clothing	t-ratio	Other	t-ratio	Transport	t-ratio	Leisure	t-ratio
Women having superior education	−0.014	−2.600	−0.013	−4.040	−0.068	−9.750	0.035	12.100	−0.001	−0.310	0.043	6.660	0.004	1.700
Computer	−0.006	−3.200	−1.600	0.001	0.005	2.670	−0.003	−3.320	0.000	0.500	0.001	0.830	0.000	0.360
Good heating system	−0.009	−5.130	−7.750	0.001	0.043	24.740	−0.007	−6.930	0.000	0.770	−0.018	−10.690	−0.002	−4.480
Number of rooms in the house	−0.003	−3.710	−4.120	0.000	0.009	10.880	−0.002	−4.140	−0.001	−3.790	−0.001	−1.790	0.000	0.170
Urban	−0.021	−4.310	−4.040	0.001	0.069	19.070	0.001	1.110	−0.006	−6.900	−0.029	−10.330	−0.005	−6.480
Household type	−0.001	−1.230	1.810	0.000	0.003	5.440	−0.001	−3.390	0.000	0.150	−0.001	−2.140	0.000	1.860
Number of cell phone	−0.007	−7.820	0.001	3.130	0.004	4.420	0.002	3.410	0.001	2.860	−0.002	−3.110	0.000	−0.460
Full price-Food	−0.270	−55.410	0.017	26.010	0.186	38.880	0.024	19.390	0.007	13.340	0.025	28.860	0.006	15.060
Full price-Pc&Health	0.017	26.010	−0.060	−92.060	0.020	26.680	0.000	−0.380	0.002	13.650	0.013	30.320	0.004	22.110
Full price-Housing	0.186	38.880	0.020	26.680	−0.281	−50.070	0.016	12.680	0.009	14.760	0.036	40.800	0.007	13.900
Full price-Clothing	0.024	19.390	0.000	−0.380	0.016	12.680	−0.045	−52.840	0.000	1.140	0.005	12.620	−0.001	−5.760
Full price-Education	0.007	13.340	0.002	13.650	0.009	14.760	0.000	1.140	−0.001	−2.720	0.003	13.630	0.001	11.450
Full price-Transport	0.025	28.860	0.013	30.320	0.036	40.800	0.005	12.620	0.003	13.630	−0.092	−92.260	0.006	25.540
Full price-Leisure	0.006	15.060	0.004	22.110	0.007	13.900	−0.001	−5.760	0.001	11.450	0.006	25.540	−0.025	−84.360
Full price-Other	0.005	9.090	0.003	15.720	0.008	13.970	0.002	7.890	−0.023	−80.340	0.004	17.380	0.001	8.330
Y	0.740	9.810	−9.780	0.045	0.703	7.390	0.130	4.300	0.008	0.350	−0.847	−14.470	−0.166	−7.640
Y^2	−0.057	−10.670	9.250	0.003	−0.055	−8.090	−0.006	−2.940	0.000	−0.120	0.066	16.050	0.012	7.630

Under-reporting Self-employment (Yr) and Wage earners (Ys)	Parameter	t-ratio			
k (under reporting ratio for Yr)	1.418	18.880			
v (under reporting ratio for Ys)	1.098	24.720			

Stock-Yogo weak ID test (endogenous regressor: income)	(Critical values)	>5%	>10%	>20%
Minimum eigenvalue statistic $F(5, 33732) = 17.94$	2SLS relative bias	18.37	10.83	6.77

Sargan statistic (overidentification test of all instruments): 6.560   Chi-sq(4) p-value = 0.8335

Source: own calculations.

Table A3. Results for full expenditures based on the complete demand system: all populations (GMM), 2007–2011

Variables	Food	t-ratio	Pc&Health	t-ratio	Housing	t-ratio	Clothing	t-ratio	Other	t-ratio	Trans-port	t-ratio	Leisure	t-ratio
Constant	17.890	0.770	−15.19	−1.99	65.685	4.400	11.528	3.410	−27.9077	−1.240	−15.540	−1.250	−18.910	−1.220
2007	−	−	−	−	−	−	−	−	−	−	−	−	−	−
2008	−0.006	−1.530	0.003	0.930	−0.010	−1.190	−0.005	−3.060	0.004	0.840	0.004	1.410	0.010	1.920
2009	−0.003	−0.760	0.007	2.620	−0.013	−1.630	−0.008	−5.030	−0.005	−1.010	0.005	1.810	0.014	2.840
2010	0.002	0.670	−0.002	−0.630	0.012	1.540	−0.003	−2.130	−0.008	−1.780	−0.001	−0.380	0.000	−0.090
2011	−0.015	−3.390	0.012	4.290	−0.035	−3.400	−0.013	−6.610	0.015	3.010	0.010	2.800	0.021	4.160
OECD equivalence scale	0.014	6.770	−0.006	−4.880	0.001	0.250	0.006	5.980	−0.001	−0.460	−0.001	−0.280	−0.011	−5.120
Home ownership	−0.012	−3.960	0.005	3.080	−0.016	−2.130	−0.005	−3.710	0.008	2.620	0.004	1.640	0.012	4.430
Men in white collar occupation	−0.080	−2.470	−0.619	−5.520	0.495	3.810	−0.296	−6.040	0.983	5.480	1.510	5.880	−1.985	−5.820
Women in white collar occupation	0.042	4.520	−0.026	−4.720	0.105	5.720	0.027	7.350	−0.043	−4.300	−0.033	−6.090	−0.062	−6.360
ln(age)	0.002	0.230	0.031	5.100	−0.071	−2.970	−0.038	−8.200	−0.013	−1.120	0.001	0.100	0.121	12.040
Men self employed × Male in white collar occupation	0.108	2.680	0.511	4.600	−0.408	−2.630	0.245	5.110	−0.842	−4.910	−1.304	−5.330	1.689	5.100
Men wage worker × Male in white collar occupation	0.029	0.860	0.715	6.170	−0.631	−4.880	0.322	6.180	−1.019	−5.360	−1.656	−6.130	2.224	6.260
Men having permement contract	0.001	0.070	−0.046	−7.590	0.053	2.430	−0.023	−4.820	0.055	4.280	0.097	7.720	−0.135	−9.940
Women having permement contract	0.087	6.900	−0.043	−5.810	0.138	3.970	0.026	4.120	−0.075	−5.690	−0.013	−1.180	−0.107	−11.240
Men having fixed-term contract	−0.003	−0.420	0.006	0.850	0.001	0.080	0.000	0.100	−0.011	−1.070	−0.013	−0.930	0.021	1.110
Women having fixed-term contract	0.104	6.830	−0.051	−5.600	0.134	3.400	0.025	3.440	−0.065	−4.180	−0.005	−0.420	−0.127	−10.380
Men don't have education	0.123	0.010	4.931	0.350	−32.963	−1.420	−5.633	−1.080	9.549	1.640	10.100	0.780	0.000	0.000
Men having primary education	0.307	5.870	−0.164	−6.420	0.553	4.350	0.153	6.590	−0.384	−8.650	−0.100	−2.320	−0.294	−11.120
Men having secondary education	0.340	6.520	−0.179	−7.020	0.641	4.980	0.158	6.770	−0.433	−9.780	−0.153	−3.540	−0.300	−11.950
Men having superior education	0.248	6.630	−0.127	−6.830	0.468	5.040	0.113	6.750	−0.327	−10.190	−0.119	−3.850	−0.208	−11.030
Women don't have education	0.000	0.000	4.987	0.360	−33.133	−1.420	−5.680	−1.090	9.680	1.660	10.141	0.780	0.096	7.190
Women having primary education	−0.392	−5.430	0.231	5.970	−0.725	−4.180	−0.054	−1.750	0.371	5.140	0.151	3.010	0.385	7.120
Women having secondary education	−0.079	−2.330	0.038	1.790	−0.112	−1.340	0.043	2.800	0.026	0.620	0.052	2.210	0.044	1.300

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Variables	Food	t-ratio	Pc&Health	t-ratio	Housing	t-ratio	Clothing	t-ratio	Other	t-ratio	Transport	t-ratio	Leisure	t-ratio
Women having superior education	0.266	6.480	−0.159	−7.510	0.492	4.640	0.119	6.140	−0.311	−8.400	−0.062	−1.760	−0.295	−13.810
Computer	−0.001	−0.460	0.000	−0.290	−0.004	−0.610	−0.003	−1.890	0.005	1.340	0.006	1.790	−0.002	−8.660
Good heating system	−0.015	−5.260	0.003	1.580	0.003	0.380	−0.005	−3.420	0.005	1.640	0.001	0.190	0.007	2.230
Number of rooms in the house	0.000	−0.240	−0.001	−1.460	0.003	1.500	0.000	−0.800	−0.003	−2.400	0.000	−0.240	0.000	0.340
Urban	−0.028	−4.400	0.024	6.500	−0.034	−2.170	−0.011	−3.590	0.018	2.900	−0.031	−5.290	0.053	8.380
Household type	0.004	5.050	−0.002	−3.610	0.008	4.470	0.001	3.070	−0.005	−5.380	0.001	0.940	−0.006	−5.340
Number of cell phone	0.001	1.510	0.000	−0.740	0.007	3.810	0.002	5.410	−0.004	−3.760	−0.005	−5.260	−0.002	−1.190
Full price-Food	−0.043	−14.620	0.007	4.500	0.003	0.450	0.000	0.200	0.012	5.900	0.014	5.790	0.004	3.230
Full price- Pc&Health	0.007	4.500	−0.019	−21.560	0.016	3.890	0.001	1.950	−0.002	−1.450	−0.001	−0.480	−0.002	−3.830
Full price-Housing	0.003	0.450	0.016	3.890	−0.084	−3.810	0.003	0.780	0.012	1.920	0.029	4.170	0.013	5.820
Full price-Clothing	0.000	0.200	0.001	1.950	0.003	0.780	−0.012	−14.860	0.001	0.790	0.005	3.650	0.001	1.930
Full price-Education	0.012	5.900	−0.002	−1.450	0.012	1.920	0.001	0.790	−0.017	−6.260	0.001	0.490	−0.004	−4.090
Full price-Transport	0.014	5.790	−0.001	−0.480	0.029	4.170	0.005	3.650	0.001	0.490	−0.042	−18.440	−0.004	−4.410
Full price-Leisure	0.004	3.230	−0.002	−3.830	0.013	5.820	0.001	1.930	−0.004	−4.090	−0.004	−4.410	−0.005	−5.410
Full price-Other	0.003	3.650	−0.002	−4.680	0.008	3.870	0.001	3.840	−0.004	−5.880	−0.002	−3.670	−0.003	−10.600
Y	−5.333	−6.710	3.099	8.160	−9.707	−5.010	−1.754	−5.070	5.599	8.480	1.617	2.620	5.620	15.500
Y^2	0.389	6.700	−0.228	−8.220	0.711	5.000	0.131	5.150	−0.411	−8.560	−0.114	−2.510	−0.414	−16.020

Under-reporting Self-employment (Yr) and Wage earners (Ys)	Parameter	t-ratio
k (under reporting ratio for Yr)	1.184364	32.22
v (under reporting ratio for Ys)	1.180907	29.73

Source: own calculations.

**Table A4. The income part of wage earners and self-employed, 2007–2011
(as % of GDP)**

Years	Shares	
	Self-employed	Wage earners*
2007	0,211	0,355
2008	0,204	0,377
2009	0,208	0,359
2010	0,201	0,417
2011	0,194	0,423

* Including regular employee.

Source: Republic of Turkey Social Security Institution, 2016.

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Blockchain technology and smart contracts: A potential tool for improving operational profit margin

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Abstract

This study presents a practical framework for implementing blockchain technology, specifically smart contracts, to optimise operations and enhance financial performance in the Consumer Packaged Goods (CPG) sector. It identifies best practices for operational efficiency and outlines the structural flow and challenges of implementing smart contracts in a small-scale CPG company. While blockchain is often associated with cryptocurrency, its value lies in enhancing core business processes such as vendor selection, procurement and legal compliance monitoring. The framework integrates blockchain-enabled smart contracts with project management lifecycle updates to streamline operations, enhance cash flow and reduce the Cost of Goods Sold (COGS). It highlights how procurement processes, legal requirements and vendor management can be streamlined through smart contracts, providing transparency, reducing delays and ensuring regulatory

Keywords

- blockchain
- smart contracts
- COGS
- EBIT
- procurement
- inventory
- profit margin
- corporate operations

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compliance. Blockchain is a decentralised database, and its applications span procurement, production processes and inventory management. However, leveraging blockchain effectively requires smart contracts. Integrating these contracts with project management tools ensures efficient operations and measurable financial metrics. This interdisciplinary approach combines technology, business law and project management to deliver actionable insights. The study highlights how modest operational efficiencies can drive profitability in low-margin industries, such as CPG, and establishes a foundation for future implementation studies across other sectors.

Introduction

This project examines the impact of blockchain technology, as found in smart contracts, on improving the financial performance of companies with smaller profit margins, such as those in the Consumer Packaged Goods (CPG) sector. Given the number of startups registered post-COVID-19 within the CPG sector, we are ahead of the curve in examining the impact of blockchain on small CPG companies. Blockchain technology, on which cryptocurrency relies for its efficient delivery, has proven to be more relevant and pervasive in business practices than the notion and utility of the cryptocurrency itself (Hashemi et al., 2020; Polyviou et al., 2019). In recent times, cryptocurrency has experienced its ups and downs on the financial markets (Allen & Bryant, 2019; Chen et al., 2021; Sahoo et al., 2020). In contrast, blockchain technology is slowly and surely integrating into business practices (Pankratov, 2021). It will undoubtedly play an increasingly significant role in small startups, which, by nature, are more agile than established businesses. We explore the connectivity between the use of smart contracts, based on blockchain practices, and their impact on improving operational cash flows, specifically affecting the Cost of Goods Sold (COGS) and Earnings Before Interest and Tax (EBIT).

Blockchain is a shared database in which information is recorded in sequential blocks. It can store many types of data, including procurement records, assembly-line production details and inventory information. The use of smart contracts – self-executing agreements built into the blockchain – is becoming increasingly widespread and popular.

However, the effective use of blockchain spans several areas of business and requires coordinated updates. It affects vendor selection and procurement process-

es, as well as the monitoring of legal and regulatory issues. It also influences the project management lifecycle, which must be adapted to support greater agility. This study presents a framework for integrating blockchain into vendor and procurement activities, legal monitoring and compliance, as well as the adjustments needed across project lifecycle management. It also clearly shows the financial metrics that can be impacted by incorporating blockchain. This interdisciplinary approach combines technology, business law and project management to deliver actionable insights and measurable financial metrics.

Business law and traditional contracts provide the legal foundation by defining the rights, responsibilities, obligations and expectations between parties. Smart contracts are automated digital agreements recorded on the blockchain that execute automatically when predefined conditions are fulfilled (Gilcrest & Carvalho, 2018). These contracts represent a fusion of technology and legal frameworks, translating business agreements into enforceable code. These legal frameworks govern critical business functions, including vendor selection, procurement and inventory management, ensuring compliance, accountability and transparency across the supply chain. Smart contracts build on these legal principles by embedding them into automated workflows, adding efficiency by removing the need for intermediaries and enabling transactions to occur seamlessly when agreed-upon conditions are met. By aligning legal agreements with blockchain-enabled smart contracts, businesses can streamline these operational areas, minimise risks and improve cash flow. This integration ensures processes are executed accurately and efficiently, with minimal administrative overhead. The result is a reduced COGS and improved profitability, which is particularly vital for companies in sectors like CPG, where tight margins demand operational precision.

Project management tools align the interdisciplinary components of blockchain, business law and smart contracts to ensure smooth implementation and efficient operations. This integration is crucial in sectors such as CPG, where even slight improvements in cash flow and reductions in the COGS can have a substantial impact on profitability. Two primary methodologies are relevant: Kanban (Gemino et al., 2020) and the process-based approach, commonly known as the waterfall method (Zerjav, 2021). Kanban offers a visual overview of work status, showing which tasks have begun, which are in progress, and which are currently on hold; however, it lacks the depth required to manage financial ledgers. Agile approaches, such as Scrum (Dong et al., 2024), are unsuitable for smart contracts, as daily adjustments are unnecessary; project deliverables are predefined in the contracts. The process-based approach is more effective, given the structured nature of smart contracts. It provides detailed control over tasks by accounting for factors like resource availability, task dependencies, cost variances, risks and scope impacts. This approach ensures that each task aligns with the contractual obligations enclosed in the smart contract.

1. Motivation

According to a Deloitte report (Deloitte, 2022), the global blockchain market is projected to grow at a Compound Annual Growth Rate (CAGR) of over 60% through 2030, with more than half of consumer-goods companies actively exploring blockchain solutions for supply chain transparency and automation. Recent analysis by the World Economic Forum highlights that rising raw material costs and supply chain disruptions are compressing margins, making operational efficiency and cash flow optimisation a top priority for CPG firms. Despite this momentum, most existing research focuses on blockchain security or cryptocurrency applications rather than developing practical frameworks for linking blockchain-enabled smart contracts to measurable financial outcomes such as EBIT or COGS. This study addresses that gap by offering a replicable, operations-focused methodology that demonstrates the direct financial impact of blockchain adoption in a real-world CPG setting.

This study examines how blockchain technology and smart contracts can be utilised to enhance financial performance for companies operating on narrow profit margins, with a focus on the Consumer Packaged Goods sector. Blockchain's utility extends far beyond cryptocurrency – it can streamline procurement, production and inventory management processes, providing transparency and automation across operations. Smart contracts, by automating accounting and operational workflows, enable the precise calculation of key financial metrics, such as Earnings Before Interest and Taxes, and help reduce the Cost of Goods Sold, a critical factor for improving profitability in low-margin industries.

2. Methodology

The research follows a business clinical study methodology, mirroring the structured approach of clinical trials to ensure rigor and replicability. In Phase One, the problem statement and research hypothesis (or research question) are clearly defined, establishing the foundation for the study. Phase Two involves gathering pre-intervention metrics and developing a practical implementation framework that addresses the identified challenges. In Phase Three, this framework is deployed as a pilot project within a small CPG company, enabling real-world testing of vendor selection, procurement processes and legal compliance workflows. Post-implementation results are then collected and analysed to measure impact on

operational efficiency, cost reduction and financial performance. The final phase focuses on optimisation, where processes are refined based on the outcomes of the pilot, followed by sharing the post-optimisation results and recommendations for industry adoption.

This paper represents Phase Two of the research: it presents the problem statement and hypothesis and proposes a comprehensive implementation structure. It outlines specific updates for vendor selection, procurement practices, business law compliance and enhancements to the project management lifecycle. These contributions have been incorporated into the Introduction section to clarify the study's context and relevance.

The planned application in a small CPG company serves as a practical test case, using blockchain-enabled automation to enhance operational efficiency, optimise cash flow and increase overall profitability. This research employs a methodology similar to that of a clinical study, utilising a single company as the initial implementation site to investigate challenges, refine processes and measure outcomes. By integrating accounting principles with blockchain solutions and updating project management lifecycles to accommodate vendor, procurement and legal compliance requirements, the framework provides a replicable model for sustainable financial improvement. If successful, it could serve as a template for broader adoption across industries facing similar margin pressures.

To strengthen the analytical rigor of Phase Two, this study incorporates empirical insights from prior research on blockchain-enabled supply chain efficiency. Deloitte (2022) highlights that blockchain automation significantly reduces administrative processing time, reconciliation effort and manual verification steps, improvements particularly relevant for CPG procurement and inventory workflows. Complementing these industry findings, Kouhizadeh and Sarkis (2018) demonstrate, through empirical and conceptual analysis, that blockchain adoption reduces transaction costs, minimises information asymmetry and improves traceability across supply chains. Similarly, Saberi et al. (2019) show that blockchain-based supply chains exhibit measurable gains in transparency, coordination and cost efficiency, including reduced delays and lower resource waste.

Drawing from these studies, we use the documented ranges of efficiency gains, such as reductions in transaction complexity, improved synchronisation between supply chain actors, as well as the elimination of redundant verification activities, to construct expected-impact benchmarks for the planned Phase Three pilot implementation. These benchmarks support a preliminary sensitivity analysis of how improvements in procurement cycle time, vendor compliance accuracy, and inventory visibility could translate into reduced COGS and improved operational profitability. Incorporating these empirical insights into Phase Two strengthens the methodological foundation of the framework and establishes clear, evidence-based expectations for validation during Phase Three.

This paper explores smart contracts and blockchain processes to identify best practices for operational efficiency. Section 3 outlines the fundamentals of blockchain. Section 4 examines whether distributed ledger technology (DLT) can replace traditional ledgers for cost-effective operations. Section 5 discusses the impact of blockchain and smart contracts on project management. In the last, Section 6 addresses current challenges in adopting blockchain and smart contracts within a small CPG startup, offering a concrete organisational context for analysing the problem at hand. The conclusion highlights their potential to automate operational accounting, thereby assessing the impact of smart contracts and blockchain on increasing the operating profitability of smaller companies.

3. Blockchain technology, smart contracts – working in unison

Blockchain technology operates on the principle of decentralisation, meaning that no single entity controls the entire network; the users are stakeholders and nodes in the distributed ledger technology (DLT). Instead, the network is maintained by a network administrator or software developer (Teamhub, 2023). This distributed nature of blockchain ensures there is no single point of failure, making it highly resilient and secure. A distributed ledger is a database that can be shared among multiple participants (Cieplak & Leefatt, 2017, p. 420). It is a decentralised digital record shared instantaneously across the network of participants to establish consensus without a centralised repository of information (Raskin 2017, p. 318). Each participant (or node) holds a copy of the master ledger. Whenever changes are made to a participant's copy, the network is notified and must agree on which changes will be permanently reflected in the master ledger (Nash 2019, p. 799). From a legal standpoint, blockchain development led to the emergence of smart contracts. Based on the distributed ledger technology (Nevil, 2025), smart contracts constitute the "next step in the progression of blockchains from a financial transaction protocol to an all-purpose utility" (Jani, 2020). The code is embedded in the distributed ledger, and once it is activated, it will execute automatically, ensuring that neither party can fail to perform (McKinney et al., 2018). Courts should not need to step in to enforce the smart contract for payment, for example, as once the predetermined event or condition occurs, failure to pay is not a possible outcome within the code (ISDA & Linklaters, 2017).

Since blockchain technology serves as the underlying framework for smart contracts, or self-executing digital contracts whose terms have been translated into code, it offers a paradigm shift in how contractual agreements are executed and

enforced. By leveraging blockchain's inherent characteristics, smart contracts provide transparency, immutability and automation to the operational process, thereby addressing critical pain points faced by companies with tight profit margins.

It is important to note that smart contracts have been gaining momentum, and their validity is increasingly recognised, particularly by state law. For example, Tennessee law states, "Smart contracts may exist in commerce. No contract relating to a transaction shall be denied legal effect, validity or enforceability solely because that contract is executed through a smart contract" (Tennessee Code Annotated (T.C.A.) § 47-10-202). A growing number of states have adopted similar provisions, such as Iowa in 2022 (Iowa Code Annotated (I.C.A.) § 554E.3) and Arizona in 2017 (Arizona Revised Statutes (A.R.S.) § 44-7061). However, these are general provisions whose purpose is to recognise smart contracts and their validity, but they do not address the issues raised by their use.

Despite their many advantages, smart contracts present legal challenges. One of the primary concerns is whether smart contracts constitute legal contracts (Harris Sliwoski, 2023). Even though some smart contracts may legally be considered contracts if they meet all the legal requirements, there is currently no consensus about their definition and their legal nature (Kasatkina, 2021, p. 203), as a smart contract may be considered either a mere computer code (Kasatkina, 2021, p. 204) or a real legal agreement, contractual obligations of the parties being discharged through their automated execution by the computer program (Kasatkina, 2021, p. 204). In addition, smart contracts may give rise to new torts in cases of negligent coding or negligent updates (Temte, 2019, p. 97), not to mention potential data privacy violations (Deloitte, 2022), as smart contracts are not entirely confidential (Gilcrest & Carvalho, 2018, p. 3280).

Within the smart contract, the rules governing payment, resource adjustments and schedule impacts are controlled by the "if/when... then..." code (Filatova, 2020), which is written into the blockchain (Norris, 2019). The program developer or contract business administrator stipulates controls and updates. The DLT controls the release of funds, transactions and status, and interfaces with tools used to manage the project. The hope is that the blockchain will reduce the need for interaction between project stakeholders and clients by updating the nodes in the DLT, so that all who have access to updates within the project are consistently dealing with the project's current official version through their "hash" signatures. This will enable triggering actions that are less likely to produce errors and redundancies among the different stakeholders.

Similarly, smart contracts are specifically established to automate those aspects of "traditional" contracts that have clearly defined outcomes (Jani, 2020), i.e. that are more technical and straightforward than natural language elements, whose subtleties and complexities (like a dispute resolution clause) cannot be conveyed by code (Nash, 2019, p. 821). Using middleware, such as "cryptlets" written in

a programming language, will allow the project manager to integrate with smart contracts and the DLT (Frank, 2016).

The discussion above brings us to the central focus of our research question.

4. Research question: from ledger to blockchain format

To examine the research question, "Can blockchain aid in improving operating profit for companies with slim profit margins, we decided to outline a well-established approach to financial management and accounting, including the calculation of Earnings Before Interest and Tax (EBIT). Additionally, we chose this path to give full credence to our single data point: one small company, perhaps a startup, which can increase its operational efficiency and demonstrate this via a universally acceptable metric, EBIT (Ahluwalia et al., 2020).

Let us begin by outlining the flow of operational transactions that comprise the EBIT process and affect the cost of goods sold. These transactions, recorded in a ledger format, track operational performance through standardized accounting line items, regardless of a company's size or industry (Brigham & Houston, 2015).

The typical format runs as follows:

Sales – Operating Costs = Earnings Before Interest, Taxes, Depreciation and Amortisation (EBITDA)
EBITDA – Depreciation and Amortisation (DA) = Earnings Before Interest and Taxes (EBIT)
EBIT – Interest (I) = Earnings Before Taxes (EBT)
EBT – Taxes = Earnings After Tax or Profits from Operations
Profits from Operations + Depreciation and Amortisation = Net Cash Flow from operations

The main issue here lies in controlling and streamlining both fixed and variable operational costs, as these affect the "cost" of all goods sold. Controlling costs is especially difficult for manufacturing firms operating on slim profit margins, particularly small companies or startups. Among the components of costs (COGS), variable costs are often the least controllable for such firms, defined as follows:

– procurement of raw materials, including their sourcing and pricing,
– trade credit or accounts payable used to finance procurement,
– inventory management, encompassing the financing and storage of inventory and its eventual conversion into accounts receivable or cash as goods are sold,
– collection of accounts receivable or provision of firms' credit policies,

– control and management of all peripheral costs associated with the above activities, such as warehousing, advertising and other management services.

All five of the above activities require tightly coordinated contractual connectivity. When even one link in this chain breaks down, the cost of goods sold is likely to be adversely affected.

The example below illustrates two of the five elements – procurement and inventory management – in a theoretical form, showing how they operate as an executable internal pathway within the firm. This pathway can then be extended to connect with the pathways of external stakeholders, such as raw-material suppliers, creating a broader chain in which all parties work together to improve their collective cost of goods sold.

4.1. Procurement of raw materials through vendor selection and ensuing accounts

Vendor selection is a pivotal process in the intricate landscape of small companies, intimately tied to operational efficiency and profitability. However, traditional approaches to vendor selection often encounter significant challenges, hindering the smooth operation of small enterprises. These challenges include information asymmetry, trust deficits and high transaction costs, which can significantly impact the bottom line of small companies. In response to these challenges, blockchain technology emerges as a promising solution to transform vendor selection dynamics, particularly through the lens of smart contracts (Bai et al., 2021; Guleria & Sharma, 2020).

One of the primary challenges in traditional vendor selection processes is information asymmetry, in which small CPG companies often lack access to reliable information about potential vendors' capabilities, reputations and performance. This information gap can lead to suboptimal vendor choices and operational inefficiencies. Real-world examples, such as Walmart (Hyperledger, 2024) and IBM's collaboration to enhance food traceability and safety through blockchain technology (Sristy, 2021), illustrate how smart contracts can mitigate information asymmetry by providing transparent, tamper-proof records of vendor interactions. Additionally, Procter & Gamble (Ledger Insights, 2021) has implemented blockchain technology in its supply chain to improve transparency and traceability, ensuring the authenticity and quality of raw materials sourced from vendors.

Moreover, trust deficits and opaque contractual agreements pose significant challenges for traditional vendor selection processes, often leading to disputes and misunderstandings between parties. Smart contracts address these challenges by

automating contract execution and establishing transparent and verifiable records of all transactions and commitments. Maersk's TradeLens platform, powered by smart contracts, exemplifies how blockchain technology can enhance trust and transparency in vendor relationships by streamlining global trade processes and reducing paperwork (Maersk, 2021). For small CPG companies, smart contracts offer the promise of automated execution of predefined contract terms, eliminating the need for intermediaries and reducing transaction costs and processing time.

Smart contracts enable automated payments tied to quality metrics, incentivising vendors to meet performance standards and ensuring accountability. Blockchain's immutable audit trail supports fair dispute resolution, enhancing vendor relationships, product integrity and operational efficiency for small CPG companies.

Consider a small apple juice CPG company seeking to optimise its vendor selection process for sourcing organic apples. Integrating smart contracts via blockchain allows the company to establish transparent sourcing protocols, ensuring adherence to organic standards and traceability throughout the supply chain. Automated payment processes based on quality metrics incentivise vendors to consistently deliver high-quality produce. At the same time, the immutable audit trail provided by blockchain technology facilitates transparent record-keeping and dispute resolution. In this way, smart contracts empower small CPG companies to streamline vendor selection processes, mitigate challenges and build trust-based relationships with their vendors, ultimately driving sustainable growth and profitability in the dynamic CPG industry.

Let's take an example of vendor selection. This vendor selection draft outlines the criteria and process for selecting vendors to source organic apples for our small apple juice Consumer Packaged Goods company. This document will provide transparency and guidance to all stakeholders involved in the vendor selection process. The vendor selected can be "coded" for digital operability using selection criteria presented below.

Criteria for vendor selection:

– organic certification: vendors must possess a valid organic certification from accredited certifying bodies to ensure the integrity of the apples sourced,
– quality standards: apples must meet specified quality standards in terms of freshness, flavour and appearance,
– reliability and timeliness: vendors should demonstrate a track record of reliability and timely delivery to meet our production schedules,
– price competitiveness: competitive pricing while maintaining quality standards is essential to ensure cost-effectiveness,
– sustainability practices: preference will be given to vendors employing sustainable farming practices to minimise environmental impact.

Vendor selection process:

- pre-qualification: interested vendors are required to submit their company profile, including certifications, quality control measures and references,
- evaluation: the vendor selection committee will evaluate vendor proposals based on the predetermined criteria,
- negotiation: shortlisted vendors will be invited for negotiation sessions to finalise terms and conditions, including pricing, delivery schedules and quality assurance measures,
- contract signing: upon successful negotiation, contracts will be signed outlining the terms and conditions of the agreement,
- monitoring and performance evaluation: the performance of selected vendors will be monitored regularly against predefined key performance indicators (KPIs).

In the smart contract coding, vendors can be added with their details, including organic certification, quality score, reliability score and price score. This ensures transparency and eliminates biases in the vendor selection process. The authors' proposed flow for automated procurement and inventory management is provided in Appendix, Table A1.

Thus, smart contracts, facilitated by blockchain technology, offer small CPG companies a powerful tool to enhance vendor selection processes, mitigate traditional challenges and foster more transparent and efficient supply chains. By embracing these innovations, companies can gain a competitive edge, improve operational efficiency and build stronger, trust-based relationships with their vendors, ultimately driving sustainable growth and profitability in the dynamic CPG industry.

4.2. Inventory management and procurement management

Inventory management is crucial to business success, yet traditional practices often suffer from inefficiencies, inaccuracies and transparency issues. Blockchain technology and smart contracts offer innovative solutions by enabling real-time visibility into inventory levels and movements across the supply chain (Gaur & Gaiha, 2020). These tools automate inventory tracking and reconciliation, reducing stockouts, overstocking and inefficiencies. For example, IBM and Walmart's Food Trust platform leverages smart contracts, enabling companies to optimise supply chain efficiency, enhance resource allocation and improve overall operational performance.

Effective inventory management is vital for business success, yet traditional methods often suffer from inefficiencies and transparency challenges. Blockchain

and smart contracts provide real-time visibility into inventory levels and movements, automating tracking and reconciliation to reduce stockouts and overstocking. For instance, IBM and Walmart's Food Trust platform highlights blockchain's ability to create a transparent, immutable ledger for inventory transactions. By leveraging these technologies, companies can optimise supply chain operations, enhance resource allocation, and improve overall efficiency, offering a transformative solution to traditional inventory management challenges.

Blockchain technology transforms procurement by replacing paper-based processes with automated, DLT-based systems, reducing errors, delays and costs through minimised human intervention. Smart contracts streamline multi-party transactions, ensuring compliance and transparency with immutable, auditable operations on the blockchain, enhancing efficiency and trust. Figure 1, which lists the relevant nodes, illustrates this process.

Supplier
Ethical sourcing ensured

Manufacturer
Measure and reduce environmental impacts. Complete data visibility on single shared ledger

Regulator
Reduced need for regulators. Smart contracts ensure quality control throughout the supply chain

Logistics
Automated real-time transport updates

Wholesaler
Manage stock with real-time data

Retailer
Certainty of product provenance and authenticity

Consumer
Supply chain insight empowers informed decision making

cointelegraph.com

Figure 1. Benefits of traceability using blockchain in supply chain
Source: based on: (Singh, 2022).

Consider a small apple juice CPG company supplying its products to a large retailer. The company faces challenges in managing inventory levels, tracking product movements and ensuring timely replenishment to meet customer demand. By implementing smart contracts, the company can automate various aspects of inventory management.

Similarly, the following tasks in inventory management can be more efficiently managed using smart contracts on a blockchain platform:

1. **Automatic Replenishment**: Smart contracts automate inventory replenishment for small CPG companies, such as those producing apple juice, by triggering orders based on predefined criteria. Integrated with inventory systems, they monitor stock levels in real-time and automatically place replenishment orders when levels drop below a set threshold. This ensures optimal inventory levels, minimises stockouts and guarantees an uninterrupted supply to retailers. By eliminating manual intervention, smart contracts streamline operations, reduce administrative overhead and improve supply chain efficiency, enabling the company to focus on core activities while maintaining seamless inventory management.

2. **Automatic Payment**: Traditional inventory management in the Consumer Packaged Goods sector often involves manual, error-prone financial transactions. Smart contracts automate these processes by executing payments based on predefined terms encoded within the contract. For instance, upon delivery, a smart contract can automatically process payments according to agreed conditions, ensuring transparency and trust as transactions are immutable and verifiable on the blockchain. This automation reduces administrative burdens, streamlines workflows and enhances operational efficiency. By minimising manual intervention, smart contracts enable CPG companies to focus resources on core activities, driving cost savings and improved business performance.

3. **Delivery Slips**: Smart contracts digitise and standardise delivery slips, critical for tracking product movement within the supply chain. For instance, when apple juice products are shipped, the smart contract automatically generates a digital slip detailing product information, quantities, shipment date and destination. Stored immutably on the blockchain, this slip ensures transparency and provides a verifiable transaction record. By reducing paperwork and minimising errors, smart contracts streamline the delivery process, enhance communication among stakeholders and facilitate more accurate reconciliation. Their transparency fosters trust and accountability, strengthening relationships between the CPG company and its partners.

4. **Tracking and Traceability**: Smart contracts enable small CPG companies in the apple juice industry to achieve precise product tracking across the supply chain. Integrated with IoT devices and RFID tags, they capture real-time data on product movement and location. For example, RFID tags in packaging can record

when shipments leave the facility, reach distribution centres, or are delivered to retailers. This visibility allows proactive decisions, such as rerouting to avoid delays or optimising distribution to cut costs. Blockchain's immutable ledger enhances transparency, trust and accountability, fostering efficiency and stronger supply chain relationships.

Table 1. Procurement and inventory workflow – traditional vs blockchain

Workflow component	Traditional procurement / inventory model	Blockchain-enabled smart contract model	Expected financial impact
Purchase Order (PO) creation and approval	Manual data entry; multi-level approvals; frequent delays.	Automated PO creation triggered by predefined conditions; instant validation.	Reduction in cycle time. Faster production scheduling. Improved working capital.
Vendor verification and contract compliance	Verification through email/document uploads; prone to errors; inconsistent audit trail.	Vendor credentials and contract terms stored on-chain; immutable, auto-verified.	Reduction in compliance-related disputes & rework. Reduction in administrative cost.
Goods receipt and inventory updates	Batch updates by warehouse staff; lag between physical receipt and system updates.	Real-time inventory updates recorded via smart contract events.	Lower inventory holding cost due to better demand-supply alignment.
Invoice processing and reconciliation	Manual matching of PO, goods receipt and invoice; high rate of mismatches.	Automatic three-way matching executed by smart contracts.	Reduction in reconciliation cost. Fewer payment delays and penalties.
Payment settlement	Payment triggered manually; delays due to verification steps.	Automatic payment initiation after contract conditions met.	Stronger cash flow measurable EBIT improvement.
Recordkeeping and audit	Paper-based or siloed digital records; difficult audits.	Immutable ledger with complete audit trail; easy compliance checks.	Reduced audit hours. Lower overhead expenses.
Dispute resolution	Lengthy back-and-forth communication; unclear data sources.	Transparent, real-time shared ledger reduces ambiguity.	Fewer disputes. Reduction in hidden costs affecting COGS.
Overall governance and visibility	Fragmented visibility; coordination required across teams.	End-to-end transparency across procurement, inventory and finance.	Improved management decision-making. Higher operational efficiency.

Source: own elaboration.

Table 1 compares the traditional procurement and inventory workflow with the proposed blockchain-enabled smart contract model, demonstrating how automation, transparency and real-time validation directly contribute to reductions in COGS, improvements in cash flow and measurable EBIT enhancement.

Implementing smart contracts demonstrates how automation, transparency and traceability can enhance inventory management processes, ultimately driving operational efficiency and customer satisfaction.

5. Project management techniques for effective implementation

Project management plays a pivotal role in translating blockchain and smart contract concepts into practical, measurable business outcomes. It provides the necessary structure for planning, resource allocation, scheduling and risk management, ensuring that technological innovation aligns with business objectives. In blockchain-enabled projects, effective project management bridges the gap between technical execution and financial performance, coordinating tasks, dependencies and stakeholder communication across multiple nodes and teams.

Smart contracts automate the execution of predefined business rules, but project management ensures their seamless integration into existing workflows. Each task within the implementation framework functions as a modular "block", incorporating essential project elements such as scope definition, schedule tracking, cost variance, risk mitigation and progress reporting. These data blocks can be shared across the blockchain network to maintain transparency and real-time alignment with the validated project baseline. This transparency not only enhances accountability but also supports Earned Value Management (EVM) principles, enabling continuous performance assessment through metrics such as cost and schedule variances, critical ratios and efficiency indices. By embedding these project management methodologies into the blockchain framework, organisations can create a synchronised ecosystem in which automated smart contracts trigger updates, and project managers monitor deviations and optimise delivery. The outcome is a more agile, data-driven project environment that minimises administrative overhead, strengthens stakeholder confidence and directly supports the financial and operational objectives outlined in earlier sections.

The above scenarios in project management can kick off a cost variance and schedule variance analysis (Kerzner, 2022). Cost variance (CV) represents the difference between the earned value and the actual cost payment. The earned value

payment (Christensen & Heise, 1993, pp. 7–15) is earned based on the plan cost. A table for each status report period can be set up, and the cost variance can be assessed as positive, neutral or negative, based on the actual earnings.

The cost can also define the schedule impacts based on the cost through the schedule variance analysis. Schedule variance (SV) is the difference between the earned value and the planned value. Since cost is rate times duration, we can factor out the cost rate through a distributed process of math, leaving you with just the schedule impacts. This leaves the project manager with a status statement indicating whether the project is ahead, on schedule or behind schedule. This can be reported to the team using a project management Application Programming Interface (API), as blockchain does not allow data to be overwritten or changed (Hewavitharana et al., 2019). Once CV and SV are generated, they can be used to define the critical ratio (CR) (Larson et al., 2024), which tells the project manager that the plan is underperforming and must be updated, or the blockchain is overperforming, meaning too much money and resources are being allocated to the blockchain.
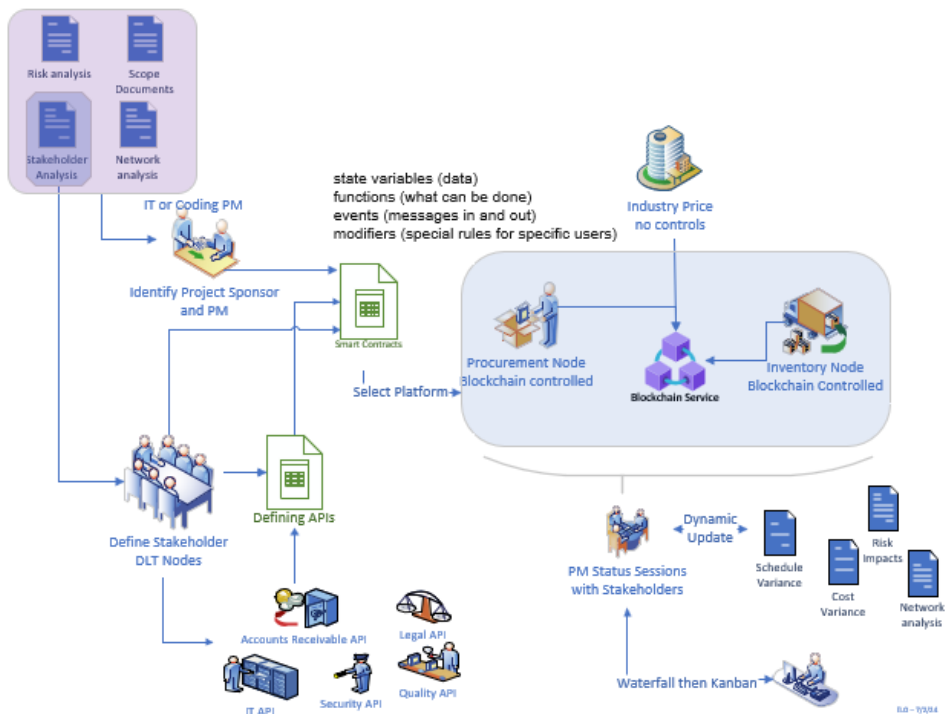

Figure 2. Project management (PM) mindset for blockchain

Source: constructed by the authors as updated PM flow.

With that information, the blockchain smart contracts (Norris, 2019) can be renegotiated, ensuring that funding and resources are updated with each status report period. This prevents the project from starving for resources or over allocating resources that could be used elsewhere. Figure 2 below shows the project management mindset for managing blockchain status.

Smart contracts automate procurement, payments and inventory management processes by executing predefined terms. However, these automated systems still require oversight, especially when discrepancies arise. Critical Ratio (CR) analysis (Kerzner, 2003) enables project managers to monitor performance, indicating whether resource estimates are overstated (sandbagging) or if the project is at risk of contract violations due to resource depletion. If the CR exceeds or falls below the set thresholds, an Estimated to Completion (ETC) analysis (Fleming & Koppelman, 2010) can be used to forecast potential risks, allowing for timely interventions.

Blockchain's transparency minimises manual intervention, but APIs integrated with the system can enhance visibility by dynamically reporting project status, cost variances (CV) and schedule variances (SV). Earned Value (EV) analysis (Naeni et al., 2011) helps track project progress, resource conflicts and discrepancies between planned and actual outcomes. These metrics provide stakeholders with actionable insights, ensuring the blockchain remains aligned with the project's goals.

The automation within blockchain systems allows smart contracts to address operational changes in real-time. For instance, a smart contract in a small beverage company can trigger a replenishment order when the retailer's inventory reaches a critical level, thereby avoiding shortages. Integrating blockchain with project management tools ensures seamless operations without the need for constant human intervention. Project managers must also define clear contractual terms within the smart contracts, including start and end dates, resource allocation and contingency plans for delays or resource unavailability. Escalation paths embedded in the contracts can initiate corrective actions if deliverables or scope are at risk, maintaining the integrity of both the blockchain and the project.

While blockchain automates many aspects, project management ensures alignment between the blockchain ledger and real-world operations. APIs can report discrepancies between the planned baseline and actual outcomes, enabling project managers to adjust resource allocation, scheduling or scope accordingly. These tools mitigate risks and optimise procurement outcomes, particularly in industries with tight margins.

By integrating EV analysis with smart contracts, project managers gain greater control over project timelines, cost structures and resource management because blockchain can track assets at any point in time (Hewavitharana et al., 2019). This approach allows for continuous monitoring and adjustment, minimising disrup-
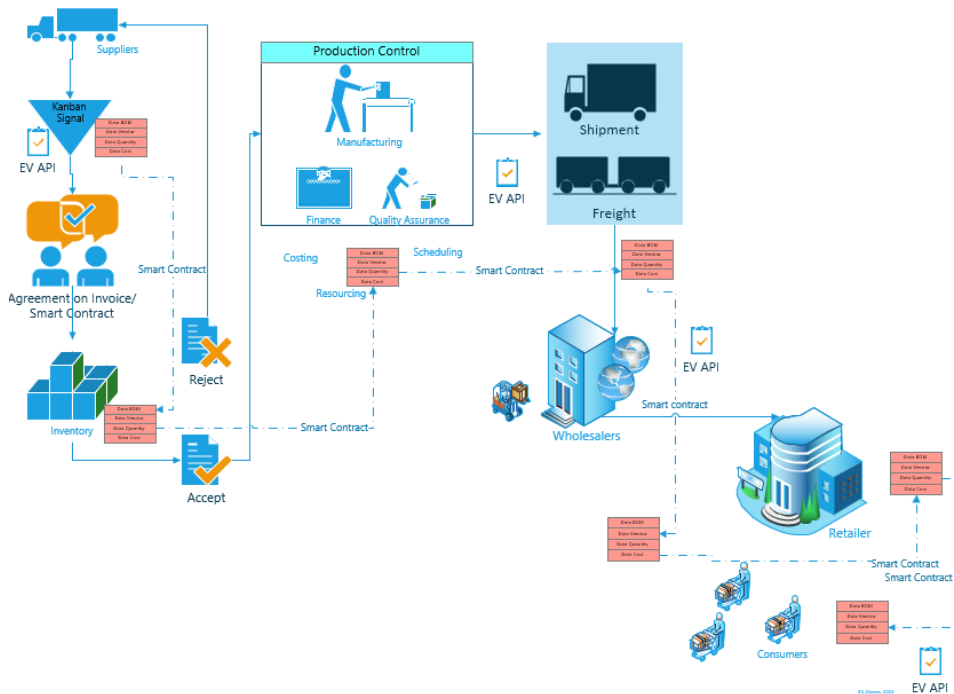
Figure 3. Smart Contract EV/API

Source: authors' own elaboration.

tions while capturing valuable data for future projects. In this way, project management complements blockchain automation by consistently achieving operational efficiencies and financial objectives. Figure 3 illustrates the flow and monitoring of the EV.

6. Practical challenges for implementation of blockchain

The blockchain assumes that many operational items will already be in place for it to work. One potentially problematic issue is the assumption that resources will be available when the contract states they should be. The project team may reassign these tasks to other projects if the smart contract indicates that an action has not been completed and holds payment or resources. When the contract states that all conditions are satisfied, it will authorise the next steps, even if the resources required may not be readily available.

Our first step is to identify and define the process. This is necessary to address the challenges that a clinical study will face while aiming to improve operational performance and reduce COGS. Below are some of the challenges we have identified, along with opportunities to improve operational processes.

1. Buyer involvement.
    The blockchain/smart contracts will not be implemented until both parties, producers and, eventually, buyers (B2C or B2B), agree to use the blockchain technology on the same blockchain platform.
2. Cost and complexities.
    A readily available blockchain platform can be employed if both parties agree on a specific Cloud environment on a pre-selected blockchain platform, which could cost approximately $5,000 per month. This cost is solely for infrastructure. Additionally, there is the cost of hiring in-house personnel, including a smart contract programmer, who is needed to write smart contracts. This is an additional cost. Other complexities include integrating blockchain with current software packages, as well as regulatory/legal issues (Fulmer, 2018), among others.
3. Software automated internal business operations.
    Blockchain is just a digital ledger. To seamlessly impact business operations, decisions must be automated. For example, an order to replenish stock should be automatically triggered from the buyer to the seller. Payment transactions, order generation and automated status checks are tasks involved. These can be triggered only if the buyer and seller already have software that automates business operations.
4. Identify the best "ledger"/"account" within business operations.
    COGS is a metric achieved by pooling several accounts, or "ledgers", that have both cash inflows and outflows. The question, then, is which of these accounts offers the greatest cost-effectiveness when placed on a blockchain – is it inventory, procurement or another operational ledger entirely?
5. Identify the appropriate external stakeholder to partner with for blockchain implementation.
    Supply chain links, even for smaller CPG companies, are varied and numerous. From raw-material procurement to value-adding suppliers, the question becomes which link/node offers the strongest partnership for testing a blockchain process. Should the pilot involve an ingredient supplier, a wholesale distributor or another stakeholder in the chain?

These are just a few elements that pose significant roadblocks to blockchain implementation. However, over time and as business practices become increasingly digitised, many of these roadblocks will either fade away or be replaced by relevant digital platforms.

7. Future directions

Building on the implementation framework developed in Phase Two, the next stage of this business clinical study will focus on pilot deployment and empirical validation within a small CPG company. Phase Three will operationalise the proposed blockchain-enabled smart contract model across selected workflows, specifically vendor selection, procurement management, purchase order management and quality-control documentation. This real-world implementation will enable continuous monitoring of workflow speed, cost reductions and contractual compliance using both automated and manual performance indicators.

To strengthen empirical contribution, Phase Three will incorporate quantitative impact measurement, informed by findings from previous studies and industry benchmarks. For example, Deloitte (2022) reports that blockchain-based automation in supply chain processes can reduce administrative processing time by 30–50%, lower reconciliation costs by 20–40% and improve working capital availability by 3–6% due to faster approvals and settlement cycles. In CPG operations, some other research estimates that even a 1–2% reduction in COGS can lead to disproportionately larger gains in EBIT for firms operating on narrow margins. These benchmarks will guide the performance expectations of our pilot study and serve as comparative indicators for assessing improvements in procurement cycle time, inventory holding costs and transaction-related expenses.

Phase Three will also evaluate organisational readiness, including the training requirements for finance, procurement and legal teams, the integration needs with existing ERP systems, and the governance mechanisms necessary to support smart contract execution.

Overall, the future phases of this clinical-style methodology will transform the conceptual framework into an evidence-based operational model, enabling us to validate financial impact, identify best practices and develop a replicable roadmap for broader adoption across the CPG sector and other low-margin industries.

Conclusions

In this paper, our objective is to outline, in chronological order, the challenges and benefits at different stages of implementation that can be employed by a set of CPG producers and their B2B partners, provided they are in mutual agreement to test the process.

Smart contracts can enable cost-effective operations through the inherent efficiencies, automation, transparency and security of blockchain technology.

Additional benefits include faster decision-making time, reduced authorisation requirements and the elimination of unnecessary steps, all of which are inter-connected. However, the remaining questions are at what stage of production, at what level of earnings before interest and tax (EBIT), and at what profit-margin threshold blockchain becomes cost-effective?

Based on the findings, we recommend that companies initiate pilot implemen-tations in high-impact areas, such as vendor payments, purchase order tracking and quality assurance approvals – processes that often bottleneck CPG supply chains. Firms should also invest in training project managers and finance teams to understand smart contract design, compliance implications, and the integra-tion of smart contracts with existing ERP systems. Measures such as defining clear performance metrics (COGS reduction, cycle time improvement and working capi-tal gains) and continuously monitoring them will allow firms to evaluate ROI and make data-driven scaling decisions. Project management tools and methods are used to ensure the operations run smoothly. The blockchain's automated actions will allow the project team to focus on risk mitigation and future project designs.

Our next step in this clinical-style study with a beverage manufacturing firm is to validate this framework under real-world conditions, measuring its effect on procurement cycle time, inventory holding costs, and transaction cost reduction. If successful, this model could serve as a replicable pathway for other CPG com-panies and industries with tight margins to achieve greater operational efficiency, stronger cash flow management and improved profitability through blockchain-enabled automation (Raskin 2017, p. 309).

Appendix

Table A1. The flow of automated procurement and inventory management proposed by the authors

If	Then	Comment
...YOURPACK delivers the packaging line to Panache until the 1st of March 2025	...50 per cent of contract amount is automatically paid to the account of YOURPACK	
...YOURPACK delays the delivery of packaging line to Panache until the 1st of March 2025	...payment to YOURPACK is calculated as 50 per cent of the contract minus 0.3 per cent of the contract amount per one day of this delay	The delivery is finalised after quality inspector of Panache digitally approves the incoming quality control checklist
...packaging line is reaching the planned production output of 2,000 bottles per shift	...50 per cent of contract amount is automatically paid to the account of YOURPACK	
...packaging line delays reaching the planned production output of 2,000 bottles per shift	...payment to YOURPACK is calculated as 50% of the contract minus 0.3% of the contract amount per one day of such delay	Production output is calculated by packaging line automatically and is sent on hourly basis to both companies
...Panache delays the payment based on abovementioned conditions more than for 24 hours	...packaging line gets blocked automatically until the payment is received by YOURPACK	Blocking and unblocking of packaging line is steered by the system which receives the input from blockchain protocol

Source: authors' own elaboration.

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The role of the primary balance in assessing the financial situation of local government

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Abstract

The key aspect of assessing the financial condition of local government units in Poland is compliance with the individual debt repayment and service ratio. Equally important is the budget balance – especially if it is negative, in which case funding sources must be identified. The operating balance – the difference between current revenues and expenditures – also significantly impacts debt service ability and is embedded in the Polish legal-financial framework. Currently, financial assessments focus mainly on the budget and operating balances. However, the authors propose incorporating an additional measure – the primary balance – defined as the difference between total revenues and expenditures, excluding debt servicing. This study aims to apply the primary balance to evaluate the financial condition of all local government units in Poland over the period 2004–2023. The findings confirm the value of using the primary balance as a key indicator of financial stability.

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Introduction

The performance of public functions by local government units (LGUs) requires them to have stable sources of funding. The lack of sustainability, continuity and certainty of funding can be viewed through the prism of financial risk. Generally, in finance, risk is understood as both an opportunity and a threat, most often in the context of deviations from planned values. The materialisation of risk can have both positive and negative consequences. It can also be understood as the probability of failing to achieve assumed objectives (Jajuga, 2007, p. 13). However, in the case of public finances – including local government finances – financial risk is perceived mainly in a negative way, as the inability to finance and thus implement public tasks (Wiśniewski, 2011, pp. 85–87). Poniatowicz (2010, p. 326) stresses that risk is defined as the probability of incurring a loss. Liquidity risk is considered to be a crucial risk, the occurrence of which can lead to destabilisation in key areas of the functioning of public entities. Thus, it may not only shake the financial situation of a public entity, but also have an impact on the economic, social and political spheres (Owsiak, 2017, p. 929).

The financial security of public sector entities is generally understood as the ability to finance public functions and, in particular, to repay and service debt in the lack of long-term changes in fiscal policy. If this is not the case, a situation may arise where governments can use debt instruments to finance long-term imbalances (deficits). This can lead to a debt spiral in which debt service costs can increase significantly (Buiter, 1985, p. 15).

Many considerations have been made in assessing the financial health and thus the financial security of LGUs, focusing, among other things, on ensuring liquidity (Groves et al., 1981, p. 6) or ensuring high quality public services, and thus meeting the needs of the population at an appropriate level (Alam et al., 2017, p. 75; Wang et al., 2007). For this reason, the study of the primary balance, which is understood as the difference between the revenues and expenditures of the budget excluding the cost of debt service, becomes more important. On this basis, it is possible to indicate the risks associated with the burden of debt service expenditures on the budget, as well as the sensitivity of the expenditures structure to changes in debt service costs.

In this context, the report of the Supreme Audit Office is significant, as it identified a number of irregularities that not only led to a deterioration of the financial situation but also identified the risk of a decrease in the quality of public services provided. As part of the survey conducted by the Supreme Audit Office, representatives of the LGUs identified the following risks (among others) resulting from the deterioration of the financial situation (Najwyższa Izba Kontroli, 2024):

– the lack of ability to absorb external funds,

– the risk of withdrawing from projects already implemented, especially investment projects.

Therefore, the authors of the article apply one measure – the primary balance – to local government units in Poland. The study was carried out for all units in the years 2004–2023. The results obtained make it possible to highlight the importance of this measure in the study of the financial situation of units, especially from the point of view of the burden of debt servicing costs. In addition, it was possible to highlight discrepancies between different types of units in terms of this characteristic, also in dynamic terms. The results obtained justify the use of the primary balance as an important indicator in assessing the financial situation of local government units.

1. Literature review

The starting point for this discussion is the concept of budgetary balancing, which focused on reducing government intervention in the economy, which, among other things, had the effect of creating long-term deficits and financing them with debt. These issues have been considered in the context of benefits to society as a whole, and in particular the expansion of social welfare. Balancing the budget is one of the main objectives of public finance management. For this process, it is necessary to increase revenues and decrease expenditures. In addition, the budget balance is important for the decision-making process (Rubin, 2020, p. 197). Debt-financed budgetary expenditures shift the burden over time. In addition, the future generation of taxpayers is not represented at the time the debt is incurred, and this may create a temptation for current taxpayers to take on more debt than is actually needed (Barro, 1974, p. 1116; Wagner, 2004, pp. 197–198).

In this context, the discussion about the threat to ongoing private investment posed by the accumulation of public debt is also relevant, as it may be crowded out of the market. Furthermore, such a situation may lead to an excessive increase in the tax burden, which may not be acceptable or understandable for a given generation (Ferguson, 2015, p. 198). Indeed, public debt should only be incurred over a certain period of time and should therefore not lead to a loss of confidence among citizens (Peukert, 2006, pp. 491–495). Roberts (1942, pp. 260–261), on the other hand, also pointed out that excessive tax burdens (as a result of new debt) can drive capital out of the country. Lenders will continue to finance the government's debt if the interest rate is high enough (Stiglitz & Rosengard, 2015, p. 52).

In view of the above-mentioned effects of over-indebtedness and the uncontrolled use of debt instruments by public authorities, the approach to fiscal stabili-
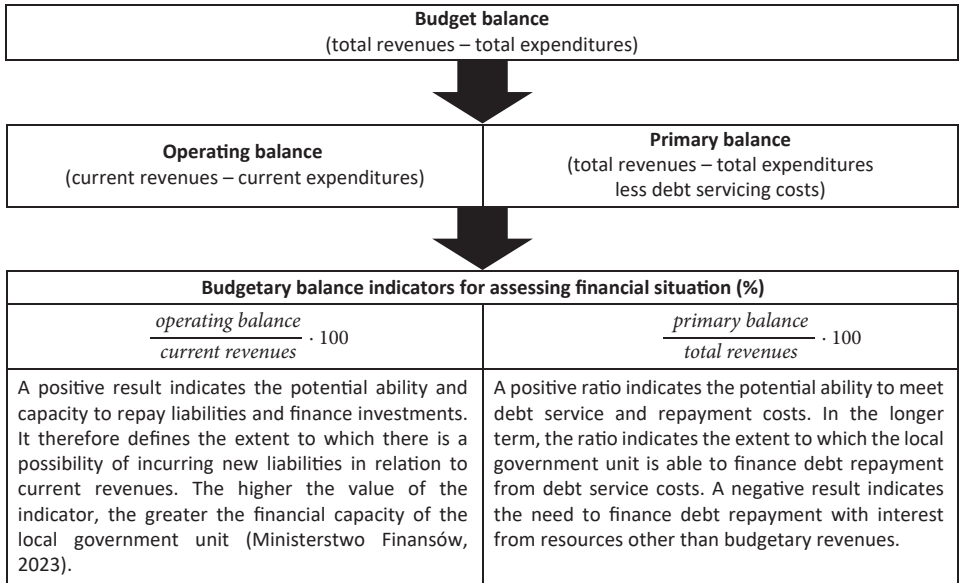
sation becomes important. First, the coordination of debt and fiscal policy should be a consequence of changes in tax revenues in relation to changes in debt. This is because tax revenues change directly in response to an expenditures shock. This phenomenon is accompanied by a smoothing of tax rates, with the result that only a small part of investment spending is financed by current tax changes. Thus, weaker shocks mean that debt is less responsive to a shock, and government revenues must respond to changes in government debt in a way that is consistent with the rationale for the existence of fiscal restraint (Bhandari et al., 2017, p. 630; Canzoneri et al., 2016, pp. 50–52; Corden, 2010, pp. 44–46; Domar, 1944, pp. 798–827). Second, it should be borne in mind that the "golden rule of public finance" has its justification in deficits to promote investment. Consequently, they can be covered by future revenues, provided there is a broad tax base (Dosi et al., 2022, p. 173; Ostry et al., 2015, p. 9).

For years, various indicators have been used to assess the security of public finances, the values of which are supposed to determine their well-being. The best known and most popular solutions in this respect are the nominal convergence indicators used in the European Union, i.e. indicators representing the ratio of the budget deficit and public debt to a country's GDP (TFEU, 2016, Article 126). At this point, it is worth mentioning a complementary measure of the security of public finances – in this particular case of local governments – which is the primary balance, i.e. the budget balance excluding debt service expenditures. In this context, the fiscal rules applicable to local government units in Poland are relevant, the most important of which is the rule of balancing the current budget, the so-called operating budget (Ustawa, 2009, Article 242). This rule affects the ability of local government units to finance debt repayment and servicing.

On this basis, it is justified to use the primary balance rule as a complement to both the fiscal rules applied and the indicators for assessing the financial sustainability of local government units (Scheme 1).

The concept of using the primary balance as a complementary measure for assessing the financial sustainability of LGUs has its place in the literature. If the level of government debt is stable in the longer term, this implies that the primary surplus should be sufficient to finance all debt burdens. However, the positive rate of change in relation to GDP could represent a dangerous situation for the safety of public finances. In this context, it is necessary to calculate the measure such as the ratio of the primary budget balance to GDP (Džakula & Karalić, 2013 p. 71). This measure is particularly important in a period of high interest rates, as it makes it possible to determine the sensitivity of the budget to a change in interest rates and, on this basis, to estimate the financial potential. Given the purpose of this paper, further considerations and empirical research will focus on the primary balance.

According to Polish fiscal rules, the budget balance is the difference between revenue and expenditure. Debt incurred and its repayment are not taken into ac-

| Budget balance |
| (total revenues – total expenditures) |

| Operating balance | Primary balance |
| (current revenues – current expenditures) | (total revenues – total expenditures less debt servicing costs) |

Budgetary balance indicators for assessing financial situation (%)	
$\dfrac{operating\ balance}{current\ revenues} \cdot 100$	$\dfrac{primary\ balance}{total\ revenues} \cdot 100$
A positive result indicates the potential ability and capacity to repay liabilities and finance investments. It therefore defines the extent to which there is a possibility of incurring new liabilities in relation to current revenues. The higher the value of the indicator, the greater the financial capacity of the local government unit (Ministerstwo Finansów, 2023).	A positive ratio indicates the potential ability to meet debt service and repayment costs. In the longer term, the ratio indicates the extent to which the local government unit is able to finance debt repayment from debt service costs. A negative result indicates the need to finance debt repayment with interest from resources other than budgetary revenues.

Scheme 1. Budget balance as a measure of LGUs financial sustainability

Source: own elaboration.

count. One of the fiscal rules designed to ensure the stability of local government finances is the operating balance.

Debt sustainability is understood as a situation in which the solvency condition is met after taking into account the cost of servicing the debt (International Monetary Fund, 2002, p. 5). In other words, the definition of debt sustainability would have to start from its opposite, i.e. a situation in which the public authorities are unable to pay their liabilities on time. In this context, the link between debt and the primary balance becomes particularly important (Wyplosz, 2005, pp. 2–3). From a debt sustainability perspective, fiscal rules based, inter alia, on different types of budget balances are relevant. Such fiscal rules can cover different subsets of fiscal volumes, including the objective of borrowing exclusively for investment purposes (Kopits & Symansky, 1998, p. 2).

For example, the Australian government, on the other hand, presents the level of the primary balance as part of its analysis of the final budget outturn for 2022–2023 (Commonwealth of Australia, 2023). The debt sustainability is preserved, when the primary budget surplus has positive reactions to the debt burden (Ostry et al., 2015). It is therefore one of the indicators used to assess the state of public finances.

The category of primary balance is the subject of consideration of many scientific studies, in which the relationship between primary balance and phenomena in public finance is proved.

Taking into account the literature on the subject, Table 1 presents selected conclusions from the academic research carried out on the primary balance and its impact on both budget categories.

Table 1. Primary balance in academic research

Author	Main conclusions
Rangarajan & Srivastava, 2003	Debt accumulation can be treated as the result of the cumulation of primary deficits and surpluses weighted by the rate of economic growth.
Qin et al., 2006; Uryszek, 2017)	Using the primary balance to assess fiscal sustainability, including local government.
ECB, 2011	Primary surpluses should be sufficient to finance debt repayment.
European Commission, 2012; Marchewka--Bartkowiak & Wiśniewski, 2015	The primary balance rule should be one of the indicators for assessing the sustainability of a country's public finances. The primary balance indicator would make it possible to assess when a country has entered a path of debt stabilisation, including public finances.
Nerlich & Reuter, 2013	Fiscal rules limiting government expenditures have a positive impact on the primary balance.
Heun, 2014	The absence of a primary deficit as a premise for sustainable public finances.
Artés & Jurado, 2018	Lower primary deficits are a consequence of the ability of majority governments to raise revenues.

Source: own elaboration based on literature.

The studies and their results presented in the table refer to the central level or to the state of public finances in general. As far as the local government sub-sector is concerned, the results of a study of 116 Spanish LGUs are worth mentioning. It was found that the control of financial sustainability can be strengthened through the systematic monitoring of expenditures resulting from commitments (Bolívar et al., 2014, p. 50).

To summarise the existing literature, one of the causes of primary deficits at the central level can be both an increase in the real level of interest rates on debt and a loosening of fiscal discipline. This often leads to the emergence of local deficits. Increases in public debt at the local level can sometimes be the result of fiscal relations between central and local governments. This is particularly evident when transfers from the central government to the lower levels are characterised by a lack of transparent criteria, sometimes also through negotiations or ad hoc topping-up of the occurring deficits (Ter-Minassian & Craig, 1997, p. 156). The statements in the literature concerning the primary balance also apply to local government units.

2. Methods and data sources

The aim of this study is to apply a measure such as the primary balance to assess the financial condition of local government units in Poland. In particular, the authors set out to identify trends in the primary balance over time and by entity, and also attempt to identify the reasons for discrepancies between the primary balance and the budget balance.

As a preliminary step, it is important to define precisely the various financial categories that are the subject of the study. In European statistics, the budget balance in the general government sector is referred to as net lending (+) / net borrowing (−)[3] and is assigned the symbol 'B.9' (according to European system of accounts – ESA, 2010). It is generally defined as the difference between total revenues and expenditures of this sector. If a central or local government spends more than it receives in the form of government revenues, the value of this balance is negative and indicates a deficit; the opposite situation represents a surplus. The value of the balance is also given by general government subsectors (ECB, 2019, pp. 11–12).

In the structure of public expenditures, those related to the ongoing servicing of the public debt (i.e. mainly interest, fees) are distinguished as a priority. Expenditures on debt service costs are referred to as 'interest payable' and are coded 'D.41 U'. The budget balance reduced by debt service costs is referred to as the primary balance, which can take the form of a primary surplus or primary deficit, respectively (ECB, 2014, p. 10). This balance reports the difference between general government budget revenues and 'pure' expenditures, i.e. excluding expenditures incurred on interest costs paid on the debt taken on. The analysis of the primary balance in comparison with the budget balance provides an indication of how much the public budget is burdened by current debt service expenditures. In addition, it makes it possible to see to what extent debt service expenses add to the budget deficit, but also from which 'sources' they are financed. The OECD in its studies adds that the existence of a primary deficit means that the government must borrow money to pay for the everyday public goods and services it provides for citizens, which may not be sustainable. The primary balance is thus a critical indicator of the short-term sustainability of a government's finances (OECD, 2021).

The subject of the study was the values of the primary and budget balance of all local government units in Poland in the years 2004–2023. The source of the data was the units' budget reports published by the Ministry of Finance. Due to the

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[3] Following the detailed methodology of ESA, these phrases can also be understood as "net increase in receivables" / "net increase in debt", which should also be regarded as the so-called net borrowing needs (Marchewka-Bartkowiak, 2011, p. 39; Wernik, 2011, p. 79).

significant diversity of the studied group, in order to ensure comparability of the examined financial categories, their values were expressed in a relative way, in relation to total revenues. Local government units are divided into six groups based on their type, because the scope of their public tasks and sources of financing differ.

3. Results

Due to the vastness of the research material, it was necessary to do some aggregation of the results obtained. Firstly, the development of the average value of the primary and budget balance in relation to total revenues for all LGUs is presented (Figure 1).
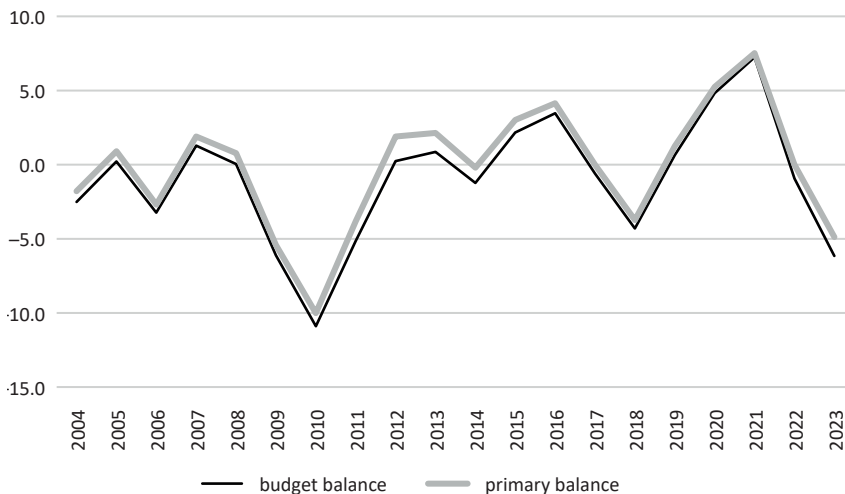

**Figure 1. Budget and primary balance in relation to total revenues –
average for all LGUs (in %)**

Source: own elaboration based on data of the Ministry of Finance (Ministerstwo Finansów, 2025).

The values presented in the above figure make it possible to identify which years in the period under study were, on average, the weakest in terms of the financial health of local government units. In particular, on average, the LGUs' negative budget balances were heaviest in the period of the global financial crisis and the years following it (2009–2011), as well as in the years 2022–2023. From the data presented, it is also possible to note the periods in which the discrepancy between the examined balances was the greatest, i.e. the debt service costs were the highest. The development of the value of costs in relation to total revenues is presented in Figure 2 – as an average for all LGUs and by the type of an LGU.
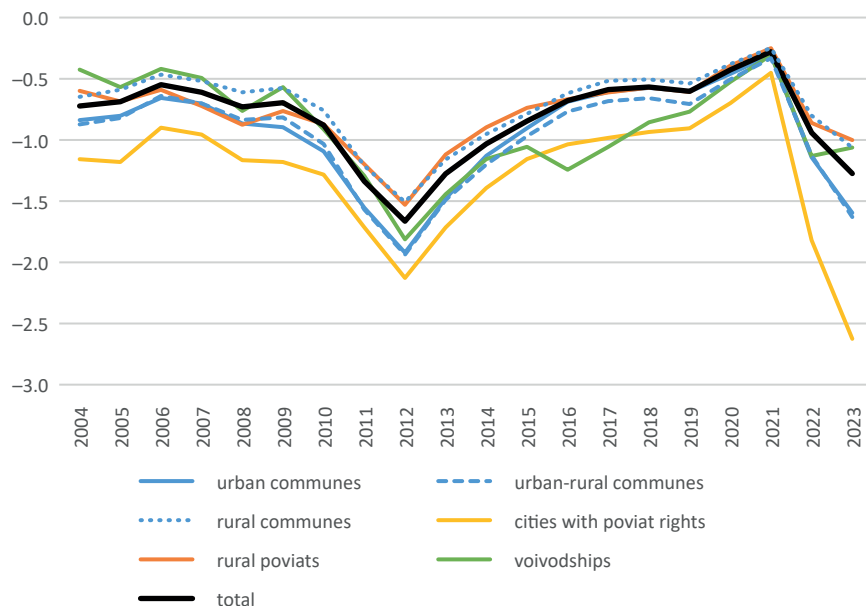
Figure 2. Debt service expenditures in relation to total revenues (in %)

Source: own elaboration based on data from the Ministry of Finance (Ministerstwo Finansów, 2025).

Debt servicing costs are presented as negative values to highlight the fact that they reduce available public resources. A combined analysis of the data presented in Figures 1 and 2 confirms that the highest debt servicing costs occurred in 2011–2015 and in 2022–2023. Thus, in these periods, the gap between the primary and budget balances was usually the largest. In addition, the breakdown of units by their type identified that, on average, the highest debt service costs were carried by cities with poviat rights.

In order to present more synthetically the differences between the primary and budget balances, as well as debt service expenditures, it was decided to divide the study period into sub-periods, distinguished by differences mainly in terms of economic circumstances:

– I sub-period – 2004–2007 – the time before the global financial crisis,
– II sub-period – 2008–2014 – the time of the global financial crisis and recovery,
– III sub-period – 2015–2019 – the time of economic prosperity, the period between the financial crisis and the COVID-19 pandemic; the period of relatively low and stable interest rates (in Poland, from March 2015 to March 2020, the NBP reference rate was 1.5%),
– IV sub-period – 2020–2023 – the time of the COVID-19 pandemic, as well as a period of turbulence related to Russia's invasion of Ukraine, resulting in high-

er spendings by LGUs due to, among other things, increased energy costs and spendings on war refugee aid.

Figure 3 shows, on average, the values of the tested balances and debt service expenditures in relation to total revenues. Debt service expenditures are again shown as negative values, reducing the primary balance into the budget balance.
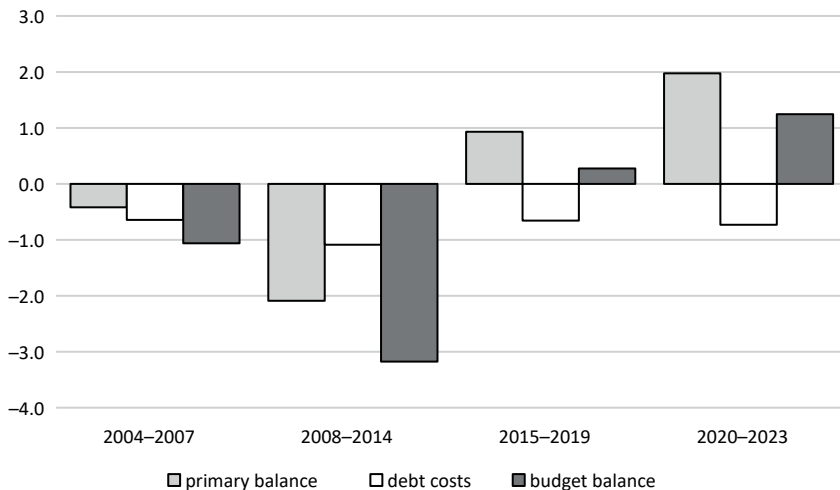

Figure 3. Primary balance, debt service expenditures and budget balance in relation to total revenues – average values for all LGUs in selected time periods (in %)

Source: own elaboration based on data of the Ministry of Finance (Ministerstwo Finansów, 2025).

In the period before the financial crisis, LGUs had, on average, a negative primary balance, meaning that usually, public revenues were insufficient to cover 'pure' public expenditures, and debt service further enlarged the budget deficit. During the crisis, the situation only deteriorated further and, for the most part, the primary deficit was higher than 2% of total revenues and debt service expenditures eventually widened budget deficits to more than 3%. In the second half of the 2010s, the financial situation of LGUs improved and, on average, units were running both primary and budget surpluses. Intriguingly, since the early 2020s – despite the COVID-19 pandemic and the negative effects of the war in Ukraine – the situation of LGUs has mostly improved even more. This situation was influenced, among other things, by the one-off transfer of additional funds from the central budget in 2021–2023. Due to the diversity of tasks performed by different types of local government units, Figure 4 presents the examined indices by LGU type.

As can easily be seen, the worst financial situation concerned cities with poviat rights, in particular in the last of the examined periods. From the mid-2010s onwards, most local government units generally recorded a positive primary bal-

urban communes

urban-rural communes

rural communes

cities with poviat rights

rural poviats

voivodeships

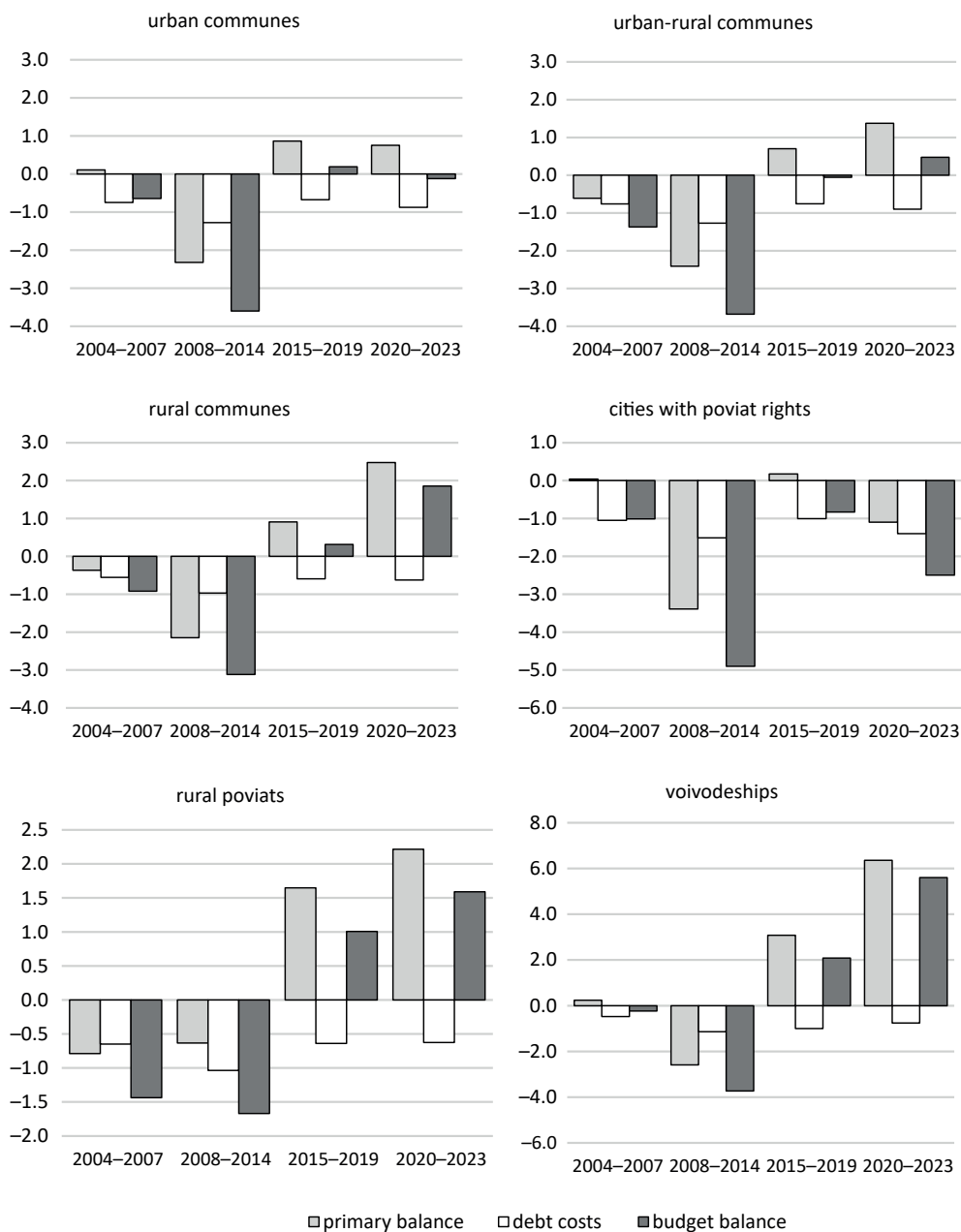☐ primary balance   ☐ debt costs   ■ budget balance

Figure 4. Primary balance, debt service expenditures and budget balance in relation to total revenues – average values for particular types of LGUs in selected time intervals (in %)

Source: own elaboration based on data of the Ministry of Finance (Ministerstwo Finansów, 2025).

ance, with cities showing the lowest values. At the same time, the average bud-
get balance was positive for most units, but remained negative in the case of cit-
ies. The early 2020s brought only a deterioration of the financial situation for cit-
ies. Generally, in recent years these units have recorded a primary deficit of more
than 1% of total revenues and, after taking into account debt service expendi-
tures, have obtained a budget deficit of more than 2% of total revenues on aver-
age. Interestingly, other units have fared much better during this period, including
primarily voivodeships, but also communes (mainly rural), as well as rural county
(poviat) units. Over the twenty-year period under analysis, a clear reversal can be
observed: counties (rural poviats) and communes – particularly rural and urban–
rural ones – initially exhibited the weakest financial positions, but have achieved
a markedly stronger financial standing in more recent years. In addition, it is easy
to see that the overall positive evaluation of the recently examined balances pre-
sented in Figure 3 is overestimated precisely by rural and urban-rural communes,
poviats and voivodeships – the averages were calculated by the number of units
and not the value of their budgets.

The results obtained correspond to analyses performed by both local govern-
ment organisations and the findings of the Supreme Audit Office in 2024. The
Association of Polish Cities pointed out the progressive deterioration of the finan-
cial situation of LGUs as early as 2020. In particular, attention was drawn to the
declining operating surplus (the positive difference between current revenues and
current expenditures), which was expected to decrease significantly in subsequent
years as a result of, among other things, planned tax changes (ZMP, 2020). It was
emphasised that in 2023 cities with poviat rights had an operating deficit of PLN
2.93 billion, which was the largest of all types of LGUs (ZMP, 2024). The worsen-
ing of the situation of cities with poviat rights in Poland in 2019–2022 was clearly
indicated by the Supreme Audit Office. One of the reasons for the weakening of
the stability of local finances was the changes introduced in Poland related to the
Polish Deal programme, as well as the discrimination of these LGUs in the distribu-
tion of government funds (Najwyższa Izba Kontroli, 2024). The above conclusions
and the impact of these actions on the primary balance are in line with the find-
ings of the literature on the relationship between representatives of the central
government and the local government sub-sector reflected in the distribution of
state budget transfers (Ter-Minassian & Craig, 1997, p. 156).

Next, an attempt was made to diagnose the reasons for the amount of local
government expenditures on debt servicing. Among the obvious reasons for the
increase in expenditures, it was necessary to examine the growth of the debt, as
well as its interest rate, which in Poland is to a large extent variable, and there-
fore dependent on changes in interest rates and the central bank's monetary pol-
icy. Clear evidence of the dependence of expenditure levels on the two identi-
fied determinants is provided by Figures 5 and 6. These figures overlay debt ser-

vice expenditures as a share of total revenues with, respectively, the growth rate of local government debt and the National Bank of Poland's reference rate – the key monetary policy rate, which directly influences interbank interest rates and thereby largely determines the interest rates on both loans contracted by local government units and the securities they issue. The cost of debt is expressed as a percentage of total revenues of the units, while the growth rate of local government debt and the NBP reference rate are expressed as percentages. The value of the NBP reference rate changes throughout the year, sometimes many times, so the values given for a certain year are a weighted average of the months in which the rate was in force.
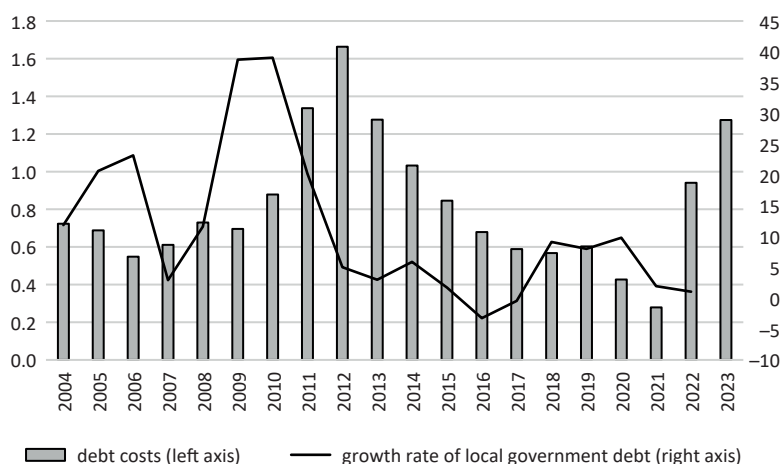

Figure 5. Debt service costs as a percentage of total revenues of LGUs vs growth rate of local government debt (in %)

Source: own elaboration based on data from the Ministry of Finance (Ministerstwo Finansów, 2025).

In the case of the impact of the growth of local government debt on the amount of expenditures incurred for its servicing, a time lag is observable, which seems justified, as liabilities drawn in a given year result in their servicing costs in subsequent years. In the case of the reaction of debt service expenditures to changes in interest rates in the economy, it is possible to speak of an immediate and obviously positive relationship. It can therefore be concluded that the predominant part of local government debt has been contracted at variable interest rates (indexed to market rates).

With reference to the primary balance rule, it is important to establish the relationship between the primary balance of the local government sub-sector and the primary balance of the general government sector. This is because the principle of balancing public finances requires taking comprehensive measures aimed at the outcome of the entire sector. Thus, it will make it possible to limit the risk
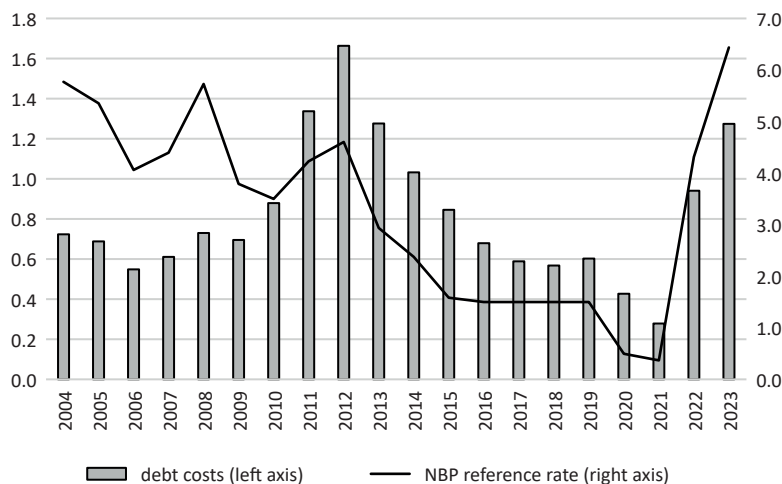
Figure 6. Debt service costs as a percentage of total revenues of LGUs vs the NBP reference rate

Source: own elaboration based on data from the Ministry of Finance (Ministerstwo Finansów, 2025).

of instability of public finances of particular sub-sectors and, consequently, of the whole sector.

Conclusions

The theoretical considerations and empirical research carried out in this article clearly indicate the importance of the primary balance in assessing the financial health of LGUs. The literature review shows that the primary balance indicator should be applied in the assessment of sustainability of local finance. Thus, it can constitute one of the fiscal rules in both the medium and long term.

Empirical studies conducted by the authors have shown that, firstly, the analysis of the value of the primary balance in connection with the budget balance provides important information on the financial stability of units. A situation in which an entity does not generate a positive primary balance and, in addition, the debt service significantly increases the budget deficit, should raise concerns about the state of its finances and trigger supervisory action. For this reason, the authors recommend the inclusion of this measure in the common assessment of LGUs' financial security.

In addition, the research carried out has proved that in recent years the situation of cities with poviat rights has deteriorated markedly. This is observable in

particular in comparison with voivodeships (for which the best situation can be observed), rural poviats and communes, mainly rural and urban-rural, whose situation in the perspective of the last two decades has definitely improved. Such a diagnosis requires a detailed analysis of, on the one hand, the tasks that cities perform and the related expenditures and, on the other hand, the local government revenues system. The persistence of such a situation in the long term may lead to a degradation in the quality of the public services provided. The weakening of the finances of cities with poviat rights has already been acknowledged by the Supreme Audit Office, which has strongly emphasised the need for stabilising changes.

Finally, it was also pointed out that debt servicing expenses depend on the level of interest rates as well as, with a lag, on the rate of debt growth. In the light of the results of the study, it is particularly necessary to introduce scenario-based methods in financial planning in LGUs, allowing the resilience of the units to a potential increase in financing costs (caused by an increase in interest rates) to be examined.

Future research could also enrich the analysis of local government financial security by incorporating assessments of gross and net borrowing needs in the context of refinancing risk management. The measures used hereby refer to net needs, but the refinancing of local government debt and the scale of this phenomenon is also relevant, which, in the context of a fluctuating environment, including the volatility of interest rates, may imply potential risks associated with refinancing risk. In addition, the evolution of the primary balance, particularly the occurrence of deficits in election years, offers prospects for using this measure in identifying the political cycle and its effects on the local government subsector.

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Measuring price dynamics from the perspective of the poorest households in Poland

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Abstract

Poland, like many other countries, lacks a price dynamics index tailored to the poorest households. The aim of this article is to develop a Subsistence-Adjusted Price Index (SAPI) – an indicator of the dynamics of the costs of living. SAPI complements the Consumer Price Index (CPI) by enabling a more accurate assessment of the real cost of living faced by the poorest households, while also allowing for regional analysis. The analysis is based on data on the subsistence minimum from the Polish Institute of Labour and Social Studies and CPI inflation data from Statistics Poland covering the period 2006–2024. The analysis revealed substantial discrepancies between the two measures: the cumulative price increase measured by the SAPI amounted to 154.87%, whereas the CPI indicated an increase of only 87.58%. In addition, the SAPI appears to lead the CPI by approximately two years. It was recommended that the SAPI be included in official statistics and adopted as an indexing factor for social benefits, minimum wages and pensions, which could improve the effectiveness of social policy and reduce income inequality in Poland.

Keywords

• Subsistence-Adjusted Price Index (SAPI)
• CPI
• subsistence minimum
• inflation
• social benefits

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Introduction

Portillo et al. (2016) propose a model that integrates monetary economics with economic development theory by incorporating a food subsistence threshold into a New Keynesian framework. The authors' key thesis is that in economies where a significant portion of the population lives close to the subsistence level, relative food prices become the main channel for transmitting economic shocks and, therefore, a significant determinant of overall inflation. This means that in such countries, classical monetary policy principles derived from models of highly developed economies may lead to erroneous conclusions and suboptimal central bank responses.

A minimum level of food consumption ($\overline{c}_F$) was introduced into the standard utility function, defining the biological minimum for household survival. This modification causes total consumption to be nonlinearly proportional to income, and the demand for food becomes nonlinear and less elastic to changes in prices and income.

The marginal utility of food increases rapidly as consumption approaches the threshold $\overline{c}_F$. Therefore, even a small increase in food prices in poor countries forces significant changes in the consumption of other goods and the structure of household expenditures. As a result, supply shocks in agriculture translate much more strongly into overall inflation and production declines in the non-food sector than in developed economies. This relationship introduces a structural mechanism that reflects the process of economic transformation – as income increases, the share of food in the basket market decreases, and the economy becomes less sensitive to food shocks.

A supply shock in the food sector of poor countries triggers a stronger increase in overall inflation, as households cannot limit their food consumption below the subsistence level. This forces a reduction in demand for non-food goods, which in turn intensifies the recessionary effect of the shock. The authors show that in such economies, more than half of overall inflation is explained by changes in food prices, while in developed economies, this share drops to a few percent.

The model developed by Portillo et al. (2016) suggests that general inflation does not accurately reflect the cost of living for households operating in different segments of income distribution. The classic index is inappropriate for measuring inflationary pressures in an economy where a large portion of the population operates under subsistence constraints. In such cases, an alternative index based on the subsistence minimum should be considered, accounting for the nonlinear structure of expenditures and the sensitivity of consumption to food prices. In economies where a significant portion of consumption is for goods that are income-inelastic, the conventional inflation index distorts the picture of inflation-

ary pressures. Introducing an index based on the subsistence level, different from traditional inflation yet correlated with it, would allow for a better measurement of the real cost of living and explain the sources of differences in inflation dynamics between income groups. Nowadays, differentiating the indicator into regional levels will allow for an even better assessment of the poverty level.

Diewert's (2020) contribution should not be overlooked in this field of research. He develops an economic approach based on the assumption that consumers make decisions to minimise the costs of achieving a given level of utility, which accounts for substitution effects – changes in consumption patterns in response to changes in relative prices. Diewert (2020) demonstrates that the typical Laspeyres and Paasche indices represent, respectively, upper and lower bounds of the Konüs index – the ratio of the minimum costs of achieving a given level of utility at different price levels – which represents the theoretical "true" cost-of-living index. He also discusses the existence of intermediate indices that provide stable reference points for maintaining a constant standard of living. He discusses superlative indices such as Fisher, Walsh, Törnqvist-Theil and CES, which are closely related to elastic forms of utility functions and accurately capture consumer behaviour in response to price changes. A strong approximation exists between these indices, making them practically interchangeable (Diewert, 2020). It highlights significant practical challenges, such as the problem of matching products in aggregated data, resulting from, among other things, irregular purchases or seasonality, which requires the use of extended reference periods and more flexible product definitions.

Turvey's (2000) article demonstrates that although the cost-of-living index (COLI) theory developed by, among others, Diewert elegantly formalises the idea of comparing the minimum expenditures needed to maintain the same level of utility at two sets of prices, it relies on assumptions that are systematically violated in actual consumer behaviour. It highlights the problems of inconsistent preferences, endowment effects, dependence of utility on the consumption of others and discrepancies between the weighting period and the price period, which undermines the interpretability of the CPI as an approximation of a true COLI. He particularly criticises the inclusion of durable goods (e.g. housing) in the index, which are of little use as a deflator, compensatory index or measure of inflation. He demonstrates that in practice, the decisive factors are a clearly defined index purpose, basic economics, common sense and, sometimes consciously adopted, arbitrary procedures. In conclusion, the author argues that the formal theory of the "true COLI" is intellectually interesting but may be largely ignored by statistical offices: it is better to openly describe the CPI as a measure of changes in the cost of a reference basket than to try to link it to a hypothetical, highly simplified theoretical construct.

These conclusions are consistent with the contributions of Lokshin et al. (2023). Their report demonstrates the impact of the cost-of-living crisis of 2022–2023 on

various household groups in Europe and Central Asia. The authors use the COLI method to construct a CPI that reflects actual consumption patterns and price changes for individual households. The paper highlights the limitations of the standard CPI, which, based on a universal consumption basket, fails to capture the range of price increases and individual differences in spending patterns. The empirical results indicate significant heterogeneity in price increases, with the poorest households suffering the most, experiencing inflation on average 2.3 percentage points higher than the wealthiest ones (Lokshin et al., 2023, p. 3). The largest differences were primarily related to increases in food and energy prices, which account for the largest share of expenditures among less affluent households. The regressive nature of inflation was particularly evident, implying the need for a more differentiated approach to social policy. The authors recommend using individual cost of living indicators to monitor and index social benefits, especially for the most vulnerable groups, such as single-person households and the elderly. The above two works provide empirical evidence of the uneven effects of inflation, especially for the poorest, and indicate the need to use more precise, individual indicators of the cost of living for monitoring and shaping social policy.

The Distributional Consumer Price Indices (D-CPIs) are a modern set of indices that measure real-time inflation heterogeneity across sociodemographic group in the US, maintaining full consistency with the methodology of the official CPI. The methodology combines monthly price changes from the CPI with annual expenditure shares from the Consumer Expenditure Survey, allowing for the calculation of group-specific inflation while maintaining a consistent total with the aggregate CPI. The study reveals that inflation has been significantly higher for lower-income groups, resulting in a real increase in income inequality that is approximately 45% faster than suggested by official data (Jaravel, 2024). Furthermore, 2.3 million people are currently misclassified above the poverty line despite being within it. In the post-COVID-19 period, inflation has been highest for the middle class, primarily due to increases in gasoline and vehicle prices, which have contributed to an accelerated real wage compression. Jaravel (2024) also highlights higher inflation rates for older adults and African Americans and explains the limitations of the methodology, including the conservative nature of the Laspeyres index and the homothetic nature of consumer preferences. The results emphasise the need to account for inflation heterogeneity in official statistics and social policy to better reflect economic reality.

While the D-CPI could be implemented in Poland, recent research has focused on a different approach – optimising the existing CPI weights – within a five-year project supervised by the Polish economist Białek[2] (2018–2023). The project in-

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[2] "Optymalizacja pomiaru wskaźnika cen dóbr i usług konsumpcyjnych" [Research project]. 2018–2023. Narodowe Centrum Nauki. (Project No. 2017/25/B/HS4/00387).

volved research on the best selection of parameters for the Fisher superlative index, which best approximates the COLI, as well as on optimising the weights and lag parameter in Laspeyres indices. One of the goals is to create a new, hybrid component index combining the advantages of various methods to minimise the CPI bias while simultaneously reducing the need for frequent, costly weight updates. It combines the ideas of Young and Lowe indices and is an innovative proposal in price index methodology, utilising additional information on the correlations between prices and product quantities. In an empirical study based on scanner data from Polish supermarkets (products such as milk, sugar, coffee, rice), the hybrid index and its geometric version proved to be better approximations for the Fisher index than the traditional Laspeyres index, despite using expenditure data from the previous period (Białek, 2020). Białek's research had previously suggested the need for optimisation – frequent updates of weights in the Polish CPI basket effectively mitigate substitution effects, and the greatest impact on bias is exerted by price imputation of new and disappearing goods, while correlations between prices and quantities have a minimal impact on the CPI bias (Białek, 2014).

1. Definition of a market basket and a subsistence minimum

Market basket is a fundamental concept in measuring inflation, denoting a set of goods and services representative of an average consumer in each country or region. This basket is a simplified model of household consumption patterns – it reflects which commodities are purchased, in what proportions, and how their prices change over time.

In practice, the inflation basket includes both tangible goods, e.g. food, clothing and fuel, and services, e.g. transportation, education and healthcare. The selection of its components is representative – the goal is to represent average consumer spending as closely as possible, rather than to fully capture all possible market transactions. Currently, the most used inflation indices are the Consumer Price Index (CPI) and the Harmonised Index of Consumer Prices (HICP).

The Consumer Price Index (CPI) is a national inflation index that reflects changes in the average price level of consumer goods and services purchased by households in each country. Data for its calculation typically comes from household budget surveys and national accounts, and the weighting structure reflects the shares of individual expenditure categories in total consumer spending. In most countries, including Poland, the CPI weights are updated periodically, usually at least every

few years, to ensure the stability of intertemporal comparisons. The CPI is used, among other things, to index wages and social benefits, deflate macroeconomic indicators and assess national price dynamics.

The Harmonised Index of Consumer Prices (HICP) is an inflation measure developed by Eurostat to ensure the comparability of inflation data across European Union member states; however, it is also introduced by countries outside the EU. The HICP coexists with national CPIs and is based on the same underlying data: both the HICP and CPI "are built on the same granular data, and uniform concepts, methods and compilation techniques are applied up to the elementary level" (Knetsch et al., 2024, p. 3). The HICP covers only households' final monetary consumption expenditure, meaning it excludes items that do not generate actual monetary flows, such as imputed rent for owner-occupied housing (OOH). An important methodological aspect of the HICP is the annual update of weights, based on the latest data on the structure of consumer spending. This allows the index to respond more quickly to changes in consumer behaviour and better reflect the current consumption structure in member states.

Another difference is the purpose of constructing both indices. The CPI is primarily used for national inflation analyses and practical applications, such as indexing benefits and wages. The HICP, on the other hand, has an international character – it provides a basis for inflation comparisons across European Union countries and serves as the key inflation indicator used by the European Central Bank in its monetary policy decision-making process in the euro area.

In this paper, the living wage or **subsistence minimum** will be defined based on an indicator developed by the Polish Institute of Labour and Social Studies (IPiSS) called *Minimum Egzystencji*, which translates to subsistence minimum (SM).

The subsistence minimum (sometimes called the biological minimum) assumes the absolute minimum necessary for survival – it marks the line of extreme poverty. It considers the costs of food, housing, clothing and footwear, health care and hygiene, as well as education. It completely ignores the costs of transportation and communications, culture, sports and recreation (Kurowski, 2002). Therefore, it is not an indicator that captures the minimum of a decent life – this is the responsibility of the IPiSS index called the *Minimum Socjalne*, translated as the social minimum. The SM index is based on data from Statistics Poland (GUS) and originally comprised, among other things, a limited list of approximately 20 product groups defined according to "safe consumption" standards. This basket included basic food items, medical supplies (limited to a small number of prescriptions per year), essential hygiene products, modest clothing and footwear (including repairs and replacements), and minimal education-related expenses, such as used textbooks and participation in a small number of school events (Deniszczuk & Sajkiewicz, 1997). It also accounts for minimal housing with access to basic utilities: "the area of the apartment was assumed to correspond to the so-called sanitary standard,

which is approximately 7 m^2 of usable area per person, i.e. approximately 5 m^2 of living area" (Kurowski, 2002, p. 4).

The most significant limitation of this approach is the lack of comparability with data prior to 2006. At that time, thorough, more restrictive changes were introduced to the basket calculation, along with annual updates of weights (Deniszczuk et al., 2006). The valuation assumed that low-income households purchase inexpensive, unprocessed food from supermarkets or local markets and take advantage of promotions and discounts. It is also assumed that low-income households experience difficulties in paying rent regularly, with some households falling into arrears. In the housing context, the phenomenon of homelessness has been recognised as a state of being below the SM level. Furthermore, it is assumed that the child's parents can take advantage of the family benefits to which they are entitled under the social assistance system. In the context of education, the household incurs expenses for necessary school supplies, such as notebooks, used textbooks, gymnastics uniforms and replacement shoes. It was also assumed that, with the exception of underwear and footwear, clothing was obtained through donations, while a limited number of children's garments – such as trousers subject to rapid wear – were purchased at markets or marketplaces. It was assumed that households purchased the least expensive hygiene products, especially those offered at promotional prices or in discount retail chains. The list of purchased medications was expanded, and it was assumed that specialist medical services would be used only by children, while other household members would rely exclusively on services covered by general health insurance. In addition, a contingency reserve of 5% of total other expenditures was included (Deniszczuk et al., 2006).

Since the basket has a weighted structure and represents the minimum needs of a household, it can function as a full substitute for the standard inflation basket. As of 2024, its simplified structure is as follows: 41% allocated to food, 42.4% to rent and energy, 2.8% to home furnishings, 3.9% to clothing and footwear, 1.7% to health care, 3.4% to hygiene and 4.8% to other expenditures (excluding education) (Kurowski, 2025).

2. Methodology

The most basic methods of calculating inflation are the Laspeyres (1871), Paasche (1874), and Fisher (1922) indices.

The Laspeyres index uses a basket of goods from a base period and measures its cost in the current period:

$$P_{La} = \frac{\sum_i p_t^i q_0^i}{\sum_i p_0^i q_0^i} \tag{1}$$

where:

p_t^i – the price of good i in the current period,

p_0^i – the price of good i in the base period,

q_0^i – the quantity of good i in the basket in the base period.

The greatest advantage of the above index is the simplicity and interpretability of price changes. However, it does not account for changes in consumption patterns and may overestimate inflation in the event of substitution of goods. The Paasche index, on the other hand, uses a basket of the current period and measures the price change relative to the base period:

$$P_{Pa} = \frac{\sum_i p_t^i q_t^i}{\sum_i p_0^i q_t^i} \tag{2}$$

where:

q_t^i – the quantity of good i in the current period.

Unlike the Laspeyres method, it considers actual consumption patterns in each period. However, it requires accurate data on current expenditures and may underestimate inflation if consumers react quickly to price increases by substituting goods. One could argue that the best indicator of inflation would be to combine these two methods by averaging them. Therefore, five decades later, Irving Fisher presented his method:

$$P_F = \sqrt{P_{Pa} \cdot P_{La}} \tag{3}$$

Currently, basket weights are updated annually; thus, a Paasche-type index with annually updated weights is applied. In the case of IPiSS SM index, the new SAPI index can be defined as follows:

$$\text{SAPI} = \frac{\text{SM}_t - \text{SM}_0}{\text{SM}_0} \tag{4}$$

The acronym SAPI stands for a Subsistence-Adjusted Price Index, which constitutes the focus of this study. The most recent research on the subsistence minimum (Kurowski, 2025) presents a rate-of-change index that partially reflects the SAPI concept. Unfortunately, a major limitation is the lack of consistent data, as IPiSS changed the method of determining SM since 2006 and the data are not fully comparable with previous years (Kurowski, 2007). Extending the analysis by recon-

structing historical data is currently beyond the scope of this work. This paper will also use the SM index per single person (average costs for single men and single women), due to its more restrictive nature resulting from higher per capita costs. The CPI is not random in nature; however, statistical tests were used to maintain standard analytical practice and enable comparison of the results with other studies.

In this work, an Augmented Dickey-Fuller test (ADF) was performed to to assess the stationarity of both indices. This was followed by correlation and cross-lagged correlation analyses, as well as the Engle-Granger cointegration test (1987), to examine the relationship between the CPI and SAPI. To test homoscedasticity, Levene's test was conducted to determine the equality of their variances. To demonstrate the possibility of regional analysis, preliminary calculations were also conducted, showing how SAPI has developed across Polish voivodeships.

3. Results

3.1. Nationwide measurements

Table 1 presents the subsistence minimum (SM) index, used as a base to calculate the Subsistence-Adjusted Price Index (SAPI).

Table 1. Subsistence minimum for a single-person household as an average value for men and women (in PLN)

2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
372.70	386.30	413.20	415.33	472.72	500.68	521.11	541.91	544.09	545.76
2016	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	
555.02	574.01	591.14	616.55	614.74	617.36	775.42	901.04	949.89	

Source: own work based on IPiSS datasets from 2006 to 2024 (IPiSS, n.d.).

Analysing the data, it can be shown that the SAPI in Poland evolved as shown in Table 2 for individual years.

Table 3 presents inflation values for the same analysed years in Poland. Average annual inflation was computed using GUS data, employing the CPI with a base year of 1998 = 100 and a chain-linked methodology based on monthly indices where the previous month equals 100. For each year, the CPI was averaged, using a weighted average based on the number of days in each month. The price dynamics index is then calculated as the ratio of the current year's average to the previous year's average. Figure 1 provides a comparison between CPI and SAPI.

Table 2. SAPI calculated from IPiSS data rounded to two decimal places

2007	2008	2009	2010	2011	2012	2013	2014	2015
3.65%	6.96%	7.78%	6.15%	5.91%	4.08%	3.99%	0.40%	0.31%
2016	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
1.70%	3.42%	2.98%	4.30%	−0.29%	0.43%	25.60%	16.20%	5.42%

Source: own work.

Table 3. Annual average CPI in Poland from 2007 to 2024; calculated using data from Statistics Poland

2007	2008	2009	2010	2011	2012	2013	2014	2015
2.39%	4.35%	3.83%	2.71%	4.23%	3.74%	1.17%	0.17%	-0.91%
2016	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
−0.65%	2.00%	1.80%	2.19%	3.36%	5.17%	14.46%	11.36%	3.81%

Source: own work based on data from Statistics Poland (GUS, n.d.).
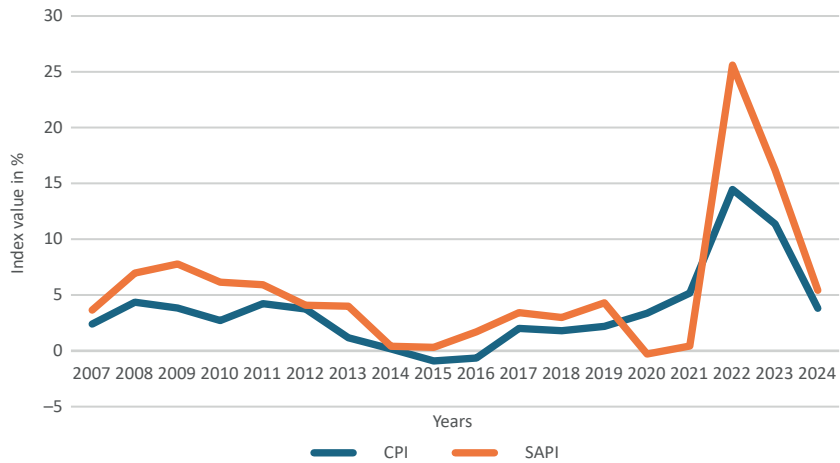

Figure 1. Comparison between CPI and SAPI in Poland from 2007 to 2024

Source: own work.

The geometric mean of annual inflation equals 3.56% for the CPI and 5.34% for the SAPI. Over the analysed period, cumulative inflation amounted to 154.87% according to the SAPI, compared with 87.58% as measured by the CPI.

Heuristic data analysis shows that the CPI uses methods that mitigate the impact of extremes, providing more stable reading, better distinguishing between core inflation and seasonal or one-off spikes, and is preferred by central banks for interest rate decisions due to its greater stability. In contrast, the SAPI is highly

sensitive to one-off changes in commodity prices, blending long-term trends with short-term effects, making it useful for monitoring current price shocks. Therefore, the CPI is a more reliable measure of long-term inflation and underlying price pressure because it reduces the impact of one-off commodity price changes and seasonality. The SAPI, on the other hand, better identifies sudden market shocks, thus better reflecting actual inflation.

In 2015–2016, Poland experienced a period of broad-based deflation, largely caused by falling energy and transport prices, which impacted the CPI. At the same time, food prices, which dominate the SM index, behaved differently – in 2016, their price growth was 1.0%. Although moderate, this represented an increase, not a decrease. The highest increases were for sugar (26.9%), fruit (5.5%), fish (3.6%) and vegetables (2.8%). The increases of other product prices included bread (0.6%), pasta products and couscous (0.5%), as well as selected types of meat: pork (1.5%), calf (1.3%) and beef (0.5%) (GUS, 2017). In 2020, the SAPI was negative, even though the CPI was positive and high – that year, the increase was in services (tourism, entertainment, culture) and discretionary consumer goods, which were included in the CPI basket but not in the subsistence minimum basket.

The year 2022 represents a special case in inflation analyses in Poland. According to the National Bank of Poland (NBP) Inflation Report (NBP, 2022), the CPI reached a record high. This increase was not due to classical demand mechanisms, but rather to an exogenous supply shock – Russia's aggression against Ukraine, a sharp rise in energy and commodity prices, and disruptions in supply chains. Furthermore, the scale of fiscal interventions (Anti-Inflation Shields or Government Solidarity Shield) and the breakdown of standard monetary policy transmission caused the relationships between inflation, GDP growth and unemployment in 2022 to deviate from historical macroeconomic relationships. During this period, high inflation coexisted with record-low unemployment and positive economic growth, consistent with the short-run Phillips curve relationship, driven by supply shocks rather than demand-pull factors. For this reason, 2022 can be considered an outlier – an unusual period dominated by one-off and external factors.

3.2. Voivodeship-wide measurements

Since 2013, the IPiSS report has also included a spatial analysis covering all voivodeships. Taking this step further, IPiSS reports since 2021 have also included SM calculations for cities with selected population ranges, allowing for even more diversification and precision in calculating actual inflation. Table 4 presents the SM values in PLN for individual voivodeships in the years 2013–2024.

For each voivodeship, regional SAPI was calculated and presented in Table 5.

Table 4. Subsistence minimum for a single-person household as an average value for men and women in PLN in each Polish voivodeship

Region	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
DŚ	563.73	569.60	573.07	587.81	611.67	631.99	654.71	679.56	701.05	823.84	946.73	990.93
KP	539.66	536.43	540.14	549.65	561.24	585.67	608.30	632.56	660.62	777.18	896.21	938.30
LE	501.95	505.42	505.92	512.23	522.47	542.59	574.14	595.41	617.54	713.54	828.49	871.35
LU	554.56	560.19	567.90	578.90	603.22	628.79	658.66	686.26	713.90	795.71	920.67	977.04
ŁÓ	547.23	544.96	543.58	550.65	569.79	594.78	621.99	650.33	676.34	778.50	901.75	943.68
MP	534.11	531.52	534.63	541.43	560.78	581.81	605.61	633.58	665.54	762.19	870.32	933.18
MZ	525.48	530.48	534.03	544.26	561.91	575.87	595.66	619.98	650.77	775.88	908.84	951.58
OP	528.10	528.36	532.19	547.58	571.45	588.17	614.66	632.78	668.70	797.91	924.09	973.22
PK	505.59	504.87	507.10	512.09	531.14	549.45	572.56	594.47	615.20	725.21	843.84	894.78
PL	543.38	544.71	544.39	547.26	563.08	580.24	600.85	619.05	651.45	739.01	846.35	877.50
PM	563.94	573.28	573.89	581.72	603.36	623.41	646.91	671.97	697.99	839.36	965.31	1008.36
ŚL	559.82	561.81	559.08	570.91	595.01	611.61	640.57	663.98	701.21	793.37	918.78	979.79
ŚK	523.13	521.09	514.06	519.93	547.67	567.75	598.73	621.60	648.63	744.64	852.04	909.59
WM	516.32	509.25	511.44	523.94	545.20	562.69	594.37	620.89	650.22	769.52	896.29	927.95
WP	551.77	561.06	564.62	574.60	593.69	613.47	638.99	661.94	691.73	780.67	905.96	962.81
ZP	589.48	589.56	594.29	601.00	609.82	626.65	658.89	684.01	710.25	792.43	926.99	979.71

Note: the above codes mean (voivodeships): DŚ – Lower Silesian, KP – Kuyavian-Pomeranian, LE – Lublin, LU – Lubusz, ŁÓ – Łódź, MP – Lesser Poland, MZ – Masovian, OP – Opole, PK – Subcarpathian, PL – Podlaskie, PM – Pomeranian, ŚL – Silesian, ŚK – Holy Cross (Świętokrzyskie), WM – Warmian-Masurian, WP – Greater Poland, ZP – West Pomeranian.

Source: based on (IPiSS, n.d.).

Table 5. Regional SAPI and their cumulative value calculated from IPiSS data rounded to two decimal places

Region	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	CUM
DŚ	1.04%	0.61%	2.57%	4.06%	3.32%	3.59%	3.80%	3.16%	17.52%	14.92%	4.67%	75.78%
KP	−0.60%	0.69%	1.76%	2.11%	4.35%	3.86%	3.99%	4.44%	17.64%	15.32%	4.70%	73.87%
LE	0.69%	0.10%	1.25%	2.00%	3.85%	5.81%	3.70%	3.72%	15.55%	16.11%	5.17%	73.59%
LU	1.02%	1.38%	1.94%	4.20%	4.24%	4.75%	4.19%	4.03%	11.46%	15.70%	6.12%	76.18%
ŁÓ	−0.41%	−0.25%	1.30%	3.48%	4.39%	4.57%	4.56%	4.00%	15.10%	15.83%	4.65%	72.45%
MP	−0.48%	0.59%	1.27%	3.57%	3.75%	4.09%	4.62%	5.04%	14.52%	14.19%	7.22%	74.72%
MZ	0.95%	0.67%	1.92%	3.24%	2.48%	3.44%	4.08%	4.97%	19.22%	17.14%	4.70%	81.09%
OP	0.05%	0.72%	2.89%	4.36%	2.93%	4.50%	2.95%	5.68%	19.32%	15.81%	5.32%	84.29%
PK	−0.14%	0.44%	0.98%	3.72%	3.45%	4.21%	3.83%	3.49%	17.88%	16.36%	6.04%	76.98%
PL	0.24%	−0.06%	0.53%	2.89%	3.05%	3.55%	3.03%	5.23%	13.44%	14.52%	3.68%	61.49%
PM	1.66%	0.11%	1.36%	3.72%	3.32%	3.77%	3.87%	3.87%	20.25%	15.01%	4.46%	78.81%
ŚL	0.36%	−0.49%	2.12%	4.22%	2.79%	4.74%	3.65%	5.61%	13.14%	15.81%	6.64%	75.02%
ŚK	−0.39%	−1.35%	1.14%	5.34%	3.67%	5.46%	3.82%	4.35%	14.80%	14.42%	6.75%	73.87%
WM	−1.37%	0.43%	2.44%	4.06%	3.21%	5.63%	4.46%	4.72%	18.35%	16.47%	3.53%	79.72%
WP	1.68%	0.63%	1.77%	3.32%	3.33%	4.16%	3.59%	4.50%	12.86%	16.05%	6.28%	74.49%
ZP	0.01%	0.80%	1.13%	1.47%	2.76%	5.14%	3.81%	3.84%	11.57%	16.98%	5.69%	66.20%

Note: see Table 4.

Source: own work.

Between 2014 and 2024, regional SAPI ranged from 61% in the Podlaskie Voivodeship to 84% in the Opole Voivodeship. The highest values are attributed to the sharp increase in housing, services and energy costs, as well as increased demand pressure resulting from urbanisation and rising incomes. In metropolitan regions (e.g. Masovia and Pomerania), demand factors dominated, while in peripheral regions (Opole and Warmian-Masurian Voivodeships), cost factors and limited market competition dominated. The lowest values (Podlaskie, West Pomeranian and Łódź Voivodeships) suggest weaker consumer demand, lower incomes, and the impact of external factors such as cross-border trade and stable real estate prices.
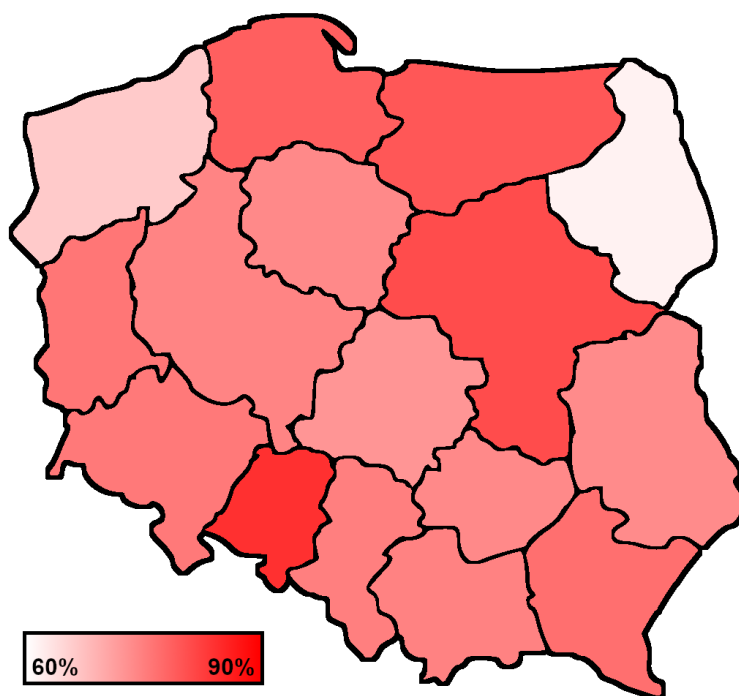

Figure 2. Cumulative SAPI value for Polish voivodeships from 2014 to 2024

Source: own work.

Regional analysis of the SAPI index reveals significant variation in the dynamics of prices for basic goods for the poorest households. As shown in Figure 2 and Table 5, cumulative SAPI growth ranged from 61% in the Podlaskie Voivodeship to 84% in the Opole Voivodeship, indicating surprising, yet predictable, disparities in inflationary pressures between regions. The factors influencing these differences are beyond the scope of this study.

4. Empirical testing and validation

Each of the tests presented was performed at a 5% significance level. The Augmented Dickey-Fuller test with 1 lag was performed to test whether the CPI and SAPI are stationary. The number of lags was selected based on the AIC criterion. Both the SAPI and CPI achieve stationarity at order I(1) (then $ADF_{SAPI} \approx -4.878$ and $ADF_{CPI} \approx -3.463$. The correlation between differentiated data is $r \approx 0.887$ ($p \approx 0.000$), which confirms the short-term relationship. The Engle-Granger cointegration test (1987) allows for testing when both series are of the same order – the result $ADF \approx -3.133$ confirms the long-term relationship.

Due to the small amount of data, the Shapiro-Wilk test was used to analyse the normal distribution of differences between the indices. The test results of $W \approx 0.870$ and $p \approx 0.017$ confirm that the differences are not normally distributed. Therefore, the two-tailed Wilcoxon test was used to compare the differentiated data sets. With a p-value of approximately 0.734, the test provides no evidence of a statistically significant difference between SAPI and CPI changes; however, this may be due to the small data sample. Additionally, cross-lagged correlation was calculated on differentiated data. Tables 6 and 7 present the results for up to five lags.

Table 6. Cross-lagged correlation values with up to 5 lags between differentiated SAPI and CPI

Number of lags	SAPI is ahead by	CPI is ahead by
1 lag	0.00099874	−0.00529646
2 lags	−0.68111341	−0.27416939
3 lags	0.24192432	−0.26749151
4 lags	0.29400005	−0.10067681
5 lags	−0.05026842	0.49829130

Source: own work.

Table 7. Cross-lagged correlation *p*-values with up to 5 lags between differentiated SAPI and CPI

Number of lags	SAPI *p*-value	CPI *p*-value
1 lag	0.997	0.984
2 lags	0.003	0.320
3 lags	0.367	0.353
4 lags	0.288	0.743
5 lags	0.864	0.094

Source: own work.

The results indicate asymmetry: the only significant relationship is a moderate, negative correlation with a 2-period lead of the SAPI relative to the CPI, while the CPI does not significantly lead the SAPI at any of the lags. When the growth rate of subsistence minimum accelerated, approximately two periods later, the growth rate of the overall CPI inflation weakened. Existence costs for the poor (food, energy, basic housing) are more volatile and susceptible to commodity price shocks, causing them to fluctuate rapidly. However, the CPI is smoother because it includes services, durable goods and components less sensitive to short-term increases in food or energy prices.

Discussion and conclusions

The results indicate that the SAPI and CPI are two imperfectly synchronised inflation measures, with fluctuations in the prices of basic necessities for low-income households leading changes in overall inflation by about two periods with a negative correlation. This suggests that anti-inflation policies based solely on the CPI may not adequately reflect the actual price pressures on the poorest households. According to Portillo et al. (2016), an increase in the prices of basic goods should translate into an increase in overall inflation, so the correlation should be positive; however, the observed result is a negative correlation, which means that the increase in prices for the poorest is correlated with a subsequent decrease in overall inflation. To confirm the conclusions that SAPI changes lead CPI changes by 2 lags, I propose conducting a Granger causality test along with a sensitivity study of the 2022 outlier and extension with historical data. Although the composition of the subsistence minimum basket may raise doubts due to infrequent updates, it is still a very good indicator of the lowest poverty line. The SAPI can be useful as a tool supporting inflation analysis, especially in quickly responding to changes in the prices of basic goods, but it does not completely replace the official CPI.

An open question remains as to whether the SAPI measures the intended economic phenomenon. An index based solely on the subsistence level has a built-in static view of need. Even poor people have different preferences and needs, e.g. higher medical costs or transportation to work. A fixed basket may not adequately capture the complexity of poverty and changing needs, but it is still a significantly better indicator than the CPI. Between 2006 and 2024, the SM basket increased in price almost twice as fast as the CPI basket, which means that the poorest households experienced substantially higher inflation than that indicated by the general CPI. Over this period, cumulative inflation amounted to 154.87% according to the SAPI, compared with 87.58% under the CPI.
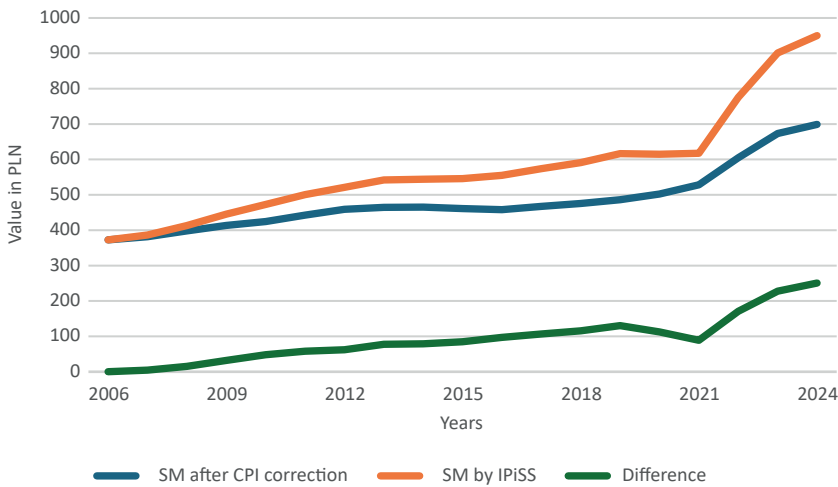
Figure 3. Differences between SM valorised with CPI and with SAPI

Source: own work.

Figure 3 shows that if the 2006 SM amount was indexed to inflation, it would reach PLN 699.09 in 2024. This means a shortfall of PLN 250.80, or approximately 26.4% of the actual SM amount in 2024. In the same year, spending on clothing, footwear, health care, personal hygiene and expenses other than food or housing amounted to 13.8% of the SM amount (Kurowski, 2025). Other conclusions should be drawn from the analysis – the fact that the CPI is not correlated with the (differentiated) SAPI means that these are two independent indicators. Considering this statement and the simulation presented in Figure 3, it would be dangerous and inappropriate to adjust social benefits based on the CPI.

Overall, the findings of this paper indicate that the SAPI could and should be used to update social benefits such as family allowances, housing benefits and social scholarships, ensuring they are aligned with the real costs of living for the poorest households. Currently the main legal act regulating the indexation of social benefits in Poland is the Act on Pensions and Disability Benefits from the Social Insurance Fund (Ustawa, 1998), which in Article 89 defines the formula as: indexation = average annual CPI in the previous calendar year + at least 20% of the real increase in average wages in the previous year. In contrast, the indexation of unemployment benefits is based solely on the CPI inflation index and does not take wage increases into account, as specified in the Act on Employment Promotion and Labour Market Institutions (Ustawa, 2004) and the Act on the Labour Market and Employment Services (Ustawa, 2025).

It can serve as a reference for setting the minimum wage and monitoring poverty and social inequality, as is the case in Georgia.

The Georgian law of 1997 introduced a systematic mechanism for monitoring and adjusting citizens' living standards by establishing and updating the subsistence minimum (Law, 1997). Based on the calculated minimum, the statistical institution Geostat determines the relationship between the basket of basic goods and the minimum income. If an increase in consumer prices causes the real minimum income to fall below the subsistence minimum, the law provides for an automatic adjustment of the minimum income, restoring it to a level that guarantees coverage of basic needs. This adjustment must be made within three months of the price change, ensuring the administration's rapid response to changes in the standard of living. A similar system could be implemented in Poland, if an annual automatic adjustment based on the SAPI were created.

Additionally, the SAPI can function as a regional measurement of inflation. The introduction of SAPI analysis down to regional structure could significantly improve the methods of measuring price dynamics in Poland. In an economy characterised by pronounced regional disparities, a uniform inflation index could lead to analytical distortions and erroneous conclusions regarding the actual economic processes occurring at the local level. First, a regionally differentiated inflation index would allow for a more precise representation of actual changes in household living costs in specific parts of the country. Second, the use of such indices would enable more equitable and effective development of state income and social policy. Adjusting the indexation of social benefits, minimum wages and pensions to the regional rate of price growth would help reduce real income inequalities resulting from geographical variations in inflation. Third, regional inflation measurement would provide valuable information for economic decision-makers at both the central and local government levels. This data could provide a basis for more precise planning of regional policy, public investments and support programs for households and businesses affected by particularly high price increases. Fourth, the publication of regional inflation indices could contribute to increased transparency and credibility of official statistics, as well as strengthen citizens' trust in institutions responsible for measuring and analysing economic phenomena. Citizens may perceive the official inflation rate as unreliable in relation to their own consumption experiences; the introduction of regional indices would allow statistics to better reflect the realities of the socio-economic life.

Considering the analysis, it seems reasonable to consider using the SAPI as a complementary tool in monitoring inflation and shaping social policy in Poland. This index, sensitive to changes in the prices of basic consumer goods, can serve as an early warning of inflationary pressures affecting the most vulnerable social groups, while also allowing for a better alignment of social benefits and the minimum wage with the real cost of living. Including the SAPI in statistical publications and in the decision-making process of public institutions could improve the ad-

equacy of social policy, increase data transparency and strengthen public trust by more realistically reflecting the costs of living for low-income households.

As a suggestion for future research, I propose conducting similar studies for other countries, particularly developing countries or the Global South. Theoretically, extending the conclusions of Portillo et al. (2016) suggests that the SAPI index would possibly correlate less with the CPI in highly developed countries and more with less developed countries. Differences between the SAPI and the CPI in these regions should be examined. Regarding the SAPI itself (as mentioned before), to further improve and implement the indicator, a sensitivity analysis should be conducted with respect to the outlier year 2022 and with respect to other, less stringent SM indicators, e.g. for households with two, three or more members. The year 2022 would require special treatment, for example, using a dummy variable or the Gregory-Hansen test (1996). This test allows us to verify whether, despite a shock, a long-term relationship between variables still exists, albeit with changed parameters. In other words, it allows us to distinguish whether 2022 represents a permanent break in the relationship or merely a shift in its level. Other tests, including ACF/PACF to confirm non-stationarity and Granger causality tests should be performed, along with ANOVA/Kruskal-Wallis to check whether the differences between voivodeships are statistically significant. Expanding the SAPI index for Poland to include data prior to 2006, using historical data should be a priority to repeat all previous statistical tests and those mentioned above.

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