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Richard J. Sweeney
In Memoriam

Richard J. Sweeney, International Editorial Advisory Board member for the *Economics and Business Review*, passed away on July 30, 2023 in Claremont, CA. He graduated from UCLA and received his Ph.D. from Princeton. Richard Sweeney was Professor Emeritus of Economics and International Finance at Georgetown University's McDonough School of Business and the Charles M. Stone Professor of Money and Finance at Claremont McKenna College. For several years he also served as editor of the *Economic Inquiry*.

His research was focused on financial markets and methods. His work was published in top finance and accounting journals such as the *Journal of Finance*, the *Journal of Financial and Quantitative Analysis*, the *Accounting Review*, the *Journal of Money*, *Credit and Banking and Financial Management*. He lectured at several European universities including those in Gothenburg and the Copenhagen Business School as well as giving lectures at the Poznan University of Economics and Business.

I met him for the first time when, with his Swedish colleague Clas Wihlborg, he came to Poznan whilst travelling in Eastern Europe to witness the beginnings of the systemic transformation after the fall of communism. Richard Sweeney helped to develop and shape EBR by publishing in the journal. The last article published by him in EBR was in 2023. We all thank Richard for all his contributions and efforts to help in the development of EBR and for his insights in the development of financial systems in Poland and Eastern Europe. His valued insights and written contributions will be sorely missed.

Tadeusz Kowalski
Editor-in-Chief

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Editorial introduction

This issue of *Economics and Business Review* answers the new set of challenges that the economic world faces nowadays. These problems arise both at the micro-and macroeconomic level. The authors of eleven papers have enriched the existing literature by sharing the results of their studies in three areas. First, the key elements of company growth and value are studied. The variety of development paths of entrepreneurship makes this area especially complex considering the sudden changes in the business environment over the last years. The second group of articles deals with quite new factors that give rise to new threats which are appearing but which also create enormous opportunities for economic decision makers. These are environmental issues, new technologies, integration between countries and social capital. The third research set addresses the current dilemmas of public authorities. The papers support answers to the questions about food security, local public debt, sustainability of public debt and the consequences of economic integration.

Just as the substantive considerations in this issue are multi-level there is also a large regional diversification in the articles. The contributors of this issue extend a very diverse worldwide point of views in representing Bosnia and Herzegovina, the Czech Republic, Denmark, India, Japan, Poland, Turkey, Ukraine and Vietnam. The papers employ a variety of research approaches that contribute to the economic debate. In addition to researchers the studies published in this issue may be useful to policy makers and practitioners.

The opening paper **Does firm size improve firm growth? Empirical evidence from an emerging economy** by Jan Bentzen and Le Thanh Tung explores the relationship between firm size and firm growth. The empirical sample covers public companies in Vietnam. The research tests the validity of Gibrat's law for various industries. It discusses The Law of Proportionate Effect that states that the expected increase in firm size is proportionate to the initial firm size. The empirical results do not give support to the hypothesis of the independence of initial company size.

The article by Aditi Goel, Dolly Gaur, Khushboo Gupta and Kanishka Gupta entitled **Factors impacting export intensity of SMEs in India** analyses the impact of firm characteristics on their export intensity. The results based on the sample of fifty SMEs indicate that the expenditure on research and development, selling and distribution translates in to a much better export performance. The estimates also indicate that the international experience of man-

agers significantly helps companies to expand in markets abroad. The article offers clear recommendations for SMEs in developing countries with respect to their expansion towards international markets.

The paper entitled **The choice of external financing source: The role of company size and stock liquidity** by Szymon Stereńczak and Jarosław Kubiak enriches the literature on corporate finance decisions by investigating whether firms of different sizes and stock liquidities differ in the choice of external sources of financing. The broad sample includes companies listed in CEE countries. With the background of the pecking order theory and information asymmetry the results show that companies with less liquid shares prefer issuing debt more than others.

The next article is written by Ömer Faruk Gültekin, Ramazan Sayar and Yılmaz Onur Ari and is titled **Socio-economic determinants of environmental degradation: Empirical evidence for the Environmental Kuznets Curve**. This study identifies socio-economic determinants of environmental degradation based on data from sixty two countries that cover the period of 1995–2019. The results reveal that there is not a single Kuznets Curve that can be applied to all countries which suggests that environmental policies should be adjusted more carefully for different country groups. However, the study also shows some common trends among the analysed countries revealing that the amount of schooling and life expectancy are positively correlated with pollution, while democracy, trade openness and economic freedom are correlated negatively.

The next paper prompts a reflection on innovation as discussed in the paper entitled **New technologies in the financial industry: Case of Poland** proposed by a research team: Małgorzata Iwanicz-Drozdowska, Ewa Cichowicz, Marianna Cicirko, Marcin Kawiński and Agnieszka K. Nowak. The special interest of the authors is in the scope and consequences of the application of new technologies within the banking and insurance sectors in Poland. It points to the importance of customers' needs, cost-cutting and the achievement of more efficient internal processes.

The article on **Formulary apportionment in the European Union—future research agenda** by Markéta Mlčúchová is inspired by a recent legislative initiative in the European Union to replace separate accounting with formulary apportionment. The aim of that initiative is to harmonise the corporate tax regulations among European member countries. Anticipating the increase in the scholarly discourse on the formulary apportionment method the study uses a systematic literature review to synthesise the existing knowledge on this topic. Furthermore, based on a set of one hundred and eleven reviewed articles eight main thematic clusters concerning the formulary apportionment method are being identified.

The research paper entitled **The relationship between social capital and economic growth on a provincial and regional basis** is authored by Abdulmuttalip Pilatin and Tunahan Hacıimamoğlu. The study uses the data for

Turkey for the period of 2007–2018 and employs the panel Granger causality test to analyse the relationship between the social capital index and economic growth at the provincial level. The results show that there is no single type of relationship between social capital and economic growth and that such a relationship seems to depend on local characteristics. More precisely the results reveal that there is a unilateral relationship from the GDP to the social capital in sixteen provinces, from the social capital to GDP in nine provinces and bilateral causality in forty five provinces. At the same time, no significant relationship has been found in eleven provinces.

The next article aims to assess the level of food security in Ukraine in comparison to global regions and European countries. It is written by Tatyana Melnyk, Yuliia Tunitska and Dmytro Banas and entitled **Food security of Ukraine: National and global level**. The study compares a broad set of indicators (including population dynamics, food balance, FAO indicators and the Global Food Security Index) and concludes that Ukraine is lagging behind European or global levels of food security with the exception of fish products. The study also identifies barriers to improving Ukraine's food security that consist of such factors as incomplete reforms, inadequate funding, underdeveloped infrastructure, corruption and non-compliance with standards.

The next paper by Monika Banaszewska, entitled **Spatial interactions in local public debt. Evidence from Poland,** extends the finance literature. The issues raised in this paper are of great importance for local authorities. The study is based on a broad sample of municipalities in Poland and offers empirical evidence of positive spatial interactions among local budgetary policies. The study also documents a strong persistence in debt levels and suggests that municipal debt in Poland serves as the instrument of local development policies.

The subsequent contribution constructs an overlapping-generations model to analyse the effect of fiscal deficit on fertility and sustainability of public debt. The paper is written by Hiroki Aso and Mitsuru Ueshina and is entitled **Fertility, fiscal deficit, and sustainability of public debt in an endogenous growth model**. The study shows that an increase in fiscal deficit reduces fertility because of a lowering disposable income. What is more the numerical simulation suggests that an increase in child allowance raises fertility but may negatively affect the sustainability of public debt if the fiscal deficit is large. The paper claims that countries relying on the public budget to address fertility decline should reduce the fiscal deficit instead of increasing the child allowance.

The issue closes with an article by Mehmed Ganic and Amila Novalic titled **Does regional trade integration reinforce or weaken capital mobility? New evidence from four free trade areas.** It analyses whether a higher level of trade openness and the presence of legal protection for investors enhances the impact of trade bloc membership on capital mobility. The empirical re-

search is based on data for 2000–2020 of four trade blocs: Eurasian Economic Union, Central American and Dominican Republic Free Trade Agreement, Central European Free Trade Agreement, and the Pacific Alliance. The study employs fully modified and dynamic ordinary least squares estimators and a panel quantile regression cointegration estimator. The results indicate that while a country's membership in a trade bloc generally improves capital mobility the legal protection provided to investors and high trade openness do not necessarily have such an impact in the trade blocs analysed.

Joanna Lizińska
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Does firm size improve firm growth? Empirical evidence from an emerging economy

Jan Bentzen[1]

Le Thanh Tung[2]

Abstract

This study aims to examine the relationship between firm size and firm growth in Vietnam. The literature does not in general give support to Gibrat's law stating that the expected increase in firm size is proportionate to its initial size, or that firm growth rates are independent of firm size. The present study relies on a sample of 578 listed Vietnamese companies representing eight different industries and covering the period 2010 to 2020. The analysis reveals that growth in firm revenues does not give support to a hypothesis of independence of initial firm sizes. When the firm size is measured by total assets the opposite result appears, i.e. the Gibrat's law is not rejected. When including also the age of the firms in the test methodology the conclusion will be that firm growth—measured by revenue or assets—in all cases will decrease with firm size.

Keywords

- Gibrat's law
- corporate growth
- Vietnamese companies
- emerging economy
- panel data analysis

JEL codes: L25, C23

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Introduction

Market entry and the performance of new as well as incumbent firms in industries has always been a central topic in industrial economics. The European Union and a number of countries globally have for a long time designed special measures in their industrial policies to support small and medium-sized firms which is a topic that has attracted a lot of political focus due to a belief in the developments of private companies as an important creator of more jobs. Of course, the political focus on creating special supporting schemes for small firms seems to be founded on a presumption that they have competitive disadvantages compared to larger firms.

One of the first and most famous contributions to the discussion of the importance of firm size for firm growth is Gibrat (1931) who presents a formal model of firm growth later on designated as 'The Law of Proportionate Effect'. According to this 'Law' the expected increase in firm size is proportionate to the initial firm size. The main reason for this relationship is that large firms also have a proportionally larger growth potential than small firms because they sell their products on a larger market. As the absolute growth of a firm is proportional to firm size Gibrat concludes that firms' growth rates are independent of their initial size. Another implication of Gibrat's law is that if firms' growth opportunities are randomly distributed then the distribution of firm size would be skewed and approach a lognormal distribution after a number of periods and independent of the initial distribution of firm size. In fact, this prediction is much in line with the actual firm size distribution in most industries and countries. Thus, many of the earliest empirical investigations of Gibrat's law tested the actual firm size distribution against a theoretical statistical distribution.

This paper aims to test the validity of Gibrat's law by using a sample of Vietnamese listed companies. Unlike many previous results which often focus on specific industries or only large firms the dataset used is very up-to-date with 578 companies representing all industries in the period of 2010 to 2020. Firms such as banks or other financial institutions are excluded from the data set due to their complex structure making them inappropriate for the present analysis. The database is a balanced panel data set and it has a suitable time-series span to identify the relationship between the firm size and firm growth in Vietnam.

The article is organized as follows. Firstly, a short introduction and then Section 1 gives a survey of the recent empirical literature on Gibrat's law. Section 2 presents the methodology and the empirical model to be estimated. Section 3 includes the data description and the results from the empirical analysis. Finally, the last Section concludes.

1. Literature review

The relationship between firm growth and firm size has been addressed in a large number of theoretical studies as well as empirical studies. The growth of firms is important for the general performance of an economy and the interest in this topic has increased significantly during recent years. Gibrat's law has been employed in some previous studies to examine how the firm size affects its growth and with a hypothesis that large and small firms grow at the same rate and hence the growth of firms is independent of the firm size (Gibrat, 1931). While there are a number of previous results that support the validity of Gibrat's law indicating that a firm's growth is independent of its initial size (e.g., Buckley et al., 1984) some empirical studies confirm the failure of this theory (Shapiro et al., 1987) or find more mixed evidence (Audretsch et al., 2004). Most of these studies have been done with firm data from developed countries and less evidence is available from developing or emerging countries.

The evidence in favour of Gibrat's law is typically found in the studies conducted in the 1960s or 1970s (e.g., Hart & Prais, 1956; Simon & Bonini, 1958). In the context of the robust development of technologies and increased globalization during recent decades some studies reject Gibrat's law as firms' growth rates seem to be significantly correlated with firm size. Likewise, Daunfeldt and Elert (2013) analyze a sample of Swedish firms covering five industries and the results reject Gibrat's theory as small firms grow faster than large firms. However, Gibrat's law is confirmed when industry-specific regressions are applied and factors such as minimum efficiency scale, market concentration ratio or the number of young firms in the industry therefore influence the test results. Aydogan and Donduran (2019) strongly reject Gibrat's law in the case of Turkish firms where firms do not grow in proportion to their size; the reason seems to be that the economic environment in Turkey was beneficial for smaller firms in the period and hence they experienced a faster growth.

In general, there are only a few empirical studies related to testing Gibrat's law for developing countries. Firm growth is considered important for the economic development and in developing countries, the relationship between firm growth and firm size is investigated in relation to fast growing countries. Bigsten and Gebreeyesus (2007) analyze the determinants of manufacturing firm growth in Ethiopia. The empirical results show that firm growth decreases with its size and therefore smaller firms are found to have higher growth rates than larger firms. Park et al. (2010) conclude with data from Korea that firm size and age have significant negative effects on firm growth and they find a significant positive effect on firm survival in the case of manufacturing industry. Rasiah et al. (2014) examine the same relationship between firm size and growth for the construction sector in Malaysia. The results show that

growth contributed significantly to profitability in small and medium firms but they also showed that firm size and growth are independent and in this sense give support to Gibrat's law. Yu (2016) also investigates whether the firm size is independent of firm growth with a sample of mobile phone firms in mainland China, Hong Kong and Taiwan. The empirical findings are generally in favour of independence between firm size and growth, but for subsamples the study shows that a number of firms affected by innovation and technology development are not giving support to Gibrat's law. Villari et al. (2021) investigate the firm growth model for service industries in India. The study finds a significant relationship between firms' growth and their size and age where the knowledge-intensive service sector has experienced different growth patterns compared to other sectors. To conclude, the literature review most studies do not lend support to Gibrat's law and this also seems to be the case for developing countries.

2. Data and the empirical test methodology

The data used in the empirical analysis is firm-specific and collected for listed Vietnamese companies where annual reports of the firms contain the economic information needed for the present purpose. The data covers the period 2010 to 2020 and is included in the data set for firms with accountant reports each year giving information on total assets, annual turnover, profits, year of establishment and some other variables. In total 578 firms are included in the data set and they cover eight industries; approximately half of the firms belong to manufacturing industry. Thus, the final data set is a balanced panel including 578 firms for a time span of eleven years. Since 1986 economic reforms have been initiated in Vietnam and these have contributed to a transformation towards more economic growth and increased welfare. The number of private firms has increased and the economy has become much more integrated in the world economy during the last couple of decades (see Le & Nguyen, 2018). Therefore, also listed companies with relevant accounting data are present and the information can be applied for economic analysis as with the topic on firm growth addressed in this analysis. The data from the listed firms are checked by audit companies and also by the Ministry of Finance and are therefore in a common or consistent format in relation to empirical analysis.

Various measures of firm size are considered in the literature and with the present data set either annual turnover or total assets can be selected as the measure of firm size. In the empirical tests both variables is included although the turnover might seem to be the most appropriate measure. The variable total

assets is influenced by many factors, e.g., short-run financial conditions which might have a smaller effect in relation to the turnover variable and be considered less important in connection with the size measure. Turnover will also be influenced by a range of both internal and external conditions for the respective firms and therefore the assets variable is included in the test procedure.

Table 1 reports some summary statistics for the turnover, assets and age of the firms in the data set. During the decade 2010 to 2020 the total turnover increased around fifty per cent in real terms; measured by mean values and for the assets the increase was somewhat larger with a value of around eighty per cent. The mean age of the firms was eighteen years in 2010 and thus relatively young firms with also a very low standard error (0.6). There are a few more firms added to the sample after 2010 but all firms have at least an age of six years in 2020 as exhibited in Table 1.

Table 1. Summary statistics: Size and age of Vietnamese listed firms ($N = 578$)

All firms	2010			2020		
	Revenue	Assets	Age	Revenue	Assets	Age
Mean	1057	1300	18.4	1570	2355	26.9
SE of mean	124	146	0.6	243	508	0.6
Minimum	0.7	7.8	1	0.1	9.6	6
Maximum	48076	39679	58	66830	254940	68

Note: The size is measured as revenue and assets in billion VND (2010-prices) and is reported as the mean value of the respective firms and with the standard error of the mean also reported. The age variable is the mean age since establishment (in years).

Source: own elaboration.

The empirical studies differ in relation to the estimation methodologies applied and it is intended to include two different approaches to test the validity of Gibrat's law. Some studies use a dynamic approach based on a random walk model specification: $z_{t,i} = \beta z_{t-1,i} + \varepsilon_{t,i}$ which in the empirical testing procedure will be (see Chesher, 1979):

$$\Delta z_{t,i} = \gamma z_{t-1,i} + \varepsilon_{i,t} \tag{1}$$

Gibrat's law holds if the restriction $\gamma = 0$ is fulfilled ($\gamma = \beta - 1$), i.e. the growth rates are independent of size which also implies that growth rates are persistent over time.

However, if serial correlation is present in $\varepsilon_{t,i}$, estimation gives biased parameters and therefore the empirical specification can be extended to deal with autocorrelation in the residuals (see Audretsch et al., 2004) and a second order process for the stochastic term is included:

$$\varepsilon_{t,i} = \rho\varepsilon_{t-1,i} + \omega\varepsilon_{t-2,i} + \nu_{t,i} \quad (2)$$

Adding this to the error term gives the empirical Model 1 to be estimated:

$$\Delta z_{t,i} = (\beta - 1 + \rho)z_{t-1,i} + (\omega - \beta\rho)z_{t-2,i} - (\beta\omega)z_{t-3,i} + \upsilon_t \quad (3)$$

The panel data relates to the listed Vietnamese companies and $z_{i,j}$ is measured (in log values) by the deviation of the firm size from the average size of companies within an industry thereby including an industry-specific fixed effect. Firm size will be measured by the total turnover (revenue) as an appropriate definition of size but the data also includes information for firm assets which will be included in the tests.

Alternatively, firm's size can be calculated in real terms, e.g., total turnover deflated by an appropriate price index—thereby ignoring the industry-specific mean values—and in this case the panel data will require some fixed effects' correction. Staying with the first-mentioned demeaned values of variables is deemed more appropriate when using panel data and they are usually the preferred measure of firm size found in the empirical literature on this topic. The parameters in Model 1 will be estimated by using a non-linear iteration procedure for the panel data with variables in logs and Gibrat's law is considered to be fulfilled when (β, ρ, ω) is equal to (1, 0, 0). The Model 1 from (3) is a dynamic panel model with lagged values of the dependent left-side variable included and this gives rise to a problem of endogeneity due to the dependence between these lagged values and the error term. This problem is addressed by using instrumental GMM estimations where lags of the right-hand variable(s) are included as instruments (Arellano & Bond, 1991). This procedure will be utilized when estimating the parameters from (3) and with results presented in Table 2.

As an alternative methodology—instead of the procedure related to Model 1 (Evans, 1987)—is followed where the firm growth is specified as a function of size and age as the age information for all firms is also possessed. There are a number of studies taking the same approach to the empirical tests and applying a second order logarithmic expansion of the firm growth relation including both size and age (see Shanmugam & Bhaduri, 2002; Villari et al., 2021). With the same notation and variables in log values but including age (a) the empirical relation to test is Model 2:

$$\Delta z_{t,i} = \gamma_0 + \gamma_1 z_{t-1,i} + \gamma_2 a_{t-1,i} + \gamma_3 z_{t-1,i} \cdot a_{t-1,i} + \gamma_4 (z_{t-1,i})^2 + \gamma_5 (a_{t-1,i})^2 + \varepsilon_{t,i} \quad (4)$$

The variables are in demeaned values before applied in the Model 2 as panel data is used which is a similar procedure in relation to Model 1. Due to the lags there is a dynamic panel data model where the estimated parameter values may be influenced or biased due to autocorrelation. Therefore, the

model will be estimated[3] including a correction for first order autocorrelation where allowance is made for different autocorrelation coefficients among all panel members (i.e. 578 firms) which will take up some degrees of freedom in the estimations but forcing the same autocorrelation function to all panel members will influence the results and is therefore not the optimal procedure. The main interest is of the parameter estimates to size and age, i.e. whether firm growth is related to firm size and age (see Evans, 1987).

3. Empirical test results

The size of firms will be measured by both the turnover as well as assets measured in the Vietnamese currency (VND) and, as mentioned earlier, the estimations will include both Model 1 and Model 2 in order to evaluate whether the choice of functional form and estimation strategy will influence the final conclusions. Table 2 reports the parameter estimates for Model 1 as well as the overall test statistic for the restriction in relation to the three parameters.

Table 2. Model 1: Parameter estimates and test statistics, all firms ($N = 578$) manufacturing ($N = 280$)

Variable (log)	$N \times T$	β	P	ω	χ^2-test
Revenue:	2761	0.9793	0.0254	1.6199	28.90***
All firms		*(0.1518)*	*(1.6896)*	*(2.4419)*	[0.00]
Manufacturing	1339	1.0398	–0.8289	0.6471	13.16***
		(0.0293)	*(0.7778)*	*(1.5310)*	[0.00]
Assets:	2772	1.0056	–0.4182	0.4494	2.44
All firms		*(0.0043)*	*(0.6173)*	*(0.3812)*	[0.49]
Manufacturing	1347	1.0110	0.1626	0.1855	5.77
		(0.0060)	*(0.7623)*	*(0.3318)*	[0.12]

Note: The number of observations (firms) in the different industries is reported in the first column. Standard errors are reported in parentheses. The χ^2-test of the (β, ρ, ω)-restriction with p-values reported in parentheses, where *** indicates a rejection of the restriction at (least) the one per cent level of significance. Model 1 is estimated including lagged values of z_t (instruments in a GMM estimation) as mentioned in the main text.

Source: own elaboration.

In Model 1 the estimates of β, ρ and ω should be (1, 0, 0) in order not to reject the hypothesis of firm growth independent of firm size and including the correction for autocorrelation as mentioned in the former section. The

[3] All estimations of both models are done in the software Rats from Estima.com.

results in Table 2 reveal the revenue size measure for all firms as well as for the sub-sample of manufacturing firms and demonstrate that the restriction for the three before-mentioned parameters is not fulfilled, i.e. rejecting the hypothesis of a random walk in relation to Model 1. Thus the empirical evidence is not in favour of Gibrat's law for the Vietnamese firms when the size measure is total revenue. When the size measure is total assets the opposite result seems to be the case and thus the Gibrat's law is not rejected.

The next step in the test procedure is to include Model 2 where also the age of the firms is included. The present data set for Vietnamese firms includes the age variable and thus allows for estimating Model 2 which is of importance as the age is expected to influence firm growth potential. Table 3 exhibits the fixed effects parameter estimates of the model where a flexible procedure for correcting first-order autocorrelation is also included as mentioned in the methodology section.

Table 3. Model 2: Parameter estimates and test statistics, all firms (*N* = 578) and manufacturing (*N* = 280)

Variable	Revenue all	Manufacturing	Assets all	Manufacturing
γ_0	0.0033	0.0090	0.007	0.0014
	(0.0070)	*(0.0106)*	*(0.0031)*	*(0.0044)*
γ_1	–0.4156***	–0.8070***	–0.2356***	0.2391***
	(0.0412)	*(0.0746)*	*(0.0232)*	*(0.0426)*
γ_2	0.0905	0.6356***	–0.0697	0.3249***
	(0.1015)	*(0.1810)*	*(0.0474)*	(0.0734)
γ_3	0.0364***	0.1623***	0.0018	0.0161
	(0.0135)	*(0.0234)*	*(0.0075)*	*(0.0129)*
γ_4	0.0376***	0.0337***	0.0154***	0.0228***
	(0.0028)	*(0.0046)*	*(0.0033)*	*(0.0048)*
γ_5	–0.0863***	–0.2192***	–0.0165	–0.1038***
	(0.0233)	*(0.0398)*	*(0.0107)*	*(0.0156)*
Autocorrelation (range)	[–1.24; 1.26]	[–1.07; 1.20]	[–0.98; 1.28]	[–1.27; 1.10]
R^2	0.29	0.21	0.14	–0.01
N × T	5024	2435	5036	2444

Note: The parameter estimates refer to Model 2 with standard errors reported in parentheses, where *** indicates significance at (least) the one per cent level. All variables are demeaned corresponding to including fixed effects in the panel data. Thereafter the model is estimated with a correction for first order autocorrelation (Cochrane-Orcutt procedure). The autocorrelation parameter is allowed to vary between the firms and the span for this parameter is reported in the sharp parenthesis.

Source: own elaboration.

The parameter estimates are reported for the variables revenue and assets respectively and also with a separate result for the manufacturing sector. As mentioned earlier the revenue is probably a better measure of firm size compared to the assets which might be influenced by various factors, e.g., financial conditions, especially in the short run. For the last case in Table 3 using assets for the manufacturing sector the model is not at all appropriate as revealed by the negative R^2 value. For the other cases the parameter estimate of γ_1 is negative and significant and therefore gives no support to Gibrat's law. Growth is negatively related to firm size which is also in accordance with many other studies. The study by Evans (1987) reports negative parameter estimates for both firm size and age which corresponds to the findings in many other studies as exhibited in the survey in Bartolini et al. (2020)

Table 4. Parameter estimates of γ_1 for specific industries (Model 2)

	Revenue	**Assets**
Basic industry	–0.0407 (0.2633)	**–0.3299**** *(0.1390)*
Manufacturing	**–0.8070***** (0.0745)	**–0.2391***** *(0.0426)*
Tech	0.3359 *(0.3247)*	–0.2661 *(0.2174)*
Infrastructure	**–0.4124***** *(0.1622)*	–0.1898 *(0.1013)*
Transport	**–0.5322***** *(0.1704)*	–0.1562 *(0.1363)*
Wholesale	**–0.3199***** *(0.1058)*	**–0.2711***** *(0.0777)*
Real Estate	**–0.2819**** *(0.1172)*	**–0.1713***** *(0.0619)*
Health	–0.8065 *(0.4858)*	1.1517*** *(0.3746)*
All firms	**–0.4156***** *(0.0412)*	**–0.2356***** *(0.0232)*

Note: Parameter estimates of γ_1 and the parameter estimates refer to Model 2 with standard errors reported in parentheses where ** indicates significance at the five per cent level and *** significance at the one per cent level. A constant term and other variables from Model 2 are included in the estimations but the values are not reported. All variables are demeaned corresponding to including fixed effects in the panel data and thereafter the model is estimated with a correction for first-order autocorrelation (Cochrane--Orcutt procedure), allowing the autocorrelation parameter to vary between firms. The latter procedure is only followed for the first two industries since for the last six cases there is a restricted number of observations and in these cases a common value of the autocorrelation parameter is imposed.

Source: own elaboration.

with the general conclusion of a negative relationship between growth and firm size/age. The parameter estimate to firm age (γ_2) is insignificant in two of the cases but positive and significant for the manufacturing sector that can be related to older firms having more experience, a better organization and management (see Villari et al., 2021). The remaining three variables are included in the model due to the second order expansion and are of less interest compared to estimates of the size and age parameters but they are mostly significant and the overall degree of explanation reasonable for the first three cases. The parameter γ_1 is of the main interest and Table 4 reports the estimated values for the specific industries from Model 2 with only the size parameter reported.

Most cases in Table 4 have a significant, negative parameter estimate to the firm size (γ_1) and only one case (Health) has a positive value. Thus, there is similarity between the industries with a growth rate declining with firm size which is consistent with the general findings in the literature. The main findings in relation to developing countries are summarized in Table 5 and the present analysis is in line with these studies showing non-acceptance of the Gibrat's law.

Table 5. Firm's growth: Main findings from selected studies of developing countries

Study	Industry (data)	Factor	Effects
Das (1995)	computer	sales	positive (age) negative (size)
Liu et al. (1999)	electronics	employment	negative (size, age)
Shanmugam and Bhaduri (2002)	manufacturing	sales	positive (age) negative (size)
Simbana-Taipe et al. (2019)	service	sales employment	negative (age)
Villari et al. (2021)	service	sales	negative (large size, age)

Source: own elaboration.

However, based on the cheap labour cost approach the Vietnamese companies often employ a labour-intensive technology model which of course requires a large amount of labour in the production of goods or services (see Gregorio, 2018). The technology investments are not increased sufficiently and the larger companies using labour decrease in the average labour productivity, the long-run average total cost rises as output increases and the larger companies can exhibit diseconomies of scale. Thus, larger companies can have lower growth potential compared to smaller companies.

A specific element in emerging economies like Vietnam is that listed companies with large assets are priority customers in the banking system and hence they may more easily obtain advantages in the form of credits and preferential loans from commercial banks (see Pincus, 2016). Many companies drive corporate growth by a high level of financial leverage with loans from the banking system which is the case for many large companies in Vietnam based on their official financial annual reports. However, the commercial interest rate in Vietnam is significantly higher than in other economies and therefore large companies face a risk of bankruptcy when the market moves in an unfavourable direction (see Ninh et al., 2018; Thuy et al., 2022). This phenomenon is an important reason why large companies have lower growth rates compared to smaller companies.

Conclusions

The Law of the Proportionate Effect states that firm growth rates are independent of their size and the present study involves two of the methodologies most often applied for testing the hypothesis. The study uses a large sample of Vietnamese firms to evaluate the validity of Gibrat's law for various industries spanning the period 2010 to 2020. Firm size can usually be measured as total revenue (turnover) or total assets and both variables are included in the tests.

The growth rate of firms is modelled as a function of lagged firm size and corrected for any problems of autocorrelation and endogeneity in relation to a dynamic panel data model. This procedure follows a vast amount of empirical studies from recent decades of which Chesher (1979) is an early study from this tradition. For the total turnover as the firm size measure there is no empirical evidence that the firm growth rate should be independent of the initial firm size, and this result holds when testing for all firms (N = 578) as well as for the manufacturing industry (N = 280). When total assets are included as the size measure in the test methodology the Gibrat's law cannot be rejected for all firms and also for the manufacturing industry, i.e. the growth in assets may be independent of the initial size. In the final part of the analysis the age of the firms is included as a control variable and for all cases the findings show that the larger the firm, the smaller the growth rate. This conclusion also seems valid for the eight specific industries included in the analysis. Thus, in total the empirical results do not leave much support for Gibrat's law in connection with Vietnamese firm data.

The conclusion in relation to Vietnamese firms is in accordance with most studies of Gibrat's law for developing countries as illustrated by the selected

studies reported in the former Table 5. Many studies, like the present one, rely on data for listed firms and then there may be a bias in relation to all firms in a certain industry or country. Non-listed firms in relation to for example a stock exchange registration may be of interest as their growth behaviour may differ due to a recent upstart or active in a new industry. Additionally, future studies of the Gibrat's law should also deal with a closer comparison with the findings for industrialized and developing countries, respectively, in order to ascertain whether the law is related to a specific development stage—or not at all seems to be valid as appearing in several studies.

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Factors impacting export intensity of SMEs in India

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Abstract

The aim of the paper is to explore the factors impacting export intensity of SMEs in India. It examines the influence of various firm level variables on export intensity. The sample considered for the study includes 50 SME firms from different industries ranging from equipment and manufacturing to textile. Data for ten years (2011–2020) has been analyzed for drawing relevant results. For regression, Least Square Dummy Variable corrected (LSDVC) estimates have been used to address the issue of heteroskedasticity and autocorrelation issue present in the data. The results arrived at indicate that the expenditure incurred on research and development, selling and distribution acts as an investment which provides returns in terms of better export performance. Also, top managers having international experience can be an important asset for a firm looking for expanding in international market. These results have substantial implications for the management of SME firms.

Keywords

- exports
- SMEs
- India
- LSDVC regression
- international exposure of management

JEL codes: F10, F18, M16

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Introduction

In the process of the internationalization of firms, the most common and convenient entry mode is exporting. Nearly 25% of the worldwide gross domestic product is contributed by global export trade (World Bank, n.d.). In spite of the tremendous growth of foreign direct investments, firms from emerging economies prefer exporting as it is simplest mode for entering into foreign markets (Singh, 2009). Exporting does not require high financial and human resources which makes it a favourable mode of entry into foreign markets specifically for small firms wherein there is low resource commitment and high flexibility. Therefore, analysis of factors impacting the export intensity of small firms is significant as export intensity is a measure which is commonly considered to study the export performance. Considerable research has been done to understand the ability of the such small firms (Castellani et al., 2022; Esteve-Perez & Rodriguez, 2013; Gashi et al., 2014; Love et al., 2016; Pacheco, 2016).

Small and medium-sized enterprises (SMEs) are regarded as an economy's backbone. They play a significant role in the world economy in generation of employment. An understanding of the internationalization process of SMEs, specifically those from emerging economies, is required in order to help such firms in their growth process and also maintain the economic vitality of these economies. SMEs in emerging economies consider exporting as the most favourable mode for entering into foreign markets. The share of Micro, Small and Medium Enterprises (MSME) in 2019–2020 towards India's GDP was 30%, MSME share in India's total industrial production was 36.9% and MSME accounted for 49.5% of India's total exports (Ministry of MSME, 2021). SMEs usually start with exporting as their first step towards internationalization as it helps them in the accumulation of relevant markets, institutional and product knowledge which is further beneficial in international expansion for them (Love et al., 2016). Despite the potential relevance of this subject area, our comprehension of the factors impacting export competitiveness of SMEs is still limited. In the past the majority of research has been done based on the experiences of developed countries (Galati & Crescimanno, 2014; Love et al., 2016; Majocchi et al., 2005). A search in the Scopus database showed that there are some 600 studies which explore the area of export intensity.

Out of these about 10% are India specific; of which less than one fourth are based on SMEs. Therefore, a study of the factors impacting the export performance of SMEs in a developing economy such as India can provide a significant contribution to the export literature.

Export performance is impacted by number of variables which could be related to managerial (e.g., education of managerial team, commitment to exports, international exposure, perceived export barriers), physical (size of the firm, financial resources and location of the firm), organizational (e.g., experience and capabilities of the firm, general export strategy, strength of products), and relational resources (supply chain links, interpersonal research, distribution channels, foreign market visits and customer relationships) (Ibeh & Wheeler, 2005;Rodríguez & Orellana, 2020). In the current study, for delimitation purposes, the focus is on factors related to a firm and top managerial team. The main question addressed in this paper relates to how the firms' size, experience, propensity to innovate, advertisement expenditure and top managerial teams' international experience influence the export activity of SMEs. An extensive literature review showed that there has not been much research regarding the export performance of SMEs in India which is highlighted in the later sections. There have been very limited studies on the contribution of top managerial teams' international exposure on exporting activities of an SME firm in a developing economy as most of the studies have focused on other firm specific factors (Oura et al., 2016; Tajeddin & Carney, 2019). The current study investigates the effects of the top managerial teams' international exposure along with other firm level variables on export intensity considering it as an equally important variable. Also, in past studies, firm specific and management related variables were researched in separate papers but to the best of the authors' knowledge this is the one of the pioneering studies including both the category of variables in one paper on Indian SMEs.

The paper is structured as follows. The first section lays the conceptual framework and theoretical review of the relationship between export intensity and the other independent variables mentioned in the previous paragraph. The second section sets out the research methodology. In the third section, results are presented, which are followed by the conclusion of the paper.

1. Conceptual framework and review of literature

Export intensity is a well-researched area especially in developed countries and many different variables have been considered as its determinants. Most important and relevant variables have been identified and included in the present study and they are discussed in this section.

1.1. Export intensity and innovation

Product innovation in an organization can be explained as working upon an idea to bring about features which are new to a product or to create a new product f. It can be stated that a firm which innovates is the one which introduces technologically new or substantially improved products for the period under review (OECD, 1997). Success of innovative products depends upon its newness and utility. The innovation process involves research and development efforts, specialized human resources or technical equipment and it results in new or substantially improved products (Pla-Barber & Alegre, 2007).

The impact of innovation on exporting has received a lot of attention in literature on international business. It has been proven in a large number of empirical studies that innovation has an essential role in determining the volume of a firm's international sales and how many different markets it serves. The majority of the research on innovation and export performance points to a positive relationship of innovation and exporting (Charoenrat & Amornkitvikai, 2021; Fernández-Mesa & Alegre, 2015; Ossorio, 2018; Radicic & Djalilov, 2019; Spuldaro et al., 2021; Tavassoli, 2017). Literature on innovation management and technology in general predicts that firms which innovate have a propensity to enter international markets in order to boost sales volume and disperse the fixed expenses of innovation across more units (Rogers, 2004). Esaku (2020) suggested that providing smaller firms with technological capabilities increases their chances of entering into the export markets. Though there have been few exceptions in the past (Becchetti & Rossi, 2000) previous research has been able to consistently support that innovation encourages exports. It is important for firms to innovate in order to achieve and uphold the competitive advantage as well as for increasing their growth potential. Innovation is an important dimension of a firm's growth strategy as per the theory of Krugman (1979). Its envisaged impact on export performance provides a reason for firms to invest more in research and development as organizations which innovate are more likely to export to cover their cost of research. Therefore it can be said that the technologically advanced products have a wider geographic range.

Previously research has been done to explore how SMEs deal with the limited resources in order to compete abroad (Brouthers et al., 2015). Rogers (2004) asserts that the firms which innovate are inclined towards entering foreign markets with the purpose of increasing their sales' volume. This growth strategy helps SMEs which usually encounter substantial disadvantages in the domestic marketplace because of a lack of management prowess, financial resources and the experience curve effect. Thereby with help of innovative strategies SMEs can enhance their volume of exports. Rodríguez and Rodríguez (2005) researched the influence of technological capacities of Spanish ma-

nufacturing firms over its export intensity. Their results indicated that both innovation inputs (R&D spending) and outputs (product innovations and patents) had a positive and considerable effect on export intensity. Pla-Barber and Alegre (2007) examined the link between innovation and export volume in the French biotechnology industry. They found that in this science-based industry the aforementioned relationship is strongly positive due to its high technology profile. Kumar and Siddharthan (1994) examined the association of technology with trade behaviour of Indian enterprises and found that the technology plays a crucial role in explaining the export habits of firms in industries with low and medium technology.

For firms to be able to compete in the marke , R&D intensity for technological innovation is an important business strategy. It has been shown in the past research that firms which allocate a large proportion of their revenue on R&D are likely to experience more growth than those firms which do not. Increased R&D intensity in domestic firms has a positive impact on their domestic sales and exports (Sun & Anwar; 2015).

On the basis of above theory it has been hypothesized that:

H1: There is a significant positive relationship between R&D intensity and export intensity of Indian SMEs.

1.2. Export intensity and firm experience

Another important determinant factor of export intensity is the experience of the firm. Any firm which intends to enter new markets has to face new cultures, political regimes, distribution systems and languages, all of which can be learned by allocating more time and resources. A firm's experience is assessed in terms of age of the company and the number of years the firm has been exporting. The relationship between firm experience and exports has been studied by many researchers. Analysis of these two variables suggests a positive relationship between them (Behmiri et al., 2019; Reis & Forte, 2016; Revindo & Gan, 2018). Esaku (2020) signalled that the exporting experience of the firm has a substantial influence on the firm's choice to invest in regard to upgrading production technologies which in turn has a positive effect on export intensity among small firms. Majocchi et al. (2005) studied firm experience as an important factor having a bearing on export performance as it provides the firm with more wisdom regarding management, international trade and business partnerships. Researchers discovered that Italy's older businesses are more export intensive. Hence a firm's age is often considered as a key determinant of its international activity. As studied by Suárez-Ortega and Álamo-Vera (2005), in their research on the wine industry

of Spain the experience of a firm in market development can be considered as a significant variable in explaining both the propensity to engage in exporting as well as the intensity of export activity. However, on the contrary few studies have also shown insignificant and even opposite results (Charoenrat & Amornkitvikai, 2021).

Accordingly, it has been hypothesized that:

H2: There is significant positive relationship between the age of the firms and export intensity of Indian SMEs.

1.3. Export intensity and advertisement

One of the ways to increase sales in the globalized world market is to spend more on marketing activities. A number of empirical studies to assess the relationship between export intensity and advertising expenditures have been done time and again. It has been found that expenditures on advertising exert a positive effect over export intensity. A favourable correlation between advertising and geographical diversification has been shown in a number of studies (Kim & Mathur, 2008). Galati and Crescimanno (2014) studied Italian wineries and concluded that allocating funds for advertising is an important strategy for ensuring the entry of firms in new markets, for their survival and for their success. Advertising helps in enhancing the firms' competitive position in the market by either increasing its value appropriation opportunities or by decreasing the same for the competitors of the firm (Chu & Keh, 2006).

A number of theoretical studies show that the firms which invest more in advertising are likely to have more geographical spread as they possess intangible assets such as brand name recognition and a reputation premium which can be passed on to new countries without difficulties (Rondi et al., 2004).

Thus the current study presents hypothesis as:

H3: There is a positive relationship between advertisement expenditure and export intensity of Indian SMEs.

1.4. Export intensity and firms' size

Size of the firm is amongst one of the most significant factors influencing export operations. It has also been one of the most widely analyzed factors having an impact on exporting in international business literature. There is substantial evidence showing a positive effect of size on export intensity (Behmiri et al., 2019; Cancino & Coronado, 2014; Majocchi et al., 2005; Reis & Forte,

2016; Wagner, 1995). However, some studies revealed negative or no relationship between size and export performance (Pla-Barber & Alegre, 2007). Wagner (1995) suggested that with greater size the availability of financial and managerial resources increases which increases the ability of firms to absorb the risk related to exporting. The business of exporting incurs a lot of fixed costs such as assembling a committed team for managing export operations, costs of extensive market research and redesigning the products to suit the requirements of foreign customers. Larger firms have more resources to easily handle such costs. Firms which are larger in size have a greater ability to increase the resources, handle the risks better than smaller firms and also have a greater bargaining power. Calof (1994) asserted that the impact of international mistakes is more substantial for smaller firms than it would be for larger firms and in addition due to lack of information smaller firms may be more risk averse.

Preece et al. (1998) argued that entering into a number of foreign markets is more challenging than entering into a single-country which makes global diversity positively influenced by firm size. The resource-based view of the firm also highlights a favourable relationship between the firm's size and export performance (Barney, 1991). It explains that the size of the firm represents its resource base for the purpose of several growth and development activities such as diversifying the products and geographic markets. Firm size indicates the availability of managerial and financial resources within a firm. When a company has an excess of these resources it is more inclined to explore expansion opportunities. According to Bernard and Jensen (1999) the larger size of a firm implies that it has a strong domestic position which gives it a leverage in international markets as well. For the firms in emerging markets size becomes more important as there most of the enterprises are small and still in their growth phase in the domestic market. Smaller firms in such markets often face constraints on technological, financial and personnel resources which makes it difficult for them to venture into risky activities such as exporting.

All the above-mentioned arguments direct to a positive association of size with export sales. Accordingly, it is hypothesized that:

H4: There is a positive relationship between size of a firm and export intensity of Indian SMEs.

1.5. Export intensity and international exposure of top management

One of the explanatory variables of growth of the company in the globalization process is the international experience (Oura et al., 2016). Export

experience of managers is one of the key drivers of export decisions in firms. Exposure to international business environment helps in enhancing the ability of the top leaders to analyze various influencing factors in international markets such as culture, taste and preferences of consumers and the economic environment of different countries. Such leaders are also better equipped to identify international opportunities and use them to their best advantage (Casillas et al., 2015; De Clerq et al., 2012; Love et al., 2016; Masso et al., 2015). Working for the international companies or attaining education in a foreign land helps the managers to obtain exposure to international markets (McDougall et al., 2003). Therefore managers with international experience add to the knowledge pool of the firm and directly contribute to the export potential of the business (De Clerq et al., 2012). It also helps the executives in developing external ties and relational capital which makes the access to and processing of information much simpler in comparison with top executives who lack international exposure (Gulati, 1995). Hence it is hypothesized that:

H5: There is a positive relationship between international exposure of top management and export intensity of Indian SMEs.

2. Research methodology

The primary objective of this study is to investigate the influence of various factors on the export patterns of Indian firms. Thus this section specifically discusses the variables taken under consideration, the relationship studied, techniques used for drawing the results anda description of the data sources and sample selection.

2.1. Research framework and variables

A research model (Figure 1) has been laid out to address the research gap and explore how the firms' size, experience, propensity to innovate, advertisement expenditure and top managerial teams' international experience influence the export activities of SMEs. The variables used in the analysis are listed in Table 1. The primary objective of the work is to study export intensity in Indian SMEs which is why export intensity has been considered as the dependent variable, Export is the first stage of internationalization and is the main variable studied in this paper. It is calculated as the ratio of total export sales to total sales.

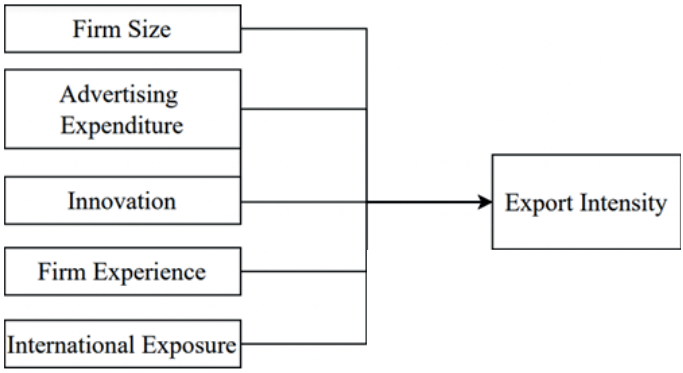

Figure 1. Proposed research framework

Source: authors' compilation.

On the basis of an extensive literature review five independent variables are considered to explain the export behaviour of SME firms of India. Firm size is taken by many studies as the explanatory variable (Behmiri et al., 2019; Cancino & Coronado, 2014). Firms which are larger in size have a greater ability

Table 1. Variable description and estimation

Variable	Description	Formula
Dependent variable		
Export intensity (ExP_Int)	The percentage of exports out of total sales.	$\frac{\text{Total Exports}}{\text{Total sales}} \times 100$
Independent variables		
Firm size (Size)	The logarithm of total sales	Log of Total Sales
Advertising expenditure (SD_Int)	Selling and Distribution (S&D) expenditure as the percentage of total sales	$\frac{\text{Selling and distribution expenses}}{\text{Total sales}} \times 100$
Innovation (RD_Int)	Research and Development (R&D) intensity measures the R&D expenditure as percentage of total sales.	$\frac{\text{R\&D expenditure}}{\text{Total sales}} \times 100$
Firm Experience (FExp)	A firm's age, i.e., number of years from year of incorporation	Time since the incorporation (in years)
International Exposure (Int_Exp)	A dummy variable which shows whether any person from the top management has worked or studied in any other country out of India.	Dummy values are allotted as follows: 1 – presence of foreign exposure 0 – absence of foreign exposure

Source: authors' compilation.

to increase their resources, handle the risk better than smaller firms and also have better bargaining power. Similarly advertising expenditure is considered an important explanatory variable in the past studies as advertising expenses facilitate the entry of firms into new markets. The firms which spend more on advertising are likely to generate more sales in foreign markets especially with growing globalization. Advertising expenses are a part of a larger group of expenses, that is 'selling and distribution expenses'. Since most of the SMEs did not provide data for advertising expenditure hence selling and distribution expenses are taken to calculate the S&D intensity which is the ratio of selling and distribution expenses to sales. Furthermore, innovative firms are expected to enter more foreign markets to increase their revenues and cover their expenses. At the same time innovative products appeal to customers both in domestic as well as global markets. R&D intensity is the variable used to measure a firm's likelihood to innovate. Majocchi et al. (2005) contends that experienced firms gain more maturity in dealing with international trade partners. Hence the age of firms is taken as another variable to explain export intensity.

Furthermore, international exposure of top management is also given due consideration as foreign education and international work experience helps them to take export related decisions (Love et al., 2016).

2.2. Empirical model

To examine the factors influencing the export intensity of firms this study has considered a panel regression model. However, keeping in mind the possible heteroskedasticity and autocorrelation issues in the secondary data the dynamic panel data model has been used for regression purposes. The fundamental dynamic panel regression equation has been mentioned below (equation 1):

$$y_{it} = \gamma y_{i,t-1} + \beta' x_{it} + \varepsilon_{it} + \nu_{it}, \qquad i = 1, ..., N; \qquad t = 1, ..., T \tag{1}$$

Specifying the equation for the present study equation (2) has been derived as given below:

$$\begin{aligned} Exp\_Int_{it} = \alpha Exp\_Int_{it-1} + \beta_1 Size_{it} + \beta_2 SD\_Int_{it} + \beta_3 RD\_Int_{it} + \\ + \beta_4 FExp_{it} + \beta_5 Int\_Exp_{it} + (\varepsilon_i + \nu_{it}) \end{aligned} \tag{2}$$

The need to address unobservable individual effects requires switching to first differences (equation 3).

$$\begin{aligned} \Delta Exp\_Int_{it} = \alpha \Delta Exp\_Int_{it-1} + \beta_1 \Delta Size_{it} + \beta_2 \Delta SD\_Int_{it} + \\ + \beta_3 \Delta RD\_Int_{it} + \beta_4 \Delta FExpit + \beta_5 \Delta Int\_Exp_{it} + \Delta \nu_{it} \end{aligned} \tag{3}$$

The evidence provided in Judson and Owen (1999) gives support for the superiority of corrected Least Square Dummy Variable estimates (LSDVC) over biased LSDV and traditional GMM estimates. In addition the LSDV estimates become inconsistent in cases of large *N* and finite *T*, as it is there in the present work (Bruno, 2005). Equation (4) gives estimation of LSDV:

$$y_{it} = \alpha + \beta' X_{it} + \mu' Z_{\mu,it} + v_{it}, \qquad i = 1, \ldots, N, \qquad t = 1, \ldots, T \tag{4}$$

where, $Z_{\mu, it}$ denotes a dummy variable which takes value 0 for all observations (it) where i is not equal to j and takes value 1 for all observations (it) where i is equal to j.

The small sample bias consistent with LSDV has been corrected by researchers in the past. Kiviet (1995) formulated bias correction for linear LSDV, whereas Bun and Carree (2006) provided correction of LSDV bias for the non-linear relationship. Both studies have assumed homoscedastic disturbances. The issue of heteroskedastic disturbances in LSDVC has been addressed by Bun and Carree (2006). The same has been followed in this study along with the initial consistent estimator given by Blundell and Bond (1998). As stated by Bogliacino et al. (2012), LSDVC starts with a dynamic panel estimate which is system GMM in the present case and thereafter depends on 'recursive correction' of the bias.

2.3. Sample

As already discussed, SMEs play an important role in India's economy. MSME share in India's total industrial production was 36.9% in 2019–2020 and accounted for 49.5% of India's total exports (Ministry of MSME, 2021). For this reason, the focus of the present paper is on this particular sector. The following criteria are used by the Indian Ministry of Micro, Small, and Medium Enterprises (https://msme.gov.in/know-about-msme) to define micro, small, and medium enterprises.

- A micro enterprise is defined as any business with a maximum investment in plant, machinery, or equipment of Rs. 1 crore and a maximum annual revenue of Rs. 5 crores.
- Any business with an annual revenue of less than Rs. 50 crore and an investment in plant, machinery, or equipment of less than Rs. 10 crore is considered a small enterprise.
- Any business with an annual revenue of up to Rs. 250 crore and an investment in machinery and equipment of up to Rs. 50 crore is considered a medium enterprise.

There is dearth of publicly available data for micro enterprises, therefore, the sample of this current paper is restricted to small and medium enterprises. Using the definition of SMEs given by the Ministry as the criteria a list of firms was retrieved from the ProwessIQ database. Out of the 647 firms satisfying the criteria of being an SME only 50 made it to the final sample because of lack of availability of data .

The sample firms were from different industries and their distribution is shown in Table 2.

Table 2. Industry-wise sample size

Industries	Number of firms
Equipment manufacturing	15
Chemicals	13
Pharmaceuticals	9
Food	7
Textiles	3
Others	3
Total	50

Source: authors' compilation.

For these sample firms the data was collected for a ten year period from 2011–2020. The data for all the variables was collected mainly from the ProwessIQ database. For any missing information the annual reports were referred to. For gathering the information about the international experience of the top management of each of sample firms the Bloomberg website was used along with the annual reports.

3. Results and analysis

3.1. Descriptive statistics

Table 3 shows the descriptive statistics of all the variables used in the study. The mean values, standard deviation, minimum and maximum values of dependent and four independent variables are presented. The mean value of export intensity shows that on average the sample firms generated 21.81% of their total revenue from exports. There are companies with no exports

(as evident from minimum value of 0) as well as with almost all the sales as exports (as evident from the maximum value of 99.9%). A minimum value of S&D intensity and R&D intensity is zero showing that there are some firms which do not spend on selling and distribution and research and development. However the maximum value of R&D intensity is 132.69 revealing that some firms really invest in research and spend as high as 132.69% of their sales revenue for research and development.

Table 3. Descriptive summary of the data

Variables	Mean	Standard deviation	Minimum	Maximum
Exp_Int	21.808	27.765	0	99.9
Size	7.030	0.845	1.649	8.855
SD_Int	4.119	5.510	0	84.615
RD_Int	1.051	6.292	0	132.692
FExp	27.88	17.245	1	91
Int_Exp	0.614	0.487	0	1

Source: authors' computation.

The descriptive statistics of the age of the sample firms show that their age ranges from 1 year to 91 years with the average age being 27.88 years. The international experience of management is a dummy variable with two possible values of 0 and 1: 0 for no international exposure of top management and 1 for presence of international exposure. For the dummy variable, the mean value is estimated to be 0.614. This implies that 61.4% of the firm years saw the board of directors having international exposure. It can also be inferred that directors in most of the firms have had international experience. The standard deviation does not hold much relevance in the case of binary dummy variables as it basically shows only the impact of just the sample size.

3.2. Correlation analysis

When multiple variables are included in a regression model It is crucial to make sure that the independent variables do not have a strong correlation with one another. In the case of a high degree of correlation between explanatory variables the standard errors of regression coefficients increase leading to unstable coefficients. Also a high correlation makes it difficult

to judge the individual importance of the independent variables. Gujarati and Porter (2009) suggest that correlation values of 0.8 or 0.9 are problematic. Table 4 shows correlation coefficients among dependent as well as independent variables. None of the variables have a correlation coefficient of 0.8 or more. This means multicollinearity is not a problem with the present sample. Further, only S&D intensity is positively correlated to export intensity while size, R&D intensity and age are negatively correlated with export intensity.

Table 4. Correlation between dependent and independent variables

	Exp_Int	Size	SD_Int	Innovation	Age
Exp_Int	1.000				
Size	–0.030	1.000			
SD_Int	0.029	–0.136	1.000		
RD_Int	–0.002	–0.257	0.590	1.000	
FExp	–0.138	0.290	0.054	–0.034	1.000

Source: authors' computation.

Multicollinearity is also checked by Variance Inflation Factors (VIFs). VIFs indicate whether the independent variables have a strong linear relationship with each other. VIFs of more than 10 are problematic and may bias the regression results (Field, 2013). Table 5 shows the VIF values for each variable and none of them have VIF of 10 or more.

Table 5. Multicollinearity: Variance inflation factor

Variables	VIF	1/VIF (tolerance)
Size	1.25	0.799
SD_Int	1.58	0.633
RD_Int	1.62	0.619
FExp	1.13	0.889
Int_Exp	1.10	0.911
Mean VIF	1.33	

Source: authors' computation.

Furthermore, a tolerance statistic of below 0.2 can be a cause of concern (Field, 2013). None of the variables havea tolerance value less than 0.2. This means the data used in this analysis is free from multicollinearity bias.

3.3. Diagnostic tests

To understand the data better and to decide on the most appropriate regression technique some diagnostic tests must be performed. They help to ensure that the basic assumptions of multiple regression are met. For these reasons, heteroskedasticity and autocorrelation are checked. Regression models assume that the error terms have a constant variance, i.e., they are homoscedastic across all the predicted values of the dependent variable. Error terms are heteroskedastic when the error term variance is not constant. To check for heteroskedasticity the Breusch-Pagan Test is applied. The null hypothesis of this test is that the errors have a constant variance. The p-value (in Table 6) shows that the null hypothesis is rejected at 1% level of significance indicating that the error terms are heteroskedastic.

Table 6. Diagnostic tests

Test conducted		**Results**	
Breusch Pagan Test	**Heteroskedasticity**	**Chi2 (1)**	**Prob > chi2**
	H0: Constant variance	36.38	0.000
Woolridge Test	**Autocorrelation**	**F(1, 49)**	**Prob > F**
	H0: No first-order autocorrelation	43.355	0.000

Source: authors' computation.

No autocorrelation in the error terms is another assumption of multiple regression model. To check for this assumption the Woolridge test is used. The null hypothesis of this test is also rejected for the present data. Hence, it can be concluded that errors are in fact autocorrelated.

3.4. Regression analysis

Since the present data has problems of autocorrelation and heteroskedasticity a dynamic panel regression model of Least Square Dummy Variable Corrected (LSDVC) is used which is suitable in the present scenario. The results of this model are presented in Table 7.

The regression analysis revealed that all the independent variables showed a significant and positive relationship with the dependent variable, Export Intensity (Exp_Int). Besides the independent variables the lag value of export intensity (Exp_Int l1) is also considered in the present regression model. The

Table 7. Regression analysis: Least Square Dummy Variable Corrected (LSDVC)

Exp_Int	Coefficient	Standard error	*z*	95% confidence interval	
Exp_Int (l1)	0.863*	0.038	22.53	0.788	0.938
Size	0.625*	0.224	2.79	0.186	1.065
SD_Int	0.688**	0.296	2.33	0.108	1.268
RD_Int	2.835*	0.922	–3.07	1.028	4.641
FExp	0.061***	0.035	1.72	0.008	0.131
Int_Exp	0.104**	0.042	2.50	0.023	0.185
Wald $chi^2(8)$	2764.25				
Prob > chi^2	0.000				
Arellano-Bond test: AR (1)					
z	–5.58				
Prob > z	0.000				
Arellano-Bond test: AR (2)					
z	0.02				
Prob > z	0.980				
Sargan Test					
chi2(43)	57.91				
Prob > chi^2	0.34				

Note: * shows 10% significance level, ** shows 5% significance level, *** shows 1% significance level

Source: authors' computation.

coefficient shows that last year's exports effect the exports of the present year as well. The results support the 4th hypothesis. As expected Size showed a positive impact on Exp_Int as larger firms have more managerial and financial resources to handle additional costs associated with export operations including the funds required for market research and product development as per the requirements of foreign customers. Hypothesis 3 is also supported at 5% level of significance. Incurring expenditures on selling and distribution activities helps to improve the competitive position of the firms by building up the brand value and recognition of the firms as well as their products. Hence selling and distribution expenses (SD_Int) showed a positive impact on export intensity of the firms. Innovation has also been used as an important explanatory variable in previous studies (Radicic & Djalilov, 2019; Spuldaro et al., 2021). To proxy for this variable R&D intensity (RD_Int) has been used which also showed a significant and positive relationship with export intensi-

ty at 10% level of significance. To raise sales' volume and distribute the fixed cost of innovation over more units, innovative businesses frequently expand into overseas markets. The results further reveal that firm experience showed a significant positive relationship with export intensity (at 1% level of significance) with a coefficient of 0.061. Firms which wish to enter new markets have to face new cultures, varied tastes and preferences, different political regimes, distribution systems and diverse languages; all of which take time to learn. Hence, the firms with more age and experience tend to enter and perform better in foreign markets. Lastly, international exposure of top management has a positive impact on export intensity thereby supporting Hypothesis 5. When the top management has prior international exposure, they have a better understanding of the macro as well as micro environment of foreign companies. This helps them in identifying international opportunities and using them to the best of their advantage.

3.5. Post-estimation tests

The model used for regression analysis needs to be further tested for post--estimation. For this purpose, the Sargan test has first been used to check if the instrument variables satisfy overidentifying restrictions. The results shown in Table7 imply that there is no such issue because the results have failed to reject the null hypothesis of the test. Auto-correlated first differenced error terms at an order beyond 1 shows that the moment condition assumed in the model is invalid. Thus, to check for this the Arellano-Bond test, i.e., AR1 and AR2 has been conducted. The results show that though the null hypothesis for serial correlation is rejected at order 1, however, at order 2 contrary results are arrived at. Hence, it can be inferred that the first differenced error term at order 1 are serially correlated but the same is not true for the disturbances at order 2. In the light of the performed tests the empirical model is correctly specified.

Conclusions

This study was conducted to empirically find out if certain firm specific factors have significant impact on export intensity. It was hypothesized that firm specific factors such as firm size, selling and distribution intensity, research and development intensity, age of the firm and management specific factors such as international experience of top-level management have a positive

impact on the export intensity of the firm. It is shown that firm size, selling and distribution intensity, research intensity, age of the firm and the international experience of top-level management have significant influence on export intensity.

Through the empirical analysis presented in the paper it was found that research and development expenditure have a positive and significant influence on the export intensity. This shows that Indian SMEs should try to improve their innovation capacity by giving importance to research and development activities. The firms engaging themselves in research and development activities gather rich technology which helps them in increasing their exports. The cost of these activities is then spread over larger number of units. Firms such as Agrahyah Technologies, Befach 4X and Bellatrix Aerospace are amongst the top innovative MSMEs in India which are doing exceptionally well in their respective fields (*The Economic Times*, n.d.). It was also found that there is a positive and significant impact of firm size on export intensity. Larger firms have more export intensity as compared to smaller ones which could be because of availability of better financial resources. On this basis it could be suggested to Indian policy makers to formulate export promotion measures keeping in mind the smaller firms as they contribute towards a large percentage of Indian exports.

The study also shows that industry experience is a significant variable and the relationship between age and export intensity is positive. Prior knowledge is important in developing international markets. Getting a foothold in international markets is a learning process which evolves over time. Firms with more experience also attain more maturity in terms of management, international trade, business partnership and customer relationships (Majocchi et al., 2005). The empirical analysis shown in the paper provides a strong validation of the influence of advertising on export intensity. Allocating funds for selling and distribution activities helps firms in enter into new markets and in acquiring intangible assets such as brand name recognition which in turn can help in entering other markets. It was also found that international exposure of top management significantly and positively influences export intensity. Managers when exposed to international business environment acquire the knowledge of culture of other nations and tastes and preferences of foreign consumers which help them in taking better export decisions.

This study has implications for managers of SMEs. The results can be used by the managers to improve their exports. Firms should invest more proactively in their innovation efforts as this will ultimately help them increase their growth potential and achieve sustained competitive advantage. While firms with large size have more funds to support their entry into foreign markets their entry will also help them to achieve economies of scale. All firms should consider their expenditure on selling and distribution activities as an investment which is bound to provide them with benefits of product recognition

and improved brand value. Furthermore, SMEs would gain from hiring personnel with foreign experience and also provide their employees with more opportunities to learn in a foreign environment. Since the small firms are a very large number in India they could help tremendously in narrowing the trade deficit by contributing more towards exports and thus the Government support to SMEs will be mutually beneficial for the firms as well as the economy.

Due to the limitations of the data that is currently available, firms from only four manufacturing industries were taken as the sample for the present study. This is also a single country study and the results cannot be implied for firms from other emerging markets. However, despite these limitations this study can be used as a reference for other research papers such as those comparing the large and established business firms with SMEs or comparing the results with the SMEs of other nations. The present research studies only the direct impact of the independent variables on the dependent variable. Future studies can also study the mediation and moderation effect of other variables.

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The choice of external financing source: The role of company size and stock liquidity

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Abstract

This paper aims to answer whether firms of different sizes and stock liquidities differ in the choice of external sources of financing in companies listed in CEE countries. To this end the net debt issuance is regressed on the financial deficit. In regressions Pecking Order Coefficients are allowed to vary across firms with different sizes and stock liquidities. The results indicate that companies with less liquid shares prefer issuing debt to cover financial deficits more than companies with more liquid shares. This implies that stock liquidity may substitute debt issuance in alleviating the adverse effects of information asymmetry, especially in relatively small companies. This is the first study in which the relationship between liquidity and debt-equity choice is considered solely from a pecking order theory point of view. Also this is the first study in which stock liquidity effects on capital structure are studied in the CEE countries. Research results may point to the advantages of increasing the liquidity of shares which may contribute to reducing information asymmetry and thus a better allocation of resources.

Keywords

- stock liquidity
- debt-equity choice
- external financing
- financial deficit
- pecking order theory

JEL codes: G12, G14, G15, G32

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Introduction

One of the important tasks of business management is to reduce the negative effects of information asymmetry. According to the pecking order theory such a result can be achieved by appropriately shaping the capital structure. The problem of information asymmetry affects smaller companies to a greater extent and is more acute in less mature capital markets which certainly include those in Central and Eastern Europe (CEE). Capital markets in post-communist countries experience severe information asymmetry and investors' rights protection is quite poor. Thus, external investors in these countries may have significantly less knowledge about the company than insiders do. As it is more difficult for small businesses to access capital to reduce negative information asymmetries it is worth seeking alternative methods of achieving this goal.

As suggested by recent research on the intersection of the stock market microstructure and corporate finance improving stock liquidity may be one such method. This is because stock liquidity seems to alleviate the adverse effects of information asymmetry (Jiang et al., 2017; Stereńczak & Kubiak, 2022). Therefore, this research aims to answer whether firms of different sizes and stock liquidities differ in the choice of external sources of financing financial deficits in companies listed in CEE countries. This would permit an answer as to whether higher stock liquidity can substitute debt issuance in reducing the adverse effects of information asymmetry.

There is no single theory which directly explains why stock liquidity should have an effect on companies' debt-equity choices. However, several existing capital structure theories provide some indirect reasoning for the existence of stock liquidity effects on debt-equity choices. The first is the static trade-off theory. Stock liquidity affects companies' cost of equity (Amihud & Mendelson, 2000) hence according to that theory it also affects company target leverage. The second theory is the dynamic trade-off theory. Stock liquidity affects the cost of issuing equity (Butler et al., 2005) which impacts the speed of leverage adjustment towards the target. Finally, the effect of stock liquidity may also be explained in terms of the pecking order theory. According to that theory, companies with large information asymmetry concerns should prefer external debt financing more than firms with less information asymmetry. High liquidity makes stock prices more informative (Fang et al., 2009; Wang & Wei, 2021) and alleviates the adverse effects of information asymmetry (Jiang et al., 2017; Stereńczak & Kubiak, 2022). Thus, stock liquidity may influence a firm's preference for debt financing.

Research on the stock liquidity effects on companies' capital structures has appeared only recently and is based on the trade-off theories of capital structure. These studies confirm the effect of stock liquidity on a firm's debt-equity choice. Lipson and Mortal (2009), Nadarajah et al. (2018) and Dang

et al. (2019) prove that firms with more liquid shares are less leveraged due to lower cost of equity. Chen et al. (2020) find similar though they attribute this relationship to information asymmetry and blockholders' threat of exit. Lipson and Mortal (2009) find that firms with more liquid shares prefer equity financing when raising capital. The same relationship was observed by Rashid and Mehmood (2017) for the Pakistani and Dutta et al. (2022) for the Indian market. Ho et al. (2021) investigate the effect of liquidity on the speed of adjustment (SOA) of capital structure and find that firms with more liquid stocks have faster SOA. Also Nguyen et al. (2021) find that firms with more liquid bonds relative to stocks have higher leverage. This paper aims to answer whether firms of different sizes and stock liquidities differ in the choice of external sources of financing financial deficits in CEE countries. Therefore, unlike the previous research presented above, the analyses are based on empirical verification of the pecking order theory. Recent studies on the relationship between stock liquidity and capital structure focus mainly on trade-off theories. Thus, this study is the first in which the relationship between liquidity and debt-equity choice is considered solely from a pecking order theory point of view.

The study contributes to the ongoing research on the intersection of stock market liquidity and corporate finance. Recent studies in this field suggest that liquidity affects companies' financing decisions either by impacting target leverage (Dang et al., 2019; Lipson & Mortal, 2009; Nadarajah et al., 2018; Nguyen et al., 2021) or by impacting the speed of adjustment of capital structure (Ho et al., 2021). By analysing the liquidity effect on the companies' scopes for debt financing of a deficit another proof of the dependence of corporate capital structure on stock liquidity is provided. The study results suggest that firms with more liquid shares are more willing to issue equity to cover their financial deficit than firms with less liquid equity. This is visible especially in relatively smaller companies.

This study also contributes to the literature on the pecking order theory. According to that theory, when raising capital companies aim to minimize the adverse effects of information asymmetry between insiders and outsiders. Therefore, when companies need to raise external capital they should prefer issuing debt as it arises less adverse effects of information asymmetry. The study results suggest that stock liquidity may substitute debt issuance in alleviating the adverse effects of raising external capital. If this supposition is true, shocks to the company's stock liquidity may alter the choice of the source of external financing.

In addition, the research is important because it examines the scale of financing deficit with debt in the context of mitigating the effects of information asymmetry through relatively higher stock liquidity dependant on the size of the company. Kumar et al. (2020) pointed out the research gaps and proposed future research areas on the capital structure of small companies.

One of these areas is the search for other than the classic factors of capital structure; one such factor may be stock liquidity. The capital structure choices between equity and debt are different for small firms than for large firms in part because small businesses tend to be more informationally opaque than large firms (Berger & Udell, 1998). From this perspective small companies should raise external capital to a greater extent through debt.

As Martinez et al. (2019) pointed out only a few studies analyse the capital structure of small and medium-sized companies in emerging countries. Thus, as this study covers fourteen markets of Central and Eastern Europe, it also contributes to the literature on emerging and frontier stock markets. CEE markets provide an interesting setting for a study on stock liquidity effects on external financing sources especially for small companies. According to Hasan et al. (2017), small companies constitute a key element in enabling CEE countries to transition from a planned to a market economy. Moreover, these exchanges are relatively young and underdeveloped markets. According to the MSCI classification, CEE markets are either emerging or frontier. Due to a generally low level of development CEE markets are densely populated by low-liquid shares and small-cap stocks, experience severe information asymmetry and poor investors' rights protection. Even more importantly firms in CEE countries are focused more on indirect bank financing rather than on direct financing through the capital markets. Also a relatively high percentage of small and medium-sized companies in CEE countries use internal financing which may result from low financial market development (Moritz et al., 2016). A significant number of large companies in CEE countries, however, are State Owned Enterprises (Matuszak, 2020) which may have an effect on their choices of financing sources. These features may significantly influence the liquidity effects on the choice of the source of external financing.

The remainder of the paper is structured as follows. Section 1 provides a brief literature review and develops hypotheses tested in the empirical part of the study. Then Section 2 depicts the sources of data and methods applied. Section 3 presents baseline empirical results and robustness tests are provided in Section 4. The final section discusses and concludes the results.

1. Literature review and hypotheses development

According to the pecking order theory, when raising capital companies do not aim to reach their target leverage but use such financing sources that will minimize the adverse effects of information asymmetry. Therefore, companies should prefer debt to finance their deficits as debt financing causes less adverse effects of information asymmetry. Shyam-Sunder and Myers (1999)

found that the pecking order theory reliably describes the behaviour of U.S. companies. Fama and French (2002) concluded that the pecking order theory 'wins' over the trade-off theory but only in explaining the case of low-leveraged and relatively more profitable firms. Frank and Goyal (2003) showed that debt is a preferred source of raising capital in large firms. Small companies use debt to a lesser extent as compared to big ones. Halov (2006) claimed that the choice of a financing source depends on both the current and future level of information asymmetry. Companies which currently are characterized by a significant information asymmetry may choose to issue equity instead of debt because they expect an amplification of the information asymmetry in the long run. This coincides with Myers and Majluf's (1984) conclusions who recommended that corporations that do not suffer from information asymmetry should build their financial slack in future. Shen's (2014) research indicates that companies replace equity with debt when information asymmetry increases. Qu et al. (2018) find that consistent with the predictions of the pecking order theory companies whose shareholders face more severe informational disadvantages are associated with a higher degree of leverage.

Thus, according to the pecking order theory, debt financing is supposed to mitigate the negative effects of information asymmetry. However, recent studies show that stock liquidity may alleviate this problem. High liquidity makes stock prices more informative (Fang et al., 2009; Jiang et al., 2017; Wang & Wei, 2021). Bakri et al. (2020) stated that in emerging markets with high information asymmetry the informational effect of stock liquidity is crucial in mitigating information asymmetry as compared to the developed markets with lower information asymmetry. Stereńczak and Kubiak (2022) pointed out that high stock liquidity in the CEE markets prompts investors to gain additional information to mitigate adverse selection concerns. Based on the indications of the pecking order theory and the empirical evidence on the role of stock liquidity in mitigating adverse selection problems the following hypothesis is stated:

H1: Firms with more liquid shares prefer financing their financial deficit through equity issuance more than firms with less liquid shares.

Several publications on the pecking order theory indicate that the firm's size is an important aspect in differentiating the capital structure. Smaller companies are affected by various information asymmetries issues such as adverse selection and moral hazard, among others (Martinez et al., 2019). On the one hand, more debt raising can be expected in these companies. As Berger and Udell (1998) emphasized financial intermediaries play a crucial role in the private markets as information producers who can assess small business quality and address information problems through the activities of screening, contracting and monitoring. On the other hand, small companies face greater constraints in accessing external debt financing with

respect to large companies and those limitations arise mainly due to asymmetric information problems between borrowers and lenders (Beck et al., 2005). This may result in higher debt issuance costs for small companies compared to large ones. In addition, they are characterised by insufficient creditworthiness.

The difficulties in obtaining credit by small and medium-sized enterprises are well known in literature. Stiglitz and Weiss (1981) described the phenomenon of credit rationing. The authors found that pledging outside collateral may help resolve adverse selection problems when the borrower has more information about the quality of the investment than the lender and may help prevent credit rationing. The fact that smaller companies are treated unfairly in access to bank loans has been highlighted in a study by Nguyen and Ramachandran (2006). Czerwonka and Jaworski (2021) examined the small and medium-sized enterprises' capital structure determinants in Central and Eastern Europe and found that these firms' leverages do not exceed their debt capacities which is consistent with the pecking order theory. The aforementioned obstacles in obtaining credit may in part explain the findings of Frank and Goyal (2003) who revealed that larger firms are more likely to follow a pecking order than small ones. The greater leverage of large companies is among others a result of a greater ability to collateralise credit.

As noted above the liquidity of shares is capable of being a substitute for issuing debt in alleviating adverse effects of information asymmetry. However, due to the limited availability of debt for small and medium-sized enterprises the second hypothesis is stated as follows:

H2: The negative relationship between stock liquidity and the scope for financing deficit through a debt is more pronounced in relatively smaller companies.

2. Data and methodology

For the empirical study the data from the cash flow statements and balance sheets of firms listed in 14 countries of Central and Eastern Europe (Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Russia, Serbia, Slovenia, Slovakia and Ukraine) in the period from 2009 to 2021 are gathered from S&P Capital IQ database. These exchanges are relatively young markets, densely populated by low liquid shares and experience severe information asymmetry and poor investors' rights protection. These features may significantly influence the liquidity effects on the choice of the source of external financing. The distribution by country of the research sample is provided in Table 1. The initial research sample consists of 2,138 companies,

however, firms from the financial sector (493 companies) are excluded due to their unique financial statements. Also observations with incomplete financial data (1,320 observations) and less than 100 trading days within a year (5,742 observations) are discarded. The final dataset comprises 1,265 firms and 9,238 firm-year observations. The research sample is overrepresented by Polish companies which constitute over half of the sample (Table 1).

Table 1. Structure of the research sample

	Initial sample		Excluding financial firms				Final sample			
Country	Firms	% of firms	Firms	Obs.	% of firms	% of obs.	Firms	Obs.	% of firms	% of obs.
Bulgaria	236	11.04	185	1,330	11.25	8.88	106	477	8.38	5.11
Croatia	115	5.38	80	646	4.86	4.31	53	454	4.19	4.87
Czechia	62	2.90	44	246	2.67	1.64	16	79	1.26	0.85
Estonia	24	1.12	24	234	1.46	1.56	17	160	1.34	1.72
Hungary	101	4.72	50	507	3.04	3.38	43	313	3.40	3.36
Latvia	34	1.59	12	125	0.73	0.83	10	69	0.79	0.74
Lithuania	41	1.92	27	299	1.64	2.00	27	188	2.13	2.02
Poland	862	40.32	703	7,515	42.74	50.17	654	5,052	51.70	54.16
Romania	90	4.21	74	844	4.50	5.63	67	523	5.30	5.61
Russia	251	11.74	201	2,089	12.22	13.95	185	1,499	14.62	16.07
Serbia	181	8.47	134	433	8.15	2.89	34	181	2.69	1.94
Slovakia	31	1.45	23	368	3.65	2.46	7	196	0.55	2.10
Slovenia	70	3.27	60	136	1.40	0.91	29	41	2.29	0.44
Ukraine	40	1.87	28	208	1.70	1.39	17	96	1.34	1.03
Total	2,138	100	1,645	14,980	100	100	1,265	9,328	100	100

Source: own work.

Stock liquidity denotes the ability to buy or sell large quantities of shares within a short time interval, with low cost and without causing an unfavourable price impact. Defined as such it encompasses several dimensions, i.e. quantity (depth), time (immediacy), cost (tightness) and price impact (resiliency) dimensions. In the study liquidity is measured with the most commonly used proxy for liquidity, i.e. Amihud's (2002) illiquidity ratio. It reflects only the price impact dimension of stock liquidity but for robustness purposes the remaining liquidity dimensions are also taken into account. The liquidity measure is computed strictly following Amihud (2002):

$$ILLIQ_{it} = \frac{1}{NoTD_{it}} \sum_{m=1}^{NoTD_{it}} \frac{|r_{imt}|}{Val_{imt}} \quad (1)$$

where $NoTD_{it}$ is the number of trading days on stock i in year t, r_{imt} denotes log stock return on ith stock in day m of year t, and Val_{imt} is the respective daily value of shares traded expressed in millions of EUR. In order to eliminate the outliers the log transformation of ILLIQ ($lnILLIQ$) is used in the study.

For each firm-year observation in the sample the financial deficit (DEF) is computed following Frank and Goyal (2003) as a sum of the change in working capital (ΔW), investments (I) and cash dividends (DIV), less internal cash flows (C):

$$DEF_{it} = DIV_{it} + I_{it} + \Delta W_{it} - C_{it} = \Delta D_{it} + \Delta E_{it} \quad (2)$$

A financial deficit may be covered by debt issuance either by equity issuance hence DEF is expected to be equal to the sum of the net debt issued or retired (ΔD) and the net equity issued or retired (ΔE). To ensure comparability of DEF among companies of different sizes in the empirical analyses the deficit is scaled by the company's total assets. Its negative value means a surplus of funds with which the company pays back creditors or owners while a positive result means a deficit and therefore the need to raise external debt or equity.

The study also uses some control variables to capture the effect of other factors on the choice between issuing debt and equity. In particular, a firm's *Leverage* is calculated as a ratio of total debt to the book value of assets. The market-to-book value (*M-BV*) is used to proxy for past stock performance and stock overvaluation and Altman's Z-Score (Altman & Hotchkiss, 2006) to proxy for a firm's credibility. Descriptive statistics on all variables used in the study are presented in Panel A of Table 2.

Panel B of Table 2 presents some descriptive statistics for DEF values and leverage of companies covered in the study divided into groups of different sizes and stock liquidities. As depicted small firms relatively more often experience a zero value of DEF which may indicate that they rely relatively more on internal financing. This, in turn, is consistent with recent evidence by Moritz et al. (2016), Jiang et al. (2017), Neville and Lucey (2022) and Stereńczak and Kubiak (2022) among others. Among all size subsamples the proportion of deficits and surpluses within a subsample is roughly equal. The average surplus is also roughly equal across all three company-size groups. However, small firms experience relatively the highest deficits (Table 2) which is in line with the findings of De Jong et al. (2010). Small firms are also least leveraged which may seem surprising as they are subject to high information asymmetry concerns and thus should rely more on debt financing. However, taking their lower creditworthiness into account it can be assumed that this is the reason for the relatively low use of debt financing by these firms. It is in

line with research results presented by De Jong et al. (2010) and Bhama et al. (2015) who pointed out that in a situation of large deficits firms are less likely to issue more debt. In addition, Chaklader and Padmapriya (2021) noticed that financial deficit is negatively related to financial leverage for small and medium-sized firms. Thus, the relatively smaller CEE companies surveyed seem to follow patterns observed in other markets.

Table 2. Descriptive statistics

Panel A: Descriptive statistics of all variables							
Variable	**Mean**	**Median**	**Standard deviation**	**Skew-ness**	**Kurtosis**	**Min**	**Max**
DEF/Assets	1.89%	0%	7.26%	2.164	5.946	–10.36%	38.35%
ΔD/Assets	0.118%	0%	3.74%	1.041	2.827	9.42%	15.15%
lnAssets	5.710	5.296	3.344	0.387	–0.024	–7.621	16.966
lnILLIQ	2.511	3.300	3.272	–0.949	0.436	–9.762	7.174
Leverage	20.57%	17.14%	18.84%	1.014	0.822	0%	99.75%
M-BV	6,291.13	21.206	95,229.23	37.692	1,929.69	0.00004	5,995,069
Z-Score	1.738	1.349	51.174	–73.577	6,569	–5,107.66	291.36
Panel B: Deficits and leverages in subgroups							
Sample	**% of**			**Average**			**Average *Leverage***
	Deficit	***DEF* = 0**	**Surplus**	**Deficit**	***DEF***	**Surplus**	
All firms	41.72	15.91	42.37	7.45	1.89	2.88	20.57
Small	39.23	25.35	35.42	8.95	2.57	2.66	12.90
Medium	40.58	11.93	47.50	7.05	1.45	2.97	21.62
Big	45.41	10.57	44.02	6.53	1.66	2.96	26.07

Source: own work.

As the study investigates the relationship between liquidity and the degree to which deficits are financed through debt in companies of different sizes it starts by independently splitting the sample into terciles of distribution of size ($lnAssets$) and liquidity ($lnILLIQ$), obtaining 9 "portfolios" (3 x 3). Then within each of the nine portfolios the net debt issuance is regressed on the financial deficit, as in Shyam-Sunder and Myers (1999) and Frank and Goyal (2003):

$$\Delta D_{it} = a + b_{PO} DEF_{it} + e_{it} \tag{3}$$

where ΔD_{it} denotes the amount of net debt issued (retired if ΔD_{it} is negative) by the ith firm in year t, and DEF_{it} is ith firm's financial deficit (surplus

if DEF_{it} is negative) in year t, both scaled by assets. According to pecking order theory, a is expected to be insignificantly different from 0, and b_{PO} is a Pecking Order Coefficient and reflects firms' scope for debt financing. Estimating equation (3) across nine groups of companies allows a comparison of preferences for financing deficits through debt issuance for firms of different sizes and stock liquidities. According to hypothesis H1, b_{PO}s are expected to be higher for firms with more illiquid stocks. Also larger firms are expected to have higher b_{PO}s.

As company size and stock liquidity may be not only determinants of a firm's preference for debt financing of the financial deficit the b_{PO}s in equation (3) are allowed to vary across firms with different characteristics. A similar approach was applied by Ho et al. (2021) in their analysis of stock liquidity effects on a firm's speed of leverage adjustment. To this end the b_{PO} is specified as a function of the firm's size, stock liquidity and control variables as follows:

$$b_{PO} = a_0 + a_1\, lnILLIQ_{it} + a_2\, lnAssets_{it} + a_3\, lnILLIQ_{it} \cdot lnAssets_{it} + a_4\, X_{it} \quad (4)$$

where *X* denotes control variables, i.e., *Leverage*, *M-BV* and *Z-score*. Recent studies proved these variables are significant for European enterprises' capital structures (Czerwonka & Jaworski, 2022). Similar to Nehrebecka and Dzik-Walczak (2018), in equation (4) also country, industry and year fixed effects are included to control for unobservable heterogeneity among different countries (resulting, e.g., from differences in legal frameworks or in financial systems), industries (e.g., mainly from differences in asset structures) and years (e.g., due to macroeconomic conditions). As Koralun-Bereźnicka (2018) noted among European companies the country effects as well as the industry effects can have even stronger impact on capital structure than company size. Macroeconomic conditions, especially banking sector health, economic growth and inflation rate, determine companies' accessibility of debt to firms (Białek-Jaworska, 2017). Also the benign credit cycle may influence the companies' choices of external financing (Altman & Kuehne, 2016), and this also can be captured by year fixed effects. Combining equations (3) and (4) the standard model of firm's scope of debt financing expands and yields the following panel data regression:

$$\begin{aligned} \Delta D_{it} = a + (a_1\, lnILLIQ_{it} + a_2\, lnAssets_{it} + a_3\, lnILLIQ_{it} \cdot lnAssets_{it} + \\ + a_4\, X_{it} + Country + Industry + Year)\, DEF_{it} + e_{it} \end{aligned} \quad (5)$$

where *Country*, *Industry* and *Year* denote country, industry and year fixed effects respectively. To avoid heteroskedasticity and cross-correlation of residuals resulting from unobservable heterogeneity among firms, standard errors are clustered at the firm level. According to the hypotheses, it is expected that $a_1 > 0$ (H1) and $a_3 < 0$ (H2); also, $a_2 > 0$ is expected.

3. Empirical results

First, all companies in the research sample are independently sorted into terciles of distribution of size ($lnAssets$) and liquidity ($lnILLIQ$) and assigned to one of 9 "portfolios" (3 x 3). Within each portfolio a companies' scopes for financial deficit through debt issuance (b_{PO}) are estimated in line with equation (3). b_{PO}s estimated among nine groups of companies are presented in Table 3. The values in Panel A of Table 3 show that the relationship between stock liquidity (as measured by the Amihud ratio) and the scope for financing deficit (negative or positive) through debt is different for small versus large companies. On average the largest firms in the sample exhibit the highest scopes for financing deficit through debt issuance (as measured by the b_{PO} – the Pecking Order Coefficient). Small and medium-sized companies finance their deficits using debt to a lesser extent.

Despite their lower creditworthiness and leverage small companies with illiquid stocks reveal a greater scope for financing deficit through debt than small companies with a higher level of stock liquidity. A similar and even more clearly visible relationship pertains for medium-sized companies. Low liquidity of a company's shares results in a smaller preference for financing deficit through equity issuance (Table 3). Surprisingly the reverse relationship is visible in large companies. In the case of the biggest firms in the sample companies with highly liquid shares prefer debt financing of their deficits more than companies with moderately liquid and illiquid shares.

Differences in estimated scopes for financing deficit through debt issuance among groups of companies of different stock liquidity are statistically significant. The results of the Chow F-test indicate that most of the differences among the values of b_{PO} are statistically significant. Only in two cases the Chow F-test fails to reject the null hypothesis that the coefficients among the two groups are equal. The first one is the case of small firms and the difference in b_{PO}s among the groups of companies with liquid and moderately liquid shares. Also the difference in b_{PO}s among the groups of large companies with moderately liquid and illiquid shares is statistically insignificant. Details on the p-values of the Chow F-test are available upon request.

It is widely agreed that large companies are more resilient to the negative effects of information asymmetry. If stock liquidity alleviates the adverse effects of information asymmetry (Jiang et al., 2017; Stereńczak & Kubiak, 2022), capital structure choices of companies with less information asymmetry concerns may be less affected by stock liquidity. Lower liquidity of their shares plausibly does not 'force' them to finance their deficit to a greater extent with debt than companies with higher stock liquidity. Variations in creditworthiness and resilience to the negative effects of information asymmetry may therefore account for differences in the way deficits are financed and the

Table 3. Pecking Order Coefficients in companies aggregated in terciles by size and liquidity

Panel A: All cases				
Size / liquidity	Average	Liquid	Moderately liquid	Illiquid
Small	0.197***	0.113***	0.131***	0.245***
	(16.38)	(3.709)	(6.609)	(11.52)
Medium	0.429***	0.324***	0.473***	0.592***
	(20.08)	(8.829)	(14.12)	(15.28)
Big	0.524***	0.693***	0.421***	0.342***
	(22.11)	(26.70)	(8.667)	(5.114)
Panel B: Surpluses				
Size / liquidity	Average	Liquid	Moderately liquid	Illiquid
Small	0.666***	0.614***	0.734***	0.636***
	(23.39)	(4.620)	(11.64)	(15.02)
Medium	0.695***	0.676***	0.745***	0.673***
	(28.25)	(12.76)	(21.21)	(13.12)
Big	0.738***	0.822***	0.705***	0.476***
	(25.98)	(22.31)	(12.51)	(4.278)
Panel C: Deficits				
Size / liquidity	Average	Liquid	Moderately liquid	Illiquid
Small	0.051***	-0.001	-0.002	0.095***
	(4.557)	(0.047)	(0.116)	(4.472)
Medium	0.220***	0.129***	0.241***	0.477***
	(8.146)	(3.226)	(5.533)	(7.261)
Big	0.311***	0.539***	0.178***	0.166**
	(9.653)	(11.63)	(3.309)	(2.240)

Note: The Table presents Pecking Order Coefficients (b_{PO} from equation (1)) for companies sorted independently by size and liquidity. Panel A presents the coefficients for all cases, Panel B presents the coefficients for cases of surplus (negative DEF), and Panel C contains the coefficients for cases of deficit (positive DEF). t-statistics with robust standard errors clustered at the firm level are given in the parentheses and asterisks denote the statistical significance at the 0.1 (*), 0.05 (**) and 0.01 (***) level.

Source: own work.

opposite relationship between stock liquidity and the extent to which deficits are financed by debt in companies of different sizes.

The above results provide partial support for hypothesis H1. It is only confirmed for small and medium-sized companies. The higher scope for issuing debt to cover a deficit in companies with less liquid stocks confirms a negative relationship between stock liquidity and preference for debt financing. Large companies do not exhibit a negative relationship between stock liquidity and scope for financing deficit through debt issuance, thus confirming hypothesis H2.

The results allow the statement that stock liquidity may be an alternative to debt in alleviating the adverse effects of information asymmetry in relatively smaller companies. In cases when they face low stock liquidity they rely on debt more than in cases when their stocks are more liquid. This should be particularly relevant when they face a deficit and need to raise funds. In the case of a surplus and repurchase of capital information asymmetry concerns should be of less importance. To check this the Pecking Order Coefficients are estimated separately for the surplus and deficit cases; the results are presented in Panels B and C of Table 3.

The behaviour of firms that experience financial surplus (negative values of DEF) differs from that presented by firms with a financial deficit (positive values of DEF). Consistent with previous findings by De Jong et al. (2010). Pecking Order Coefficients are higher for surpluses than for deficits which means that in the case of a surplus firms repay relatively more debt than firms with a deficit issue it. By repaying debt firms with a financial surplus increase their financial slack and debt capacity to finance future deficits.

In the case of a surplus no clear variation in Pecking Order Coefficients between groups of firms with different stock liquidity is visible. This means that the stock's liquidity does not differentiate the value of the debt repaid. In addition the Chow F-test suggests that only the differences in b_{PO}s among the groups of big companies with various levels of stock liquidity may be considered statistically significant at a reasonable confidence level. Details on the *p*-values of the Chow F-test are available upon request.

Results for the cases of deficit mimic those shown in Panel A of Table 3, both in terms of values of the b_{PO} coefficients and the statistical significance of their differences among groups of companies of different stock liquidity. This means that for relatively smaller companies greater debt issuance occurs in companies with low stock liquidity than in companies with more liquid stocks. For large companies the opposite relationship is observed. Large companies with less liquid shares are less likely to issue debt to cover their deficits than large companies with more liquid shares.

So far the results partially confirm hypothesis H1 and fully confirm hypothesis H2. According to this firms with less liquid shares tend to issue more debt to cover their financial deficit. This is visible in small and medium-sized com-

panies which are affected by more information asymmetry concerns and are more vulnerable to its adverse effects. However, it is still possible that previous results are driven by other factors that correlate with either company size or with stock liquidity. To alleviate this concern model (5) in which the firm's scopes for debt financing of the deficit are allowed to vary with several characteristics is estimated. As Breusch-Pagano and White's tests fail to reject the null hypothesis that the variance of residuals is constant among the panel units to avoid the adverse effects of heteroskedasticity estimated standard errors are clustered at the firm level. Meanwhile Durbin-Watson statistics suggest a possible autocorrelation of residual in the models. However, according to Petersen (2009), additional clustering of standard errors by time units would gain only marginal profit as the number of time clusters in the regressions is small. To further alleviate this concern bootstrap *t*-statistics (not tabulated) are also estimated and the results remain qualitatively unchanged. Estimated coefficients are provided in Panel A of Table 4.

Columns (1)–(2) present coefficients for models without control variables and fixed effects. Columns (3)–(7) present the estimated coefficients for models with control variables and/or fixed effects for country, industry and year. VIF and BKW (Belsley et al., 1980) statistics suggest a potential collinearity problem resulting from including country, industry and year fixed effects in regressions. However, the estimated coefficients, both in terms of magnitude and statistical significance, are similar among models with and without effects

Table 4. Stock market liquidity, company size and the scope for debt financing

Panel A: All cases							
Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)
a	–0.003*** (7.922)	–0.003*** (8.262)	–0.003*** (7.010)	–0.002*** (6.611)	–0.002*** (6.750)	–0.002*** (6.698)	–0.002*** (6.695)
a_1	0.015*** (4.149)	0.024*** (4.457)	0.012*** (2.717)	0.019*** (2.905)	0.016** (2.464)	0.013* (1.947)	0.032*** (3.188)
a_2	0.063*** (21.79)	0.063*** (21.81)	0.049*** (10.14)	0.080*** (9.286)	0.074*** (8.059)	0.072*** (7.889)	0.079*** (8.535)
a_3		–0.002** (2.017)					–0.003** (2.395)
Control variables	No	No	Yes	Yes	Yes	Yes	Yes
Country effects	No	No	No	Yes	Yes	Yes	Yes
Industry effects	No	No	No	No	Yes	Yes	Yes
Time effects	No	No	No	No	No	Yes	Yes
Number of obs.	9,238	8,304	8,190	8,190	8,190	8,190	7,518
Adjusted R^2	0.403	0.421	0.446	0.480	0.496	0.501	0.521

Table 4 continued

Panel B: Surpluses							
Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)
a	–0.005*** (9.982)	–0.004*** (8.876)	–0.004*** (9.719)	–0.002*** (4.802)	–0.002*** (4.686)	–0.002*** (4.733)	–0.002*** (4.731)
a_1	0.050*** (10.87)	0.082*** (8.711)	0.035*** (7.060)	0.0004 (0.053)	–0.0005 (0.072)	–0.002 (0.274)	0.001 (0.049)
a_2	0.078*** (26.33)	0.076*** (25.37)	0.049*** (10.93)	0.020** (2.251)	0.017* (1.752)	0.015 (1.482)	0.015 (1.457)
a_3		–0.005*** (3.185)					–0.0003 (0.242)
Control variables	No	No	Yes	Yes	Yes	Yes	Yes
Country effects	No	No	No	Yes	Yes	Yes	Yes
Industry effects	No	No	No	No	Yes	Yes	Yes
Time effects	No	No	No	No	No	Yes	Yes
Number of obs.	4,382	4,382	4,019	4,019	4,019	4,019	4,019
Adjusted R^2	0.424	0.434	0.472	0.532	0.541	0.548	0.548
Panel C: Deficits							
Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)
a	0.015*** (14.90)	0.015*** (16.58)	0.014*** (13.51)	0.013*** (14.44)	0.012*** (13.93)	0.012*** (13.62)	0.011*** (13.89)
a_1	–0.001 (0.282)	0.003 (0.607)	–0.002 (0.427)	0.014** (2.111)	0.012* (1.743)	0.009 (1.281)	0.026*** (2.674)
a_2	0.039*** (11.11)	0.039*** (11.57)	0.031*** (6.106)	0.065*** (6.927)	0.060*** (6.026)	0.059*** (5.956)	0.066*** (6.592)
a_3		–0.001 (0.856)					–0.003** (2.120)
Control variables	No	No	Yes	Yes	Yes	Yes	Yes
Country effects	No	No	No	Yes	Yes	Yes	Yes
Industry effects	No	No	No	No	Yes	Yes	Yes
Time effects	No	No	No	No	No	Yes	Yes
Number of obs.	3,922	3,922	3,499	3,499	3,499	3,499	3,499
Adjusted R^2	0.144	0.144	0.180	0.228	0.251	0.259	0.262

The Table presents the estimated coefficients of the model (5). Control variables are: *Leverage*, *M-BV* and *Z*-Score. presents the coefficients for all cases, Panel B presents the coefficients for cases of surplus (negative *DEF*), and Panel C contains the coefficients for cases of deficit (positive *DEF*). *t*-statistics with robust standard errors clustered at the firm level are given in the parentheses and asterisks denote the statistical significance at the 0.1 (*), 0.05 (**) and 0.01 (***) level.

Source: own work.

and hence it can be concluded that potential collinearity is not a severe concern. As the models in columns (2) and (7) include the interaction between size and liquidity the observations with $DEF = 0$ are dropped to further alleviate the collinearity concerns. In line with the expectations a_1s are significantly positive and a_3s are significantly negative regardless of the model specification. In models not including the interaction between the size and stock liquidity a_1s are visibly of lower magnitude than in models including the interaction which is not surprising due to negative a_3s. Significantly positive a_1s mean that firms with less liquid shares (i.e., higher values of $lnILLIQ$) tend to issue more debt to cover their financial deficits. Negative a_3s (Table 4) indicate that this relationship is less pronounced in bigger firms, which are less vulnerable to the adverse effects of information asymmetry.

The effect of stock liquidity on firms' scope for debt financing of the deficit is not only statistically significant but also economically meaningful. One standard deviation increase in $lnILLIQ$ (which denotes the deterioration in stock liquidity) results in an increase in the firm's scope for issuing debt (as measured by b_{PO}) by 3.93%–6.21%. However, taking the soothing effect of firm size on liquidity effects on b_{PO} (models (2) and (7)) into account an increase in the firm's scope for debt financing due to a one standard deviation increase in $lnILLIQ$ is 7.85%–10.47%.

To verify if stock liquidity is equally important to firms facing a deficit and facing a surplus model (5) is estimated separately for the surplus and deficit cases and the results are presented in Panels B and C of Table 4. The results seem to confirm earlier conclusions from the results presented in Table 3, i.e., stock liquidity is important to firms especially when they face a deficit and need to raise capital. This is confirmed by significantly positive a_1s though it is statistically significant only if control variables and fixed effects are included in the models. In a case of a surplus a_1s become insignificant if other firm characteristics and fixed effects are controlled for which suggests that stock liquidity is not important to the firm's decision on how to repay the capital.

Interestingly adjusted R^2s are higher for models estimated for surplus cases than for models estimated for deficit cases. This suggests that the pecking order theory better explains firms' behaviour when they face a surplus rather than a deficit. This implies that when a firm faces a surplus it repays the debt to maintain its financial slack which can be used to finance potential future deficits.

All the results confirm both hypotheses. Companies with more liquid shares prefer financing their financial deficit through equity issuance more than firms with less liquid shares which is suggested by positive a_1 coefficients. The negative relationship between stock liquidity and the scope for financing deficit through debt is more pronounced in relatively smaller companies which is evidenced by negative a_3 coefficients. As smaller companies are more vulnerable to the adverse effects of information asymmetry the existence of stronger ef-

fects of stock liquidity on a firm's debt financing suggests that stock liquidity may substitute debt issuance in alleviating the adverse effects of information asymmetry. Thus, companies can mitigate information asymmetry concerns not only by issuing debt when they need to raise external financing but also by taking actions aimed at enhancing the liquidity of their shares.

4. Robustness tests

As Amihud's (2002) ratio used in the baseline study to measure stock liquidity reflects only the price impact dimension of stock liquidity (resiliency) the robustness of the results presented in Section 4 is tested by taking the remaining liquidity dimensions into account. To this end stock liquidity is measured with alternative measures reflecting various liquidity dimensions. In particular Percent Quoted Closing Spread (Chung & Zhang, 2014) that reflects tightness, Liu's (2006) measure to reflect immediacy and the turnover ratio to measure market depth are used. Then the analyses from Section 4 are repeated for each of the alternative liquidity measures. For the sake of brevity the results are not presented but available upon request. The results are qualitatively similar to those presented in Section 4 hence the conclusions remain unchanged if other liquidity proxies are considered. It can thus be concluded that the results are unbiased by the choice of liquidity measure and that all dimensions of stock liquidity affect companies' preferences for debt financing of their deficits.

As Polish companies constitute over half of the research sample the sample is split into two subsamples: Polish and non-Polish companies. This allows a check to be made as to whether the results are not driven by patterns observed solely for Polish firms. For the sake of brevity the detailed results are not presented but are available upon request. To sum up the subsample analysis suggests that the results and conclusions are not driven by Polish companies.

Conclusions

This paper aimed to answer whether firms of different sizes and stock liquidities differ in the choice of external sources of financing in companies listed in CEE countries. In general the study presents that companies with less liquid shares prefer debt financing of the financial deficit more than companies with more liquid shares. The magnitude of this relationship varies according

to the company size. The findings are also in line with Frank and Goyal (2003) who revealed that large firms are more likely to follow a pecking order while small firms rely more on equity financing. However, despite smaller companies being less creditworthy and less leveraged the negative relationship between stock liquidity and scope for financing deficit through debt is more pronounced in these firms. The relationship between stock liquidity and the scope for financing deficit through debt is particularly relevant when firms face a deficit and need to raise capital. In the case of a surplus and repurchase of capital, information asymmetry is a less concerning issue which makes the relationship under scrutiny less visible.

This study does not contradict recent evidence on the relationship between stock liquidity and capital structure but complements it. Lipson and Mortal (2009), Nadarajah et al. (2018) and Dang et al. (2019) prove that firms with more liquid shares are less leveraged. This study suggests that this may be due to the lower preference for debt financing of the deficit in these companies. Also Chen et al. (2020) attribute the lower debt usage by firms with more liquid shares to information asymmetry which is also evidenced here although based on a different capital structure theory. Again based on the trade-off theory of capital structure Lipson and Mortal (2009) find that firms with more liquid shares prefer equity financing when raising capital and this study generates similar conclusions based on the pecking order theory. Thus, this paper proposes different mechanisms driving the relationship between stock liquidity and a company's capital structure.

The study results suggest that liquidity can substitute debt issuance in reducing the adverse effects of information asymmetry especially in relatively smaller companies. Thus, liquidity-enhancing actions may influence the choice of funding sources. Based on this research the reasons for the differences between companies of different size in the relationship between stock liquidity and the scope for financing deficit through debt can be traced to variations in creditworthiness and resilience to the negative effects of information asymmetry.

The findings may be interesting to managers, policymakers and investors. Because stock liquidity is capable of substituting the issuing of debt in alleviating the adverse effects of information asymmetry managers may find support in this research for taking liquidity-enhancing actions as this can give the company benefits by increasing the information content of share prices and lowering the adverse selection costs. This concerns in particular small firms. Such liquidity-enhancing actions may include disclosing more information of high quality and attracting more investors to increase the number of shareholders (Amihud & Mendelson, 2000; Pham et al., 2023).

Not all the factors that affect stock liquidity are controlled by the issuing company and especially in the CEE policymakers may be encouraged to implement systemic solutions to support stock liquidity and improve access to

credit enhancement programmes for smaller enterprises which may indirectly result in a better allocation of resources. The systemic solutions supporting stock liquidity are not limited to shaping appropriate regulations but may also consist of implementing new, more cost-efficient trading technologies which speed the trading and make it more frequent (Amihud & Mendelson, 2000). Another important factor is a general interest in investing in capital markets. Policymakers should provide conditions attracting various types of investors: individual and institutional, short- and long-term, domestic and foreign as investor heterogeneity improves stock liquidity (Chan et al., 2022). Investors who analyse the capital structure of companies can understand the potential reasons for the variation in the degree to which companies of different sizes finance their deficits through debt issuance.

Although the presented results quite clearly indicate that stock liquidity is capable of substituting for the issuing of debt in alleviating the adverse effects of information asymmetry this capability should be further investigated. A comparative study on the relationship between stock liquidity and the choice of external financing source among the markets of different levels of development, investors' protection rights and the strength of legal and political institutions could be of great interest. Although country effects were included in the research there is certainly a need to examine them in more detail. Another possible extension of the research would be a study using a more accurate proxy for information asymmetry.

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Socio-economic determinants of environmental degradation: Empirical evidence for the Environmental Kuznets Curve

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Abstract

The aim of the paper is to examine socio-economic determinants of environmental degradation. The empirical study employs quantile regression which enables separate predictions for different levels of the dependent variable to be made. This study investigated 62 countries from low, middle and some high income countries for 1995–2019. The Environmental Kuznets Curve (EKC) is verified for the aforementioned countries in analyzing the relationship between economic growth and carbon emissions using quantile regression. The study also revealed that the schooling rate has a pollution-increasing effect. In addition to the reducing effects of trade openness, democracy, and economic freedom variables on environmental degradation, the opposite effect of life expectancy at birth is observed, increasing environmental degradation. In this context, this paper concluded that the EKC hypothesis is not supported. The government should encourage pollution-reducing policies in low and middle income countries.

Keywords

- environmental degredation
- economic development
- EKC
- panel data
- quantile regression

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Introduction

Environmental degredation throughout the world has prompted an increasing number of scholars to look into the reasons. Environmental changes and their driving forces, such as economic growth and environmental degredation, have a complicated connection (McPherson & Nieswiadomy, 2005).

An important indicator of environmental degredation has been acknowledged as CO_2 emissions. While energy production-based CO_2 emissions were 20,516.0 Mt CO_2 in total in the 1990s, this figure increased to 33,513.3 Mt CO_2 in 2018 (IEA, 2021). While the world average of CO_2 emissions was 3.12 tons per capita in 1960, this figure peaked at 4.70 tons in 1979 and was 4.48 tons in 2018. It is known that developed countries make the highest contributions to these averages. For example, while the global greenhouse gas emission per capita of the USA was 16 tons in 1960, it increased to 22.51 tons in 1973 and decreased to 15.24 tons in 2018 (World Bank, 2021). Still, United States is responsible for 24% of the global emissions (Buks & Sobański, 2023).

Continuous research is carried on finding out the determinants of environmental degredation and how they affect the environment. In this study, 62 low-, middle-, some high-income countries with available data were examined between 1995–2019. In order to extend the previous literature the number of variables was increased and the hypotheses with different and current methods was tested. Furthermore, the ecological footprint and carbon emissions are the two most commonly cited indices of environmental degradation. Carbon emissions were utilized as an indication of environmental degredation in this study.

Economic issues such as energy, production, foreign trade and education have recently been added to the long-established theoretical foundation and have been associated with environmental degradation (e.g., Anwar, Sinha et al., 2021; Sun, 2022; Voumik et al., 2023). This study aims to enrich the literature by adding the total carbon emissions of countries, per capita income level in 2015 constant prices, the second and third power of income per capita, average schooling rate, trade openness, average life expectancy, democracy, and economic freedom index to the model.

The main focus of this study is to reveal the effects of the main socioeconomic variables reflecting the increase in welfare in low and middle-income and some high-income countries on pollution. The most important questions to ask at this point:

1. How does the level of income per capita, which represents the increase in welfare, affect pollution and what are the dimensions of this effect?
2. What is the relationship between average schooling and pollution-representative carbon emissions?
3. How does trade openness affect pollution?
4. As an output of the economic development process, what is the effect of life expectancy at birth on pollution?
5. How do changes in variables such as democracy and economic freedom as representatives of economic and social life affect carbon emissions as a representative of pollution?

With the above items the study's research questions are formulated and the results emerge to support the claims put forward here. Policy recommendations are evaluated by calculating pollution projections and turning points in line with the results.

The remainder of the paper is organized as follows: Section 1 provides an overview of the theoretical and empirical literature. Section 2 presents the data and methods. Section 3 discusses empirical findings and results. The final Section contains discussion, concluding remarks and limitations of the study.

1. Literature review

1.1. Theoretical literature review

Kuznets (1955) discovered that income inequality initially impedes economic growth as measured by GDP per capita but that after economic growth reaches a certain level, income inequality tends to diminish. This trajectory reveals the "Kuznets Curve," an inverted U-shaped link between income distribution and economic growth. However, as a result of the emergence of a relationship similar to an inverted U shape between income level and environmental degradation, this concept has gained importance for the environment and energy economics literature.

Another inequality-environmental degradation channel is theoretically related to Veblen (1934) effect. This theory proposes that the rich consume expensive items and services that are very visible to the public in order to attain status or favour. This indicates that increased inequality may lead to in-

creased consumption competition (Schor, 1998) resulting in more emissions. In other words, as a results of inequality, working hours' increase. These increased hours mean increasing consumption of energy and carbon emissions (Aye, 2020; Fitzgerald et al., 2015; Knight et al., 2013).

1.2. Empirical literature review

1.2.1. Literature regarding environmental degredation-education nexus

In empirical literature there are many studies that investigate the impact of education on environmental degra dation, particularly in developing countries. For example, using GMM-System panel technique, Romuald (2010) found that while education is not a main factor in the increase of carbon dioxide emissions, it is a factor in the growth of pollution however the effect is mitigated by the presence of political institutions in 85 countries. Similarly, Fotourehchi (2017) states that the education level decreases environmental pollution through a strenghtening of environmental public pressure and awarenesss in developing countries using panel data between 1999 and 2014. Alkhateeb et al. (2020) examined the influence of education on CO_2 emissions in Saudi Arabia from 1971 to 2014. They revealed that primary education could not affect CO_2 emissions but secondary education reduces the environmental degradation. Thus they opined that improving higher education activities in Saudi Arabia helps to avoid negative consequences on the environment. Similarly, Zhu, Peng et al. (2021) asserted that expanding the higher education scale and enhancing the higher education quality may help reduce carbon emissions in China. Employing the de Kónya method Aytun and Akın (2021) investigated the association between education and CO_2 emissions in fourteen developing nations from 1990 to 2017. The findings revealed a link between education and CO_2 emissions in Chile and Poland. Because these nations had the greatest levels of education and income in the research the authors stated that education policy may be viewed as a critical strategy in mitigating environmental pollution. Eyuboğlu and Uzar (2021), asserted that higher education can be used to overcome environmental problems for Turkey after testing higher education and CO_2 data by ARDL technique during the period 1983–2017. Finally, Hassan, Batool et al. (2022) calculated the impact of education on carbon emissions in BRICS nations between 1990 and 2015. They found that education considerably improves environmental quality and diminishes energy poverty indirectly.

Recently studies can be found regarding the effects of online education amid the COVID-19 pandemic. For example, Yin et al. (2022) showed that on-

line education can significantly reduce energy consumption and lower carbon emissions due to less usage of transportation and electricity consumption in Chinese universities.

In general, there is a strong belief in the newest literature that increasing the quality of education will reduce carbon emissions and improve air quality (e.g., Eyuboğlu & Uzar, 2021; Hassan et al., 2022; Khan, 2020; Zhu, Peng et al., 2021). As a counter finding, O'Neill et al. (2020) found that improving educational quality causes s a modest net increase in carbon emissions but significantly improves Human Development Index values which is an indicator that correlates with the adaptive capacity to climate impacts in developing countries. This result indicates that the relationship between education and carbon emissions is worth examining.

1.2.2. Literature regarding environmental degradation-economic growth nexus

According to the empirical literature the dynamic impacts of development on environmental quality are being investigated to assess the validity of the Environmental Kuznets Curve (EKC). The first studies on this subject belong to Grossman and Krueger (1991) and Holtz-Eakin and Selden (1995) who mentioned the existence of an inverse relationship between economic growth and environmental quality. Studies following those aforementioned and testing the validity of EKC can be grouped into three categories.

In the first category, there are studies that do not support the EKC view. For example, Fodha and Zaghdoud (2010) investigated the relationship between economic growth and carbon emissions for Tunisia during the period 1961–2004 using time series data and cointegration analysis. They observed a monotonically increasing linear nexus between per capita GDP and per capita CO_2 emissions. Thus they rejected the validity of EKC for Tunisia. Ozturk and Acaravci (2010) identified an N-shaped association between economic growth and carbon emissions in Turkey using the ARDL bounds testing technique from 1968 to 2005. Similarly, Pal and Mitra (2017) examined the CO_2 emissions-growth nexus by making a comparative analysis between China and India for the years 1971–2012. As a result of the ARDL analysis, the authors revealed that there is a N-shaped relationship between the variables. This rejects the EKC hypothesis. Lastly, Zafar et al. (2022) asserted that economic growth contributes to the corruption of environmental quality in 22 top remittance-receiving countries over the period 1986–2017. Azomahou et al. (2006) explore the question of the existence of an EKC using a nonparametric approach in their study. In this framework they modelled the relationship between carbon dioxide (CO_2) emissions and GDP per capita. The dataset used is a balanced panel of 100 countries and it covers the period 1960–1996.

They first addressed the structural stability of the relationship between CO_2 emissions and GDP per capita and found evidence of the structural stability of the relationship over the period 1960–1996. As a result of the study the authors revealed that economic development is not a sufficient condition to reduce CO_2 emissions.

Second category studies support the validity of EKC hypothesis. Hassan, Zaman et al. (2015) investigated short and long-run carbon emissions in relation to economic growth, poverty and income inequality in Pakistan over the period 1980–2011 by using multivariate cointegration approach. They found that there is a significant negative relationship between growth and carbon emissions and economic growth and poverty while there is a positive nexus between growth and income inequality in the short-run. The results of EKC hypothesis showed an inverted U-shaped trajectory in relation to economic growth in Pakistan. Prasetyanto and Sari (2021) employed the Error Correction Model (ECM), Engel, and Granger estimating approaches to investigate the relationship between environmental degradation and economic growth in Indonesia from 1994 to 2018. They asserted that the EKC was proven both in the short and long term. Using the ARDL technique Genç et al. (2021) investigated the short- and long-run dynamic impacts of output variation on CO_2 emissions in Turkey from 1980 to 2015. In the study it is concluded that economic growth increases carbon emissions in the long run but fluctuation in output reduces carbon emissions. In addition they found that the EKC is valid for Turkey.

The third category consists of studies that reveal mixed findings regarding the CO_2 emission-growth relationship. For example, when Rasli et al. (2018) used CO_2 as an environmental pollution indicator in their investigation they found that EKC's validity was rejected for undeveloped and developing countries whereas when nitrogen oxide is taken instead of CO_2, it is positively related to GDP and the EKC is accepted.

1.2.3. Literature regarding environmental degradation-other socio-economic variables nexus

Carlsson and Lundström (2001) analyzed the effect of political and economic freedom on carbon dioxide (CO_2) emissions in their study by using the panel data analysis method for 75 country data. According to the analysis results, an increase in economic freedom reduces CO_2 emissions when the share of the public sector in the economy is low. However, economic freedoms increase CO_2 emissions when it is high.

Li and Reuveny (2006) examined the data from 134 countries from the 1980s, 1990s, and 2000s and found that democracy reduces CO_2 emissions. The relationship between democracy and environmental quality is estimated

by Mak Arvin and Lew (2011) using Generalized Least Squares (GLS) data from 141 developing countries from 1976 to 2003. Their CO_2 emission results by income group show that more democracy has a positive effect on CO_2 emissions in both upper and lower-middle-income countries. Eren (2022) suggested that environmental degradation is less in countries with a high understanding of democracy.

Le et al. (2016) investigated the relationships between particulate matter emissions as an indicator of environmental degradation, openness to trade, real GDP per capita and GDP per capita squared using a panel data model with data from 98 countries for the period 1980–2013. As a consequence of the study they discovered that increased trade openness leads to environmental degradation for the worldwide sample. However, it is important to note that the outcomes vary depending on the nations' wealth levels. Trade openness benefits the environment in high-income nations while harming the environment in middle- and low-income countries. The findings support the prevalent belief that affluent countries dump their pollutants on impoverished countries.

Gulistan et al. (2020) used yearly data from 112 nations from 1995 to 2017 to examine the influence of economic development, energy consumption, trade openness and tourism on environmental degradation as measured by CO_2 emissions. For predictions, the authors employed Pooled OLS, fixed and random effects models and GLS. Further liberalization of trade in Latin America and the Caribbean, the Middle East and North Africa, and Sub-Saharan Africa has been observed to be dangerous for the environment.

Anwar, Sinha et al. (2021) investigated the effects of urbanization, renewable energy consumption, financial development, agriculture and economic growth on CO_2 emissions in 15 Asian economies between 1990 and 2014 using the Fully Corrected Least Squares (FMOLS) Method. With the analysis made in the study they concluded that urbanization, financial development and economic growth increase CO_2 emissions but that renewable energy consumption reduces CO_2 emissions and the effect of agriculture is insignificant.

Sun et al. (2022) evaluated the relationship between globalization, green innovation, renewable energy consumption, economic growth, population and carbon emissions in ten polluted countries using data from 1991 to 2018. Following the theoretical basis of the Stochastic Impacts by Regression on Population, Affluence and Technology (STIRPAT) model and using the Moment Quantile Regression (MMQR) methodology. As a result of this study globalization leads to higher emissions in all quantities (low, medium and high emission levels). Besides, green innovation mitigates carbon emissions but the mitigation effect is only significant at higher emission levels. This shows that green innovation is beneficial at high levels of environmental pollution. Similarly, renewable energy consumption is negatively and significantly correlated with carbon emissions. This means that renewable energy consump-

tion helps to tackle the problem of carbon emissions at lower and higher pollution levels.

Recently, Bucak (2022) explored the effect of the economic freedom index of Turkey, Mexico, China, India, Brazil, Russia and Indonesia on the ecological footprint of the 2000–2017 period using panel data analysis methods. As a result of the analysis the author found that when the economic freedom index increased by 1% the ecological footprint decreased by 0.35%.

In the existing literature there are different views and conclusions regarding the impact of socio-economic variables on environmental degradation. This requires a reconsideration of the study with a different empirical methodology.

2. Data set and model

Variables were examined in the study in order to demonstrate the influence of socioeconomic factors on pollution. Studies from the current literature were used to help determine them. While the presence of more studies in the related literature provides an advantage in the selection of variables it may pose a risk in terms of the originality of the study. In order to extend the previous literature, both the number of variables have been increased and the hypotheses have been tested with different and more up-to-date methods. In this regard the study's data were chosen for the period 1995–2019 from 62 countries with the majority of the data coming from poor and middle-income countries and only with a tiny portion coming from recently high-income countries. It is also noteworthy that the country set is as large and contains as many different countries as possible within the selected period in terms of the sound results of the study. One of the most important reasons for selecting low-income country groups is to examine the relationships of these variables with pollution. In contrast their efforts to converge with developed countries for welfare increase and some of these efforts are based on economic liberalism, democracy and economic freedoms as a representative of institutional change. Today as the driving force of economic development it is suggested that underdeveloped and developing countries also implement the policies implemented by developed countries. Especially low-income countries were included in the model due to the desire to investigate the pollution effects of the policies implemented by underdeveloped and developing countries. Countries included in the model are those whose data can be accessed on a sound basis. Low- and middle-income countries whose data are available are also included in the model. On the other hand relatively high-income countries were also included in the model in order to investigate the effects of welfare increase and pollution at different levels in

the model. The aim here is to both examine the relationships between variables at different quantile levels by providing an econometric advantage and to support the claims made by creating a model from different country groups. However, there are some factors that limit the period range obtained for the data such as the excessive number of variables to be used in the data set, the limitations in obtaining the data and the unavailability of data for some countries. Benefitting from the extant literature, total carbon emissions of countries, income level per capita with fixed prices in 2015, squared income per capita, cubic income per capita, average schooling rate, trade openness, average life expectancy, democracy and economic freedom index were determined as the variables used. While variables such as per capita income, development of economic freedoms and average life expectancy among the variables used in the model reveal the welfare and health-based effects of economic development, instruments such as schooling and the development of democracy reflect the effects of social and social development. The income per capita also includes characteristics such as the rate of urbanization which increases with income, and energy consumption which increases appropriately. The variables stated above are not included in the model to prevent the possibility of multiple connections. Per capita income illustrates the evolution of urbanization with rising energy consumption and it has taken on the function of indirectly reflecting economic, social and health trends.

As stated in the introduction firstly, the relationship between income per capita and carbon emission at different quantile levels will vary depending on the low and high carbon emissions. The validity of the Environmental Kuznets Curve depending on the direction of these relationships will be investigated. In the next phase the relationship between trade openness, mean schooling and life expectancy at birth with carbon emissions will be investigated. The next stage will investigate democracy and economic freedom index and pollution relationships as representatives of economic and social freedoms and the direction of these relationships will be investigated. The aim is to reveal the effects of the variables that play a role in the economic development process on pollution in the group of heterogeneous countries with different pollution levels and different economic development levels. The databases from which the variables used in the model are obtained and the abbreviations to be used in Table A1 (see Appendix 1).

One of the variables—carbon emission—reflects the total emission levels of the countries included in the model. The GDPPC income level is based on 2015 constant prices. The mean schooling rate was obtained from United Nations Development Program data (Alkhateeb et al., 2020; Scheidt, 2019), Trade Openness—the ratio of countries' foreign trade to their national income (Eren, 2022; Gulistan et al., 2020)—and Life Expectancy at Birth data were provided from The World Bank and Democracy (Eren, 2022; Li & Reuveny, 2006) was obtained from the Freedom House database. Freedom House evaluates

the civil liberties of citizens living in countries and the development process for the protection of property rights with a score of 1–7. While the highest level of democracy is indicated for the countries with 1 point, it is stated that the countries with 7 points have the lowest democracy and an enthusiastic authoritarian management approach. In this context, evaluations of the effects of democracy and authoritarian structures on the level of pollution may make the study even more important. The natural logarithms of the variables used in the study were taken (Alshehry & Belloumi, 2016; Bunnag, 2023; Harbaugh et al., 2002; Ojaghlou et al., 2023; Shafik & Bandyopadhyay, 1992; Shahbaz et al., 2014; Terrell, 2020) However, it has been determined that the democracy is calculated as one point for some countries in the model. For the natural logarithmic values in the model not to be negative a method frequently used in the literature was applied and the following arrangement was made for the democracy variable in the model (Busse & Hefeker, 2007; Odugbesan et al., 2021):

$$y = \ln\left(x + \sqrt{(x^2 + 1)}\right)$$

By employing formation the problem of obtaining negative values of democracy data was solved and the research model was created. In the light of the above information the research hypotheses are as follows:

H1: There is an "inverted N" relationship between per capita income level and pollution.

H2: There is a positive relationship between mean schooling and pollution.

H3: There is a negative relationship between trade openness and pollution.

H4: There is a positive relationship between life expectancy at birth and pollution.

H5: There is a positive relationship between the coefficient of democracy and pollution.

The fact that the number of nations is more than the number of years while developing the model allows for the use of several estimating methods in the model. Estimation tests to be used depending on the validity of the primary test reveal the effects of socioeconomic-based variables on the pollution determination process in low and middle-income country groups and will support these countries in the policies that they will develop in the fight against pollution. In terms of verifying the hypotheses the increase in the variety of prediction tests to be applied to the model has particular importance in terms of the study's originality and contribution to the literature. On the other hand testing the primary research questions of the study with different estimation tests is one of the study's strengths.

Quantile regression is used to investigate the differential distribution effects of some different socioeconomic factors on pollution (Sini et al., 2022). While quantile regression represents the dependent variable's conditional distribu-

tion (Koenker & Bassett, 1978) it may also offer a comprehensive output of the factors influencing the dependent variable (Eren, 2022). One of the critical advantages of quantile regression is that it is resistant to problems such as heteroscedasticity and cross-section dependence (Koenker & Hallock, 2001). Quantile regression can also resist outlier and non-normal distributions (Zhu, Duan et al., 2016). However, quantile regression does not include the unobserved heterogeneity of a country in the model. Many studies in the literature use the quantile regression approach with panel data. Especially recently some studies control the individual heterogeneity that has not been observed with different quantile levels and thus make it possible to predict the conditional heterogeneous covariance effects of dependent variable factors (Chen & Lei, 2018). One of the essential advantages of the quantile regression used in the estimation process is that it provides the opportunity to evaluate the relationship between pollution and socioeconomic factors much more soundly in countries with different economic structures. In countries with different quantile ranges the effects of variables may be different which is another advantage of quantile regression which provides estimation in heterogeneous panels. The fact that quantile regression creates variable results in countries with different pollution levels will also contribute to the economic development processes of country groups by providing an advantage in policy proposals to be formed for country groups. The conditional quantile for x_i of y_i to be created for the carbon emission model can be expressed as follows:

$$Q_{y_{it}}(\tau \mid x_{it}) = x_{it}^{\tau}\beta_{\tau}$$

$Q_{y_{it}}(\tau \mid x_{it})$ stands for τ quantile of the dependent variable. x_{it}^{τ} τ shows the vector of explanatory variables for country *i* in year *t* for quantile (Wu et al., 2018).

In the empirical parts of the study the descriptive statistics of the variables, cross-section dependency tests, multicollinearity tests, first and second-generation unit root tests, quantile regression estimation tests and calculation results of turning points were evaluated.

Based on the above expressions the model of the study for quantile regression is:

$$Q_{\tau}(CO_{2it}) = \alpha_{\tau} + \beta_{1\tau}GDPPC_{it} + \beta_{2\tau}GDPPC_{it}^{2} + \beta_{3\tau}GDPPC_{it}^{3} + \beta_{4\tau}School_{it} + \\ + \beta_{5\tau}Trade_{it} + \beta_{6\tau}Life_{it} + \beta_{7\tau}Democracy_{it} + \beta_{8\tau}Economic\,Fredom_{it} + \mu_{it}$$

"CO_2" total carbon emissions, "GDPPC" per capita income, "$GDPPC^2$"per capita income squared, "$GDPPC^3$" per capita income cubed, "School" average schooling, "Trade" trade openness, "Life" life expectancy at birth, "Democracy" democracy coefficient, "Economic Freedom" index of economic freedom, "μ_{it}" represents the error term of the model. $\beta_{1\tau}$ indicates the parameter of the variable in the τ quantile.

For the research to validate the EKC hypothesis the turning points for a cubic model were calculated. For the EKC hypothesis to be valid in the quadratic models the coefficients of the variables are expected to be "$\beta_1 > 0$", "$\beta_2 < 0$" at the calculated turning points but conversely the turning point can also be calculated. Although the calculations used to test the validity of the Environmental Kuznets Curve are generally quadratic calculations are made using cubic models in recent studies. Accordingly calculating the turning points in the EKC model as a quadratic version based on quantile regression is shown below:

$$PEAKCO2_{\tau} = -\frac{\beta_{1\tau}}{2\beta_{2\tau}}$$

The EKC process is valid when the milestones contain the result $\beta_1 > 0$, $\beta_2 < 0$ (Dinda, 2004; Stern, 2004).

As used in the study when an estimator such as "β_3" is added to the analysis the turning points calculation for the cubic version of the model is shown below. Here the coefficients β_1, β_2 and β_3 are interpreted together when calculating the turning points. When the coefficients are significant turning points can be calculated in cases where an N or an inverse N-shaped relationship occurs (AlKhars, et al., 2022):

$$PEAKCO2\beta_1 = \frac{-\beta_{2\tau} - \sqrt{\beta_{2\tau}^2 - 3\beta_{1\tau}\beta_{3\tau}}}{3\beta_{3\tau}}$$

$$PEAKCO2\beta_2 = \frac{-\beta_2 + \sqrt{\beta_2^2 - 3\beta_1\beta_3}}{3\beta_3}$$

3. Findings

The information obtained about the basic tests and the study's estimation results are included in this section. The descriptive statistics of the study are given in Table A2 (see Appendix 1).

Descriptive statistics values for the series were created from natural values of the variables. The variables have 1,550 observations in total. In addition, all variables in the Jarque-Bera test has statistically significant results at 1%. This illustrates that the series is not normally distributed. It is an expected result that the series are not normally distributed because there are countries with different economic structures and sizes in the model. The coexistence of a heterogeneous group of low, middle and high income countries will cause the series not to be normally distributed as expected. In this case the

quantile regression estimator to be used for the estimation of the relationships between the series will be advantageous in testing the claims unlike OLS. Table A3 (Appendix 1) shows the correlation matrix results of the series.

According to the results in Table A3 the correlations between the other variables are less than 0.70 indicating that there is no multicollinearity problem among the series. Apart from this there are moderate correlations between life expectancy and GDPPC income, economic freedom and GDPPC income. However, since the correlation levels are less than 0.70 it does not pose a risk for the model. In the continuation of the study the multicollinearity problem which reflects the correlation relationships between the variables will be investigated. VIF (Variance Inflation Factor) test results are given in Table A4 (see Appendix 1).

According to the VIF test results the mean VIF value of the model was calculated as 1.47. While the mean VIF value is higher than five points to the multicollinearity problem (Menard, 1995; O'Brien, 2007), the general idea in the literature is that the average VIF value up to ten in the models to be created is a problem (Kennedy, 1992; Marquardt 1970; Mason et al., 1989). The VIF test does not include the model's square of GDPPC since it will directly cause multicollinearity. According to the test findings the model has no multicollinearity issues. Table A5 (see Appendix 1) shows the study's cross-section dependence test findings.

The results of the CD test proposed by Pesaran for cross-section dependence also explain the strength of the cross-sectional relationship to be found in the series. Statistically significant results of the CD test show strong cross-section dependence in the series. CD cross-section dependence tests developed by Pesaran are powerful tests, but they are also suitable for cases where $N > T$. However, in cases where $N > T$, using the LM test can also create pitfalls (Pesaran, 2020).

According to Table A5, the H0 hypothesis claims that there is no cross-sectional dependence between the series. Thus, H0 hypothesis was rejected because the p-values were less than 0.05. This result indicates that there is a cross-section dependency in the series. Finding the cross-section dependency reveals that second-generation unit root tests should be applied in the estimation process with quantile regression. The validity of second-generation unit root tests is investigated in the quantile regression estimation process. In order to better examine the unit root processes of the variables first generation unit root tests were also applied. In the literature there are studies that apply first-generation and second-generation unit root tests (Choi, 2006; Moon & Perron, 2004; Pesaran, 2007; Sini et al., 2022). Table A6 shows the results of first-generation unit root tests (see Appendix 1).

According to Table A6, carbon emission for the IPS test, GDPPC, $GDPPC^2$ and $GDPPC^3$, and the average schooling rate contain unit root at level values and the series became stationary when the first differences of all variables

were taken. In the constant and trend model, the GDPPC, its forces and the average schooling rate contain unit root in level values. All variables become stationary when the first difference of the variables is taken. For the LLC test all variables are stationary at level. In the constant and trend model while GDPPC and its forces, democracy and economic freedom index contain unit root in level values all variables become stationary when the first differences of the variables are taken. The CIPS test developed by Pesaran (2007) is used for the second-generation unit root tests that should be applied in cases where cross-section dependency is valid. The results of the second-generation unit root tests for the series are given in Table A7 (see Appendix 1).

According to the results in Table A7 when the first differences of the constant and trend unit root statistics of all variables were taken it was observed that they became stationary at 1%. CIPS unit root test results for the series were obtained from Pesaran (2007). Accordingly since the series become stationary at the same level it is suitable for quantile regression estimation (Anwar, Siddique et al., 2021; Awan et al., 2022; Bui et al., 2021; Syed et al., 2022). The quantile regression estimation results for the series are given in Table 1. While the GDPPC level had a negative impact on carbon emissions the effect was positive again in the $GDPPC^2$ and negative for the $GDPPC^3$. It is not possible to mention a significant relationship only for the q20 quantile level from the series. In this case it can be stated that a relationship in the form of "inverted N or oblique S" emerged as Dinda (2004) revealed in his study. While the GDPPC level has significant results for each level of underdeveloped, developing and some developed country groups it does not support the Kuznets curve hypothesis which reveals the pollution-producing effect of welfare increase. However, the increase in GDPPC due to increasing urbanization and energy consumption may have increased pollution and caused the Environmental Kuznets Curve process to fail. Mean schooling which allows the relationship between education and pollution to be tested has significant results at the quantile level and has a positive effect. Thus, q50, q60, q70, and q80 quantile levels have a statistically positive effect at the 1% significance level while it does not have a statistically significant effect at q10, q20, q30, and q40 quantile levels. Accordingly, while schooling has an increasing effect on pollution in countries with high pollution levels it has no statistically significant effect on pollution in countries with low pollution levels. In countries where the level of pollution is high carbon emissions may increase due to both the emissions from school construction and the increase in energy consumption after school construction. However, carbon emissions may increase using primary energy sources such as increasing schooling, building construction and heating especially in countries with high pollution levels. The point to be considered here is to prioritize the long-term effects of education on pollution. In societies with high pollution levels raising educated individuals in the long term may lead to increased demands for reduced pollution in those so-

cieties. Another important variable for the model is trade openness and the effect of trade openness on pollution is negative. Trade openness negatively affects carbon emissions at a 1% statistical significance level at all quantile levels. Commercial activities have created a pollution-reducing effect for each country where the pollution level is low, medium, and high. The effect of life expectancy at birth which is an essential representative of welfare increase for societies on carbon emissions is statistically significant and positive at the 1% level for q10, q30, q40, q50, q70, and q80 quantile levels. The results of the relationship between democracy and pollution have statistically significant and positive results at the 1% level for all quantile levels. Countries with a low democracy coefficient have a higher level of democracy. Accordingly, a higher coefficient of democracy (less democracy) means more pollution since an increase in the coefficient of democracy will mean less democracy. Consequently, in countries with different pollution levels development of democracy, depending on the awareness and the development of democratic rights and freedoms in societies, leads to pollution-reducing processes in all country groups. The emergence of this situation is possible with effects such as the increase in democratic activities, development of civil freedom, development of democratic institutions and protection of rights. The relationships s between the index of economic freedom and pollution also have similar results as h democracy. The effect of the economic freedom index which is a mixture of different levels of economic freedom, on carbon emissions is statistically significant and negative at 1% in all quantiles except for the q30 quantile level and statistically at the 10% level at the q90 quantile level. In many countries with different pollution levels as economic freedoms increase carbon emissions decrease and societies' desire to live in a cleaner world increases depending on economic freedom. In the model turning points calculated for OLS and different quantiles are given in Table 2. The approximate values of the turning points calculated in dollars and available in the table. The first and second turning points in terms of per capita income of high pollution countries are closer to each other than the first and second turning points in terms of per capita income of countries with low and medium pollution levels. This situation indicates that the intensive energy use, economic growth and development processes are operating rapidly depending on the pollution and development levels of the countries and that the production activities that cause pollution continue. While different results are calculated for different quantile levels in the calculations for model tests the results obtained using OLS estimator also differ. It is possible to mention the effects of countries having different economic structures and sizes. Moreover, the fact that the quantile regression estimation, which considers different pollution groups in various categories, contains different results at different quantile levels supports the claim. Figure 1 and Figure 2 show the visual outputs of the variables.

Table 1. Quantile regression estimation results

Variables	OLS	(1) q10	(2) q20	(3) q30	(4) q40	(5) q50	(6) q60	(7) q70	(8) q80	(9) q90
GDPPC	–105.919***	–50.34*	60.41	–68.66**	–79.55***	–123.4***	–142.2***	–124.7***	–131.0***	–77.40***
	(16.60)	(27.63)	(49.04)	(34.19)	(22.26)	(19.40)	(19.13)	(20.10)	(22.03)	(28.57)
$GDPPC^2$	12.523***	5.905*	–7.193	8.130**	9.206***	14.46***	16.68***	14.67***	15.48***	9.310***
	(1.981)	(3.279)	(5.765)	(4.018)	(2.668)	(2.348)	(2.295)	(2.416)	(2.624)	(3.326)
$GDPPC^3$	–0.488***	–0.225*	0.289	–0.315**	–0.348***	–0.557***	–0.644***	–0.569***	–0.604***	–0.369***
	(0.0783)	(0.129)	(0.225)	(0.157)	(0.106)	(0.0938)	(0.0909)	(0.0959)	(0.104)	(0.129)
School	0.423***	–0.159	–0.297	0.0851	0.347	0.586**	0.886***	1.196***	1.315***	0.446
	(0.114)	(0.166)	(0.289)	(0.191)	(0.257)	(0.298)	(0.318)	(0.387)	(0.403)	(0.929)
Trade	–1.531***	–1.841***	–1.763***	–1.409***	–1.531***	–1.493***	–1.539***	–1.570***	–1.190***	–1.159***
	(0.0954)	(0.151)	(0.218)	(0.100)	(0.125)	(0.135)	(0.149)	(0.193)	(0.247)	(0.254)
Life	3.963***	6.305***	1.363	3.816***	3.885***	3.925***	4.034***	4.789***	6.384***	0.195
	(0.500)	(0.859)	(2.201)	(0.509)	(0.471)	(0.408)	(0.488)	(0.598)	(1.655)	(1.623)
Democ	0.654***	0.934***	0.714***	0.821***	0.664***	0.610***	0.644***	0.669***	0.696***	0.412***
	(0.0550)	(0.104)	(0.138)	(0.107)	(0.0770)	(0.0503)	(0.0466)	(0.0658)	(0.0853)	(0.137)
Freedom	–2.900***	–2.005***	–1.596	–2.559***	–3.244***	–3.515***	–3.333***	–3.200***	–3.527***	–2.665*
	(0.349)	(0.489)	(1.158)	(0.404)	(0.320)	(0.278)	(0.389)	(0.689)	(0.881)	(1.414)
Constant	227.3***	142.0*	–149.6	204.2**	242.7***	364.4***	416.3***	362.6***	372.4***	244.5***
	(40.07)	(74.08)	(129.6)	(96.03)	(61.38)	(53.04)	(53.24)	(55.58)	(59.54)	(82.49)
Turning point	7.648 (1) 9.459(2)	7.233 (1) 9.340 (2)	– –	7.030 (1) 9.767 (2)	7.334 (1) 10.299 (2)	7.611 (1) 9.700 (2)	7.640 (1) 9.648 (2)	7.642 (1) 9.577 (2)	7.662 (1) 9.450 (2)	7.429 (1) 9.436 (2)
Obs.	1,550	1,550	1,550	1,550	1,550	1,550	1,550	1,550	1,550	1,550

Notes: ***, **, * indicate 1%, 5% and 10% significance levels, respectively. (1) is the 1st Turning point, and (2) is the 2nd Turning point

Source: based on Stata 14.

Table 2. The approximately calculated turning points of quantile levels

Quantile level	1st Turning point	2nd Turning point
Q10	1385$	11385$
Q20	–	–
Q30	1131$	17360$
Q40	1532$	29730$
Q50	2022$	16330$
Q60	2080$	15500$
Q70	2085$	14440$
Q80	2127$	12715$
Q90	1685$	i12543$
OLS	2097$	12825$

Source: based on Stata 14.

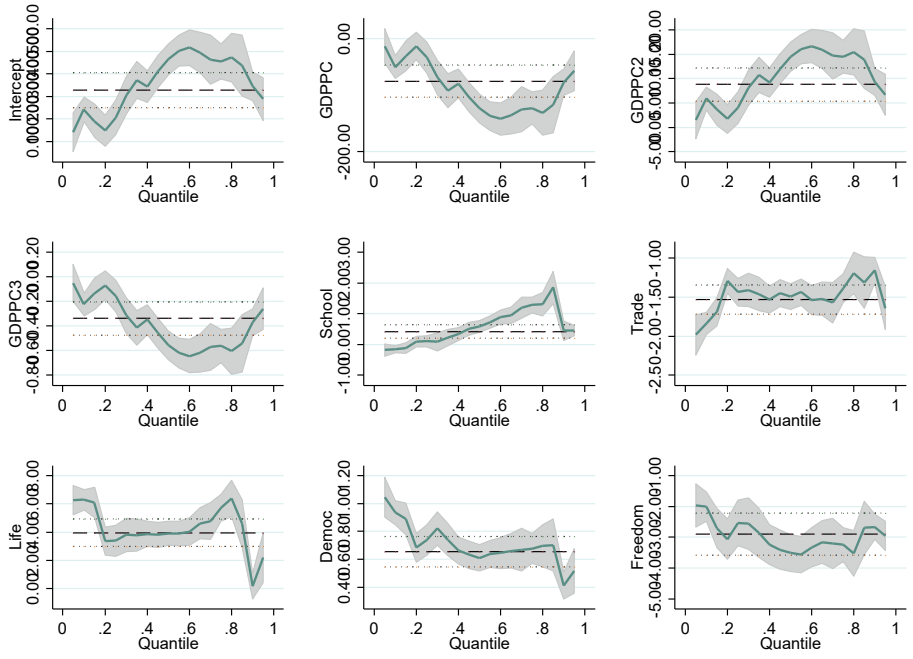

Figure 1. Quantile output

Source: own work.

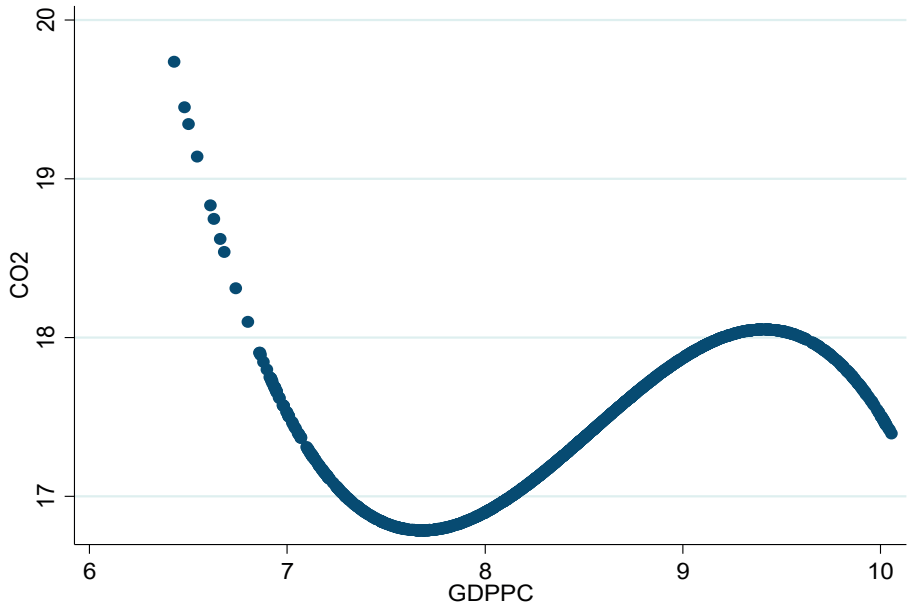

Figure 2. OLS output

Source: own work.

4. Discussion

This study investigated 62 countries with available data from low and middle-income countries from 1995–2019. In order to extend the previous literature the number of variables has been increased, and so by making use of the literature; Variables used as GDPPC, $GDPPC^2$ and $GDPPC^3$, average schooling rate, trade openness, average life expectancy, democracy and economic freedom index were determined with 2015 prices. However, since the ecological footprint and carbon emission are the most widely used indicators of environmental degradation in the literature carbon emission was used as the dependent variable in this study. The main purpose here is to reveal the relationship between environmental pollution and welfare increase and some other socioeconomic variables. Quantile regression estimation allows the investigation of changes in different country categories.

As a result of the quantile regression analysis it was found that the The EKC process is not valid for low-income and middle-income countries in analyzing the relationship between economic growth and carbon emissions. Instead, as Dinda (2004) revealed in his study it can be stated that there is an *inverted N or oblique S* relationship. The findings do not support the Kuznets curve hy-

pothesis which reveals the pollution-producing effect of welfare increase. This also confirms Schor's (1998)'s thought by not supporting Kuznets's inverted U hypothesis. It can be stated that is caused by the different economic structures of the country groups in the model and the polluting lifestyle caused by the production process that creates the pollution and a lack of environmental awareness. An unfair income distribution and higher working hours support the expression of a polluting lifestyle and emissions. The increase in GDPPC due to increasing urbanization and energy consumption may have increased pollution and caused the Environmental Kuznets Curve process to fail (Aye, 2020; Fitzgerald et al., 2015; Knight et al., 2013).

It has been revealed that the schooling rate has a pollution-increasing effect. While schooling has an increasing effect on pollution in countries with high pollution levels there is no statistically significant effect of the increase in average schooling in countries with low pollution levels. Education and schooling processes can increase carbon emissions in the first place with increased emissions based on energy (Romuald, 2010; Scheidt, 2019). The long-term effects of education on pollution is important. Increasing the level of education will lead to the training of educated individuals who demand pollution-reducing policies in the long term and take part in the production process to reduce pollution. However, according to the results carbon emissions may increase though the use of primary energy sources such as increasing schooling, building construction and heating, especially in countries with high pollution levels. The long-term effect of education on reducing pollution should be considered (Eyuboğlu & Uzar, 2021; Fotourehchi, 2017; Hassan, Batool et al., 2022; Khan, 2020; Zhu, Peng et al., 2021). The effect of the trade openness variable on reducing environmental degradation was observed. Trade has created a pollution-reducing effect for quantile groups that have low, medium and high pollution levels. The findings partially agree with Carlsson and Lundström's (2001) results. While pollution decreases with the increase in economic freedom and the decrease in the public sector the increase in trade openness can be evaluated as supporting the development of the private sector in an economy. While trade openness is closely related to economic freedom the decrease in emissions will also create a result in line with the literature. Considering that the pollution-reducing effect of trade openness is made with developed countries which have a heavy weight in world trade it also shows that environmental awareness has developed in high income countries. Just as trade openness the economic freedom variable has a reducing effect on environmental degradation (Bucak, 2022). In many countries with different pollution levels and as economic freedoms increase carbon emissions decrease and societies' desire to live in a cleaner world increases depending on economic freedom. Depending on the economic development processes associated with democracy and freedoms the pollution behaviour did not show the Environmental Kuznets Curve behaviour for the GDPPC and $GDPPC^2$.

It was observed that life expectancy at birth has an increasing effect on environmental degradation. The increase in life expectancy at birth has a pollution-increasing effect in countries with low, medium and high pollution levels.

Democracy reduces the environmental degradation. Depending on the development of democratic rights and freedoms in societies, social awareness at every pollution level and democracy based on this awareness leads to pollution-reducing processes in all country groups. The results support the claim that a greater level of democracy will reduce pollution. (Eren, 2022). In countries with a high level of education and high social consciousness the pollution-reducing effect of democracy will make it possible to create a cleaner and more livable world.

Conclusions and limitations

The study reveals that the Kuznets inverted U relationship is not valid and that the threshold pollution levels vary according to different income groups and so environmental policies should be handled more carefully in terms of different country groups. Reductions in long-term environmental degradation dynamics in societies with higher welfare, improved democracy and raising healthy individuals give us hope for a better future. At the same time the fact that the Kuznets model is not valid reveals that countries should be more sensitive to environmental protection and develop more protective policies.

High economic freedom and trade openness supporting democratically inclusive policies will help low and middle-income countries reach income thresholds where pollution will begin to decrease. Supporting policies that are more open to the outside supportive of economic freedom and inclusive of the society in a democratic sense will provide advantages in reducing pollution for groups of countries with moderate pollution to reach their income thresholds. As a matter of fact, the findings of the studies in the literature are in line with these claims. Higher incomes, lower pollution and healthier people are desirable for the whole world.

One of the important limitations of the study is the problems in obtaining data for different country groups. The increase in the number of variables used in the model can also cause problems in the estimation process such as multicollinearity.

Appendix 1

Table A1. Information on abbreviations of variables used in the model and the platforms from which they are obtained

Variable	Abbreviation	Database
Carbon Emissions	CO_2	OurWorldinData
GDP per capita	GDP	The World Bank
GDP per capita^2	GDP^2	The World Bank
GDP per capita^3	GDP^3	The World Bank
Economic Freedom	Freedom	Heritage.org
Mean Schooling	School	UNDP
Trade Openness	Trade	The World Bank
Life Expectancy At Birth	Life	The World Bank
Democracy	Democ	Freedom House

Source: authors' compilation.

Table A2. Descriptive statistics

	Mean	Min.	Max.	Standard deviation	Median	Skewness	Kurtosis	Jarque-Bera	Obs
CO_2 (kt)	2.55e+08	307776	1.05e+10	9.61e+08	3.11e+07	7.979879	73.91534	3.4e+05***	1550
GDP ($)	6370.837	618.367	23243.59	4871.841	4806.924	1.372979	4.452948	623.3***	1550
GDP^2 ($)	6.43e+07	382378.7	5.40e+08	9.92e+07	2.31e+07	2.560249	9.634104	4536***	1550
GDP^3 ($)	8.71e+11	2.36e+08	1.26e+13	1.98e+12	1.11e+11	3.47436	15.66441	1.3e+04***	1550
School (Years)	14.12155	2.5	13.143	2.322439	8.326	–0.102124	2.290984	35.16***	1550
Trade (%)	80.65387	15.63559	220.4068	35.33266	75.93649	0.739264	3.318283	147.7***	1550
Life (Years)	70.58271	49.475	81.67561	6.208346	72.0505	–1.365748	4.780265	686.5***	1550
Democ (1–7)	3.359355	1	7	1.528899	3	0.3331289	2.245312	65.45***	1550
Freedom (1–100)	60.50765	26	79.1	7.943645	61.05	–0.360895	3.410326	44.52***	1550

Notes: ***, **, * indicate 1%, 5% and 10% significance levels, respectively.

Source: authors' computation.

Table A3. Correlation matrix

	CO_2	GDPPC	$GDPPC^2$	$GDPPC^3$	School	Trade	Life	Democ	Free.
CO_2	1.0000								
GDPPC	0.1583	1.0000							
$GDPPC^2$	0.1616	0.9986	1.0000						
$GDPPC^3$	0.1637	0.9945	0.9986	1.0000					
School	0.0677	0.4349	0.4299	0.4237	1.0000				
Trade	–0.3896	0.2073	0.2057	0.2046	0.2753	1.0000			
Life	0.2071	0.5457	0.5412	0.5355	0.3229	0.1248	1.0000		
Democ	0.2276	–0.3967	–0.3986	–0.3988	–0.2929	–0.1830	–0.2278	1.0000	
Free	–0.2257	0.4834	0.4843	0.4842	0.1515	0.2835	0.2673	–0.4242	1.0000

Source: authors' computation.

Table A4. VIF test results

Variable	VIF	1/VIF
GDPPC	1.97	0.506996
Freedom	1.52	0.657481
Life	1.44	0.692866
School	1.37	0.731953
Democ	1.34	0.748261
Trade	1.16	0.863661
Mean VIF	1.47	

Source: authors' computation.

Table A5. Cross-section dependency test results

Variable	CD Test Value	Breusch-Pagan LM	Pesaran Scaled LM
CO_2	76.11410***	24513.16***	367.8522***
GDPPC	166.0553***	35683.80***	549.4946***
$GDPPC^2$	166.0991***	35665.90***	549.2035***
$GDPPC^3$	166.1227***	35640.46***	548.7899***
School	186.8187***	37389.71***	577.2339***
Trade	35.27508***	10710.03***	143.4036***
Life	196.4874***	40175.90***	622.5393***
Democ	114.4694***	21331.52***	316.1165***
Freedom	17.42966***	11119.50***	150.0619***

Notes: ***, **, * indicate 1%, 5% and 10% significance levels, respectively.

Source: authors' computation.

Table A6. First-generation unit root test results

IPS (Im, Pesaran, Shin)				
Variable	Constant		Constant + Trend	
	I(0)	I(1)	I(0)	I(1)
CO_2	1.59022	–18.4262***	–2.00905**	–14.9675***
GDPPC	5.80641	–10.9650***	0.37622	–8.58117***
$GDPPC^2$	6.40456	–10.9268***	0.27607	–8.47881***
$GDPPC^3$	6.99475	–10.8646***	0.20112	–8.38305***
School	–0.13622	–10.6024***	0.49504	–7.10151***
Trade	–2.86532***	–18.5330***	–2.02672**	–14.9766***
Life	–6.84924***	–23.5411***	–32.6418***	–40.3476***
Democ	–2.9E+13***	–13.6757***	–2.5E+13***	–10.9466***
Freedom	–3.67870***	–17.2880***	–1.44284*	–13.9498***

Notes: ***, **, * indicate 1%, 5% and 10% significance levels, respectively.

LLC (Levin, Lin, Chu)				
Variable	Constant		Constant + Trend	
	I(0)	I(1)	I(0)	I(1)
CO_2	–3.14855***	–14.2626***	–2.95555***	–10.6819***
GDPPC	–2.30656**	–10.3765***	–1.27643	–10.5966***
$GDPPC^2$	–1.58475*	–10.4652***	–1.36034	–10.0993***
$GDPPC^3$	–1.56480*	–10.4791***	–1.48481	–9.92887***
Energy	–2.80766***	–12.2750***	–1.13741	–9.07933***
School	–8.25518***	–8.53357***	–2.54147***	–6.23002***
Trade	–4.23463***	–17.2918***	–2.02443**	–13.8723***
Life	–10.8429***	–27.3169***	–49.2866***	–31.2176***
Democ	–3.55885***	–3.59009***	0.91486	–8.59385***
Freedom	–3.92822***	–12.4700***	–0.70003	–9.87813***

Notes: ***, **, * indicate 1%, 5% and 10% significance levels, respectively.

Source: authors' computation.

Table A7. Second-generation unit root test results

CIPS Test			
Variable	**Constant&Trend**		
	I(0)	**I(1)**	
CO_2	–2.638*	–4.960***	
GDPPC	–1.715	–3.394***	
$GDPPC^2$	–1.662	–3.364***	
$GDPPC^3$	–1.641	–3.333***	
School	–1.877	–3.690***	
Trade	–2.604*	–4.362***	
Life	–2.299	–4.061***	
Democ	–2.214	–3.759**	
Free	–2.560	–5.046***	
Critic	10%	5%	1%
Values	–2.58	–2.65	–2.78

Notes: ***, **, * indicate 1%, 5% and 10% significance levels, respectively. Constant and trended values of the series are used.

Source: authors' computation.

Appendix 2

List of countries

Albania
Algeria
Argentina
Armenia
Azerbaijan
Bulgaria
Bahrain
Belarus
Belize
Bolivia
Brazil
Botswana
Cameroon
Chile
China
Cote d'Ivoire
Colombia
Costa Rica
Croatia
Czech Republic
Dominic Republic
Ecuador

Egypt
Estonia
Fiji
Gabon
Ghana
Guatemala
Honduras
Hungary
Indonesia
India
Jamaica
Jordan
Kazakhystan
Lithuania
Latvia
Morocco
Moldova
Mexico
Mongolia
Malaysia
Namibia
Nicaragua
Pakistan
Panama
Peru
Phillipines
Poland
Portugal
Paraguay
Romania
Russia
Saudi Arabia
El Salvador
Thailand
Tunisia
Turkey
Ukraine
Uruguay
South Africa

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New technologies in the financial industry: Case of Poland

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Abstract

This study evaluates the scope and consequences of the application of new technologies (NTs) within the Polish banking and insurance sectors and thus contributes to the knowledge of CEE financial market development. The goal is to understand the implementation of particular NTs in two different sectors and identify the motivations, strategies, phases of realisation and cost efficiency depending on the institution's size. The detail of the study requires the use of qualitative research methods. In-depth interviews are employed to figure out the criteria based on which decisions to implement NTs are made. The findings indicate that the primary objective of NT implementation is to respond to customers' needs, followed by cost-cutting and achieving more efficient internal processes. The application of artificial intelligence (AI) and machine learning (ML) in risk

Keywords

- innovation
- new technologies
- artificial intelligence
- cloud computing

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management areas is still a work in progress. In the next five years cloud computing is expected to become the most important NT and thus will have to meet numerous regulatory requirements.

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Introduction

Banks and insurers operate in competitive markets where BigTech and FinTech companies are eager to enter with the direct intention to either compete or cooperate (e.g., Boot et al., 2021; Harasim, 2021). Therefore, to remain attractive regulated financial institutions "go with the flow" and implement new technologies (NTs) in line with applicable laws and regulations. This implementation is aimed at improving the productivity and efficiency of internal processes, providing high-quality products and services to customers and improving risk management techniques.

To date academic literature has represented a rather fragmented view of the application of NTs including artificial intelligence (AI) and machine learning (ML). A more comprehensive view has been offered by those studies based on the macroeconomic traits of countries to identify the factors that are important for the Fourth Industrial Revolution (e.g., Wang, Qiao et al., 2021).

Some of the literature has focused on the customer value of the application of NTs starting with Hu (2005) who investigated, with the use of big data, customer attrition among retail banks (single-bank data). Later Durkin et al. (2008) explored how banks (in a single-bank United Kingdom (UK) study) should evaluate customers' willingness to use NTs according to their level of complexity. Moreover, Miguel-Dávila et al. (2010) in a sample of Colombian customers analysed the quality of the banking services when accounting for the physical presence of bank branches, digital channels and face-to-face inte-

ractions, and also demonstrated the role they play in customer loyalty. Wang, Cho et al. (2017) investigated how important the personalisation of banking services and the segmentation of bank customers are for bank customers in China (approximately 180 customers of a commercial bank). Furthermore, Steiner and Maas (2018) asked an interesting question about the willingness of customers to disclose specific data to an insurance company; based on questionnaires from ten countries these authors found that customers may disclose data if they receive more attractive insurance policy pricing. Therefore, openness is based on the reward that may be offered by the insurer.

At the same time the role of NTs has been analysed from an organisational perspective. Cata and Lee (2008) showed the scope of the application of web-based solutions for insurance companies in the United States (US) not only as a communication channel but also as a sales channel. The above study was based on questionnaires distributed among US insurance companies.

Some studies on NTs have explored the willingness of customers to use new solutions and the barriers to their application. Digital exclusion should be identified as one of the main barriers (e.g., Solarz & Adamek, 2022, for the Polish market) to the use of NTs. Moreover, based on a survey of German customers Jünger and Mietzner (2020) identified the determinants of customers' willingness to use financial services offered by FinTech companies. Overall, a low level of trust in banks, a good level of financial education and a preference for transparency were shown to be significant in terms of the use of FinTech.

Finally, the exploration of the application of AI/ML for risk management purposes (e.g., Metawa et al., 2023, for a multifaceted view) is focused on credit risk (e.g., Altman et al. 2021; Barboza et al., 2017; Trivedi, 2020) and specifically on dividing customers into "good" and "bad" (i.e. not meeting commitments), on operational risk and money laundering (e.g., Faridpour & Moradi, 2020; Prisznyak, 2022), and—to a lesser extent—on market risk (e.g., Menendez & Hassani, 2021). These studies referred to the direct use of AI/ML for analytical purposes (a "tool" perspective), showing in many cases the superiority of NTs in detecting risk. In the present study a "tool" perspective is not taken but rather an institutional perspective and asks whether AI/ML can be used for risk management purposes.

The above studies are mostly single-country or single-entity studies based on data collected from customers or from a given entity to explore certain aspects of the adoption of a specific NT. This study attempts to present a different perspective since it takes a broader view of the use of NTs in the financial industry covering a wide variety of NT applications. As it is still not possible to identify the aspects related to NTs using data and information from financial statements a qualitative research tool is applied, namely, in-depth interviews (IDIs), conducted among financial institutions in Poland. The present work is a single-country study as is most of the literature on the use of NTs (e.g., Jünger & Mietzner, 2020; Miguel-Dávila et al., 2010; Wang, Cho et al., 2017).

The Polish financial industry is regarded as technologically advanced although in size it is much smaller than the Western European average. As Poland is a transitioning country (from a socialist to a market economy) it is an interesting case to investigate in Europe since its market is large due to the country's population and thus it has a large number of customers.

According to *The map of Polish FinTech* over 300 companies in that year and most of which were established in the last four to five years were in operation, thus exhibiting rapid development (Cashless, 2021). Early on NTs were considered a threat to the well-established financial sector but today they are seen as a source of cooperation to overcome competitors and an opportunity to develop new products more efficiently. FinTech companies are mostly low-capital entities and hence require support. Financial institutions invest, buy up or even create their respective FinTech companies. Because of these links with financial institutions startups not only usually receive financing and legal protection but are also introduced into the company structure. Thus, these startups have a unique opportunity to test their solution. Financial companies also launch special cooperation programmes with startups to implement innovations in various business areas.

One of the most important challenges faced by the financial industry is the implementation of NTs in line with strict regulations which slowly react to market changes. The Polish Financial Supervision Authority (Komisja Nadzoru Finansowego (KNF)) issued recommendations regarding the use of cloud solutions and communication on information processing by supervised entities using public or hybrid cloud computing services. The financial industry has criticised these quasi-regulations (soft law) as being a barrier to development. However, European Union (EU)-level regulations are also vital as they can be considered primary regulations many of which occur during the legislative process (e.g., Digital Operational Resilience Act (DORA)).

Based on the literature and observed use of NTs the following hypothesis is proposed:

H1: NT realisations in the Polish financial services industry are fragmented within business processes due to the use of efficiency criteria. The implementation of NTs is largely targeted at:
H1a meeting customers' needs,
H1b improving the productivity of internal processes,
H1c improving risk management practices.

The contribution to the literature consists of showing the real-life application of a wide scope of NTs in the financial industry based on a set of IDIs with representatives of banks (9), insurance companies/groups (6), financial infrastructure companies (2), a FinTech company and an external actuary expert. The goal is to understand the following:

- which of a wide variety of NTs and in which areas have they been or are they being implemented by the financial industry in Poland? (focusing on internal processes, customers' needs and risk management);
- why present realisations are fragmented within business processes?;
- the main determinants of NT implementation.

The above findings help build a theoretical framework for CEE financial market development which enriches financial market theory.

The remainder of the paper is structured as follows. In Section 1 the methodology applied in this study is presented. In Section 2, the results are presented, while in Section 3 discussion is provided. The last Section concludes the paper.

1. Methodology

Although the use of NTs is widespread in the economy and advertised frequently the sources of comparable data and information are very limited. A quantitative survey based on a questionnaire with predefined answers cannot provide detailed information on the motivations, strategies, phases of realisation and cost efficiency. Furthermore, a number of companies make statistical reasoning questionable. The potential representativeness of a quantitative study does not bring us closer to the aim of the present study.

Therefore, a qualitative tool is applied such as IDIs frequently used in social sciences. With the targeted characteristic of respondents it is possible to cover the most essential options. Answers cannot be considered representative and the outcome cannot be easily generalised. However, more than half of banks (according to the value of assets) and insurers (according to gross written premiums) are covered in this case. The respondents were selected according to the position and size of the institution. Moreover, the representatives of those market institutions which are regularly contacted by banks and insurers are included. Furthermore, an interview with an actuarial expert is carried out to better understand the involved processes.

The research team prepared an IDI scenario which is presented in the Appendix. The questions were divided into six parts devoted to the evaluation of different aspects of the application of NTs. The first part was focused on the purpose of and rationale for the use of NTs. In the second part questions were targeted at the identification of the most significant technologies including the emerging technologies of the future. The third part was devoted to the actual usefulness of the NTs as well as the barriers to their implementation. These three parts were treated as the most important content of the scenario and of this study. Furthermore, the next three parts allowed the col-

lection of opinions on the digitalisation of the Polish financial industry, public and private databases and the open finance concept.

Altogether nineteen interviews were conducted by the research team from July to November 2022 and from April to June 2023. The average time of each interview was 70 minutes and interviews were conducted using MS Teams. The representatives of nine banks, six insurance companies (or capital groups), two institutions providing informational infrastructure to the financial sector, one FinTech company and one external expert of the insurance sector were interviewed. Regarding the organisational leve, eleven interviewees represented the executive level (C level), while seven represented the expert level. The banks interviewed by the team accounted for approximately 57% market share (in terms of assets) while the insurance companies accounted for approximately 52% (in terms of gross premium written) and 50% for non-life and life insurance, respectively.

Based on interview transcripts a text mining analysis was conducted which presented the overall interview content. Three different analyses were performed. The first one (Figure 1) the word map showed that interviewees focused on implementation, customers, database and costs suggesting a pragmatic, business-oriented approach. The Insurance Guarantee Fund (UFG) was mentioned most frequently as a specific database provider.

Then items were clustered by word similarity (Figure 2). Banks and insurance companies were mostly grouped separately. Institutions that provided informational infrastructure were closer to the banking industry. The FinTech representative was close to an insurer. Large and small insurance companies had different compositions (together or apart) thus underlining the gap between the banking and insurance industries. Within the banking industry the group of small and medium-sized banks was often within one cluster. The above analysis suggested differences between banking and insurance groups in terms of their focus on NTs. However, large banks are closer to large insurers.

Figure 1. Word map

Sorce: Based on interview transcripts.

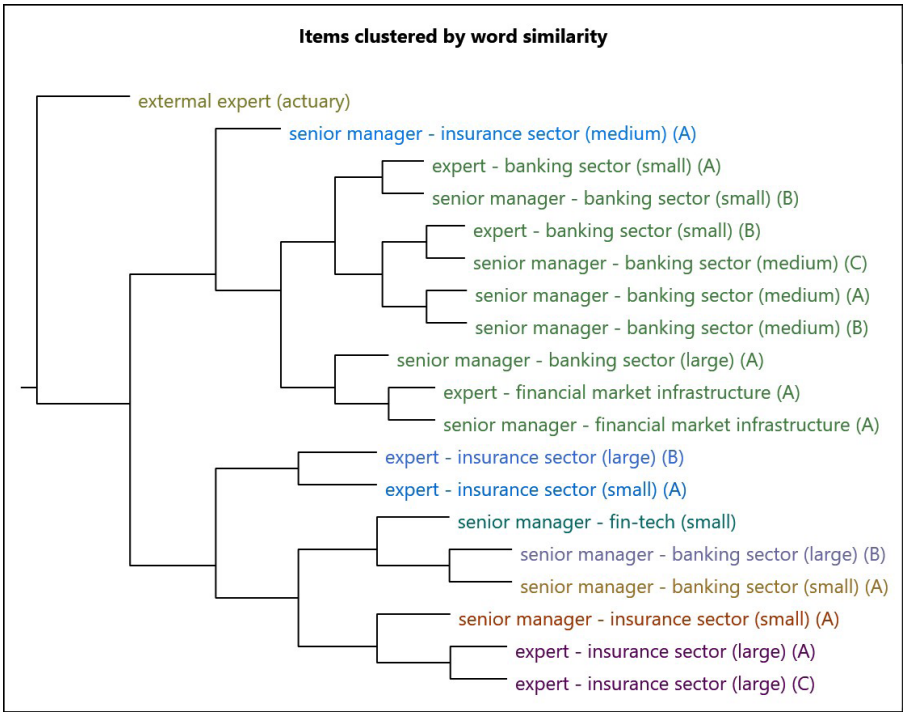

Figure 2. Entities clustered by word similarity

Sorce: Based on interview transcripts.

A word tree based (Figure 3) on a text search query showed two dimensions of risk concerning NTs. The first dimension focused on the customer and technologies suggesting that the consumer-oriented approach is leading. The second dimension concentrated on processes and technical issues. The third dimension was more oriented towards risk, costs and security. A word map suggested that interviewees face opportunities that involve some level of risk which is quite natural for public interest sectors.

2. Results

In this part a summary of the responses given by interviewees is presented. The presentation follows the parts and specific questions included in the scenario. Overall, the level of advancement of banks and infrastructure institutions is—based on the interviews—higher than in the insurance industry. One exception is pricing in which the largest insurers using NTs try to reflect customer behaviour based on “modern” data sources.

artificial intelligence in the analysis of			of fraud, influence on AML
(chatbots, voice bots), matching the profile of			and CRM
(disruptive innovation) a new way of pricing of			mainly operational risk—human error
(ad hoc), also, within the evaluation of			(image recognition)
will be exposed to new kinds of			i.e., cyber-attacks, growing dependence
because insurers do not want to take the			or even investigation processes
Facebook profile is matched with the profile of			of using big data
mitigation of			speed and efficiency of operation or
it can be a database of events and			(ML Loops—Google tool), that
new products/services/more in-depth analysis of			of underwriting; there is always a risk of unverifiability
legal departments (exception—scoring)	assessment of		[claims assessment] mobile technologies, bots
with the help of machine learning—dynamic			operational—human error
and claims (to save) and			operational—ZORO
critical for the development of business,			increase the quality of data; cyber risk
sales of products but also			of policyholder, automatic loss assessment
it is all about the improvement of			of using new technologies
ensures data collection, verification			
increased security and	mitigation of		
and thus			
improving customer service,			
decrease in costs, an increase in profitability			
client's personal data; more			
acquisition of data from the satellite of			
robots/chatbots, dynamic pricing of			
sales, new algorithms for matrices of			
beyond the context of risk			
such needs, possibility of estimation of			

Figure 3. Text search query for "risk"

Sorce: Based on interview transcripts.

2.1. Purpose of and rationale for NT introduction

The first part of the conducted interviews concerns the purpose of and rationale for introducing NTs especially from the perspective of financial sector development. The research team also asked about the essential advantages of introducing NTs as well as the associated possibilities. Interviewees indicate a wide range of objectives when asked directly about the purpose of using modern technology in financial institutions. As a primary objective interviewees mention the need to meet the expectations of customers (who expect digital financial services with 24/7 access). Because of the use of NTs there has been a clear reduction in service times and faster responses to current customer needs (real-time and time to market); these needs have been further accelerated by the pandemic as traditional service has not been possible at the time and partly due to the war in Ukraine showing the role played by NTs in business continuity. The application of NTs helps not only to retain existing customers (improved and/or new products can be offered to them) but also to attract new customers. Financial institutions using NTs are able to reduce risk which is mostly cyber risk and counterparty risk for individuals as well as increase security (by identifying customers more accurately and securing their identity) and thus gain a sustainable competitive advantage. For example, in the case of insurance companies the use of big data has resulted in a greater ability to create personalised insurance offers. It is also important to note that through the use of NTs it has been possible to significantly reduce costs (e.g., automation of processes and elimination of traditional customer service outlets) and increase the possibility of redeploying staff resources to other areas. One interviewee also points to the reduction in the time of information technology (IT) system implementations due to NTs (the faster scalability of such implementation). In the case of one of the largest financial institutions an interviewee emphasises that NTs are the "DNA" of a given financial institution as NTs have been in use for over twenty years and their use is a permanent part of their strategy.

At the same time it should be noted that interviewees stress that the use of NTs is not an end in itself. Their use is enforced by business and by the competition. Without the use of NTs a financial institution does not meet standards; therefore such a company finds itself in a "self-perpetuating circle".

According to all interviewees, a financial institution that does not have NTs and does not develop them has no future primarily because the Polish financial market is very competitive. With the increased use of NTs some new services have emerged which customers do not fully need. These services are offered to encourage and retain customers. Hence, banks in Poland use NTs to a large extent and definitely more than do those in Western Europe (e.g., compared to those in France or Germany). Technology is embedded in financial services; thus financial institutions in Poland are sometimes regarded as technology com-

panies with a licence (e.g., a bank is now an application in a mobile phone). At the same time Polish consumers are very open to and searching for NTs. In addition to customer expectations the growth of cashless transactions (including digital money transfers, e.g., BLIK) and cybersecurity issues are also highlighted.

First and foremost and with the use of NTs opportunities to increase financial performance occur. NTs allow the offering of new services that had not previously existed. For example, to estimate and value the damage in a claim it is enough for the customer to take a photo with a smartphone and send it to the insurance company or to estimate the insurance premium for drivers accounting for the number of hours spent behind the wheel (e.g., apps used by Uber drivers). Moreover, it is also possible to generate new solutions that had not previously existed, e.g., a sensor for collecting information in the car to determine the insuree's liability for damage.

The application of NTs allows the financial industry to "delocalise" the provision of financial services due to various apps and the use of the internet. It is noted that customers prefer chatbots instead of human staff because of the greater certainty of professional secrecy inherent in the former. Regarding staff, due to automation (especially for simple, repetitive activities) the effect of staff shortages has been reduced. NTs also help improve risk management practices by being able to create more accurate predictive models thereby increasing the speed of data access and improving data quality.

With that said two interviewees note that the legitimacy of NTs should depend on their usefulness and financial efficiency. An example of negative legitimacy is blockchain technology which initially seemed to be a very useful type of NT for banks but is now used mainly for "speculation and terrorist financing". Similar scepticism exists concerning cryptocurrencies.

Interviewees were asked to indicate the advantages of introducing NTs by considering two perspectives, i.e. financial institutions and customers. From the perspective of financial institutions interviewees refer mainly to the points mentioned in responses to the above questions, i.e. the possibility of gaining a competitive advantage (to retain current customers and to acquire new, especially young, customers), the cutting of operating costs (due to the increase in automation, e.g., in bulk, increase in repetitive processes, and the possibility of remote work of employees and remote customer service) and thus a reduction in the costs of the offered products, improved security and risk reduction. For example, in moving data to the cloud it increases their security as has been underlined especially after the outbreak of the war in Ukraine. NTs significantly increase the variety of tools, products, processes and distribution channels and thus allow for branding, attracting new customers and staying ahead of the competition. On the customer side NTs make life easier and more convenient as customers look for new services (value added services (VASs)). One interviewee noted that the financial industry is a pioneer and that similar solutions are implemented by other entities or economic sectors.

Interviewees identified a number of the disadvantages of introducing NTs with the high cost of implementing and maintaining products or channels using NTs at the top of the list. With a high degree of innovation business risk (e.g., the lack of acceptance and a too low demand among customers) increases. While introducing specific NT solutions it is sometimes difficult to find an economic justification. At the same time NTs are "new", underdeveloped, immature and untested, i.e. unstable. These technologies have to "undergo childhood diseases" to become "immune", which instead of improving worsens the quality of services provided to customers. For example, in the case of using facial biometrics incorrect or poor-quality photos block the service to the inconvenience of the customer. The risk faced by companies of being the first on the market therefore increases.

NTs due to the transfer of a large amount of confidential data (e.g., with cloud solutions) increase the risk of cyberattacks (e.g., on money and personal data) or failures (e.g., some divisions of the bank may not work) and the risk of fraud and the threat of money laundering. As criminals have also moved into the digital world one observed a "race between good and evil".

Interviewees highlight that NTs have led to a change in business models due to the increasing use of outsourcing (e.g., for cloud solutions), leading to a loss of control over data and processes and an increased reliance on external providers in the case of critical business functions. At the same time rules and regulations have not kept the pace with rapidly evolving NTs; thus regulators have taken such a restrictive approach to vetting the providers of these services.

NTs also require adequate competence among employees (they need to be IT experts) and with a rapidly changing environment acquiring new competencies becomes costly. However, NTs contribute to a lower demand for human capital (necessary lay-offs of employees). Moreover, the disparity in salaries between employees familiar with and those unfamiliar with NTs is noticeable.

Despite the apparent trend towards personalised services and customer care in financial institutions NTs contribute—as perceived by customers—to the dehumanisation of financial services. It is impossible to return to the days in which agents manually wrote insurance policies. The financial industry is increasingly using NTs and digitally excluded customers therefore need to be supported.

NTs have become an everyday part of our lives. Customers use NTs daily and demand them from financial institutions. Hence it would be very difficult to stop creating and using NTs. This situation also denotes a self-reinforcing, unstoppable progress. For example car rental using mobile apps means that new services have to emerge and that NTs are required. Financial institutions need to go with the flow to remain competitive (against FinTech companies) and to maintain and attract new customers. In addition the pandemic and the outbreak of the war in Ukraine have further accelerated and deepened the degree to which NTs are used in finance. Thus, interpenetration between the financial sector and the use of NTs can be considered.

According to one interviewee who declared that his institution has been using NTs for more than twenty years, the most important revolution in the financial industry involving NTs has already taken place. The value added of NTs is already clearly visible. Those NTs that are currently in use and if properly implemented can be used for a long time. According to an interviewee, in financial institutions rather than additional NTs being implemented those NTs already in use will be improved.

2.2. Examples of NTs

Following those questions concerning the rationale behind the employment of NTs the research team tries to identify the most important and promising NTs and the way in which they are developed. Although there are many NTs they are very often interconnected. Interviewees after being asked to list the most important NTs stress that such prioritisation is very difficult because various NTs may "overlap". As in the above case these aspects can be identified from the standpoints of both financial institutions and customers. From the point of view of financial institutions among the most frequently mentioned aspects are AI and ML, which are closely related. AI/ML allows for working with various data sources to diagnose customer preferences and better product positioning. Other important NTs are big data (the ability to process large datasets) and cloud solutions (which can further reduce energy consumption), behavioural biometrics (which support anti-fraud measures and facilitate the personalisation of the offer to the customer's needs), cybersecurity solutions and robotisation (chatbots and voice bots) and digital collaboration in view of the need to develop online and group working.

From the point of view of customers the following NTs should be particularly noted:

- chatbots using neural networks which are increasingly able to recognise and analyse customer statements;
- followed by ML used for dynamic risk assessment by comparing images and image recognition techniques (disruptive innovation) which makes it possible to carry out automatic damage assessment or fraud detection;
- web-based applications, which are used for insurance policy handling to report claims or applications that allow for the location of weather anomalies (by analysing disaster-prone areas it is possible to offer insurance against bad weather on holiday);
- user based insurance (UBI)-telematics which helps offer a type of insurance tailored to the person's driving style and using neurolinguistic programming (NLP) to price personal damage.

Regarding the most relevant NTs for industry in the near future (next five years), interviewees indicated primarily cloud solutions—both private and public (because of the possibility of moving data and applications to the cloud and the use of large computing capacities as well as the efficient use of energy due to environmental and social and governance (ESG)). AI/ML and big data are next on the list due to the possibility of their application in managing risks and customer expectations. Additionally, representatives of large financial institutions highlight the computational power of quantum computers and the concept of metaverses which are currently not yet considered mature NTs but are expected to be promising in the next five years.

The interviewees' list of the most innovative/pioneering/function-changing aspects of organisations is comparable to the responses presented in the previous question. Interviewees most frequently mention AI/ML and big data as well as cloud solutions and behavioural biometrics (e.g., identification by recognising the way a smartphone keyboard is touched or the way a mouse is moved which are individual to each person and can help improve cybersecurity). Attention is also drawn to the concept of the metaverse which is currently not very advanced but still promising. Moreover, a forward-looking perspective exists. An experienced respondent from the banking sector mentioned the limitations of big data processing and found concepts of small data, containerisation and micro-services compelling. An external expert talking about risk models found data preparation leading to the limitation of data to be the most time-consuming process within the modelling data themselves.

At the same time it is noted that it is difficult to identify those NTs that make the most difference in terms of the functioning of financial institutions because they have been in use and intensively developed in these institutions for many years (i.e. at least five years). Functioning without NTs now seems impossible or at the very least, inefficient.

The types of those NTs being employed in specific institutions vary widely reflecting the heterogeneous degree of development of financial institutions and the stage of implementation of NTs. The most cutting-edge financial institutions have been developing NTs for more than twenty years while others have been developing them for approximately ten years. Each NT is implemented at different times (some many years ago and others one or two years ago) and at different speeds (on average NT implementation takes twelve to fifteen months). It is also highlighted that the implementation of NTs in many financial institutions is an ongoing process. An example of this is the back office where although process automation has been taking place for more than ten years it is still being refined as it requires integration with a wide variety of IT systems. The latest NT is the metaverse concept which is a pilot programme began by one institution in June 2022.

Conversely it seems that it is not so much how long NTs have been implemented/used that is important but rather the extent to which they are being used and this is growing exponentially and there is still unlimited potential for growth.

The types of standard NTs, i.e. NTs which are no longer treated as new, mentioned by interviewees vary significantly. The most frequently mentioned standard NTs include centralised information systems, data warehouses, customer relationship management (CRM), Excel (i.e. based on models running in an Excel environment), online and mobile banking, contactless payments, decision-supporting systems, sales on remote channels, digital marketing, call centre automation, classic robotic process automation (RPA), decision automation and workplace digitalisation (digital collaboration) as 95% of employees in financial institutions can perform tasks from virtually anywhere and process data. The exceptions to the above types of NTs are AI and ML which are not yet considered standard NTs.

A broad identification of technologies is still missing in financial organisations according to interviewees. Such identification varies widely and depends on the degree of digitisation of the respective institutions, i.e. interviewees indicate both a lack of quantum computers and metaverses and a lack of chatbots and fully automated ways of remote identity confirmation (as human intervention is needed). Most interviewees point to the lack of AI/ML, cloud computing and blockchain (e.g., as a permanent storage media for documents).

Financial organisations develop NTs in house or in collaboration with FinTech companies. Interviewees most often indicate a mixed development model, i.e. the development of NTs both in collaboration with external suppliers and in house. Collaboration with external companies is most often indicated when purchasing a ready-to-use product so as to benefit from the provider's expertise. Those external companies selected for collaboration range from large professional providers (Microsoft and Amazon) and payment organisations to startups and FinTech companies. Large financial institutions often acquire promising startups and thus benefit from their solutions. Small institutions without extensive IT expertise often work with external partners in purchasing proven solutions. Internal experts are used as part of the implementation process through which other staff members can gain knowledge and experience. The decision to implement in house or with the support of external companies depends on the effectiveness of the solution and the cost and availability of specific experts in the organisation (in house).

2.3. Usefulness of NTs

The next area of the survey is dedicated to efficiency especially that concerning expenses and outcomes, the distribution of costs over time, the most and least promising areas of development and finally issues and employees' attitudes. The cost efficiency of NTs is critical for the assessment of utility. There is a group of products or services that are necessary due to intense

market competition (mobile banking apps in which clients compare services as they frequently use more than one particular type of product simultaneously), market standards (cloud computing) or regulations (statutory credit holidays applied for mortgage credits due to the sharp rise in the amount of instalments during harsh macroeconomic conditions). In such cases, cost efficiency is limited or not required at all. In the case of standard implementation based on business needs, pilots and tests proceed together with in-depth efficiency analysis based primarily on net present value (NPV). The time horizon for such analysis is three to five years; if the outcome exceeds this period then such effects are not considered business driven. Few interviewees raised the problem of the accountability of cost projections especially within the initial phases and some outcomes, such as client satisfaction. Nevertheless projects with poor potential effects are abandoned. Final approval of implementation is provided by the management board.

There are three main phases, i.e. design, implementation and maintenance. However, practitioners often combine the first two phases. The distribution of costs over time varies considerably due to the different types of projects and methodologies (e.g., waterfall and agile). According to interviewees, the waterfall methodology brings more expense at the beginning (creation and implementation phases)—from 65% to 80% (creation and implementation with six years of maintenance) of total expenses—and the rest during maintenance. Design is much more expensive than is implementation. The agile methodology provides a more even distribution of costs but the division among creation, implementation and maintenance is also less clear under this methodology. One of the interviewees offers a diverse stratification of costs with 20% for design, 5% for implementation and 75% for maintenance as the maintenance process is never passive and requires costly modifications.

A considerable part of costs is the knowledge of employees and infrastructure especially in large-scale projects. Pricing for specific solutions (tools) is based more frequently on subscriptions. Costs start with high volume but the dynamic is much slower later whereas outcomes steadily increase in terms of success. There are different possible outcomes which are mostly the reduction in other costs due to decreased fraud, a decreased number of employees (in banks), a lesser burden placed on administration focusing on following regulations or supervisory expectations and risk reduction. Possible outcomes can be opportunities to keep existing clients or attract new ones.

Generally the highest utility from engaging in NTs comes from large-volume operations and can be stratified accordingly: income, cost and security oriented. Regarding income-oriented utility it is easy for some interviewees to identify technologies that increase income or at least keep it at the previous level. Most of these technologies are linked to distribution (selling) such as digital marketing, CRM and the automatization of call centres. Interviewees also mentioned areas related to product creation and post-sale services but

do not provide examples. Cost-oriented technologies such as RPA and big data, dominate the back office. Finally, big data dominates within security-oriented areas allowing for the speeding up of end-to-end processes, the sharing of data with other financial institutions and the scoring or underwriting of processes.

It is worth mentioning that one interviewee questioned all positive outcomes; this individual cannot identify an increase in sales and can at best identify an increase in client quality and/or satisfaction. Additionally, overall spending does not change, as NTs are quite costly to implement and maintain. As cyber risk increases the security does not change significantly if at all. In other words, business with NTs has changed but not the outcome.

According to an external expert, ML in risk assessment provides an advantage compared to GLM (generalized linear model). Still ML is highly significant due to considerable improvements in classical regression analysis in recent years. Profitability then depends on the scale of processes. The data used for ML in risk management covers approximately the last three years. Hence only big institutions can provide sufficient information.

This external expert also mentioned that the random elements within ML algorithms make the identification of risk determinants less clear. An enormous number of variables increases only the problems of clients' perception of risky and safe behaviour (however, the latter feature is common to GLM as well). Furthermore, there is a pending risk of potential discrimination and financial exclusion.

Few interviewees identify the lowest usefulness of NTs as being in accounting because of constantly changing rules and compliance due to the small volume of processes. Usually most of such activities can be somehow improved by NTs but priority is given to higher-utility changes.

There are several reasons for the use of NTs not growing faster one of which is an area of regulations that are not up to date or very tough (such as cloud computing recommendations). There is also a problem with compliance as nobody is sure about the interpretation. Moreover, a lack of legal security is considered an actual problem, as are cyberattacks which make institutions vulnerable. Interviewees frequently mentioned costs as being problematic mainly in two contexts, unknown and known actual costs. High expenses are often a significant burden for small entities. Two persons also mentioned the unknown effects of half-baked technologies as a concern. A highly qualified IT staff also generates costs; it is expensive and challenging to keep such staff employed due to intense local and worldwide competition. Hence the need to maintain such staff lowers stability.

The implementation of NTs requires the involvement of not only IT specialists. Almost all processes are business oriented and hence need different skills. According to interviewees, employees' attitudes can be driven by enthusiasm, reluctance and fear. Attitudes differ depending on specific technologies. Enthusiasts are eager to participate in the development and implementation

of NTs due to potential facilities. Reluctant people do not see any or limited advantage of NTs just more challenges and effort; such employees do not notice when they gain new competencies. Fear results from possible employment cuts with some interviewees confirming the materialisation of employment cuts of low-skilled employees in the banking industry. However, in the insurance industry there have also been attempts to shift such employees to activities that increase service quality. One interviewee noted that reluctance and fear can effectively jeopardise any action towards implementing NT.

2.4. Digitalisation of the Polish financial sector

During the next part of the interview the interviewees were asked about the digitalisation of the financial sector in Poland and especially the level of development, the dynamics and clients' attitudes towards NT employment. Interviewees generally considered the digitalisation of the Polish financial market considerable compared to that in Western Europe due to the late start, newer technologies , and high technological standards of banking noting this as the reason for the relatively low popularity of FinTech. NT development exemplifies the volume of cashless transactions and underwriting processes within insurance companies. Moreover, one interviewee put Poland among countries such as Spain and Turkey. Few persons considered Asian countries as leaders in this regard primarily because of the available scale that makes NTs efficient in more business processes. Furthermore, one interviewee mentioned the lack of openness in public administration as an essential barrier to NT implementation.

Generally the perception of the Polish financial market is positive due to the high volume of cashless transactions. However, BLIK, a direct payment system introduced by banks, is assessed very differently as an example of the Polish financial sector's superiority or a lack of competitive advantage in the Polish financial market.

Interviewees were unanimous with regard to the differences among groups of clients. Demographic features play an essential role in profiling NTs. Age, level of education and place of living stratify groups of clients. The most promising yet sometimes difficult to follow clients are young, well-educated students from large cities. This group is not very loyal and compares various offers, thus stimulating development. The opposite group consists of low-educated older people from small towns and villages. This first group hardly ever visits bank branches. NTs are not helpful and are inappropriate for the latter group as customers need significant backup from traditional banking. Due to digital exclusion as for most clients hybrid solutions are prospective. Furthermore, some interviewees underlined the role of education in making NTs safe for both parties—customers and banks.

The COVID-19 pandemic has been a trigger unleashing the potential of NTs. However, the development dynamic in NTs is decreasing primarily due to tight regulations. Some interviewees pointed out that with regard to NTs a segment of corporate clients stands out significantly from retail clients. However, it is a matter of scale which is much smaller for the latter.

2.5. Databases and open finance

Finally, interviewees were asked about the availability of databases and the idea of open finance. In the part of the questionnaire dedicated to databases interviewees underline that access to information is fundamental for any activity. A malfunction of the UFG (an insurance guarantee fund) database forces insurers to halt motor insurance distribution. A similar situation takes place within the banking market. Interviewees mentioned primarily private and public databases. Financial institutions develop their databases and build them as an industry together with a banking association or guarantee fund. Private databases are assessed to be better than are public databases because of the data and modern infrastructure of the former, which is costly. Interviewees criticised public databases for their outdated information and old infrastructure. One interviewee also mentioned that public databases are developed dynamically but very often with the information provided by financial institutions. Financial institutions use and create their own databases.

The outlook of databases shows a very pragmatic approach. Through generalisation interviewees provide many examples of particular databases with detailed assessments. For example the BIK (database of borrowers) is updated but provides static functionalities and a costly pricing model (per request not per sold product). Moreover, the REGON (database of business entities) database is outdated and based on old technology, which makes the know your customer (KYC) and anti money laundering (AML) processes more tiresome.

Interviewees also mention legal limitations, the threat of breaching banking/insurance secrecy and restrictions on merging information from different databases. Interviewees are aware of the risk concerning data protection or misuse. Here one interviewee mentioned the banking association as an example of the "guard" (organising ZORO database, a database of operational risk events). However, only one interviewee notes the risk of the presence of too much individualisation with regard to risk assessment. Concerning future development interviewees frequently mention EU regulations such as DORA and Network and Information Security Directive 2 (NIS2).

Interviewees consider open finance a new opportunity but with an unspecified potential mainly for a new business model. This strategy can speed up cooperation between large and small players as it allows the provision of more

user experience (UX) services and products or the introduction of new services without building new competencies within the organisation. A few interviewees mention that NTs such as photo identification (ID/PID) can ensure the better identification of clients which is essential for developing digital financial services. Due to open finance the data owner can offer additional services. However, there are also problems such as database breaches, unauthorised data usage, fraud and customer takeovers. Much work is needed concerning data standardisation but regulations like Payment Services Directive 2 (PSD2) could help in this respect. One interviewee noted that some open finance services are already available such as account information services (AISs) and payment initiation services (PISs) but are not yet popular (i.e. they account for less than 3% of the market).

3. Discussion

There are several issues from this qualitative (Polish) research that should be compared with existing literature. The first is the attitudes and skills of financial sector employees. The Greek quantitative research (Kitsios et al., 2021) finds a positive attitude towards NTs among banks' employees. The level of potential reluctance was not mentioned. Within Polish research it is interesting that managers and experts consider the threat against NTs among employees as an essential factor that can make NTs' implementation more problematic. Both pieces of research find non-IT skills vital for the effective implementation of NTs. The development of software makes it easier to engage non-IT employees but according to Greek research banking staff and customers should be trained or educated in NTs. Selimović et al. (2021) confirm that employees of the financial sector expect involvement and support in digital work. Such an approach fosters digital transformation.

The education of customers does not appear in Polish research. Respondents perceive only a different willingness and ability to cope with NT among clients, indirectly mentioning potential financial exclusion if NTs spread more widely. The main reason is an intellectual capacity linked to the level of education and familiarity with NTs correlating somehow with age. The place of living is also noticed. Many pieces of research (e.g., Solarz & Adamek, 2022) deal with financial exclusion due to NTs in financial services echo these findings. However, at the same time other research finds NTs helpful in strengthening financial inclusion (Lee-Ying et al., 2022; Siddik & Kabiraj, 2020). NTs are considered very differently often as a barrier or opportunity. It can be a matter of perspective. It seems the closer the perspective is to business the more of a challenge it becomes. The closer it is to policy, the more it seems an opportunity.

The respondents in Polish research frequently mentioned a more intense business risk as an important drawback of NTs. Business risk is a clear outcome of any new tool or method incorporated into daily practice such as privacy (Piotrowski, 2023). Every new technology in the past brought similar risks. But not all NTs prove their usefulness. Interestingly blockchain is mentioned in this context as a business failure. Technology that promised revolutionary changes (Aashima & Mohanty, 2022) has not pleased the financial market. It was seen to be too complex and costly for market participants. The features provided by blockchain will probably be copied in the future within other, more available technologies.

Dehumanisation mentioned by respondents within Polish research is a more philosophical constatation, however, the frequently mentioned AI/ML copies human behaviour in many aspects. It creates the risk of copying discriminatory practices from the past mainly within insurance (Eling et al., 2022). In Polish research this risk was also identified primarily within the insurance industry. At the same time AI/ML feeds algorithms of robo-advisors taking the role of distributors and helping to optimise insurance coverage. It should be mentioned that the activity of robo-advisors is not fully regulated (Marano & Li, 2023). The Polish research reveals that the economic efficiency reached by AI/ML in Poland up to now is relatively small and can be profitable only on a large scale which is hardly available in the Polish market.

The scale of potential processes is a key driver of NTs development. The respondents in Polish research point to China (Muganyi et al., 2022) and India (PwC, 2022) as world leaders. These countries are characterised by large volumes, lower standards of data protection and very limited other regulations. Poland was placed with Spain and Turkey ahead of other Western European countries. The lower popularity of fintech in Poland compared to Western Europe is explained by a higher level of technological development. However, the literature also points to regulatory barriers (Shala & Perri, 2022) and poor financing programmes (Kliber et al., 2021).

Conclusions

In this study the scope of the application of NTs is identified. The analysis is based on interviews conducted with top-level managers and experts from Polish financial services' industry. Interviews (nineteen) were conducted from July to November 2022 and from April to June 2023. The hypothesis H1 was proposed stating that those NTs implemented in the Polish financial services industry are largely targeted at a) meeting customers' needs, b) improving the productivity and efficiency of internal processes and c) improving risk management practices.

Based on the interviews supporting evidence is found for two components of hypothesis H1 (H1a and H1b) while the last component (H1c) is expected to be one of the key implementations in the future. It should be noted that cybersecurity and AML now play a significant role in the abovementioned objectives. As interviewees underlined the implementation of NTs is customer and business driven and should be effective in terms of their impact on entity performance. NTs may be divided into income-oriented (e.g., NTs meeting customers' needs), cost-oriented (e.g., RPAs in the back office) and security-oriented (e.g., fraud detection systems) NTs all of which are important for entity performance from various perspectives. In the case of income-oriented solutions there is strong market pressure to offer attractive services including VASs, to keep or attract new customers which is especially important for the younger generation composed of digital natives. In the case of risk management big data AI/ML solutions are used widely in AML and fraud detection as well as for cybersecurity. Although their application for the evaluation of credit risk including credit scoring has a good background in academic literature the use of such solutions in business is still not significant. However, AI/ML algorithms are in use in credit processes to e.g., promptly verify the customer's identity in various (public and private) databases. Additionally, insurers try to use NTs in evaluating underwriting risk in motor insurance. All of the above factors show that this approach is not yet a market standard but rather an emerging approach.

As evaluated by industry representatives some NTs can be treated as standards on the market and include digital distribution channels, contactless payments, decision-supporting systems, digital marketing, call centre automation, classic RPA, decision automation and workplace digitalisation. It is worth noting that blockchain which is not a standard NT in the financial sector is not regarded as a prospective NT either. As a technology that is important for the near future cloud computing and the wider use of AI/ML are mentioned while in the distant future quantum computing and metaverses are mentioned. The extensive use of AI/ML also requires improvements in public and private databases to fit into the modern IT infrastructure of the financial industry.

The implementation of NTs is a process operated with in-house resources or, more frequently, in cooperation with specialised companies including FinTech companies. Barriers to implementation which are the deficit of human resources with NT qualifications, the rising costs of IT and IT staff and the nonacceptance of NTs by some staff should be mentioned; however, entities try to remove this barrier by using informational campaigns and outplacement opportunities.

Overall, the financial industry in Poland is advanced in the application of NTs especially in customer- and cost-oriented areas with prospects and visions for future development paths. In the coming years the use of AI/ML in risk management areas should be expanded to catch up with the degree of advancement in other areas.

This study adds to the literature an extensive analysis of the application of NTs in a transition EU country based on real-life examples. Furthermore, this work is a single-country and single-industry study the results of which may be used as a benchmark for other markets in further explorations.

Appendix

In-depth interview scenario

I. Purpose and rationale for introducing new technologies	1	In your opinion what is the purpose of using new technologies in financial institutions?
	2	To what extent is the use of new technologies justified from a financial sector development perspective?
	3	What are the main advantages of introducing new technologies?
	4	Do you see any disadvantages of the introduction of new technologies?
	5	Can you imagine the development of the financial sector without new technologies?
II. Types/examples of new technologies	1	Please list, starting with the most important, the new technologies (at least five) used in your industry.
	2	Which technology(s) will be most relevant to your industry in the next five years, or the so-called ‚technologies of the future'?
	3	Which technologies (at least three) do you consider to be the most innovative/pioneering/changing the operation of your organisation (or industry) to the greatest extent?
	4	When were (are) the abovementioned new technologies tested and when will be used (or since when have they been in use)?
	5	What can currently be considered a standard rather than a new technology?
	6	Which technologies are still lacking in your organisation?
	7	Are the new technologies being developed in your organisation in-house or in collaboration with FinTech companies?

III. Actual usefulness of new technologies	1	How do you assess the ratio of inputs to outputs of using new technologies?
	2	How do the costs of using new technologies break down by phase, creation-application (implementation)-maintenance?
	3	In which areas of the organisation's business are the above technologies most useful (e.g., distribution channels, sales, after-sales, back-office, risk management, compliance, internal audit)
	4	In which areas of the organisation's operations does the use of the new technologies provide the greatest benefits (e.g., cost reduction, improved process efficiency)?
	5	In which areas have the new technologies performed the least well? What is the reason for this?
	6	What are the largest problems or barriers to implementing new technologies?
	7	What is your organization's employees' attitude towards implementing new technologies (see the added value/do not see the added value/negative attitude)?
IV. Digitalisation of the Polish financial sector	1	How do you assess the degree of digitalisation of the Polish financial sector compared to other European/world countries?
	2	Is the pace of digitalisation adequate? Can the sector and customers keep up with the pace of digitisation?
	3	Can certain customer groups in Poland be distinguished in terms of the degree of their digitalisation characteristics, e.g., in terms of age or place of residence?
V. Databases	1	How do you assess the availability and development of public, public-private and private databases?
	2	Should other open databases be developed? If so, which ones and why?
	3	How do you assess the usability of sectoral applications, e.g., UFG fraud application, and solutions offered by BIK?
VI. Open finance concept	1	How do you assess the concept of open finance? Is it a utopia or is it the near future? What opportunities and threats do you perceive about such openness?

Sorce: own work.

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Formulary apportionment in the European Union—future research agenda

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Abstract

The aim of the paper is to identify the relevant prior research focused on the Formulary Apportionment methodology in the European Union, to explore the current literature and develop directions for future research. Reflecting upon the announced European Commission's Proposal for new framework for business taxation and the foreseeable upswing of academic discussion focused on the formulary apportionment methodology this paper represents the first systematic literature review on this topic. The study identifies eight main thematic clusters, provides an interpretative framework and suggests valuable future research directions within each thematic cluster as well as general future research agenda.

Keywords

- formulary apportionment
- Common Consolidated Corporate Tax Base
- BEFIT
- systematic literature review

JEL codes: H25, H71, K34

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Introduction

This paper reflects the impending proposal for a new framework for corporate taxation in the European Union (EU) (BEFIT Proposal)[2] which will be based on the key features of the Proposal for a Council Directive on a Common Consolidated Corporate Tax Base (CCCTB proposal)[3] such as a single corporate tax rulebook and the Formulary Apportionment (FA). Given the impending BEFIT Proposal and the anticipated increase in scholarly and political discourse on the FA methodology it may be the appropriate time to summarize the existing research, confirm some insights and develop directions for future research.

This study conducts a systematic literature review to gather and synthesize the existing research on this topic. The main aim is to identify pertinent prior research examine the current literature with a focus on FA methodology and related aspects of the previously proposed but likely to be withdrawn CCCTB proposal. In addition, the study aims to provide guidance for future research and addresses the following research question: "What are the implications for further research suggested by findings of the systematic literature review?."

The review reveals eight thematic clusters and highlights the key findings. While some topics such as the effects on tax revenue and the factors of the FA methodology were extensively researched others such as the FAs' explanatory power of the variability in profitability of Multinational Companies' (MNC) or new forms of profit shifting resulting from FA implementation received relatively little attention. Based on the review significant and promising areas for future research were identified.

The remainder of this paper is organized as follows. Section 1 clarifies key definitions and conceptual matters. Section 2 describes the methodology applied and sampling process. Section 3 continues by discussing the results of the literature review including the theoretical foundations and temporal evolution of the literature. Section 4 suggests future research avenues. Section 5 presents conclusions, contributions, and main limitations of the study.

[2] Indicated in COM (2021) 251 final, 18.05.2021. Communication from the Commission to the European Parliament and the Council. Business Taxation for the 21st Century.

[3] COM (2016) 683 final, 25.10.2016. Proposal for a Council directive on a Common Consolidated Corporate Tax Base (CCCTB).

1. Theoretical framework

The Separate Accounting (SA) and the FA are the two major principles for corporate taxation. The SA with the arm's length principle requires MNCs to calculate a separate tax base in each tax jurisdiction as if each entity within the group were independent (Weiner, 2006). Whereas the FA is used at the sub-national level in the United States (US), Canada, Germany, or Switzerland the SA is currently applied in the EU.

Under the currently applied SA methodology MNCs utilise technical disparities among tax systems of the EU Member States to pursue aggressive tax planning, misuse of transfer pricing and the use of different methods of loss compensation to minimize their tax obligations which in turn means losses in tax revenues of national budgets and distortion of the internal market. Furthermore, there is a widespread perception that MNCs and purely domestic companies bear significantly different tax burdens. Additionally, the present global taxation system is widely regarded as incompatible with the globalized and digitized economy. Given the stated points it is justifiable to engage in a discussion concerning alternative approaches to the SA methodology in the EU such as the FA approach.

The theory underlying FA methodology, despite being vague, can be considered under the concept introduced by Musgrave (1972), i.e. source taxation. The theoretical concept of the FA is based on the idea of allocating profits of MNC among different tax jurisdictions where the MNC performs economic activity. The consolidated corporate tax base is distributed according to selected variables, factors reflecting the value creation of companies hence explaining the variability in profitability (McLure, 1981). Traditionally countries with sub-national FA systems have relied on a combination of (proxies for) production factors such as tangible assets, labour and third-party sales. Table 1 compares different forms of FA used in federal economies and the FA proposed by the European Commission. Table 1 lists FA's factors applied, information whether an industry specific formula is employed and theoretical classification reflecting both supply as well as demand sides of economy are reflected by the employed allocation factors.

The FA's application within the EU was first discussed together with other alternatives to the SA methodology by the European Commission in the Communication *Towards an internal market without tax obstacles*.[4] Consequently in 2011 the European Commission presented the early CCCTB proposal[5] which was re-launched in 2016 in a two-stage approach on Common

[4] COM (2001) 582 final, 23.10.2001.
[5] COM (2011) 121 final, 16.03.2011.

Table 1. Comparison of different formula configurations

Jurisdiction	Standard FA	Industry specific FA	Theoretical classification
Germany	– cost of employees.	no	supply
Switzerland	– separate accounting results – capital/cost of employees* or sales by destination**	yes	supply
Canada	– cost of employees – sales by destination	yes	supply–demand
The US (Massachusetts)	– tangible fixed assets – sales by destination – cost of employees	yes	supply–demand
CCCTB Proposal	– tangible fixed assets – sales by destination – cost of employees – number of employees	no	supply–demand
BEFIT Proposal	– tangible fixed assets – sales by destination – cost of employees – number of employees – intangible fixed assets	yes	supply–demand

* For manufacturing. ** For commerce.

Source: based on (Mayer, 2009).

Corporate Tax Base (CCTB proposal)[6] and Common Consolidated Corporate Tax Base (CCCTB proposal).[7] The configuration of the apportionment formula is outlined in Table 1. Whilst the CCTB proposal sets a single set of rules for the calculation of the corporate tax base some provisions such as a cross-border loss relief were destined to apply only when the full CCCTB proposal comes into force. However, complexities surrounding the definition of the consolidated tax base prompted the EU to shift focus away from immediate consolidation and prioritize the establishment of a common tax base as an initial step. The FA methodology was a constant and inseparable part of the overall CCCTB project.[8] Put on hold the CCCTB project was subsequently revived in 2021 in Communication on *Business taxation for the 21st century* which proclaimed a forthcoming BEFIT Proposal to be tabled in 2023. As stated earlier the BEFIT Proposal, coincidently with the CCCTB proposal, will be based on a single corporate tax rulebook and FA methodology.

[6] COM (2016) 0685 final, 25.10.2016.

[7] COM (2016) 683 final, 25.10.2016.

[8] The overall initiative at the EU level to implement the FA methodology under multiple CC(C)TB Proposals is further referred as the CCCTB project.

2. Methodology

This study aims to provide a systematic summary of the existing literature on the FA methodology and related features of the CCCTB proposal as well as to identify pertinent themes and opportunities for future research. To accomplish this a systematic approach to the literature review was adopted following mainly studies published in the *International Journal of Management Reviews*[9] as a leading global review journal in organization and management studies and *Technological Forecasting & Social Change*[10] focused on methodology and practice of technological forecasting.

The review process consisted of several steps necessary to obtain a list of articles. Two commonly used internet-based academic databases Web of Science (WoS) and Scopus which includes the leading taxation journals such as National Tax Journal or International Tax and Public Finance were perused. The search strategy consisted of general inclusion criteria and search boundaries within each of the employed database. As general inclusion criteria the following search string was applied: "formula*" AND "apportionment*" OR "common consolidated corporate tax base". Furthermore, no time restrictions

Table 2. Search boundaries

WoS	
Search in	Title, Abstract, Author Keywords, and Keywords Plus
Boolean operator	AND between the terms
Document type	"Article"
Citation topic	"Economic Theory", "Economics"
Exclusion criteria	Proceeding papers; Web of Science Categories: Environmental Studies, Geography
Scopus	
Search in	Title, Abstract, Author Keywords
Boolean operator	AND between the terms
Document type	"Article"
Source type	"Journal"
Subject area	"Economic, Econometrics and Finance", "Business, Management and accounting", "Social Science"

Source: own work.

[9] For instance (Schaltegger et al., 2021; Ceipek et al., 2019).
[10] For instance (Ancillai et al., 2023).

were set and the filter 'Language = English' was applied. Titles, abstracts and keywords were scanned to confirm that the study fits with the review scope. Table 2 summarizes the search boundaries subsequently applied within each database.

As a result of the applied search strategy (summarised in Table 2) 152 articles in the WoS database and 155 articles in the Scopus database were identified. Nevertheless, the obtained sample contained irrelevant studies, incorrect entries and duplicates. The data cleaning consisted of the following steps. First, removal of duplicates and incorrect entries. Besides, removal of articles based on titles and abstracts to verify whether the search results fit the content scope of the review. In this stage a total number of 114 articles was removed from the sample hence 148 studies were included in the full text review. Despite a rigorous review of titles and abstracts the full text analysis, the third step, revealed that many articles did not have the desired focus and thus 31 studies were removed. Table 3 shows the sequential steps of cleaning the sample of literature.

Table 3. Database search process and results

	WoS	Scopus	Total
Initial download of literature	152	155	307
Removal of duplicates and incorrect entries	–17	–99	–114
Removal of articles based on review of titles and abstracts	–24	–21	–45
Articles subjected to full text review	111	37	148
Exclusion based on full text review	–24	–13	–37
Inclusion of articles based on backward reference search			1
Total of articles included in the systematic review	87	24	111

Source: own work.

In total 111 research papers were identified as thoroughly and explicitly addressing the topic of the FA methodology and related features of the CCCTB proposal.

3. Results

In this section the theoretical foundations and temporal evolution of the literature is discussed. Based on the full text review main streams of literature were identified and corresponding thematic clusters were proposed (see Table 4).

Table 4. Thematic clusters and respective studies[11]

Cluster	Studies
Evaluation of the FA methodology and the CCCTB proposals	Polezharova and Krasnobaeva (2020), de Wilde (2020), Petkova and Weichenrieder (2020), McGaughey and Raimondos (2019), Lehoux et al. (2019), Khan Niazi (2017), Quentin (2017), Cerioni (2016), Riedel (2011), Herzig et al. (2010), Devereux and Fuest (2010), Schreiber and Fuhrich (2009), Eichner and Runkel (2008), Fuest (2008), Bogerd (2007), Conrad (2006), Eggert and Haufler (2006), Russo (2005), Gordon and Wilson (1986)
Composition and factors of the FA methodology	Martins and Taborda (2022), Hundsdoerfer and Wagner (2020), Krchnivá and Nerudová (2018), Llopis (2017), Eberhartinger and Petutschnig (2017), Swenson (2015), Merriman (2015), Roggeman et al. (2012, 2013), Fernandez (2012), Pirvu et al. (2011), Altshuler and Grubert (2010), Eichner and Runkel (2009), Edmiston and Granado (2006), Fox et al. (2005), Hellerstein and McLure (2004), Edmiston (2002), Goolsbee and Maydew (2000), McLure (1981, 2000), Anand and Sansing (2000), Shackelford and Slemrod (1998)
The FA's explanatory Power of the variability in profitability of MNCs	Hundsdoerfer and Wagner (2020), Krchnivá and Nerudová (2018), Nerudová and Krchnivá (2016), Roggeman et al. (2012)
Ability to eliminate profit shifting and tax base erosion	Cobham et al. (2021), Bloch and Demange (2021), de Mooij et al. (2021), Nerudová et al. (2020), Greil et al. (2019), Faccio and Fitzgerald (2018), Eichfelder et al. (2018), Kiesewetter et al. (2018), Cerioni (2015, 2016), Ortmann and Sureth-Sloane (2016), Martini et al. (2016), Sadiq (2015), Becker and Runkel (2013), Buettner et al. (2011), Altshuler and Grubert (2010), Gupta et al. (2009), Jarass and Obermair (2008), Riedel and Runkel (2007), Eggert and Haufler (2006), Fox et al. (2005), Kind et al. (2005), Sørensen (2004), Nielsen et al. (2003), Wetzler (1995), Munnell (1992)
Impact on tax revenues	Cobham et al. (2021), Nerudová et al. (2021), de Mooij et al. (2021), Nerudová and Solilová (2015, 2017, 2018, 2019), Mardan and Stimmelmayr (2018), Solilová et al. (2016), Hodzic (2015), Domonkos et al. (2013), Oestreicher and Koch (2011), Pirvu et al. (2011), Altshuler and Grubert (2010), Bettendorf, Devereux et al. (2010), Gupta et al. (2009), Devereux and Loretz (2008), Eichner and Runkel (2008), Pethig and Wagener (2007), Fuest et al. (2007), Edmiston and Granado (2006), Shackelford and Slemrod (1998)
Impact on tax competition and tax rates	Perotto (2021), Liesegang and Runkel (2019), Arel-Bundock and Parinandi (2018), Mardan and Stimmelmayr (2018), Gordon (2014), Roggeman et al. (2014), Sosnowski (2014), Wrede (2013, 2014), Fernandez (2012), Eichner and Runkel (2008, 2009, 2011, 2012), Riedel (2010), Becker and Fuest (2010), Kudrle (2009), Pethig and Wagener (2007), Pinto (2007), Eggert and Haufler (2006), Kind et al. (2005)

[11] Some studies cover multiple topics and hence, are listed in several clusters.

Table 4 continued

Cluster	Studies
Welfare effects	Runkel and Schjelderup (2011), Bettendorf, Devereux et al. (2010, Bettendorf, van der Horst et al. (2010), Eichner and Runkel (2008), Kind et al. (2005), Sørensen (2004), Nielsen et al. (2003), Edmiston (2002), Anand and Sansing (2000)
Miscellaneous	d'Andria et al. (2018), Cerioni (2018), Spinosa and Chand (2018), Gutmann and de la Bletiere (2017), Lacova and Hunady (2018), de Groot (2017), Gresik (2016), Matsumoto (2016), Garbarino (2014), Borg (2013), Becker and Runkel (2013), van de Streek (2012), Martini et al. (2012), Riedel (2010), Almendral (2010), Mitroyanni and Putzolu (2009)

Source: own work.

3.1. Evaluation of the FA methodology and CCCTB proposals

A significant body of literature addressed the question of whether FA is an attractive and feasible methodology compared to SA methodology as well as the theoretical arguments for and against its introduction. Studies within this stream of literature present varying findings and no unified conclusion has been offered. This section summarizes studies highlighting the benefits of the FA, studies highlighting its flaws, studies arguing that both systems are problematic and studies providing a general evaluation of the CCCTB proposal.

Several scholars argue that the implementation of the FA within the EU is long overdue. This position is supported by Polezharova and Krasnobaeva (2020), McGaughey and Raimondos (2019), and Lehoux et al. (2019). Polezharova and Krasnobaeva (2020) emphasized that a simple and transparent taxation mechanism based on the FA is highly desirable particularly for taxing e-commerce profits of MNCs. Similarly, McGaughey and Raimondos (2019) strongly supported the adoption of FA especially in the context of problematic definitions of national taxable income for MNCs and digital business models. Lehoux et al. (2019) confirmed the advantages of FA for fair distribution of the taxation base especially in technology and capital-intensive industries. In addition, Spinosa and Chand (2018) proposed a shared taxing rights mechanism for taxing specified digital activities or services that operate remotely.

Several authors have raised concerns over the feasibility of implementing FA within the EU. Riedel (2011), Schreiber and Fuhrich (2009), and Gordon and Wilson (1986) have argued that the current SA system should be maintained due to various drawbacks of the FA methodology. Gordon and Wilson (1986) noted that the FA may lead to inefficiently low tax rates and a shift to direct taxation of property. Riedel (2011) has highlighted that high corporate tax rates under the FA may harm domestic workers and diminish wages at for-

eign affiliates. Schreiber and Fuhrich (2009) have suggested that the SA has an advantage over FA as it does not pressure EU Member States to harmonize their anti-avoidance tax rules concerning non-EU countries.

Numerous studies have addressed the feasibility and attractiveness of the FA compared to the SA with no unified conclusion. Some studies support the FA, including those by Polezharova and Krasnobaeva (2020), McGaughey and Raimondos (2019), and Lehoux et al. (2019). Others including Riedel (2011), Schreiber and Fuhrich (2009) and Gordon and Wilson (1986), suggest maintaining the status quo. Several studies conclude that both systems have flaws and suggest a combined approach including those by Petkova and Weichenrieder (2020), Quentin (2017), Cottani (2016), Herzig et al. (2010), Eggert and Haufler (2006) and Conrad (2006). Eggert and Haufler (2006) emphasized practical difficulties associated with a switch to FA in the EU. Herzig et al. (2010) suggested supplementing SA with aspects of unitary taxation where necessary. Petkova and Weichenrieder (2020) discussed a hybrid model combining features of both systems. Finally, Conrad (2006) showed that the attribution method is arbitrary if the tax systems across jurisdictions are identical and neutral.

De Wilde (2020), Khan Niazi (2017), Cerioni (2016), Fuest (2008), Eichner and Runkel (2008), Devereux and Fuest (2010), and Russo (2005) evaluated the European Commission's proposals to implement the FA system in the internal market primarily under the CCCTB proposals. Russo (2005) provided an overview of FA, summarized currently used FA in federal economies, discussed the definition of the group and tax base, and proposed an alternative method, the profit split method. Fuest (2008) suggested that more economic evidence of benefits from FA implementation is needed while Eichner and Runkel (2008) reported an increase in welfare from FA implementation in the EU. Khan Niazi (2017) stated that the CCCTB proposal is pragmatic and may result in tangible progress while Devereux and Fuest (2010) concluded that the main drawback of the CCCTB project is profit shifting to low tax countries outside the EU. De Wilde (2020) recommended remodelling the CCCTB proposal into a unitary taxation model[12] for taxing the global profits of MNCs using a destination-based FA.[13]

3.2. Composition and factors of the FA methodology

The distribution of the consolidated corporate tax base under FA is determined by chosen factors that reflect value creation which can impact the tax

[12] The unitary tax model is an approach to taxing global profits that consolidates the profits of MNCs across multiple jurisdictions.

[13] Destination-based FA is method how to tax MNCs based on where the goods and services are consumed rather than where they are produced or where the MNC is headquartered.

base distribution and potential profit shifting. Production factors based on tangible assets, labour and third-party sales have traditionally been used in sub-national FA systems while intangibles and financial assets have been excluded due to mobility and transfer pricing concerns. The design and choice of FA factors have been examined by various authors with different objectives and results. This section summarizes the main findings of this literature.

The composition of FA has been widely discussed by various authors. Pirvu et al. (2011) examined the impact of FA on tax revenues while Fernandez (2012) emphasized the importance of the FA design for practical application and conflict resolution. Altshuler and Grubert (2010) pointed out the potential asymmetry between the determinants of taxable income and the factors that enter the FA. Roggeman et al. (2013) studied the design of the FA and concluded that including more factors with equal weights would create an efficient FA and reduce MNCs' incentive for profit shifting. Krchnivá and Nerudová (2018) explored whether FA should be distinguished based on different economic sectors. Meanwhile McLure (1981)[14] argued that the FA methodology transforms corporate income tax into a direct tax on the factors applied in the FA and Goolsbee and Maydew (2000) found that using payroll in FA partially turns the corporate income tax into a payroll tax.

The labour factor has been investigated by Eberhartinger and Petutschnig (2017) who suggested that using the payroll factor based on the number of employees can help analyse the effects of employee costs on tax allocation. The importance of wages for tax allocation has been explored by Fox et al. (2005), Hellerstein and McLure (2004), Anand and Sansing (2000), Shackelford and Slemrod (1998), and McLure (1981). Goolsbee and Maydew (2000) studied the inclusion of payroll in the FA and found that it affects state-level employment. Merriman (2015) replicated their results but noted that the econometric evidence is weak.

The allocation of taxable income in the context of the FA factors has been discussed by various authors with a particular focus on the sales factor. Swenson (2015) found that a single sales factor FA had no significant effect on aggregate employment but that locally based companies could benefit from the FA application. Llopis (2017) also considered a single sales factor FA and an alternative based on assets and labour concluding that the former was more efficient at combating profit shifting by MNCs. Other authors have suggested that increasing the weight of the sales factor could have positive effects on the utilization of productive factors (Edmiston & Granado, 2006; Fox et al.,

[14] McLure (1981) claimed that by using factors as a basis for income allocation the tax burden shifts from being solely focused on the income itself to also encompassing the underlying factors, such as assets, the labour and the sales generated by the taxpayer. This transformation alters the nature of the tax system broadens its reach beyond income and potentially impacts the overall economic dynamics and behaviour of taxpayers.

2005) and mitigate fiscal externalities caused by tax competition (Eichner & Runkel, 2008). Hundsdoerfer and Wagner (2020) agreed that increasing the weight of the sales factor could improve FA performance to some extent but that significant profit deviations would remain.

Several authors have explored alternatives to traditionally applied factors in the increasingly digitalized and globalized economy. McLure (2000) addressed the application of FA to the digitalized economy and the inclusion of new types of value-creating assets. Roggeman et al. (2012) empirically tested the inclusion of intangible assets in FA while Martins and Taborda (2022) argued for the recognition of certain categories of intangible assets. Hellerstein and McLure (2004) suggested the inclusion of value added as a conceptually attractive approach but one that is subject to transfer pricing issues. The authors emphasize the considerable contribution of intangible assets to the creation of economic value and suggest their incorporation in the FA.

3.3. The FA's explanatory power of the variability in profitability of MNCs

In accordance with pertinent theory (Hundsdoerfer & Wagner, 2020; Krchnivá & Nerudová, 2018; Nerudová & Krchnivá, 2016; Roggeman et al., 2012) it is highly desirable for the allocation formula to effectively capture and mirror the profit generation process of companies. Nevertheless Weiner (2006) contended that explanatory power alone does not encompass all desired attributes.[15] The choice of factors in the FA significantly affects its ability to explain the variability in the profitability of MNCs. Several authors have examined the CCCTB FA including Hundsdoerfer and Wagner (2020), Krchnivá and Nerudová (2018), Nerudová and Krchnivá (2016), and Roggeman et al. (2012) who used microeconomic data to estimate the percentage of explained variability in profitability through regression analysis. The CCCTB FA was found as the best performing formula explaining between 26.32% and 35% of the variability in profitability. While Hundsdoerfer and Wagner (2020) found large income misallocations and systematic distortions caused by the CCCTB FA it was still considered the best-performing formula compared to alternative compositions. Additionally, Roggeman et al. (2012) found that the inclusion of intangible assets did not enhance the explanatory power of FA.

[15] Weiner (2006) asserted that the preferred formula should not be solely based on performance superiority, but rather prioritize characteristics of simplicity, comprehensibility, feasibility, and acceptability to individual states.

3.4. Ability to eliminate profit shifting and tax base erosion

There is a large body of literature examining MNCs' profit shifting activities under both SA and FA systems. Some view the FA methodology as a potential solution to this problem while others argue that FA could create new distortions and provide further tax avoidance opportunities potentially even strengthening MNCs' profit shifting activities.

Nerudová et al. (2020), Jarass and Obermair (2008), and Fox et al. (2005) examined profit shifting of EU MNCs under SA. Nerudová et al. (2020) identified primary profit shifting channels and quantified tax revenue losses. Fox et al. (2005) affirmed that SA generally leads to substantial tax distortions and tax planning opportunities. Jarass and Obermair (2008) detailed the decline in competitiveness of small and medium-sized enterprises that pay the full domestic tax rate.

Scholars have expressed a positive outlook towards the ability of the FA system to address profit shifting by MNCs. Faccio and Fitzgerald (2018), Sadiq (2015), Eggert and Haufler (2006), and Munnell (1992) are among the authors who support the FA methodology. According to Faccio and Fitzgerald (2018), FA has the potential to reduce the allocation of profits to low-tax jurisdictions where MNCs have minimal economic activities. Munnell (1992) similarly suggested that FA can effectively curb international profit shifting. Sadiq (2015) proposed the implementation of industry-specific unitary taxation based on FA as a solution to profit shifting, particularly for MNCs in the financial sector.

Cobham et al. (2021), de Mooij et al. (2021), Eichfelder et al. (2018), Kiesewetter et al. (2018), Martini et al. (2016), Buettner et al. (2011), Sørensen (2004) and Nielsen et al. (2003) have argued that while the implementation of FA may limit profit shifting under SA it may also create new opportunities for tax avoidance that must be addressed. Cobham et al. (2021) specifically discussed the application of FA at the EU level stating that it could overlook the extent of profit shifting out of the EU which was also addressed by previous studies such as Kudrle (2009), Shackelford and Slemrod (1998), Wetzler (1995) and Musgrave (1972) in the context of US MNCs. Buettner et al. (2011) noted that profit shifting incentives remain important under FA as it is only abolished within the corporate group if all group affiliates of an MNC are consolidated.

Martini et al. (2016) demonstrated that FA provides opportunities for profit shifting a view shared by Kiesewetter et al. (2018) who argued that FA may lead to a shift from manipulating reported profits to influencing the apportionment key. Eichfelder et al. (2018) supported this by suggesting that MNCs may alter the allocation of production factors and manipulate the FA factor using tax avoidance strategies. Sørensen (2004) agreed that while FA has the potential to create new distortions if existing tax rate differences are maintained. Furthermore, de Mooij et al. (2021) concluded that this is fore-

seeable based on the experience of federal states currently utilizing the FA system. Lastly, Nielsen et al. (2003) found that switching from SA to FA may strengthen profit shifting activities by MNCs in a model where transfer prices are used to manipulate the behaviour of a subsidiary.

The literature generally agrees that neither system fully prevents profit shifting and the effectiveness of each system depends on the MNCs' response to changes in corporate tax rates. This view is supported by studies such as Bloch and Demange (2021), Greil et al. (2019), Ortmann and Sureth-Sloane (2016), Cerioni (2015, 2016), Becker and Runkel (2013), Altshuler and Grubert (2010), Gupta et al. (2009), Riedel and Runkel (2007) and Kind et al. (2005).

Kind et al. (2005) argued that SA and FA differ in their ability to prevent profit shifting and maintain national tax autonomy. Riedel and Runkel (2007) found that while FA could initially reduce profit shifting from the EU to non-FA tax havens in the long run it could lead to negative externalities under the water's edge. However, the negative externality is less harmful than profit shifting under SA and may offset other externalities under FA. Altshuler and Grubert (2010) demonstrated that SA and FA distort behaviour in different ways and FA has no clear advantage over SA. Becker and Runkel (2013) concluded that both tax regimes distort the international allocation of ownership taking into consideration the behavioural changes of MNCs triggered by the shift from SA to FA. Ortmann and Sureth-Sloane (2016) analysed the conditions under which the FA or SA is advantageous for MNCs, focusing on loss-offsets. They found that the FA is preferred for increasing loss/profit streams while the SA is beneficial for decreasing profit/loss streams.

Bloch and Demange (2021) and Greil et al. (2019) have identified significant challenges associated with taxing the profits of MNCs in the digital economy and particularly digital platforms. Bloch and Demange (2021) found that digital platforms can shift profits from high-tax to low-tax jurisdictions by exploiting network externalities under SA and manipulating the apportionment key under FA even in the absence of transfer pricing. Greil et al. (2019) concluded that recent reforms aimed at curbing profit-shifting activities have led to increased legal uncertainty and while the FA has potential to mitigate this problem its integration into the existing transfer pricing framework raises complex delineation issues.

3.5. Impact on tax revenues

The literature has extensively examined the impact of the FA methodology on corporate income tax revenues. The impact of the integrated FA methodology on tax revenues for EU Member States has been a topic of interest for many authors in the context of the CCCTB proposal. Results obtained from

various researchers vary and a clear conclusion has not yet been reached. The evaluation of revenue studies presents inherent complexities due to their reliance on publicly available data. Therefore, understanding the specific formula and dataset examined is crucial for accurate assessment. To address this concern a comprehensive summary of the methodology and data of empirical studies has been provided in the Appendix for reference and further insight.

De Mooij et al. (2021) stated that large economies generally experience an increase in corporate income tax revenues under FA with developing countries gaining mostly if employment is heavily weighted in the FA. Pethig and Wagener (2007) claimed that high tax countries are likely to gain tax revenues under FA while low tax countries are likely to lose revenues. Bettendorf et al. (2010) simulated the impact with a Computable General Equilibrium (CGE) model and concluded that higher tax revenues could be achieved by the implementation of the CCCTB proposal but only if accompanied by corporate tax rate harmonization. Mardan and Stimmelmayr (2018) found that a shift from SA to FA unambiguously decreases tax revenues in the short run while in the medium-term tax revenues are still lower under FA if the probability of incurring losses or the costs of profit shifting are sufficiently low.

Various scholars including Cobham et al. (2021) and Fuest et al. (2007) have examined the potential for loss offsetting in the CCCTB proposal. Fuest et al. (2007) found that loss offsetting would cause a 20% reduction in the EU corporate tax base with larger countries gaining at the expense of smaller low-tax countries. Similarly, Cobham et al. (2021) found that implementing the CCCTB proposal with loss consolidation would lead to substantial tax revenue costs equal to about one fifth of the corporate tax base with profit shifting EU countries such as Luxembourg, Ireland and the Netherlands experiencing significant revenue losses.

Nerudová and Solilová (2019) and Oestreicher and Koch (2011) have examined the potential impact of both mandatory and voluntary implementation scenarios of the CCCTB proposal. Nerudová and Solilová (2019) found that exclusively mandatory implementation for large MNCs would lead to a 4.2% reduction in the total tax base due to cross-border loss offsetting during the consolidation regime. Conversely Oestreicher and Koch (2011) argued that the revenue effect of the CCCTB hinges on the nominal tax rate of each EU Member State resulting in a decline of 4.56% under a compulsory and 4.65% under a voluntary CCCTB.

Within this stream some authors have focused on the implications on tax revenues of individual EU Member States. Pirvu et al. (2011) found that implementation of the CCCTB in Romania would lead to a 0.04% reduction in the corporate tax base. Domonkos et al. (2013) employed a similar methodology to analyse the impact of the CCCTB proposal in Slovakia finding that it would result in a 31.9% decrease in tax revenues in 2009 and a 14.6% drop in 2010. Hodzic (2015) discussed the pros and cons of implementing the CCCTB

in Croatia while Nerudová and Solilová (2015) and Solilová et al. (2016) conducted a detailed analysis of different implementation scenarios and their impact on the tax revenues of the Czech Republic. They found that if the CCCTB were implemented obligatorily, the Czech Republic would gain an additional 3.39% of corporate tax revenue compared to the current system but if cross-border loss offsetting were allowed the Czech Republic would lose 0.78% of current corporate tax revenues. Nerudová and Solilová (2015) noted that the size of the country may affect the impact on the share of the tax base with the Czech Republic recording a 1.22% increase in tax revenues if the CCCTB proposal were introduced in all EU Member States. The authors also found a slight increase in tax revenues in Slovakia, Slovenia and Spain but a decrease in Germany, Estonia, Hungary, and Poland. Nerudová and Solilová (2018) claimed that mandatory implementation of the CCCTB system in the Eurozone would negatively affect the tax base in the Czech Republic while Nerudová and Solilová (2017) analysed the impact of the implementation steps on the amount of tax base allocated in Slovakia and concluded that while the first step would decrease the total corporate tax base by 0.27%, the overall corporate tax base in Slovakia would increase after the second implementation step by 3.02%. Devereux and Loretz (2008) performed a comprehensive analysis indicating that the corporate tax revenues of EU Member States would be reduced by approximately 2.5% on average with Hungary, the Czech Republic and Slovakia potentially gaining additional tax revenues and the largest decrease in tax bases facing Germany. However, depending on the exact design of the FA countries such as Hungary and Slovakia could see an increase in tax revenues of around 50% mainly at the expense of Denmark, Finland, Germany, Italy and Luxembourg. Finally, Nerudová et al. (2021) focused on the economic environment in the EU after Brexit and concluded that the overall tax base under the CCCTB in the post-Brexit period would decline by 5.34%. Some authors such as Bettendorf et al. (2010) have argued that an increase in tax revenues cannot be achieved if the FA is not accompanied by corporate tax rate harmonization. Thus, this paper focuses on the impact of the FA on tax competition, tax rates and related fiscal externalities.

3.6. Impact on tax competition and tax rates

This section analyses the impact of the FA methodology and partly the CCCTB proposal on tax competition[16] and the possibility of affecting corpo-

[16] Tax competition as defined in the literature refers to the phenomenon where jurisdictions engage in strategic measures to attract or retain economic activity by implementing policies that offer more favourable tax conditions compared to other jurisdictions.

rate income tax rates. Gordon (2014) conducted an analysis of corporate tax competition with regard to the CCCTB proposal and found that it would immobilize the tax base, eliminate competitive expansion and raise taxes. Furthermore, the author argued that the individual interests of EU Member States conflict with direct tax harmonization and that the CCCTB proposal is unlikely to adhere to the objectives of the EU internal market which lacks a legal basis under EU law. Kudrle (2009) argued that the global adoption of the FA could reduce the appeal of tax competition. Liesegang and Runkel (2019) found that tax revenue equalization under the FA may better mitigate detrimental tax competition. Additionally, Mardan and Stimmelmayr (2018) demonstrated that higher weighting of input shares in the FA may mitigate tax competition. However, Eggert and Haufler (2006) argued that countries are likely to offer overly generous tax breaks to MNCs. Finally, Wrede (2014) analysed asymmetric tax competition under the FA and concluded that a larger country tends to impose a higher tax rate than a smaller country.

Eichner and Runkel (2011) argued that tax rates are too low under both FA and SA systems and that changes in one country's tax rate affect other countries through changes in the interest rate. Riedel (2010) also identified inefficiencies in corporate tax rates under FA. However, Kind et al. (2005) found that reducing trade barriers under SA leads to lower equilibrium corporate taxes but higher taxes under FA. Pinto (2007) developed a framework in which regional governments strategically determine corporate tax structures under FA and concluded that tax rates increase under FA. Finally, Eichner and Runkel (2008) have shown that a transition from SA to FA using a sales-only formula would raise average tax rates by 2%.

Sosnowski (2014) and Perotto (2021) examined the CCCTB proposal's impact on tax competition. Sosnowski (2014) suggested that the CCCTB proposal could enhance transparency in tax regimes while maintaining tax competition. However, Bettendorf et al. (2010) argued that harmonizing tax rates could hamper economic growth. Perotto (2021) asserted that the CCCTB proposal could reduce incentives for profit shifting thus affecting tax competition.

MNCs engage in profit shifting through transfer pricing and debt-equity structures to reduce tax liabilities which leads to fiscal externalities and tax competition between governments. Fernandez (2012), Becker and Fuest (2010), Riedel (2010), Eichner and Runkel (2008, 2009) have investigated the fiscal externalities of corporate tax policies under both FA and SA. Becker and Fuest (2010) found that tax enforcement levels may be too high under SA due to negative externalities while under FA tax enforcement may be too low due to positive externalities. Riedel (2010) reported a sizable positive externality. Eichner and Runkel (2008) suggested that FA with a sales factor can mitigate or eliminate fiscal externalities. Eichner and Runkel (2009) analysed the taxation of MNCs under SA versus FA in the presence of labour market imperfections concluding that unemployment externalities exist under FA but not under SA.

3.7. Welfare effects

Several studies have examined the welfare implications[17] of transitioning from SA to FA. The effect of this shift was addressed by Runkel and Schjelderup (2011), Bettendorf, Devereux et al. (2010), Bettendorf, van der Horst et al. (2010), Eichner and Runkel (2008), Kind et al. (2005), Sørensen (2004), Nielsen et al. (2003), Edmiston (2002) and Anand and Sansing (2000). Bettendorf, Devereux et al. (2010) used a CGE model to assess the welfare effects of consolidation with FA and concluded that it does not yield substantial welfare gains in the EU. Similarly, Nielsen et al. (2003) and Sørensen (2004) found that the welfare effects of the transition from SA to FA are ambiguous. However, Eichner and Runkel (2008) showed that the transition to a sales-only FA results in an increase of welfare. Finally, Anand and Sansing (2000) argued that coordinated use of the same FA maximizes aggregate social welfare but that at least one state can increase its welfare by deviating from this coordinated solution.

3.8. Miscellaneous

A 'Miscellaneous' section was established to reflect additional supplementary findings. Studies by Gresik (2016), Becker and Runkel (2013), Martini et al. (2012) and Riedel (2011) focused on the behavioural response of MNCs to FA implementation within the EU internal market. Barrios et al. (2020) used a CORTAX model to investigate the macroeconomic impacts of the CCCTB proposal which aims to reduce compliance costs and increase economic efficiency. Van de Streek (2012) addressed the consolidation concept as a crucial feature of the CCCTB project while Mitroyanni and Putzolu (2009) discussed the business reorganization linked to the loss-offset of companies. The cross-border loss relief conundrum was similarly addressed by Almendral (2010). Borg (2013) and Cerioni (2015) discussed how losses are treated under the CCCTB proposal. Gutmann and de la Bletiere (2017) gave an overview of the main provisions of the CCCTB proposal containing a cross-border element. D'Andria et al. (2018) reflected on the bonus allowance for R&D in the CCCTB proposal. Garbarino (2014) addressed the major tax design issues with respect to foreign branches and controlled companies. Spinosa and Chand (2018) focused on taxing digitalized business models, Matsumoto (2016) analysed the effect

[17] Even though the stated studies define the welfare effects differently (see the list of reference for further insights) this paper utilizes a simplified understanding of the concept as typically referring to the impact of a policy, intervention, or change on the overall well-being or welfare of individuals or society.

of corporate income taxation with FA on public-input provision, Lacova and Hunady (2018) analysed the effect of the CCCTB proposal on the innovation performance of EU Member States and entrepreneurial innovation activity, de Groot (2017) discussed the participation exemption, the switch-over provision and the controlled foreign company rules in the CCCTB proposals, and Cerioni (2018) discussed complementing the harmonization of the tax base with a uniform minimal tax rate applied at the EU level.

4. Future research agenda

In line with the research question posed the possible future research avenues based on the conducted literature review are outlined. Throughout this paper it is stated that the extant research efforts are rather fragmented as outlined in Table 4 with highly heterogeneous and even opposing results. In general the future research around the FA methodology and potentially the related features of the impending BEFIT proposal should reflect the considerable changes caused by the COVID-19 pandemic, Russia's invasion of Ukraine which has, lead to price volatility, supply shortages, security issues, economic uncertainty and the realities of the digitized context and global developments. Discussing the main findings and contributions within each cluster opportunities for future research were identified in particularly important and promising areas. The identified future research agenda for selected thematic clusters is stated in Table 5.

Table 5. Future research agenda for each thematic cluster

Cluster	Future research agenda
Evaluation of the FA methodology and the CCCTB proposals	The evaluation of the FA methodology and the related features of the BEFIT Proposal should consider the increasingly digitalised and globalised context together with the considerable changes caused by the epidemiological and geopolitical realities of nowadays As asserted by Weiner (2006) the preferred formula should not be solely based on performance superiority but rather prioritize characteristics of simplicity, comprehensibility, feasibility and acceptability to individual states. Reassessing all potential formula configurations considering the stated criteria is essential

Table 5 continued

Cluster	Future research agenda
Composition and factors of the FA methodology	Reevaluating the proposition of equal weight allocation to factors in FA through an empirical examination of microeconomic data FA distinguished from the perspective of different economic sectors defined by the NACE codes with special focus on economic sectors with a relatively higher importance of intangible assets as value creating factors Research focused on alternative factors with special attention paid to the intangible assets and value added Both empirical and theoretical analysis of the amendment of the CCCTB FA suggested by the European Parliament in 2018*, i.e. extension of the FA with a fourth factor based on digital data, collected and exploited Emphasis placed on the examination of accounting standards concerning digital data, alongside the identification and analysis of potential inadequacies associated with the current state of art. Given the escalating economic significance of platform business models and the ongoing influx of corporate investments in intangible assets it becomes essential to adapt the existing international tax framework to effectively accommodate these dynamic transformations. In this regard it is crucial to thoroughly examine the inclusion of intangible assets as an integral aspect of the proposed FA considering it as a constituent of a comprehensive resolution strategy to tackle the multifaceted challenges inherent in the digitalized context
The FA's explanatory power of the variability in profitability of MNCs	The impending BEFIT FA's explanatory power of the variability in profitability of MNCs together with possible inclusion of alternative value creating factors Empirical analysis of the explanatory power of the CCCTB FA including factor digital data, as proposed by the European Parliament in 2018
Ability to eliminate profit shifting and tax base erosion	Addressing the new possible forms of profit shifting precisely manipulating / influencing the apportionment key and potential of strengthening of the profit shifting of MNCs under the FA Evaluation of each FA factor according to their robustness to profit shifting / manipulation activities of MNCs As the considered implementation of the FA methodology within the EU internal market overlooks the profit shifting of EU MNCs outside of EU jurisdictions the possible extension of FA to countries outside the EU jurisdiction and the tax revenue implications can be further analysed in both empirical and theoretical way
Impact on tax revenues	Strengthening of the research on the tax revenue implications on the EU Member States in the post Brexit period as researched by Nerudová et al. (2021) Empirical analyses of the tax revenue implications of the BEFIT FA on the EU Member States

Table 5 continued

Cluster	Future research agenda
Impact on tax competition and tax rates	Better understanding of the fiscal spill-over effects between EU Member States that choose a national subsidy or a national special depreciation and the subsequent effects on its partner countries (Petkova & Weichenrieder, 2020)
Miscellaneous	Further research both empirical and theoretical is needed to design optimal FA to distribute the profit of MNCs based on digital platforms Additionally, the impact on trade with third countries and the international competitiveness of the EU Member States, EU MNCs and EU domestic companies

* European Parliament legislative resolution of 15 March 2018 on the proposal for a Council directive on a Common Consolidated Corporate Tax Base (CCCTB).

Source: own work.

Conclusions

This paper presents a systematic literature review on the FA methodology and the related features of the CCCTB proposal considering the upcoming BEFIT proposal. The review identified eight thematic clusters (see Table 4) based on 111 research papers (see Tables 2 and 3) and separately discussed each cluster. The paper provided opportunities for future research in selected thematic clusters and a general future research direction (see Table 5).

To date no systematic literature review has been conducted on the FA methodology and the CCCTB project. Despite the valuable insights gained from existing studies there is still a fragmented understanding of the topic. This study clusters current knowledge and identifies areas for future research contributing to ongoing and upcoming academic discussions particularly with regards to the anticipated BEFIT proposal.

However, it should be noted that the review is limited to English-language peer-reviewed articles retrieved from selected search terms and databases but excluding potentially valuable insights from non-English publications, books, book chapters and/or conference proceedings.

Appendix

Study	Data sample / methodology
Nerudová et al. (2021)	Micro-data, database: Amadeus and Bankscope.
de Mooij et al. (2021)	(1) company-level data, database: Orbis, EU MNCs; (2) country-level data, affiliates of US MNCs worldwide; database: Bureau of Economic Analysis; (3) country-by-country reports by US MNCs with revenue greater than USD 850 million, database: Internal Revenue Service
Cobham et al. (2021)	Micro-data, database: Orbis, years: 2007–2015, total: 34,266 individual companies, which consolidate in up to 19,223 groups
Nerudová and Solilová (2019)	A semi-dynamic model, database: Amadeus and Bankscope, year: 2014
Nerudová and Solilová (2018)	Micro-data, database: Amadeus and Bankscope, 2,424 parent companies with 3,860 CZ subsidiaries
Nerudová and Solilová (2017)	Micro-data, database: Amadeus and Bankscope, Two groups of companies: i) SK subsidiaries of the EU parent companies (52,689 tax residents in the SK), ii) EU subsidiaries with parent companies in the SK (728 entities); year: 2015
Solilová et al. (2016)	Micro-data, database: Amadeus and Bankscope, 1,597 CZ parent companies with 2,476 subsidiaries in the CZ and other EU Member States and, 827 other EU parent companies with 1,384 subsidiaries in the CZ
Nerudová and Solilová (2015)	Micro-data, database: Amadeus, i) Parent company in CZ and subsidiaries in EU, ii) Parent company in EU and subsidiaries in EU
Domonkos et al. (2013)	Micro-data, 11 MNCs operating in the SK (8 of prevalently industrial nature, 3 service oriented), years: 2009–2010
Oestreicher and Koch (2011)	Micro-data, database: Amadeus, 11,350 EU MNCs (with 66,110 companies), years: 1994–2003
Pirvu et al. (2011)	Micro-data, 9 MNCs and all their subsidiaries active in RO (37 subsidiaries), years: 2006–2009
Devereux and Loretz (2008)	Micro-data, database: Orbis, companies registered in one of the 25 pre-2007 EU Member States
Fuest et al. (2007)	Combined dataset, DE company-level foreign direct investment data and balance sheet information on the parent companies, years: 1996–2001

Source: Own work.

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The relationship between social capital and economic growth on a provincial and regional basis

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Abstract

The aim of this study is to examine the relationship between the level of GDP per capita and social capital provinces and regions in Türkiye in the period of 2007–2018. The social capital index was used as a comprehensive variable to represent social capital. The relationships between the variables were analysed with the use of the panel Granger causality test. It was determined that there is a unilateral causality from GDP per capita to social capital in sixteen provinces, from social capital to GDP per capita in nine provinces and bilateral causality in 45 provinces. On the other hand, no significant relationship was found in eleven provinces. The results reveal that the level of social capital in terms of GDP per capita in 45 provinces in Türkiye and the level of GDP per capita in terms of social capital is a factor that should be considered. Regional causality results for Türkiye support the provincial causality results. These results provide key insights regarding the nexus between social capital and economic growth for policymakers and researchers.

Keywords

- social capital
- GDP per capita
- economic growth
- panel causality analysis

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Introduction

Economic growth is one of the vital issues that attracts the attention of economists and policy-makers. Studies examining the factors affecting economic growth and the causes of current growth differences have an important place in the literature. Economic growth theories focus on the causes of per capita income differences between countries and the sources of economic growth in the long run. Traditional factors of production encompass labor, capital, natural resources, and entrepreneurship. Traditional factors are insufficient to explain economic growth. The new economic growth theories have advanced in the form of the internationalization of technological development, the increasing importance of financial markets, the wider and more detailed treatment of the concept of capital and the institutional and non-institutional determinants of economic growth. Within this context, new variables such as human capital (Becker, 2009; Benabou, 1994; Lucas, 2015; Romer, 1990) structural capital (Bourdieu, 1986), physical capital, economic capital, intellectual capital (Edvinsson & Stenfelt, 1999; Stewart, 1997; Sveiby, 2000) and especially social capital have been used to explain the areas where traditional production factors such as labor, capital and natural resources are insufficient (Postelnicu & Hermes, 2018).

Social capital means all relationhips based on horizontal or vertical trust, norms and networks that facilitate coordination activities between individuals and institutions. Social capital can affect financial markets and economic growth through individual behavior and norm patterns (Pennar, 1997, p. 154). Social capital which is a multi-dimensional concept is also the subject of research from different disciplines. This situation brings about different definitions of social capital and its representation with various indicators (Coleman, 1994, p. 91; Putnam, 1993, p. 304; World Bank, 2011). Social capital is mostly represented by indicators such as generalized trust level, association participation, social networks and social norms. On the other side, some of these indicators are also criticized for explaining a limited dimension of social capital which is a multi-dimensional concept (Fukuyama, 1995). For this reason, in recent studies, it is seen that the social capital index which is a more inclusive and alternative indicator that takes into account all aspects of social capital has begun to be used instead of narrow-scoped indicators (Jin et al., 2019; Muringani et al., 2021; Pilatin & Ayaydın, 2022b).

Neoclassical growth theories aim to explain economic growth in terms of macroeconomic factors (Romer, 1986; Solow, 1956; Swan, 1956). Coleman's "social capital" theory, however, scrutinizes the effect of social capital on economic growth through people's trust, norms and commitment to each other (Coleman, 1990). It leads to better economic performance and this can result in higher GDP per capita. Therefore, investment in human and social va-

lues will bring success in global competition by supporting stability in financial and real markets.

Social capital contributes to economic growth through factors such as increased cooperation, trust, connectivity and coordination, knowledge sharing and innovation. The effect of social capital on economic development generally occurs in two ways at micro and macro levels. The same is true for economic growth. There is evidence that economic growth also affects social capital (Andini & Andibi, 2019). The aim of the study is to test the bi-directional causality between economic growth and social capital on a provincial and regional basis in Türkiye between 2007 and 2018. In the recent period, there are studies showing that social capital positively affects economic growth by improving the trust, social networks and social norms of societies. The original aspects of the study and its contributions to the literature are as follows. First, this study is one of the first research projects in which the causality relationship between economic growth and social capital in Türkiye, which is a developing country, is analyzed empirically on a provincial and regional basis. This is important as both the level of social capital and per capita income show changes at the provincial and regional levels. Second, current panel test techniques that allow cross-section dependency were applied instead of traditional estimation methods in empirical analysis. Test results that do not regard the cross-sectional dependence can lead to biased and misleading results (Phillips & Sul, 2003). Third, a current, original and comprehensive social capital index data produced by Pilatin and Ayaydın (2022a) is used to represent social capital in the study. Fourth, the differences between regions and provinces in Türkiye in terms of both economic and social capital levels and the effects of these differences on each other are discussed. Fifth, in addition to examining causality from social capital to economic growth, potential causality from economic growth to social capital is also investigated.

The remainder of the study is structured as follows: in Section 1, the concept of social capital is mentioned and related literature is discussed. After that, data and variables in Section 2 and methods in Section 3 are explained. The study is completed by explaining the results of the analysis in Section 4, the sensitivity results in Section 5 and finally the conclusions and policy recommendations are presented.

1. Literature review

1.1. Social capital concept

Informal institutional factors are those that affect the activities of a community or organization but have no legal or legal basis. These factors include

characteristics such as the organization's culture, values, reputation, social network, connections and collaborative capacity. Social capital is one of the informal institutional factors (Jin et al., 2019). Social capital is also expressed as the restrictions or modes of action imposed by society on people, institutions and businesses that affect the way they do business by being influenced by the rules, norms and procedures of the societies in which they live (North, 1990, p. 5). In addition, social capital which is in the class of intangible assets has a significant impact on the economic development of countries as well as investors and businesses (Tomer, 2011, p. 3).

The theoretical foundations of social capital are based on the research of Hanifan (1916) who used the concept of 'social capital' to indicate its importance for people, especially in social structure in terms of business and economy (Routledge & Amsberg, 2003). Bourdieu (1986) stated that social capital consists of the sum of the actual or potential resources associated with the membership of a group that has a permanent network of more or less institutionalized mutual acquaintance and recognition and provides some opportunities to each of its members. Coleman (1990) considered social capital as a concept that includes some institutions, organizations and structures and contributes to the formation of common qualities that facilitate certain activities of people or institutions within these structures (Coleman, 1990, p. 302). Putnam (1993) concluded that different levels of social capital between regions of Italy result in different institutional and economic performance. Likewise, Fukuyama (1995) states that countries with a higher level of general confidence, namely, with a higher level of social capital are more successful in international competition. Societies with a high level of trust spend less energy in this direction because they need less legal regulation and enforcement mechanisms. This reduces transaction costs and offers an alternative to the legal system. For this reason, social capital is closely related to performance in economic, social and political fields.

There are different definitions of social capital (Bourdieu, 1986; Coleman, 1990; Fukuyama, 1995; Guiso et al., 2004) as well as different measurement methods (Putnam, 2007; Rupasingha & Goetz, 2008; Wang et al., 2014; Woolcock, 1998). This diversity should not be interpreted as a lack of consensus on the importance and effects of social capital. There are also studies that measure social capital only with the trust question. The generalized trust question which is used to represent trust is measured by the question "In general do you think that most people can be trusted?" in the World Values Survey conducted in 87 countries (Casey & Christ, 2005).

Social capital addresses the questioned level of trust without being too closely related. The level of trust between individuals in the society is an important factor in being able to act jointly. Collective actions are possible through trust developed in society (Putnam, 1993, p. 167). However, Fukuyama (1995) who thinks that it would not be right to measure social capital with

only one trust question, thinks that people who state that most people can be trusted may have different perceptions about "most people" depending on the environment they are in (Delhey et al., 2011). In other words, while the term 'most people' is narrowly trustworthy trust may decrease in broad terms. If the community of people that those who say "most people can be trusted" actually associate differs greatly, this may mean that assessments of trust are incorrect (Fukuyama, 1995). For this reason, there are also studies in which the social capital index is created based on the norm, network and trust variables. The most widely used method in producing the social capital index is the method put forward by Rupasingha and Goetz (2008). In this study, the provincial-based social capital index data (Pilatin & Ayaydın, 2022a) created through this method was used.

Economies with higher economic performance are generally seen in countries that host institutions and organizations with higher social networks and norms. For this reason, there are studies and opinions that a higher level of economic performance emerges in countries and regions with higher social capital (Li et al., 2015, p. 135). Social capital is seen as an important variable in explaining the effective factors in the development of the economy. Fukuyama (1995) states that societies with higher generalized trust which is a determinant of social capital are more successful in international economic competition. Generalized trust is formed by ethics, norms, habits and moral obligations internalized by community members (Beugelsdijk & Schaik, 2005, p. 310). Fukuyama (1995) states that in societies with high levels of trust less legal regulation and enforcement mechanisms are used. In this respect, social capital is an alternative factor in economic structure and social relationships compared to official contracts and agreements. When the corporate system functions properly trust should only be seen as a factor that facilitates complex transactions. This situation reduces transaction costs and contributes to economic development. The generalized confidence factor is important in terms of showing a superior economic performance for developed economies. Social capital provides cooperation without the direct influence of power and market mechanism. Therefore, social capital not only serves as an alternative in legal systems but should also be seen as a facilitator of complex transactions in the issuance of contracts even in a well-functioning institutional system (Fukuyama, 1995).

1.2. Studies on economic growth—social capital nexus

The relationship between economic growth and social capital which has been the subject of many studies from different disciplines, has been extensively researched in the literature for selected countries and country groups.

In these studies, variables such as GDP per capita, economic growth, income, GDP growth and the industrialization rate which are indicators of economic growth, are used. Here GDP per capita was used as an indicator of economic growth. Most of these studies contain evidence of the positive effect of social capital on economic growth (Hjerppe, 1998; Iyer et al., 2005; Knack & Keefer, 1997; Neira et al., 2009; Perez et al., 2006; Pilatin, 2022; Postelnicu & Hermes, 2018; Westlund & Adam, 2010).

In relatively few studies, no significant relationship was found between social capital and economic growth. Furthermore, some studies have shown that social capital has a negative effect on economic growth (Fukuyama, 1995; Gambetta, 1996; Portes, 1998). Helliwell (1996) in his study of Asian countries covering the years 1987–1994 reached the conclusion that social capital and institutional quality do not have a significant effect on economic growth. Roth and Schüler (2006) in their study in which they applied panel data analysis for 49 countries, in the study conducted by Casey and Christ (2005) in the US states and in the study of 69 developing countries by Hall and Ahmad (2013) concluded that social capital negatively affects economic growth.

There are also studies examining the relationship between economic growth and social capital on a regional basis. Putnam (1993) investigated the effect of social capital on economic growth for different regions of Italy between 1970 and 1989 and concluded that social capital had a positive effect on economic growth. This study has a significant impact on the social capital literature. In a similar study by Helliwell (2007) and Putnam (1995); three different variables including civil society, institutional performance and civic satisfaction were used as social capital indicators. In the research which analyzed the effect of social capital on the development difference between the Northern and Southern regions of Italy in the 1950–1990 period, it was determined that the public participation rate had a significant effect on economic growth. Rupasingha et al. (2000) analysed 3,040 counties of the USA for the years 1990–1996 with panel OLS. Accordingly, findings have been obtained that social capital has a positive effect on income and GDP per capita variables. Iyer et al. (2005) using panel data analysis for nine regions in the USA concluded that social capital is an important variable in terms of GDP per capita. Beugelsdijk and Van Schaik (2005), in their study of the 54 EU regions between 1950 and 1998 concluded that social capital positively affects national GDP per capita. Similarly, Roth (2006) found results on the positive effect of social capital on economic growth. Akçomak and Bas ter Weel (2008) examine the interaction between social capital, innovation and GDP per capita growth in the European Union. In empirical research of 102 European regions over the period 1990–2002, it has been shown that higher innovation performance helps GDP per capita growth and that social capital indirectly influences this growth by stimulating innovation. The study also shows that social capital has no direct role in promoting GDP per capita growth in

European Union countries. Dearmon and Grier (2009) in their study of 51 selected countries determined that the factor of trust indirectly affects economic growth. Likewise, Feki and Chtouro (2014) in their study of developed and developing countries obtained strong evidence that social capital positively affects GDP per capita. Özcan and Zeren (2013) and Koç and Ata (2012) reached similar results in their studies.

Peiró-Palomino and Tortosa-Ausina (2015) in their study on the Spanish regions scrutinized the effect of social capital on regional economic growth in Spain for the period 1985–2005 using the social capital index variable, with a panel data approach. The results show that social capital has a positive effect on GDP per capita growth in the context of the Spanish provinces.

There are also studies examining the relationship between economic growth and social capital on a provincial basis. In their study, Pan and He (2010) used several different indicators of social capital and the effect of social capital on China's economic growth for the years 1978–2004 is discussed. The results reveal that social capital has a significant and positive effect on the economic growth of a province measured by GDP per capita growth in the long run.

In the study of Botzen (2016), exploratory spatial data analysis of social capital and its effect on German NUTS-3 regions and provinces is discussed. According to the results of these analyses, in Germany, the geographical scope of social capital is concentrated locally while the area of economic welfare covers a wider area. Second, in many German provinces social capital is positively correlated with GDP per capita which is used as an indicator of economic welfare. Calcagnini and Perugini (2019) used an empirical model to evaluate the role of social capital on welfare in his study for Italian NUTS-3 provinces covering the years 2003–2011. The results show that capital has a positive effect on well-being in social Italy. Juhro et al. (2022) using a modified endogenous growth model found that social capital increased growth through research and development (R&D) expenditures in 33 Indonesian provinces covering the period 2010–2018.

There is also debate in the literature regarding the determinants of social capital. In these studies, GDP per capita level is seen as an important determinant (Fischer & Torgler, 2006; Parts, 2013; Wong, 2013). For this reason, the per capita income variable was used here to analyse the reverse causality from GDP per capita to social capital.

In the literature, the relationships between economic growth and social capital are mostly examined in selected countries, country groups and regions, but there are very few studies on the basis of provinces. In this framework, the relationship between social capital and GDP per capita has been analysed empirically both on a provincial and regional basis in this paper. Therefore, the paper is expected to contribute to the existing literature as it is one of the first studies to examine the causal relationship between social capital and GDP per capita on a provincial basis.

2. Data and variables

The causality relationship between social capital and GDP per capita the was investigated both on a provincial and regional basis in Türkiye during the 2007–2018 period. In the literature mostly the relationship between economic growth and social capital has been examined nationally or regionally only in terms of the relationship between them. It has seldom been investigated whether social capital influences economic growth or whether economic growth influences social capital, or both. For this reason, the causality method was applied on regional and provincial basis. The regional classification determined by the Turkish Statistical Institute (TUIK) according to Level-2 was used. At Level-2 Türkiye consists of twelve regions as Istanbul, Western Marmara, Aegean, Eastern Marmara, Western Anatolia, Mediterranean, Central Anatolia, Western Black Sea, Eastern Black Sea, Northeastern Anatolia, Middle East Anatolia and Southeastern Anatolia. In the analysis, Istanbul was included in the Western Marmara and results were obtained for eleven regions. Since Türkiye's provincial social capital index data is only available for the years 2007–2018, the research is limited to these years. GDP per capita is symbolized by GDP p.c. and the data are obtained from the TUIK database (TUIK, 2022).

Social capital index data is utilised to represent social capital and is symbolized by SOCAP. The most up-to-date and original social capital index data produced by Pilatin and Ayaydın (2022a) for Türkiye on a provincial basis was used as the social capital index. The two network and two norm variables chosen by Platin and Ayaydın which constitute the social capital index on a provincial basis in Türkiye, are shown in Table 1.

Table 1. Variables constituting the social capital index

	Variables	Identification/Calculation	Source
Social networks	**Number of foundations**	The number of foundations per 100 thousand people on a provincial basis.	General Directorate of Foundations
	Number of associations	Number of associations per 100 thousand people on a provincial basis.	Associations Directorate
Social norms	**Participation rate in elections**	Participation rates in the general parliamentary elections held in 2007, 2011 and 2018 on a provincial basis are taken as a basis.	Supreme Election Board
	Rate of participation in surveys	Response rate to surveys conducted in World Value Survey. Wave 5 data for 2007, Wave 6 for 2011 and Wave 7 for 2018 were used. This rate is calculated over the regions at TURKSTAT Level 1 and the rate of the region it is in is taken as a basis for each province.	World Walue Survey

Source: (Pilatin & Ayaydın, 2022a).

This social capital index was derived for the first time in Türkiye to cover a period of twelve years for 81 provinces. Likewise, Rupasingha et al. (2006) derived the social capital index on a provincial basis for the years 2007, 2011, and 2018 by subjecting two networks and two norm measures to principal component analysis. Subsequently, the linear interpolation method was applied to the remaining years. This index generation method is the most comprehensive method used in many other studies (Alesina & La Ferrara, 2000; Davaadorj, 2019; Hasan et al., 2017; Jha & Chen, 2015; Jin et al., 2019; Knack, 2003; Rupasingha & Goetz, 2008). A positive and large value of the social capital index represents higher social capital and *vice versa*. The respective data for Turkish provinces in 2018 are displayed in Figure 1.

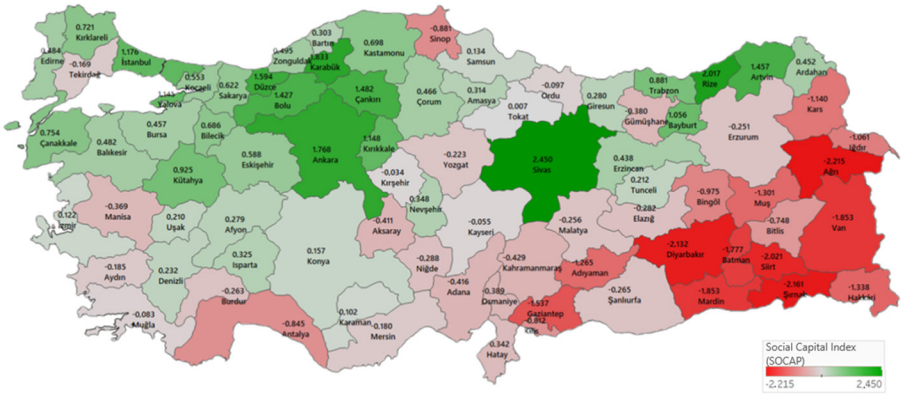

Figure 1. Social capital index in Türkiye in the year 2018

Source: (Pilatin & Ayaydın, 2022a).

As can be seen in Figure 1, Sivas (2.375) Rize (1.962) Karabuk (1.821) Ankara (1.720) Düzce (1.556) Çankırı (1.470) Bolu (1.419) and Artvin (1.418) are cities with the highest capital index. On the other hand, Şırnak (–2.269); Diyarbakır (–2.170) Ağrı (–2.123) Siirt (–2.056) Mardin (–1.917) Batman (–1.835) Gaziantep (–1.529) Hakkari (–1.453) and Adıyaman (–1.243) are the cities with the lowest social capital index. The provinces with high social capital are mostly concentrated in the Eastern Black Sea, Eastern Marmara and Western Black Sea regions while the cities with low social capital are mostly concentrated in the Southeast and Eastern Anatolia regions.

GDP per capita (GDP p.c.) is a widely employed measure to evaluate the economic growth performance. Figure 2 shows the level of GDP p.c. on a provincial basis in Türkiye in 2018.

According to Figure 2, the provinces of Istanbul, Kocaeli, Tekirdağ, Bursa, Ankara, Eskişehir, Bolu and Artvin are the ones with the highest GDP p.c. On the other side, Şırnak, Diyarbakır, Ağrı, Siirt, Mardin, Batman, Hakkari, Muş, Bingöl, Van, Bayburt, Yozgat and Çorum are the cities with the lowest GDP

Figure 2. GDP per capita in Türkiye in the year 2018

Note: As of 7.08.2023, 1 US dollar = 27 Turkish lira.

Source: own elaboration.

p.c. in Türkiye. The provinces with high GDP p.c. are mostly concentrated in the Marmara, Aegean and Mediterranean regions while the provinces with low GDP p.c. are mostly concentrated in the regions of Northeastern Anatolia, Middle East Anatolia, and Southeastern Anatolia.

3. Methods

While the GDP p.c. variable was used in logarithmic form, the SOCAP variable was used without logarithmic conversion as it expressed as the index value. The estimation models of the study are as in equations (1) and (2):

$$\ln GDP\ p.c._{it} = \alpha_0 + \beta_1 SOCAP + u_{it} \quad (1)$$

$$SOCAP_{it} = \sigma_0 + \delta_1\ ln\ GDP\ p.c. + \mu_{it} \quad (2)$$

In equations (1) and (2), α_0 and σ_0 stand for the constant term. β_1 and δ_1 represent the parameters of $SOCAP$ and $GDP\ p.c.$, respectively. $GDP\ p.c._{it}$ denotes the gross domestic product per capita of province i at time t, and $SOCAP_{it}$ shows the social capital index value of province i at time t. u_{it} and μ_{it} are the error terms of province i at time t. The i and t indices represent the section size and time dimension, respectively. t spans the period between 2007 and 2018 years. i represents 81 provinces of Türkiye.

The empirical analysis consists of three stages. In the first stage, cross-sectional dependence and slope homogeneity tests are performed to determine the appropriate unit root and causality tests. In the second stage, the stationarity properties of the variables are investigated with the CIPS panel unit root test. In the third stage, causality relationships between the variables are estimated by the Emirmahmutoglu and Kose (2011) panel causality test.

The hypotheses of the study are as follows:

HA: SOCAP Granger causes GDP p.c.
HB: GDP p.c. Granger causes SOCAP.

3.1. Cross-sectional dependence and slope homogeneity tests

Interaction and dependency between countries continue to increase due to globalization, trade openness and financial integration every passing day. Accordingly, other countries (provinces or regions) are also affected by external shocks. Ignoring this situation damages the reliability of the estimation findings (Menyah et al., 2014). For this reason, the existence of cross-sectional dependence (CSD) is investigated with the Lagrange Multiplier (LM) and CD_{LM} tests proposed by Breusch and Pagan (1980) and developed by Pesaran (2004), respectively.

Breusch and Pagan's (1980) LM test yields strong results in panels where the cross-section size (N) is relatively small and the time dimension (T) is large enough. The LM test statistic is expressed as:

$$LM = T\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{p}_{ij}^2 \tag{3}$$

where $\hat{p}_{ij}$ represents the sample estimate of the bidirectional correlation of the error term for each i. The power of the LM test weakens in large panels with $T \to \infty$ and $N \to \infty$. For large panels, Pesaran (2004) proposes an alternative LM test (CD_{LM}):

$$CD_{LM} = \left(\frac{1}{N(N-1)}\right)^{\frac{1}{2}}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}(T\hat{p}_{ij}^2 - 1) \tag{4}$$

The CD_{LM} test is normally distributed with $N(N-1)/2$ degrees of freedom and asymptotic chi-square feature. The set of test hypotheses is:

H_0: Cov $(u_{it}, u_{ij}) = 0$; Cross-sectional dependence does not exist
H_A: Cov $(u_{it}, u_{ij}) \neq 0$; Cross-sectional dependence exists

The presence of slope homogeneity is checked by the Delta ($\tilde{\Delta}$) and Adjusted Delta ($\tilde{\Delta}_{adj}$) tests proposed by Pesaran and Yamagata (2008). $\tilde{\Delta}$ and $\tilde{\Delta}_{adj}$ tests are an extended version of the Swamy (1970) test. $\tilde{\Delta}$ and $\tilde{\Delta}_{adj}$ test statistics are respectively:

$$\tilde{\Delta} = \sqrt{N}\left(\frac{N^{-1}\tilde{S} - k}{\sqrt{2k}}\right) \tag{5}$$

$$\tilde{\Delta}_{adj} = \sqrt{N}\left(\frac{N^{-1}\tilde{S} - E(\tilde{z}_{iT})}{\sqrt{Var(\tilde{z}_{iT})}}\right) \tag{6}$$

where $\tilde{S}$ is the modified Swamy test statistic; k represents the independent variable. The hypotheses of the slope homogeneity tests are as follows:

H_0: $\beta_i = \beta$; Slope homogeneity does exist
H_A: $\beta_i \neq \beta$; Slope heterogeneity does exist

3.2. Panel unit root test

Traditional panel unit root analyses referred to as first-generation unit root tests assume cross-section independence and the homogeneity of panel. First-generation unit root tests lose their reliability under the presence of cross--section depdendence (CSD) and slope heterogeneity (Hasanov et al., 2021). Pesaran (2007) developed the Cross-sectionally Augmented Dickey-Fuller (CADF) test by incorporating lagged cross-sectional means into ADF regression. The CADF test is a second-generation test that can be applied under the presence of CSD and slope heterogeneity. It also provides reliable results in both $N > T$ and $T > N$ panels (Pesaran, 2007).

Individual stationarity can be examined by calculating the CADF test statistic (Wald test statistic) for each cross-section unit in the panel. At the same time, the stationarity of the whole panel can be investigated with the cross-sectionally augmented IPS (CIPS) test statistics (Fisher test statistic which expresses the average of the CADF test statistics). The CADF regression is as follows:

$$\Delta y_{it} = \alpha_i + b_i y_{i,t-1} + c_i \underline{y}_{t-1} + d_i \Delta \underline{y}_t + e_{it} \tag{7}$$

In equation (7), $\underline{y}_t$ shows the cross-section mean of $y_{i,t}$ and $\underline{y}_{t-1}$ refers to the lagged value of $\underline{y}_t$.

The $CIPS$ test statistic is expressed as:

$$CIPS = N^{-1}\sum_{i=1}^{n} CADF \tag{8}$$

In equation (8) $CADF_i$ shows the $CADF$ t-test statistic for each cross-section in the $CADF$ regression (Pesaran, 2007). The null hypothesis supposes that the panel has a unit root.

3.3. Panel causality test

Granger causality assumes that past events influence future events. If the the capacity to estimate variable X by making use of its own past values improves by adding the past values of variable Y, it means that variable Y is the Granger cause of variable X. Here the causality relationship between the variables is examined with the Emirmahmutoglu-Kose (E-K) panel Granger causality test (2011).

The reasons for choosing the E-K panel Granger causality approach can be explained as follows. First, in the E-K panel Granger causality test, the variables are not estimated by making them stationary as in Dumitrescu and Hurlin's (2012) panel causality test because in the E-K panel Granger causality test, the critical condition is instead the maximal order of integration of the variables (i.e. at which maximal degree the variables are stationary). Therefore, the E-K panel Granger causality test can be reliably applied in stationary, non-stationary and cointegrated or non-cointegrated panel conditions. Second, it considers CSD with its bootstrap feature and can be used reliably under the presence of slope heterogeneity. Third, test results are available for each cross-section and the whole panel. The weakness of the E-K panel Granger causality test is that it neglects asymmetric and nonlinear relationships. The E-K panel Granger causality test estimates the $k_i + d\max_i$ lagged VAR model in heterogeneous mixed panels (Emirmahmutoglu & Kose, 2011):

$$x_{i,t} = \mu_i^x + \sum_{j=1}^{k_i+d\max_i} A_{11,ij} x_{i,t-j} + \sum_{j=1}^{k_i+d\max_i} A_{12,ij} y_{i,t-j} + u_{i,t}^x \tag{9}$$

$$y_{i,t} = \mu_i^y + \sum_{j=1}^{k_i+d\max_i} A_{21,ij} x_{i,t-j} + \sum_{j=1}^{k_i+d\max_i} A_{22,ij} y_{i,t-j} + u_{i,t}^y \tag{10}$$

In equations (9) and (10) x_i and y_i represent GDP p.c. while $y_{i,t}$ stands for SOCAP respectively. A refers to the fixed matrix of parameters allowed to change between cross-sections. u_i refers to the error term. k_i and $d\max_i$ denote the lag length and the maximal order of integration. Since the study covers a limited period (2007–2018), the appropriate lag length is one.

4. Empirical results

LM and CD_{LM} tests were applied to determine CSD. The cross-section dependence test results are given in Table 2. The null hypothesis which assumes the absence of cross-sectional dependence was rejected for SOCAP at a significance level of 1% in all regions. For GDP p.c., it was rejected at a significance level of 10% in Eastern Marmara, 5% in Aegean and Northeastern Anatolia, and 1% in the remaining regions.

Table 2. Cross-sectional dependence test results

CSD tests	GDP p.c.		SOCAP		GDP p.c. = f (SOCAP)	
	LM test	CD_{LM} test	LM test	CD_{LM} test	LM test	CD_{LM} test
Regions	**Test statistics**					
Western Marmara	23.034***	2.914***	100.000***	20.125***	69.164***	13.230***
Aegean	43.666**	2.093**	280.000***	33.675***	170.498***	19.042***
Eastern Marmara	39.006*	1.471*	280.000***	33.675***	222.619***	26.007***
Western Anatolia	23.007***	8.168***	30.000***	11.023***	23.803***	8.493***
Mediterranean	45.162***	2.293***	279.870***	33.658***	176.204***	19.805***
Central Anatolia	333.339***	40.810***	280.000***	33.675***	305.666***	37.105***
Western Black Sea	90.254***	4.770***	450.000***	42.691***	251.437***	21.760***
Eastern Black Sea	53.921***	7.106***	150.000***	24.648***	95.929***	14.776***
Northeastern Anatolia	33.091**	1.866**	210.000***	29.163***	82.412***	9.476***
Middle East Anatolia	55.392***	3.660***	280.000***	33.675***	152.240***	16.602***
Southeastern Anatolia	64.698***	3.382***	360.000***	38.184***	229.677***	22.825***

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Source: own work.

However, the null hypothesis for the model was rejected at a 1% significance level in all regions. Thus, it has been determined that there is a cross-section dependence in all regions for the variables and the model. In other words, it has been determined that a shock that occurs in any part of Türkiye affects other parts of Türkiye.

Slope homogeneity was examined by $\tilde{\Delta}$ ve $\tilde{\Delta}_{adj}$ tests. $\tilde{\Delta}$ ve $\tilde{\Delta}_{adj}$ test results were presented in Table 3.

According to the $\tilde{\Delta}$ test and $\tilde{\Delta}_{adj}$ test statistics in Table 3, the null hypothesis that the panel is homogeneous was rejected at a 1% significance level in all regions. Thus, it was determined that the slope coefficient differs between

Table 3. Slope homogeneity test results

GDP p.c. = f (SOCAP)	$\tilde{\Delta}$ test	$\tilde{\Delta}_{adj}$ test
Western Marmara	5.891***	6.717***
Aegean	11.685***	13.323***
Eastern Marmara	4.692***	5.349***
Western Anatolia	3.851***	4.391***
Mediterranean	5.529***	6.304***
Central Anatolia	10.269***	11.708***
Western Black Sea	6.847***	7.807***
Eastern Black Sea	10.798***	12.312***
Northeastern Anatolia	8.213***	9.364***
Middle East Anatolia	4.374***	4.987***
Southeastern Anatolia	4.801***	5.474***

Note: *** indicates significance at the 1% level.

Source: own work.

the sections and that the panel was heterogeneous. Afterward, the stationary properties of the variables were examined with the CIPS panel unit root test. CIPS panel unit root test results were shown in Table 4.

Table 4. CIPS panel unit root test results

Level	GDP p.c.	SOCAP
Regions	**Test statistics**	**Test statistics**
Western Marmara	–1.637	–1.240
Aegean	–2.604**	–1.468
Eastern Marmara	–1.535	–2.528**
Western Anatolia	–1.088	–1.580
Mediterranean	–2.800**	–1.160
Central Anatolia	–2.790**	–0.636
Western Black Sea	–1.687	–1.166
Eastern Black Sea	–1.912	–1.370
Northeastern Anatolia	–1.779	–1.173
Middle East Anatolia	–1.431	–1.725
Southeastern Anatolia	–2.445*	–0.908

Note: ** and * indicate significance at the 5% and 10% levels, respectively. Critical values are –2.97 (1%), –2.52 (5%) and –2.31 (10%).

Source: own work.

When the CIPS panel unit root statistics are examined in Table 4, the null hypothesis that the panel has a unit root for the GDP p.c. variable was rejected at the significance level of 5% in Aegean, Mediterranean and Central Anatolia, and 10% in Southeastern Anatolia. It has been determined that other regions have unit roots at the level. In other respects, the null hypothesis which supposes that the panel has a unit root for the SOCAP variable was rejected at a 5% significance level only in Eastern Marmara. It was determined that in the other regions, SOCAP has unit roots at the level. In the next step, the causality relationships between the variables were examined with the E-K panel Granger causality test. For the cross-section unit (provinces), E-K panel Granger causality test results were reported in Table 5.

Table 5. Results from the E-K panel Granger causality test by provinces

Direction	GDP p.c. ⇏ SOCAP Wald stat.	SOCAP ⇏ GDP p.c. Wald stat.	Decision
Western Marmara			
Istanbul	7.123**	0.182	Unidirectional
Tekirdağ	0.120	0.086	No causality
Edirne	46.229***	6.614***	Bidirectional
Kırklareli	122.637***	3.821**	Bidirectional
Balıkesir	6.458**	10.134***	Bidirectional
Çanakkale	4.275**	3.632*	Bidirectional
Aegean			
İzmir	0.304	0.093	No causality
Aydin	76.928***	8.966***	Bidirectional
Denizli	9.505***	15.012***	Bidirectional
Muğla	10.136***	8.212***	Bidirectional
Manisa	3.538*	0.206	Unidirectional
Afyonkarahisar	18.948***	5.425**	Bidirectional
Kütahya	3.827**	12.405*	Bidirectional
Uşak	3.698*	10.754*	Bidirectional
Eastern Marmara			
Bursa	16.818***	8.284***	Bidirectional
Eskişehir	14.43***	6.597***	Bidirectional
Bilecik	14.656***	3.725*	Bidirectional
Kocaeli	2.198	1.928*	Unidirectional
Sakarya	16.679***	7.623	Unidirectional
Düzce	16.368***	5.978	Unidirectional
Bolu	8.684***	5.866	Unidirectional
Yalova	1.508	23.347***	Unidirectional

Direction	GDP p.c. ⇏ SOCAP Wald stat.	SOCAP ⇏ GDP p.c. Wald stat.	Decision
Western Anatolia			
Ankara	6.361**	15.143***	Bidirectional
Konya	1.844	4.396**	Unidirectional
Karaman	0.733	0.055	No causality
Mediterranean			
Antalya	3.390*	3.374*	Bidirectional
Isparta	1.642	11.457***	Unidirectional
Burdur	20.373***	11.925***	Bidirectional
Adana	20.750***	11.291***	Bidirectional
Mersin	1.327	6.399**	Unidirectional
Hatay	9.340***	50.881***	Bidirectional
K. Maraş	9.123***	11.318***	Bidirectional
Osmaniye	11.887***	27.599***	Bidirectional
Central Anatolia			
Kırıkkale	1.167	7.487***	Unidirectional
Aksaray	4.479**	1.707	Unidirectional
Niğde	3.28*	5.268**	Bidirectional
Nevşehir	8.323***	10.441***	Bidirectional
Kırşehir	1.855	4.794**	Unidirectional
Kayseri	4.983**	14.577***	Bidirectional
Sivas	3.098*	13.987***	Bidirectional
Yozgat	6.591***	20.564***	Bidirectional
Western Black Sea			
Zonguldak	3.967**	23.385***	Bidirectional
Karabük	3.129*	7.146***	Bidirectional
Bartın	15.015***	14.219***	Bidirectional
Kastamonu	3.347*	21.089***	Bidirectional
Çankırı	14.425***	10.819***	Bidirectional
Sinop	6.022**	7.496***	Bidirectional
Samsun	23.931***	8.57***	Bidirectional
Tokat	10.335***	1.093	Unidirectional
Çorum	37.449***	71.261***	Bidirectional
Amasya	4.849**	0.748	Unidirectional
Eastern Black Sea			
Trabzon	4.913**	11.917***	Bidirectional

Direction	GDP p.c. ⇏ SOCAP Wald stat.	SOCAP ⇏ GDP p.c. Wald stat.	Decision
Ordu	5.933**	0.281	Unidirectional
Giresun	6.461**	0.298	Unidirectional
Rize	2.946*	3.758*	Bidirectional
Artvin	0.529	1.527	No causality
Gümüşhane	4.601**	1.434	Unidirectional
Northeastern Anatolia			
Erzurum	28.888***	23.263***	Bidirectional
Erzincan	2.147	5.774**	Unidirectional
Bayburt	0.406	2.193	No causality
Ağrı	13.587***	2.066	Unidirectional
Kars	4.726**	0.126	Unidirectional
Iğdır	1.534	0.477	No causality
Ardahan	0.614	0.000	No causality
Middle East Anatolia			
Malatya	3.021*	15.611***	Bidirectional
Elâzığ	16.310***	10.261***	Bidirectional
Bingöl	20.813***	18.517***	Bidirectional
Tunceli	6.645***	12.514***	Bidirectional
Van	3.340*	1.184	Unidirectional
Muş	18.131***	2.449	Unidirectional
Bitlis	15.750***	2.499	Unidirectional
Hakkâri	2.473	3.710*	Unidirectional
Southeastern Anatolia			
Gaziantep	8.511***	6.148**	Bidirectional
Adıyaman	12.528***	2.833*	Bidirectional
Kilis	0.203	0.661	No causality
Şanlıurfa	25.049***	50.932***	Bidirectional
Diyarbakır	8.765***	30.065***	Bidirectional
Mardin	1.862	0.055	No causality
Batman	4.769**	13.559***	Bidirectional
Şırnak	0.732	1.448	No causality
Siirt	0.836	1.529	No causality

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. ⇏ indicates "does not cause".

Source: own work.

According to the E-K panel causality test results shown in Table 5, bilateral causality was found in Edirne, Kırklareli, Balıkesir and Çanakkale in Western Marmara and unilateral causality from GDP p.c. to SOCAP in Istanbul while no significant relationship was found in Tekirdağ. In Aegean, no meaningful relationship was found in İzmir while unilateral causality from GDP p.c. to SOCAP was found in Manisa and bilateral causality was found in Aydın, Denizli, Muğla, Afyonkarahisar, Kütahya and Uşak. Unilateral causality was determined from GDP p.c. to SOCAP in Sakarya, Düzce and Bolu in Eastern Marmara and from SOCAP to GDP p.c. in Kocaeli and Yalova. It was determined that there is bilateral causality in Bursa, Eskişehir and Bilecik. While it is seen that there is unilateral causality from SOCAP to GDP p.c. in Konya in Western Anatolia and bilateral causality in Ankara no significant relationship was detected in Karaman.

While unilateral causality from SOCAP to GDP p.c. was identified in Isparta and Mersin in Mediterranean, bilateral causality was found in Antalya, Burdur, Adana, Hatay, K. Maraş and Osmaniye. Unilateral causality was determined from SOCAP to GDP p.c. in Kırıkkale and Kırşehir in Central Anatolia and from GDP p.c. to SOCAP in Aksaray. It was found that there is bilateral causality in Niğde, Nevşehir, Kayseri, Sivas and Yozgat. While there is unilateral causality from GDP p.c. to SOCAP in Tokat and Amasya in the Western Black Sea, there is bilateral causality in Zonguldak, Karabük, Bartın, Kastamonu, Çankırı, Sinop, Samsun and Çorum.

It has been observed that there is unilateral causality from GDP p.c. to SOCAP in Ordu, Giresun, Gümüşhane in the Eastern Black Sea and bilateral causality in Trabzon and Rize. No significant relationship was found in Artvin. While causality was determined from GDP p.c. to SOCAP in Ağrı and Kars in Northeastern Anatolia and from SOCAP to GDP p.c. in Erzincan, bilateral causality was detected in Erzurum. No significant findings were found in Bayburt, Iğdır and Ardahan. There is a unilateral causality from GDP p.c. to SOCAP in Van, Muş and Bitlis in Middle East Anatolia and from SOCAP to GDP p.c. in Hakkari. In Malatya, Elazığ, Bingöl and Tunceli, it was found that there is a bilateral causality relationship. In Southeastern Anatolia, there was a bilateral causality relationship in Gaziantep, Adıyaman, Şanlıurfa, Diyarbakır and Batman while no significant relationship could be determined in Kilis, Mardin, Şırnak and Siirt.

The causality test results reported in Table 4 were shown on the map in Figure 3 by province. When Figure 3 was examined, a bilateral relationship was found between GDP p.c. and SOCAP in 45 of 81 provinces. It was observed that there was a unilateral causality from GDP p.c. to SOCAP in sixteen provinces and from SOCAP to GDP p.c. in nine provinces. In eleven provinces, no significant relationship was found between GDP p.c. and SOCAP.

The provinces in the east of Türkiye are in a disadvantageous position in terms of economic and social aspects compared to the provinces in the west. This is because the provinces in the West are production and industrial zones

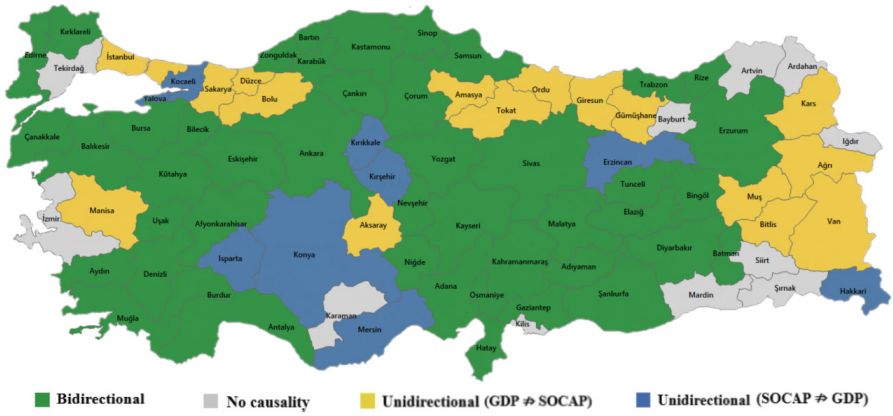

Figure 3. The E-K panel Granger causality test results by the provinces

Note: GDP = GDP p.c.

Source: own elaboration.

and are close to ports and transportation lines. In some provinces, the absence of a causal relationship can be explained by the fact that they are provinces in the east of Türkiye that are below Türkiye's average in terms of economic development, transportation and population. Table 6 demonstrates the results from the E-K panel Granger causality test by regions.

Table 6. Results from the E-K panel Granger causality test by regions

Direction	GDP p.c. ⇏ SOCAP	SOCAP ⇏ GDP p.c.	Decision
Regions	Fisher stat.	Fisher stat.	
Western Marmara	194.618***	34.484**	Bidirectional
Aegean	148.135***	79.543**	Bidirectional
Eastern Marmara	114.025***	83.818*	Bidirectional
Western Anatolia	14.267	25.485*	Unidirectional
Mediterranean	98.813***	159.260**	Bidirectional
Central Anatolia	50.781**	100.793***	Bidirectional
Western Black Sea	150.811***	194.648***	Bidirectional
Eastern Black Sea	37.996*	28.977	Unidirectional
Northeastern Anatolia	66.501***	45.013*	Bidirectional
Middle East Anatolia	108.614***	86.767**	Bidirectional
Southeastern Anatolia	82.669***	127.680**	Bidirectional

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. ⇏ indicates "does not cause".

Source: own work.

According to the Fisher test statistics in Table 6, a unilateral causality was found from GDP p.c. to SOCAP in Eastern Black Sea region and from SOCAP to GDP p.c. in Western Anatolia. Bilateral causality was found in Western Marmara, Aegean, Eastern Marmara, Mediterranean, Central Anatolia, Western Black Sea, Northeastern Anatolia, Middle East Anatolia and Southeastern Anatolia. Regional causality test results are displayed on the map in Figure 4.

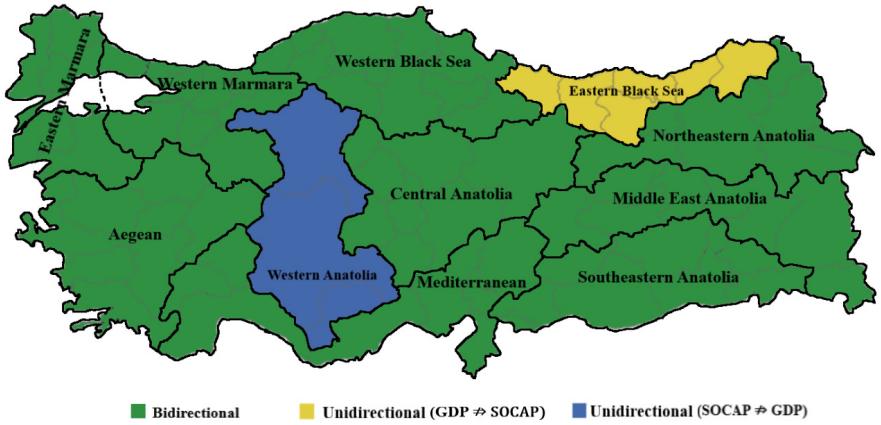

Figure 4. The E-K panel Granger causality test results by regions

Source: own elaboration.

It was determined that there was a bilateral relationship between GDP p.c. and SOCAP in all regions except Western Anatolia and Eastern Black Sea regions in Figure 4. There is a unilateral causality from GDP p.c. to SOCAP in Eastern Black Sea and from SOCAP to GDP p.c. in Western Anatolia. Regional results are more general than causality results on a provincial basis. While provinces in the east of Türkiye that are below average in terms of economic development, transportation and population may affect the results, regional outputs provide more clarity to the results and support the results on a provincial basis.

5. Sensitivity test

The robustness of the results of the causality relationship between the variables is checked for the whole panel in Türkiye. For this purpose, the E-K panel Granger causality test results for Türkiye are given in Table 7.

According to the E-K panel Granger causality test results for Türkiye in Table 7, a bilateral causality relationship was found between GDP p.c. and

SOCAP in 48 provinces of Türkiye. A unilateral causality was obtained from GDP p.c. to SOCAP in thirteen provinces and from SOCAP to GDP p.c. in eight provinces. No significant relationship was found in twelve provinces. Finally, it was determined that there is a bilateral relationship between the related variables in Türkiye. Accordingly, it is seen that the results obtained for the whole panel largely support the results obtained on the provincial and regional basis.

Table 7. The E-K panel causality test results for Türkiye

No relationship			
Ardahan	Artvin	Bayburt	Iğdır
İzmir	Karaman	Kilis	Kocaeli
Mardin	Siirt	Şırnak	Tekirdağ
Unidirectional relationship from GDP p.c. to SOCAP			
Ağrı	Aksaray	Amasya	Bitlis
Giresun	Gümüşhane	İstanbul	Kars
Manisa	Muş	Ordu	Tokat
Van	-	-	-
Unidirectional relationship from SOCAP to GDP p.c.			
Erzincan	Hakkari	Isparta	Kırıkkale
Kırşehir	Konya	Mersin	Yalova
Bidirectional relationship			
Adana	Adıyaman	Afyonkarahisar	Ankara
Antalya	Aydın	Balıkesir	Bartın
Batman	Bilecik	Bingöl	Bolu
Burdur	Bursa	Çanakkale	Çankırı
Çorum	Denizli	Diyarbakır	Düzce
Edirne	Elazığ	Erzurum	Eskişehir
Gaziantep	Hatay	Kahramanmaraş	Karabük
Kastamonu	Kayseri	Kırklareli	Kütahya
Malatya	Muğla	Nevşehir	Niğde
Osmaniye	Rize	Sakarya	Samsun
Sinop	Sivas	Şanlıurfa	Trabzon
Tunceli	Uşak	Yozgat	Zonguldak
Türkiye			

Source: own work.

Conclusions

In this paper, the causality relationships between GDP p.c. and social capital in Türkiye during the period of 2007–2018 were examined both at provincial and regional level. Differing from the majority of previous studies, social capital was represented by the social capital index which is a proxy of more comprehensive. The relationships between variables were examined using the E-K (2011) panel Granger causality test. In the analysis for provinces, it was concluded that there is a bilateral causal relationship in 45 provinces, a unilateral causality from GDP p.c. to SOCAP in sixteen provinces and from SOCAP to GDP p.c. in nine provinces.

In regional results, it was determined that there was a bilateral relationship between the mentioned variables in all the regions except the Western Anatolia and Eastern Black Sea regions. On the one hand, it was observed that there was a one-sided relationship from GDP p.c. to SOCAP in the Eastern Black Sea and from SOCAP to GDP p.c. in Western Anatolia. These results supported the results obtained on a provincial basis. Except for İzmir and Tekirdağ provinces, any causal relationship was determined in the provinces of Bayburt, Karaman, Kilis, Artvin, Ardahan, Iğdır, Mardin, Siirt and Şırnak which are low-population and underdeveloped in terms of income and industry. It is thought that the presence of high immigration from the eastern regions to İzmir and Tekirdağ provinces might account for the absence of a substantial relationship between the variables. At least one unilateral causality relationship was found in all other 70 provinces and a bilateral causality relationship was found in 45 provinces. Furthermore, in order to test the sensitivity of the results, a causality test was performed for a single panel covering all provinces. It was determined that the sensitivity results largely supported the main results.

In 45 provinces (in 56% of provinces) with notable population and economic scale, there existed a causal relationship between GDP p.c. and social capital. In regional analysis, it was determined that there was a bilateral causality relationship in 10 regions (in 83% of provinces) of twelve regions. The results for Türkiye in general supported the previous literature. For the coherence and reliability of the study, it is crucial that the causality results obtained for the provinces, regions, and nationwide analysis are mutually affirmative.

The results revealed that the level of social capital in terms of GDP p.c. in 45 provinces in Türkiye and the level of GDP p.c. in terms of social capital were factors that should be considered. Additionally, it was established that GDP p.c. was determinant for SOCAP in 16 provinces while SOCAP was determinant for GDP p.c. in 9 provinces. The results of the study predominantly provided evidence that indicated the presence of reciprocal interaction between GDP p.c. and social capital in Turkey. These revealed that on the one hand,

practices that contribute to the level of social capital supported GDP p.c. in Türkiye and that, investments made for GDP p.c. encouraged social capital.

In provinces where unilateral causality is detected, appropriate policy recommendations should be put forward by considering the direction of the relationship. Accordingly, in 16 provinces where there is a unilateral causality from GDP p.c. to SOCAP, priority and weight should be given to measures to support the level of GDP. Within this scope, investment and employment opportunities in these 16 provinces should be reviewed and initiatives aimed at enhancing the current capacity should be undertaken.

On the other side, in 9 provinces where unilateral causality from SOCAP to GDP p.c. was detected, strategies supporting the level of social capital should be implemented to improve the level of GDP p.c. In this context, priority should be assigned to essential policy implementations that foster the advancement of social capital levels in these provinces. Although there is no precise formula for enhancing social capital level, policies can be implemented to improve and increase the level of trust by fostering connections and networks among individuals by working in this direction. Undoubtedly, the implementation of regulatory and supportive policies in both spheres will both improve the level of social capital and positively affect GDP p.c.

It is vital to focus on GDP p.c. by ensuring regionally and geographically balanced growth. It is noteworthy that the disadvantaged provinces and regions in the east of Türkiye suffer from low both per capita income and social capital. Hence, strategies that eliminate regional inequalities in income distribution and give priority to disadvantaged provinces and regions should be implemented.

This study has some limitations. First, in the investigation of the relationship between social capital and GDP p.c., the causality test is solely employed and coefficient estimation is ignored. Second, the observation range of the variables (2007–2018) in the study covers a limited period. Third, asymmetric and non-linear test methods are neglected in the analysis since the E-K causality test analyzes linear relationships between variables. Therefore, different variables and different social capital indicators can be used in future studies. The bidirectional relationship between social capital and GDP p.c. can be explored in different countries and regions and particularly on the basis of provinces in Türkiye through utilizing asymmetric or non-linear test techniques in future studies.

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Food security of Ukraine: National and global level

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Abstract

The aim of this paper is to examine the level of food security in Ukraine in comparison to global regions and European countries in the context of the COVID-19 pandemic and the Russian-Ukrainian war. For this purpose, a variety of indicators were examined including population dynamics, food balance, FAO indicators, and the Global Food Security Index. The results show that in spite of its agricultural potential Ukraine is behind the global and European indicators of food security with the exception of fish products. Barriers to achieving high levels of food security include incomplete legislative reforms, inadequate funding, infrastructure deficiencies, corruption and non-compliance with standards. International cooperation and improved national and regional strategies are needed to overcome the consequences of the war.

Keywords

- food security
- food security indicators
- export
- import
- import dependence
- self-sufficiency
- consumption of food products

JEL codes: Q17, Q18, R11, R58

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Introduction

The food problem has always been in the centre of attention at different stages of society's development as evidenced by the continuous improvement of relevant national programmes primarily in the most developed countries of the world, such as the United States, Japan and EU members. The level of sufficient supply of qualitative food products is a strategically important element of social stability and economic sovereignty and preservation of the nation's health.

Today the optimistic strategies of countries and international organizations regarding the elimination of all forms of malnutrition have turned out to be ineffective. First, the COVID-19 pandemic has had a devastating impact on the global economy and triggered a recession not seen since the Second World War exposing the shortcomings of existing food systems which endangered the lives of people in all regions of the world, especially the least developed countries and exacerbated food insecurity. Thus, in 2020 compared to 2019 the increase in the cost of a healthy diet under the conditions of growing poverty and income inequality caused an increase in the number of people suffering from hunger by 161 million to 811 million people and those who did not have access to a sufficient amount of food—by 320 million people (FAO, 2022).

Despite the pandemic crisis Ukraine as one of the world's largest suppliers of food of animal and vegetable origin (in particular in 2020: 6th place among world exporters of grain crops; 8th place—seeds and fruits of oil plants; 5th place—fats and oils of animal and plant origin) (Melnyk et al., 2021) supplied the countries of the Middle East, Europe, Southeast Asia and North Africa with food. Export of Ukrainian agricultural products to the world market in 2021 accounted for the lion's share of Ukrainian exports (41%) and covered the food needs of 400 million people (Ministry of Agrarian Policy and Food of Ukraine, 2022). The value of production of agriculture and related industries is 20% of Ukraine's GDP and at the same time 70% depends on exports (State Statistics Service of Ukraine, 2022).

The Russian-Ukrainian war for the second time in a short period put humanity in danger of food collapse and deep economic upheavals. Russian aggression and the blockade of Black Sea ports caused interruptions in the supply of food to foreign markets and an increase in world prices because Ukraine and the Russian Federation collectively account for 30% of world wheat exports, 15% of corn and 80% of sunflower oil trade (Ministry of Agrarian Policy and Food of Ukraine, 2022). Each element of the value creation chain of the agricultural sector of Ukraine was negatively affected and its production and export potential weakened. Prolonging the destructive military actions on the territory of Ukraine means a further reduction in food supplies. For Ukraine it prompted a decrease in the liquidity of agricultural producers, an increase

in inflation and unemployment, a decrease in the financing of the healthcare and social protection system which also affects the availability of food and the quality of nutrition.

Therefore, in the context of the aggravation of the global food crisis as a result of the Russian-Ukrainian war there is an urgent need to improve the policy of strengthening food security at national and global levels and to develop effective mechanisms for supporting the agricultural sector based on the application of a comprehensive approach to monitoring the level of food security. This factor indicates the relevance of the chosen research topic.

In general this study addresses the research gap in understanding food security in Ukraine by conducting a comprehensive analysis and comparing the country's key indicators with global and European averages. It also considers the impact of the Russian-Ukrainian war on food security and adds value by providing policy recommendations to strengthen food security in Ukraine.

The article is organised as follows. Section 1 offers an overview of the literature on food security. In Section 2 the comprehensive approach was used. The results of applying this approach are shown in Section 3. Section 4 discusses the impact of the COVID-19 pandemic and the Ukrainian-Russian war on food security and nutrition. The conclusions offer some final remarks, acknowledge the study's limitations and highlight possibilities for future research.

1. Literature review

Many works are devoted to the improvement of methodical approaches for assessing the level of food security. A system of indicators is proposed forecasting by main groups of food products and assessing the state's real needs for resources for their production. Basic indicators of the food strategy as a component of the state's agrarian policy are defined (Nikonenko, 2022). The methodology of the integral assessment of food safety has been improved taking into account the indicators approved by the government as well as an assessment based on the specified indicators of the risks to food safety (Skrypnyk & Starychenko, 2017).

Ukrainian researchers assess the current level of food security in Ukraine and determine the trends in the change of the main indicators according to the national methodology of the CMU which takes in to account the influence of various factors at different levels of management (Babych, 2018). The peculiarities of food security in Ukraine in the conditions of the pandemic were studied and the measures of the economic policy to ensure it were systematized (Tyutyunnikova & Skochko, 2020). In particular the question of minimizing the degree of import dependence of the country's food market is con-

stantly in the field of interest. The commodity and geographical structure of the import of agricultural products in Ukraine was analyzed and the ways of increasing the level of self-sufficiency of the domestic food market and reducing dependence on foreign food supply were assessed (Dukhnytskyi, 2020a).

Scientific research on current global trends in food security deserves special attention. The determinants of the formation of the country's food potential have been identified: conflicts and wars, global pandemics (COVID-19), climate variability and its extreme manifestations, economic slowdowns and economic downturns, and nutrition policy (Pogorelova, 2022).

A significant number of scientific works are devoted to issues of the food security of Ukraine in the context of globalization. Attention is focused on its unsatisfactory level in the global rating and the presence of problems in providing the population with food in view of the growth of threats in the agricultural sector (Horin, 2020). The challenges of the Ukrainian food industry to strengthen global food security in the face of internal and external challenges are substantiated (Pasichnyk, 2020; Sychevskyi, 2019). The dynamics of the geographical structure of food consumption in the last 40 years in the world were analysed, the energy value of the modern diet of a typical inhabitant of the planet was determined, the consumption indicators in the key countries of each geographical region and the differentiation of costs for organic products depending on the purchasing power of buyers in comparison with Ukraine were explored (Dukhnytskyi, 2020b). An assessment of the dynamics of Ukraine's self-sufficiency in basic food products was carried out, the prerequisites and prospects of the national product manufacturer entering the foreign market were analyzed (Samoilyk et al., 2019; United Nations, 2022).

Since the beginning of the large-scale invasion by the Russian Federation on the territory of Ukraine many foreign scientific works have appeared devoted to the analysis of threats to global and regional food security. In particular the most vulnerable regions and countries were identified, the lessons of previous food crises and the necessary measures to protect the most vulnerable countries in the short term were analyzed as well as the long-term directions of the policy of diversification of food, fertilizers, energy, production and trade (Britchenko et al., 2022; Kibrom et al., 2022). The need to unite world governments, donors and other interested parties in order to intensify the protection of future generations from the devastating consequences of malnutrition and prevent food insecurity is justified (Ivashchenko et al., 2018; Osendarp et al., 2022; Sun et al., 2022).

In existing papers the current trends of food security in Ukraine and the regions of the world in the context of their interdependence are touched upon in a fragmentary way. There are no detailed studies which provide a comprehensive assessment over a long period. The recent years have been characterized by crisis changes due to the application of quarantine measures related to COVID-19 and the large-scale invasion of the Russian Federation of

Ukraine as compared to regions of the world and developed European countries. The identification of shortcomings and potential opportunities to ensure a sufficient level of food consumption by the population at national and global levels consitute the purpose of this research.

2. Methodology

In order to study the food security of Ukraine and its factors in comparison with regions of the world and developed European countrie a comprehensive approach that combines international approaches and a modified national approach is applied. It encompasses quantitative indicators which allow such an assessment. Firstly, the level of food security of the state (region) as a whole is considered: population, food balance indicators and FAO food security indicators. Secondly, the focus is put on major food groups (bread and bakery products, potatoes, vegetables, gourds, fruits, berries and grapes, sugar, oil, meat and meat products, milk and dairy products, fish and fish products, eggs): indicator of the sufficiency of consumption of a particular product, the capacity of the domestic market of the product, the share of food imports of the product, the balance index, food self-sufficiency (formulae 1-5). Third, the success of the state in solving internal problems of economic accessibility, physical availability and quality of food is analysed with the use of the Global Food Security Index. The formulae for the abovementioned indicators are as follows:

$$I = \frac{Cf}{Cr} \tag{1}$$

where:

I – an indicator of the adequacy of consumption of a particular product,
Cf – the factual consumption of a particular product per person per year,
Cr – the rational consumption rate of a particular product per person per year, agreed with the Ministry of Health,

$$C_i = F_i P \tag{2}$$

where:

C_i – the domestic market capacity of the i-th product,
i – the type of product,
F_i – the annual average per capita consumption of the i-th product,
P – the average annual population,

$$P_i = \frac{Imi}{Ci} 100\% \quad (3)$$

where:

P_i – the share of food imports of the i-th product,
i – the type of food product,
Im_i – the import of the i-th product,
C_i – the capacity of the domestic market of the i-th product

$$I_{s.b.} = \frac{E}{Im} 100\% \quad (4)$$

where:

$I_{s.b.}$ – the state of balance index (export-import coverage index or import-export coverage ratio),
E – the value of exports,
Im – the value of imports,

$$SS = \frac{Vi}{ICi} 100\% \quad (5)$$

where:

SS – self-sufficiency in food (resource potential of the food security industry),
V_i – the volume of production of the i-th food product,
IC_i – the internal consumption of the i-th product which includes the consumption fund, costs for fodder and seeds.

The study offers also an overview of the effects of the war with Russia on the food security of Ukraine and the world and the measures of institutional international support.

3. Results

The global population growth trend observed during 2000–2020 will continue in all regions of the world (except Europe) over the next 30 years mainly due to African and Asian countries and in 2050 will reach 9,772 million people which will obviously increase food consumption. During 2010–2021 the volume of food production in the world increased as a whole (by 25.2%), as well as by individual product groups (grains, dairy products—by 30%, oil seeds—by 34% among the leaders) (Table 1). At the same time the consumption of

Table 1. Dynamics of the components of food resources of the world in 2010–2021 in million tons

Indicator		2010	2021	Growth, %	
				in 2021 to 2010	in 2021 to 2020
Food, total	Production	3 860.9	4 835.0	25.2	1.4
	Trade	746.6	1 189.3	59.3	–1.6
	Total consumption, incl.	3 164.9	3 896.4	23.1	1.4
	food	1 810.6	2 110.3	16.6	1.9
	feed	898.0	1 222.6	36.1	0.7
	Other consumption	456.3	566.2	24.1	1.2
Grain, incl.	Production	2 241.3	2 799.3	24.9	0.8
	Trade	282.1	473.1	67.7	–1.2
	Total consumption, incl.	2 272.7	2 784.9	22.5	0.9
	food	1 058.0	1 179.2	11.5	1.1
	feed	766.6	1 046.3	36.5	0.7
	Other consumption	448.2	566.2	26.3	1.9
Wheat	Production	655.3	776.6	18.5	0.2
	Trade	125.3	191	52.4	2.6
	Total consumption, incl.	663	765.2	15.4	0.8
	food	468.2	531.3	13.5	1.3
	feed	120.3	149.8	24.5	3.5
	Other consumption	74.4	90.6	21.8	0.6
Meat	Production	294.2	355.5	20.8	5.1
	Trade	26.7	42.1	57.7	1.0
	Total consumption	290	354	21.8	5.3
Oil crops, including	Production	298.6	401.1	34.3	2.1
	Trade	161.7	235.8	45.8	–1.6
	Total consumption	290.8	405.6	39.5	0.9
Vegetable and animal fats	Production	181.3	241.3	33.1	3.0
	Consumption	177	245.3	38.6	1.2
	Trade	92.4	132.7	43.6	–1.6
Sugar	Production	166.3	169.5	1.9	–0.2
	Trade	51.3	60.1	17.2	–1.2
	Consumption	164.1	170.5	3.9	–0.5

Table 1 continued

Indicator		2010	2021	Growth, %	
				in 2021 to 2010	in 2021 to 2020
Milk and dairy products	Production	713.6	927.8	30.0	1.5
	Trade	47	88.1	87.4	2.4
Fish and fish products	Production	146.9	181.8	23.8	4.1
	Trade	55.2	61.4	11.2	–3.0
	Total consumption, incl.	146.9	181.8	23.8	4.1
	food	121.1	161.7	33.5	4.5
	feed	17.6	16	–9.1	–0.6
	Other consumption	8.1	4	–50.6	5.3

Source: calculated by the authors based on FAO data.

food resources increased by 23.1% (grains—by 22.5%, meat—by 21.8%, fish and fish products—by 23.8%, oil crops—by 39.5%). Cereals and in particular wheat play a special role in providing the world's population with food with 68% of its production in 2021 going to food and only 19% to animal feed. The international food market was repidly growing during the period under study. The total trade volume increased by 59.3%, in particular, for grain—by 67.7%, meat—by 57.7%, vegetable and animal fats—by 43.6%, and milk and dairy products—by 87.7%.

The COVID-19 pandemic has had a significant impact on increasing the number of undernourished people worldwide. The pandemic has disrupted global and regional food systems including food production, distribution and access. Containment measures, movement restrictions, and supply chain disruptions have challenged food production and availability. This has resulted in economic shocks including job losses, reduced incomes and increased poverty rates. Many vulnerable populations particularly those in the informal sector or low-income jobs have faced significant financial hardship making it difficult for them to afford nutritious food (Gebeyehu et al., 2022). This economic downturn has exacerbated food insecurity and led to an increase in the number of undernourished people. Restrictions on movement and labour shortages have disrupted agricultural activities including planting, harvesting and transportation. Farmers have faced challenges in accessing markets and investments resulting in lower agricultural productivity and reduced food availability. Together these factors contributed to an increase in the number of undernourished people during the COVID-19 pandemic. Despite an increase in global GDP per capita food system disruptions and social protection challenges have led to an increase in the prevalence of undernourishment.

Addressing the food security and nutrition consequences of the pandemic requires comprehensive strategies that focus on ensuring access to nutritious food, strengthening social protection systems and supporting agricultural activities and livelihoods (Kakaei et al., 2022).

Under the conditions of the COVID-19 pandemic in 2020 the number of undernourished people was 720 million which is 131 million more than in 2010. This is under the conditions of an increase in GDP per capita in the world as a whole (by 16.5 %) and in most regions (Africa by 2.4%, North America by 10.1%, Europe by 7%, Asia by 31.5%) except for South America (decrease of 2.6%). After a period of relative stability in 2014–2019 the prevalence of malnutrition in the world increased from 8.4% in 2019 to 9.9% in 2020 (Table 2).

At the same time the unevenness of the geographical structure of the starving is a cause for concern. In Africa in 2020 21% of people were malnourished which is twice as much as in other regions of the world and three percentage points higher than in 2010. In South America (with 7.8% of malnourished people) this indicator increased during 2010–2020 by 2.1 percentage points, in Oceania (with 6.2% of malnourished people) by 0.6 percentage points. Only in Asia is there a gradual decrease in the number of starving people by 0.5 percentage points with the growth of GDP by 31.5% for the studied period.

The lack of quality nutrition in sufficient quantity is the reason for the steady increase in the percentage of overweight children (primarily in the countries of South and North America in 2020 it was 9.1%, 8.3%, respectively; in Europe 8.2%) and the prevalence of anaemia among women of reproductive age in all regions of the world, primarily in Africa (38.9%) and Asia (32.7%).

Small positive trends in 2010–2020 in the world as a whole include an increase in the percentage of people using safe drinking water (from 65.8% to 74.3%), safely managed sanitation services (from 39.9% to 54%), and a decrease in the percentage of children under five who are stunted (from 27.7% to 22%) (except for North America). In 2020 the highest average levels of food and energy adequacy were achieved in North America (149% or 3769 kcal/capita/day) and Europe (136% or 3395 kcal/capita/day), with the highest average energy requirements for food of 2543 kcal/cap/day and 2498 kcal/cap/day, respectively.

The analysis of Ukraine's food security indicators according to the FAO methodology for 2018–2021 revealed a slight gap in the global and European averages (Table 2) as well as a significant difference in the indicators of developed European partner countries and competitors in the agribusiness market. The nutrition of the population of Ukraine is sufficiently supplied with energy (125%), while the world average is (124%) but lower than in the European level (136%) and the studied EU countries (129–141%) (Table 3). With GDP per capita half the level of Europe the percentage of undernourished people in Ukraine in 2020 was generally at the European average (<2.5%) but severe

Table 2. Food security indicators of world regions in 2010–2020 (according to the FAO methodology)

Indicator	World		Africa		North America		South America		Europe		Asia	
	2010/2009–2011	2020/2018–2020	2010/2009–2011	2020/2018–2020	2010/2009–2011	2020/2018–2020	2010/2009–2011	2020/2018–2020	2010/2009–2011	2020/2018–2020	2010/2009–2011	2020/2018–2020
Average sufficiency of food and energy supply (in percent) (on average over 3 years), %	119	124	112	112	144	149	126	127	134	136	115	123
Food energy supply used to estimate the prevalence of malnutrition (average over 3 years), kcal/capita/day	2831	2950	2531	2566	3662	3769	3003	3046	3378	3395	2718	2908
Gross domestic product per capita, PPP, distribution (constant international $ 2011), I$	13890.5	16194	4605.2	4714.9	53381.8	58764	14921.8	14532.3	33959.7	36342.4	9033.7	11883
Prevalence of malnutrition (average for 3 years), %	9.4	8.9	18.7	19	<2.5	<2.5	5.9	6.3	<2.5	<2.5	9.7	8.2
Number of undernourished people (million, %) (annualized)	636.8 (9.2%)	768 (9.9%)	187.4 (18%)	281.6 (21%)	(<2.5%)	(<2.5%)	22.5 (5.7%)	33.7 (7.8%)	(<2.5%)	(<2.5%)	400.1 (9.5%)	418 (9%)
Percentage of population using safe drinking water services, %	65.8	74.3	–	–	95.5	97.3	76.2	80.1	92.2	93.5	64.7	78.2
Percentage of population using safely managed sanitation services, %	39.9	54	–	–	76.8	81.1	24	33.7	73.6	73	35	55.7
Number of children under five with stunted growth (modelled estimates) (million, %)	180.5 (27.7%)	149.2 (22%)	59.5 (35.9%)	61.4 (30.7%)	0.6 (2.7%)	0.7 (3.2%)	3.6 (10.9%)	2.8 (8.6%)	2.1 (5.4%)	1.8 (4.5%)	110.7 (30.1%)	79 (21.8%)
Number of overweight children under the age of five (modelled estimates, (million, %)	36.4 (5.6%)	38.9 (5.7%)	8.5 (5.1%)	10.6 (5.3%)	2 (8.6%)	2 (9.1%)	2.5 (7.6%)	2.6 (8.2%)	3.9 (9.9%)	3.3 (8.3%)	17.9 (4.9%)	18.7 (5.2%)
Number of women of reproductive age (15-49 years) affected by anaemia (millions, %)	512.7 (28.6%)	570.8 (29.9%)	99.7 (39.9%)	122.7 (38.9%)	7.7 (9.4%)	9.8 (11.7%)	20.8 (19.6%)	19.5 (17.3%)	25.9 (14.5%)	26.5 (16%)	347.5 (31.2%)	380.7 (32.7%)
Minimum energy requirement (kcal/cap/day)	1823	1828	1720	1737	1947	1948	1844	1856	1931	1919	1818	1827

Source: based on FAO data.

Table 3. Food security indicators of Ukraine and selected European countries in 2018–2021

Indicator	Period	Ukraine	Germany	France	The Netherlands	Poland	UK
Average sufficiency of food energy supply (%) (on average over three years)	2018–2020	125	141	141	129	142	133
Food energy intake used to estimate the prevalence of malnutrition (kcal/cap/day) (three year average)	2018–2020	3092	3569	3516	3311	3552	3304
Gross domestic product per capita, PPP, distribution (constant international $ 2011)	2020 (2021)	12377 (12943.6)	50922.4 (52930.8)	42025.6 (45187.4)	54209.6 (56761)	32238.2 (34363)	41627.1 (45839.2)
Prevalence of malnutrition (%) (on average over three years)	2018–2020	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
Prevalence of severe food insecurity among the total population (%) (on average over three years)	2018–2020	2.5	0.7	0.7	1.4	<0.5	0.7
Number of people with a serious food insecurity problem (million) (on average over three years)	2018–2020	1.1	0.6	0.4	0.2	0.2	0.5
Political stability and absence of violence/terrorism (index)	2019	–1.52	0.58	0.31	0.86	0.52	0.52
Percentage of the population using safe drinking water services (%)	2020	89	99	99	99	98.3	99
Percentage of population using safely managed sanitation services (%)	2020	72	97.1	78.6	97.5	90.5	98.1
Percentage of children under five with stunted growth (modelled estimates), %	2020	15.9	1.6	–	1.6	2.3	–
Percentage of overweight children under the age of five (modelled estimates), %	2020	17	4.1	–	5	6.7	–
Prevalence of anemia among women of reproductive age (15–49 years), %	2019	17.7	11.7	10.6	12.8	–	11.1

Notes: * <2.5—the proportion of undernourished people less than 2.5%; <0.1—fewer than 100,000 people; "-"—no data available.

Source: (Eurostat, 2022).

food insecurity was characteristic for 2.5% of the population (1.1 million inhabitants) which is five times more than in the reference countries (0.5–1.8%). Problems with political stability and the presence of violence in the state had a negative impact on the food security as evidenced by the negative value of the corresponding index (–1.52).

It is positive that the percentage of the population using at least basic sanitary services (97.7%) is approaching the level of the Netherlands and is higher than the world average (78%) and the European average (96.6%) and only two percentage points lower than in comparable countries. The percentage of the population using at least basic clean drinking water (93.9%) and safely managed sanitation (72%) in Ukraine is significantly lower than in comparable countries especially Germany (99% and 97% respectively) and the UK (99% and 98%).

Although the percentage of children under five years of age with stunted growth, with excess weight and the percentage of women of reproductive age with anaemia in Ukraine is lower than the world average it is 4, 2, and twice higher than in developed EU countries which indicates a threat to the formation of healthy future generations—a critical factor of economic growth and international competitiveness.

The analysis of the dynamics of food security indicators by geographical regions of the world within the main food products during 2010-2019 revealed the general trends of the level of their food security: an increase in the consumption of all main food products as evidenced by the dynamics of indicators of the capacity of food markets; growing import dependence for all basic food products. The indicator of consumption sufficiency the main product which is sufficiently represented in the daily diet of the population of all regions of the world without exception is bread and bread products. Yet the level of import dependence on them in 2019 compared to 2010 increased by eight percentage points and was 38.9% (in Africa 45.3%, South America 68%, North America 40%, Asia 24%, Oceania 83%, Europe 118%). At the same time the studied regions have a high resource potential for food security, with the exception of Africa, where indicators of self-sufficiency in bread products, sugar, vegetable oils, meat products and fish products range from 66% to 93%.[4] The countries of this region have a negative foreign trade balance in most major food groups as evidenced by the import coverage index, primarily for bread, sugar, vegetable oils, meat, eggs and dairy products: 7.2%, 40%, 19%, 9.3%, 48.1%, 46.2% respectively.

In Ukraine the negative trend of insufficient nutrition which is characteristic for the entire period of the state's independence and still persists. The majority of the population is limited in access to high calory, quality food products in sufficient quantities the consumption of which ensures a healthy

[4] The data is available from the authors upon request.

life. Thus, during 2010–2019 for all food groups but vegetable oils, bread and bread products the consumption was lower than the defined rational norm. The consumption of fruits and berries, a source of necessary vitamins, is significantly behind both the norm and the developed EU countries by two to three times. The recommended level for dairy products and meat products and fish was achieved at only 52%, 67% and 60% respectively. At the same time there was a decrease in the capacity of the domestic market for most products (except for meat and dairy products).

In recent years the population's food needs within the limits of its purchasing power have been realized mainly at the expense of domestically produced products. Traditionally the domestic market is highly dependent on imports of fish products (79.6%), fruits and berries (42.6%) and vegetable oils (palm, soybean and rapeseed) (42.9%). In general duringthe period 2010–2019 Ukraine had a high food resource potential in most product groups (even higher than in the UK for all types of food studie, except for bread, dairy products and vegetable oils), primarily for bread and bakery products (1143.5%) and vegetable oils (1279.8%), except for fish products (21.1%), fruits, berries and grapes (82%) as evidenced by the decline in food self-sufficiency rates. However, there is a significant gap behind the achievements of most European countries, such as the Netherlands (self-sufficiency for the whole group ranges from 167 to 669%, except for bread products (12.8%) and fruits and berries (44.9%)), France (108–261%, except for eggs (96%), fish products (28.6%) and vegetables (74.8%), Poland (114–391%, except for fish products (46%)). In addition, the low level of the import coverage index and hence the negative balance of foreign trade in Ukraine is unfortunately characteristic of the mentioned fish and fish products (4.9%), vegetables (80.2%), fruits (57.9%), milk and dairy products (61.9%) as well as potatoes (1.6%). Despite the significant potential for the development of Ukraine's agro-industrial complex the country's food security level according to the GFSI remained almost the same in 2012–2021 and in 2021 amounted to 62 points which corresponds to 58th place among 113 reference countries (Table 4).

The analysis of the components of the general index made it possible to find out the reasons for the unsatisfactory state and potential opportunities for increasing the level of food security in the country (Table 5). According to the accessibility component Ukraine dropped by seven points and took 58th place in the rating which is due to the low level of compliance with food safety programmes as a result of the insufficient level of reforms of national legislation on state control of food quality in accordance with EU standards within the framework of the Association Agreement. According to the availability component Ukraine is in 74th place due to the weak level of state support for research and development in agricultural sciences which in the total volume of 2020 was only 7% of expenditure while for technical sciences it was 57.7% (State Statistics Service of Ukraine, 2021).

Table 4. Global Food Security Index (GFSI) of Ukraine and selected European countries in 2012–2021

Indicator	Ukraine		United Kingdom		The Netherlands (N)		France (F)		Germany (G)		Poland (P)	
Rating*/Rank												
General environment	62.0/58		81.0/3		79.9/6		79.1/9		78.7/11		74.9/22	
1) Accessibility	73.9/58		91.1/4		89.7/13		90.3/9		90.1/10		87.0/25	
2) Availability	51.8/74		72.7/11		73.7/10		67.0/24		69.3/18		65.0/30	
3) Quality and safety	71.9/55		89.6/14		92.2/7		92.1/8		87.8/18		80.5/40	
4) Natural resources and sustainability	49.3/56		69.0/6		61.2/18		67.5/8		66.0/11		65.0/14	
Change in rating/rank in 2021 compared to 2012												
General environment	+4.2	▼1	+6.1	▲14	+2.4	▲3	0	▼4	+1.1	▼3	+4.4	▲3
1) Accessibility	+1.9	▼7	+6.4	▲17	+0.2	▼11	+1.4	▼5	+1.9	▼1	+3.1	▼1
2) Availability	+4.8	▲2	+4.6	▲8	+2.3	▲2	–6.3	▼19	–1.2	▼4	+3.4	▲2
3) Quality and safety	–1.4	▼9	+0.4	▼2	–1.4	▼3	–0.5	▼3	–4.2	▼12	–1.0	▼9
4) Natural resources and sustainability	+13.2	▲50	+14.1	▲12	+10.6	▲11	+9.4	▲3	+9.0	▲3	+13.3	▲13

Rating: 80–100—very good; 60–79.9—good; 40–59.9—moderately; 20–39.9—weak; 0–19.9—very weak.

Source: compiled by the authors based on the Economist Impact.

Table 5. Strengths and weaknesses of Ukraine and selected European countries according to the GFSI in 2021

Indicator	Rating				
	very good (80–100)	good	moderate	weak	very weak
1) Accessibility					
1.1) Change in average food costs	U, UK, N,F	P	–	–	–
1.2) Share of the population below the poverty line	U, UK, N, F, G,P	–	–	–	–
1.3) Inequality-adjusted income index	N, F, G	U, UK, G, P	–	–	–
1.4) Tariffs on imports of agricultural products	–	U, UK, N, F, G, P	–	–	–
1.5) Food security programs	UK, N, F, G, P,	–	U	–	–
1.6) Market access and agricultural financial services	UK, F, G, P	U, N	–	–	–
2) Availability					
2.1) Adequacy of supply	UK, F, N, P	U, N	–	–	–
2.2) Agricultural research and development	–	–	UK, G, P	U, N, F	–
2.3) Agricultural infrastructure	N, F	UK, G	U, P	–	–
2.4) Instability of agricultural production	–	U, UK, N, P	G	F	–
2.5) Political and social barriers of access	UK, N, F, G	P	–	U	–
2.6) Loss of food	U, UK, N, F, N, P	–	–	–	–
2.7) Commitment to food safety and access policy	–	–	B,H	–	U, F, G, P
3) Quality and safety					
3.1) Dietary diversity	N	UK, F, G, P	U		
3.2) Nutritional standards	N, F	UK, G	U, UK, P		

Table 1 continued

Indicator	Rating				
	very good (80–100)	good	moderate	weak	very weak
3.3) Availability of trace elements	U, UK, N, F, G, P	–	–	–	–
3.4) Protein quality	U, UK, N, F, G, P	–	–	–	–
3.5) Safety of food products	U, UK, N, F, G, P	–	–	–	–
4) Natural resources and sustainability					
4.1) Exposition Availability?	G	N, P	U, UK, N	–	–
4.2) Water	–	UK, N	–	F, G	U, P
4.3) Land	N, P	U, UK, N, F	–	–	–
4.4) Oceans, rivers and lakes	–	–	UK	F	U, N, G, P
4.5) Sensitivity	U, UK, F, N, P	–	H	–	–
4.6) Political commitment to adaptation	UK, N, F, G, P	–	U	–	–
4.7) Demographic stress	U, UK, N, F, G, P	–	–	–	–

Notes: grey cells – the level occupied by Ukraine.

U—Ukraine, UK—United Kingdom, N—Netherlands, F—France, G—Germany, P—Poland.

Source: based on data from the Economist Impact.

The agricultural infrastructure is unsatisfactory due to the lack of a fully-fledged agricultural market and an effective network of wholesale markets of agricultural products, an unrealized potential of agricultural service co-operation, insufficient level of technical support by laboratories for product quality control of the process of realization of agricultural products through fairs, underdeveloped channels for realization of agricultural products and an imperfect logistic' infrastructure. The transport infrastructure of Ukraine was sufficient to satisfy the basic needs of the economy. Although during 2019–2021 the amount of investments in road construction projects increased five times (from UAH 21.3 billion to UAH 106 billion respectively) (Gmyrin, 2022; Oliinyk et al., 2021). In 2021 quality and service, transportation efficiency, energy efficiency, safety level, environmental impact did not meet modern

requirements as evidenced by the low integral indicator of the infrastructure index (2.76 points out of 5 possible) (Infrastructure index of the European Business Association, 2021). Port infrastructure is characterized by problems with the concentration of cargo flows, underdevelopment of container and multimodal logistics infrastructure.

In addition, Ukraine has a high level of corruption and risks related to political stability as well as inadequate implementation of food security and access policy commitments. According to the rating component—food quality and safety—Ukraine dropped by nine points and took 55th place in particular due to unsatisfactory levels of diet diversity. This means a significant share of products that contain crumb (except cereals, root crops, and potatoes) and compliance with nutritional standards.

Before the war Ukraine embarked on a path to strengthen national food security: in 2021 it joined the UN Committee on World Food Security. For the first time in history the International Grains Council was headed by a representative of Ukraine. An action plan was developed to transform food systems in Ukraine by 2030.

The military actions of the Russian Federation on the territory of Ukraine have had a negative impact on the functioning of its food systems: integral supply chains of agricultural and food products were disrupted and thus activities related to the creation of added value in the agricultural sector; the sowing campaign was interrupted in the regions where most of the wheat is grown—Kharkiv, Odessa, Zaporizhzhia (30% of the sowing areas). The export of Ukrainian products to foreign markets is complicated due to the blockade of Ukrainian ports. Before the war 60% of agricultural products were exported by sea including up to five million tons of agricultural products through the ports of Odessa and Mykolaiv. Therefore, against the background of limited supply on the world market serious threats have also arisen in global food security with a sharp further increase in food prices and the risk of a global jump in inflation in countries with underdeveloped economies (the Middle East and North Africa). Thus, the average value of the grain price index in March 2022 was 170.1 points which was 17.1% higher than in February (Figure 1) and reached its maximum level since 1990. The average values of the oil and meat price indexes in March 2022 also reached record levels of 248.6 and 120 which are 23% and 4.8% higher than at the beginning of the invasion.

Ukraine is traditionally one of the leaders in the production and export of wheat—the most important universal food and fodder product (Table 6). During the studied period the country's exports increased almost twofold and and amounted to 32.2 million tonnes, i.e. 4.7% of the global trade which allowed the country to take 4th place after the USA (17.9%), the EU (9.8%) and Canada (5.8%). The country's exports of wheat to the international market increased 3.4 times and amounted to 10% of the world's supply while the export quota increased 2.7 times and in 2021 amounted to 59%. Similar dynam-

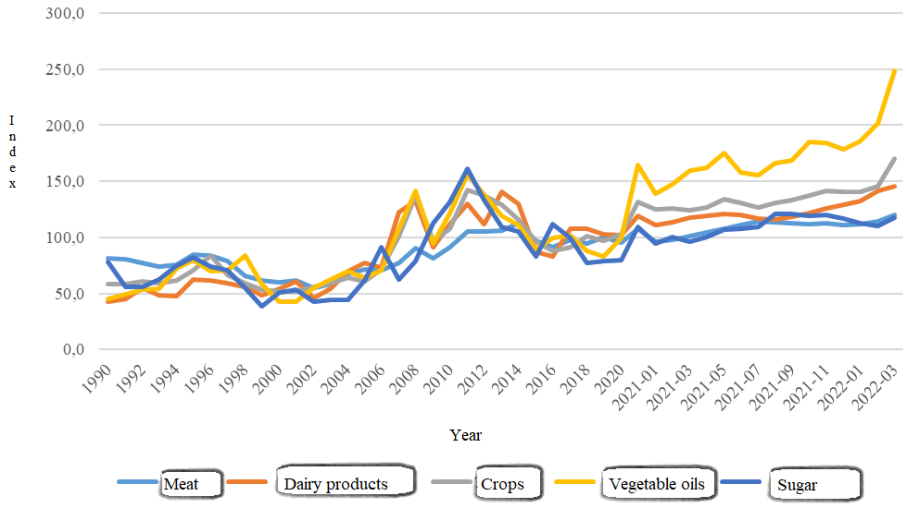

Figure 1. Dynamics of the food price index in the world in 1990–2022 (2014–2016 = 100)

Source: based on FAO data.

ics were observed only in India and Russia who increased their export share in the global market by 26 and 5.3 times and increased their export quota by 22.8 and 4.3 times, respectively (Dutchak et al., 2020).

Countries which are dependent on the import of Ukrainian wheat as evidenced by the share of their imports in the total supply were in critical condition even before the war and the blocking of exports from Ukraine, taking into account their weak positions in the global food security rating, means that they suffer the most from an increase in the world wheat prices (Table 6). The largest competitor of Ukraine in this market is the Russian Federation.

At the beginning of the war the government of Ukraine approved and began implementing the Plan to Ensure Food Security of the State under Martial Law which provides monitoring by the state of food security and agricultural infrastructure in general. Additionally, it provides support to food producers, targets assistance to socially vulnerable categories of the population and exerts centralized control over food prices. Under the conditions of the liquidity crisis in the agricultural sector of Ukraine and as a result of the delay in the export of the harvest in 2021 due to the blocking of the state's maritime transport infrastructure the Ministry of Agrarian Policy and Food of Ukraine introduced the mechanism for providing state guarantees to agricultural producers for the implementation of spring field work (the total need is 100 billion hryvnias). Support is offered primarily for small and medium-sized agricultural producers with a turnover of no more than 20 million euros per year (equivalent to an enterprise which cultivates up to 10,000 hectares). The aid encompasses compensation for the interest rate on loans of up to 50 million

Table 6. Import of wheat from Ukraine and its main competitors in 2020

Importer	GFSI value (rating)	Share of wheat imports by countries in 2020, %							
		Ukraine	Russian Federation	Canada	USA	Australia	Argentina	Kazakhstan	Turkey
Belarus	70.9(36)	7.2	88.4	0.0	0.0	0.0	0.0	0.0	0.0
Egypt	60.8(62)	32.1	64.1	0.4	0.5	3.0	0.0	0.0	0.0
Greece	73.3(27)	8.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Indonesia	59.2(69)	26.4	0.0	22.4	11.7	9.3	22.7	0.0	0.0
Israel	78(12)	18.0	34.8	4.7	0.0	0.0	0.0	0.0	0.0
Jordan	64.6(49)	29.3	38.3	0.0	0.0	0.0	0.0	0.0	0.0
Kazakhstan	69.2(41)	0.0	82.6	0.0	0.0	0.0	0.0	0.0	0.0
Malaysia	70.1(39)	28.4	3.8	11.1	22.5	32.7	0.0	0.0	0.0
Morocco	62.5(37)	17.2	7.7	19.8	0.0	0.0	0.0	0.0	0.3
Myanmar	56.7(72)	10.2	0.0	5.1	24.6	50.9	0.0	0.0	0.0
Pakistan	54.7(75)	50.0	47.1	0.0	0.0	0.0	0.0	0.0	0.0
Philippines	60(64)	9.4	8.2	4.2	49.9	10.9	1.6	0.0	0.0
Qatar	73.6(24)	69.2	39.7	0.0	0.2	11.6	0.0	0.0	0.0
Saudi Arabia	68.1(44)	8.3	31.9	0.0	0.0	9.2	0.0	0.0	0.0
South Africa	57.8(70)	2.7	25.0	6.7	3.4	0.0	0.0	0.0	0.0
Spain	73.6 (24)	9.0	0.5	2.2	0.9	0.0	0.0	0.0	0.0
Sri Lanka	54.1(77)	8.2	29.6	35.3	9.9	3.4	0.0	0.0	–
Switzerland	80.4(5)	2.3	10.2	0.0	0.0	0.0	0.0	0.3	0.0
Thailand	64.5(51)	18.2	10.1	9.2	22.4	11.2	17.4	0.0	0.0
Tunisia	62.7(55)	49.2	5.6	16.3	1.5	0.0	0.0	0.2	–
Turkey	65.1(48)	12.4	21.5	4.7	0.0	0.0	0.0	0.1	0.0
UAE	71(35)	0.6	38.6	17.0	2.4	10.9	0.0	0.0	0.0
Vietnam	61.1(61)	8.5	14.8	8.0	16.9	30.2	6.8	0.0	0.0

Notes: * "-" – no data available.

Source: calculated by the authors on the basis of the State Statistics Service of Ukraine, Economist Impact, UN Cometrade.

UAH and lending for up to six months (for carrying out agricultural activities (sowing) during the period of martial law). The maximum amount of the state guarantee for portfolio loans has been established up to 80% (Cabinet of Ministers of Ukraine, 2022).

In order to simplify the procedures and facilitate the sowing campaign during martial law additional seed certification procedures were cancelled. A producer is allowed to operate agricultural machines without their registration. Online platforms were created to collect the actual needs of agricultural producers during sowing operations and to improve the logistics routes of agrarians under martial law.

The world community quickly reacted to the worsening of the food security crisis in Ukraine as a result of the war. On March 24, 2022 the UN General Assembly adopted the resolution "Humanitarian consequences of the aggression against Ukraine" which expressed concern about the impact of the war on food security on a global scale. The EU as a major producer and net exporter of agricultural products introduced the programme of emergency support for Ukraine's food security and compensation for the consequences of the war to the amount of 330 million euros (AgroPolit, 2022). Assistance was provided for the planting and cultivation of grain and oil crops in order to ensure both domestic needs for food products and maintaining the level of export potential of Ukrainian producers. At the same tim , the EU initiative contributed to the food security of North Africa and the Middle East, Asia and sub-Saharan Africa which depend on Ukrainian grain imports.

In order to overcome obstacles to the export of Ukrainian food, primarily grain and to create "solidarity routes", the European Commission together with interested parties promotes the implementation of the following measures: provision of additional rolling stock, ships and trucks to Ukrainian exporters by EU market participants, the creation of a logistics platform for finding partners ensuring the priority of export of Ukrainian agricultural products by increasing the capacity of transport roads and transshipment terminals, implementation of the agreement on road transport with Ukraine, ensuring maximum flexibility and sufficient staff to speed up customs clearance procedures at checkpoints, increasing capacities for temporary storage of Ukrainian export goods on the territory of the EU, increasing the carrying capacity of the infrastructure of new export corridors and relevant connections in the context of the reconstruction of Ukraine. In order to support the Ukrainian exporters of agricultural products the EU suspended the application of the input price system for fruits and vegetables and cancelled the tariff quotas for these goods for the year starting from June 4, 2022.

Thanks to the signing of the Istanbul Agreement on the export of Ukrainian grain by Ukraine on July 22, 2022 with Turkey and the UN and their mirror agreement with the Russian Federation which identified the ports of Pivdennoho, Odessa and Chornomorsk as key for the export of Ukrainian cargo

22 days after the start of the "grain corridor" (August 1, 2022) 33 ships with 719.5 thousand tons of agricultural products left Ukrainian seaports (Ministry of Agrarian Policy and Food of Ukraine, 2022; Zharykova, 2022).

The FAO in coordination with the Government of Ukraine has developed and is currently implementing a Rapid Response Plan for the deterioration of the food security situation in Ukraine and the limited availability of important agricultural resources (including seeds, fertilizers, pesticides, equipment, fuel and livestock supply) which arose as a result of a combination of material, technical and financial factors. It provided financial assistance to small and medium-sized farms in Ukraine for the period up to December 2022 to the amount of $115.4 million, which is necessary for 376,660 households (979.320 people) (FAO, 2022).

4. Discussion

The study provides an analysis of the impact of the COVID-19 pandemic and the Ukraine–Russia war on food security and nutrition. The global trends in food consumption and production are taken into account. The analysis reveals a significant increase in the number of undernourished people worldwide during the pandemic despite overall economic growth and which has worsened as a result of the war. The disruptions in agricultural activities and the challenges faced by farmers in accessing markets and inputs have contributed to reduced food availability (Nascimento et al., 2019).

The study also highlights the uneven distribution of undernourished people, with Africa experiencing the highest prevalence of malnutrition. It further emphasizes the negative consequences of insufficient nutrition including the increasing prevalence of overweight children and anaemia among women of reproductive age. However, there are positive trends in access to safe drinking water, sanitation services and a decrease in stunted growth among children except for North America. The analysis of Ukraine's food security indicators points to a slight gap with global and European averages as well as significant differences within developed European countries and agribusiness market competitors.

The results indicate that economic growth alone is not sufficient to address food insecurity and malnutrition. Despite an increase in global GDP per capita the COVID-19 pandemic has led to a significant increase in the number of undernourished people worldwide. This is attributed to the disruptions in food systems including production, distribution and access caused by containment measures and supply chain disruptions. The study underscores the importance of comprehensive strategies to address the food security and nutrition con-

sequences of the pandemic. It also highlights the need for efforts to improve self-sufficiency in critical food products, enhance domestic production and address gaps in access to safe drinking water and sanitation services.

The findings have important implications for global food security and public health. The increase in the number of undernourished people during the pandemic poses a significant threat to the well-being of populations and future generations. Insufficient nutrition contributes to health issues such as overweight children and anaemia among women of reproductive age which can impact economic growth and international competitiveness. The uneven distribution of undernourished people, with Africa experiencing the highest prevalence, calls for targeted interventions and support in those regions. The study highlights the urgent need for comprehensive strategies that ensure access to nutritious food, strengthen social protection systems and support agricultural activities and livelihoods to address the food security and nutrition challenges exacerbated by the COVID-19 pandemic.

Conclusions

The results of the analysis for 2010-2021 show the following trends. The population growth in all regions of the world which is expected to continue in the future is accompanied by an increase in food consumption of primarily cereals, meat and vegetable and animal fats primarily used for nutritional purposes. The rise in global malnutrition is due to the intensification of the main negative factors (climate change and slower economic growth) as a result of the global COVID-19 pandemic amid deepening regional food inequality. Growing import dependence primarily on bread and bakery products, vegetable and animal fats ensures that the population of all regions of the world meets the rational daily nutrition standards while eggs, potatoes, meat, and dairy products are consistently in short supply; all regions of the world except Africa have significant resource potential for food security.

Ukraine is behind the world and European averages in some of the indicators of food security. There is also a significant difference with respect to the indicators of food security among the developed European countries. Despite the persistence of a long-term trend of food insecurity except for vegetable oils, bread and bakery products, the food needs of Ukrainian and European population are met mainly through domestic production. Despite the significant export potential of Ukraine's agro-industrial complex the foundation of internal security can be strengthened if the reforms of national legislation in the area of state control over food quality are completed. They include: increased funding for production, research and development in agriculture,

development of agricultural infrastructure, reduction of corruption and risks associated with political stability, fulfilment of food security commitments and access policies.

In order to minimize the manifestations of the global food crisis as a result of the war of the Russian Federation against Ukraine it is necessary to concentrate the efforts of the world community on the long-term effective support and protection of the agro-industrial complex of Ukraine. There is a need to intensify cooperation with international and intergovernmental organizations regarding the restoration of global value chains. It will also contribute to the reliable provision of food to the population of Ukraine.

While the study provides valuable insights into the impact of the COVID-19 pandemic and the Russia-Ukraine war by showing the production trends on food security and nutrition there are limitations to consider. The analysis is based on available data and indicators which may have inherent limitations and potential measurement errors. The study focuses on macro-level trends and may not capture specific local or regional variations in food security and nutrition. Moreover, the analysis does not explore the specific socio-economic and cultural factors that contribute to food insecurity and malnutrition. Further research and data collection efforts are needed to gain a more nuanced understanding of these factors and their impact on food security.

The study highlights several avenues for further studies. First, there is a need for more research on the socio-economic and cultural determinants of food security and nutrition particularly in regions experiencing high levels of malnutrition. Understanding the specific drivers of food insecurity can encourage targeted interventions and policy measures. Second, future studies could explore the long-term impacts of the COVID-19 pandemic on food systems and the effectiveness of various strategies implemented to mitigate these effects. This can provide valuable insights for preparedness and response measures in future crises. Additionally, further analysis is warranted to assess the effectiveness of current efforts to improve access to safe drinking water, sanitation services and to reduce stunted growth among children. Evaluating the impact of these interventions can guide future policies and programmes aimed at improving health outcomes and reducing malnutrition. Prospects for further research encompass also the investigation of internal factors of food security in Ukraine under the influence of the COVID-19 pandemic and the devastating consequences of the large-scale Russian invasion.

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Spatial interactions in local public debt. Evidence from Poland

Monika Banaszewska[1]

Abstract

The aim of the paper is to investigate spatial interactions among the debt of 2,442 municipalities in Poland over the period 2005–2020. Using the dynamic spatial Durbin model with two-way fixed effects, it provides empirical evidence of positive spatial interactions. It is estimated that an increase in debt per capita in a given municipality by PLN 100 is related to an increase in the debt per capita in neighbouring municipalities by PLN 8–10. The result is robust to the various specifications of spatial weight matrix (contiguity vs. inverse-distance with a cut-off). It is also found that municipal debt in Poland suffers from high persistence over time. Keywords: municipalities, dynamic spatial Durbin model, debt persistence.

Keywords

- municipalities
- dynamic spatial Durbin model
- debt persistence

JEL codes: H74, H77

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Introduction

Spatial interactions among local budgetary policies are predicted using various causal mechanisms. The main lines of argumentation include fiscal competition, yardstick competition and the spill-over hypothesis. The first hypothesis attributes co-movements in fiscal decisions to inter-municipal competition for mobile capital and labour (Agrawal, 2015; Janeba & Todtenhaupt, 2018; Wilson, 1999). The second one ascribes spatial interactions to political competition. Tax burden, the scope and quality of local public services, etc. in neighbouring municipalities constitute a 'yardstick' by which to assess the performance of authorities in a given municipality (Besley & Case, 1995; Dubois & Paty, 2010; Ferraresi, 2021). According to the latter, local activities that create external effects either lessen or strengthen the need for specific actions in neighbouring municipalities (De Siano & D'uva, 2017; Ferraresi et al., 2018; Ogawa & Wildasin, 2009).

There is an abundance of empirical studies documenting spatial interactions with respect to local taxes and local expenditures (for a recent review please consult: Agrawal et al., 2022). They fail to provide a comprehensive picture of local competition if municipalities are eligible to incur debt (Borck et al., 2015). Yet, while there are numerous studies on internal (e.g., demographic structure) and external (e.g., legal constraints) drivers of municipal debt, the spatial context of debt issuance is largely ignored (Balaguer-Coll et al., 2016; Działo et al., 2019; Ehalaiye et al., 2017; Navarro-Galera et al., 2017). This research gap calls for further empirical analyses also because of the fact that sustainable debt is key for the sustainable local public finance (Bröthaler et al., 2015; Fan & Lv, 2012; Uryszek, 2018). Local public debt is without doubt of concern to fiscal policymakers in the European Union as numerical fiscal rules that directly or indirectly limit subnational public debt are in force in 21 out of 27 Member States (as of the year 2022) (European Commission, n.a.), including Poland, whose municipalities are the object of this study. Additionally, the strength of spatial interactions offers indirect evidence of whether the issue of soft budget constraints should be a concern. If municipal authorities predict to obtain central government aid in case of financial problems, they more eagerly engage in fiscal competition so one should expect a high spatial coefficient on debt (Borck et al., 2015). The contribution of this paper to the existing literature is twofold. First, the paper adds to an emerging strand in the empirical literature on spatial interactions concerning debt (Germany: Borck et al., 2015; Spain: Balaguer Coll & Toneva, 2019; China: Han et al., 2022; Liu et al., 2022). Second, it accounts for the extension of preliminary spatial analysis for Poland by Kopańska and Kopyt (2018), who employed cartograms, Moran I statistics and tools to identify hot (cold) spots with respect to municipal debt.

Poland is a suitable testing ground. First, there is uniform fiscal legislation with respect to local deficit and public debt. Second, Polish municipalities actively utilise their right to incur debt. As an illustration, in the period under study (the years 2005–2020) there were fewer than 4% municipality–year observations with debt equal to zero. On average, in the period mentioned, debt accounts for 23.8% of municipal revenues.

The structure of paper is as follows. Section 1 reviews the existing theoretical and empirical literature. Section 2 introduces the institutional background. Then, in Section 3 data, methods and research hypotheses are described. Section 4 presents the results of empirical analysis and a discussion. Finally, some concluding remarks are presented in the Conclusions.

1. Literature review

Basically, debt (stock variable) is the sum of previous deficits (flow variable). Nevertheless, in practice, this relationship is much more complex and is modified *inter alia* by foreign exchange fluctuations and higher-tier government bailouts. The previous literature documents numerous determinants of local public debt, which are summarized in Figure 1. They include both internal and external factors. The former factors include, for instance, revenue

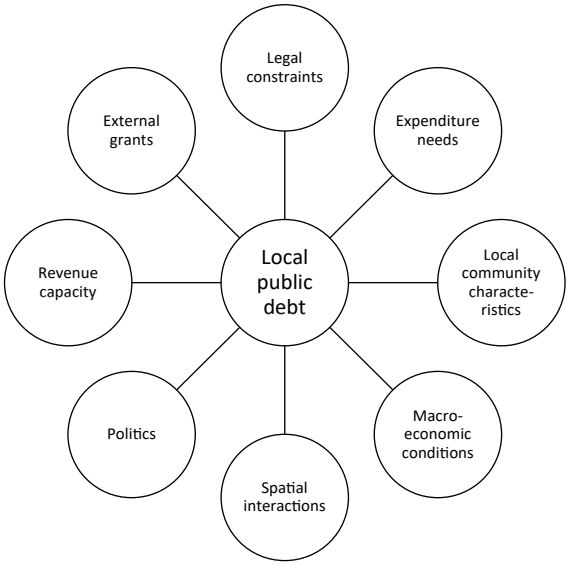

Figure 1. The overview of determinants of local public debt

Source: own work on the basis of (Balaguer-Coll et al., 2016; Działo et al., 2019; Ehalaiye et al., 2017; Navarro-Galera et al., 2017).

capacity and local community characteristics, whereas the latter encompass macroeconomic conditions and external grants, among others. Figure 1 shows that they are not limited to fiscal and economic determinants since budgetary decisions are made by politicians, who intend to maximise their voter support and/or maximise local community well-being.

Although the impact of demographic, fiscal, socio-economic and political determinants has to be kept in mind, the focal point of the analysis in this current paper are interactions among neighbouring municipalities with respect to debt. Hence, it is advisable to discuss possible underlying mechanisms. According to the hypothesis of fiscal competition, local government units try to attract mobile capital and labour with the use of lower taxes and/or extra expenditures (Agrawal, 2005; Janeba & Todtenhaupt, 2018; Wilson, 1999). Consequently, one can expect (at least in the short term) a positive spatial correlation with respect to municipal debt. Another explanation of spatial co-movements in fiscal policies is provided by the hypothesis of yardstick competition. This hypothesis is formulated under the assumption according to which the aim of local authorities is to maximize the probability of re-election. Since there are no absolute measures to assess the incumbent's performance, the situation in neighbouring municipalities serves as a "yardstick" to voters considering whether to support the incumbent. Knowing that local politicians mimic tax cuts and expenditure increases in neighbouring municipalities (Besley & Case, 1995; Dubois & Paty, 2010; Ferraresi, 2021). Despite different incentives, the effect in the form of spatial debt interactions is the same as in the case of fiscal competition. The positive spatial co-movements of municipal debt are predicted. The third line of argumentation ascribes spatial co-movements in budgetary variables to external effects. This time the sign of respective spatial coefficient is not unambiguous as fiscal decisions in a given municipality may either lessen or strengthen the need for specific actions in neighbouring municipalities depending on the type of external effect: positive or negative (De Siano & D'uva, 2017; Ferraresi et al., 2018; Ogawa & Wildasin, 2009).

There are only a few studies closely related to the topic of this paper. They deserve a review in more detail. Borck et al. (2015) analyse the spatial interactions with respect to local debt using the sample municipalities in the two largest German states, Bavaria and North Rhine-Westphalia, in the years 1999–2006. They employ various analytical tools: the panel spatial lag (SAR) model, the panel spatial Durbin model with FE, and the dynamic panel spatial Durbin model with FE. Their main finding is that spatial coefficient ranges from 0.16 to 0.33. An analogous research question is addressed by Balaguer Coll and Toneva (2019). This time the subjects of the analysis are municipalities located in the Valencian Community (Spain) in the year 2015. Since the dataset encompasses a single year, the set of regressions includes S2SLS and spatial lag (SAR) models. The estimation of the spatial coefficient (0.30–0.32)

is coherent with the upper bounds in the paper by Borck et al. (2015). Despite the different research sample and analytical approach, the estimations point to a fairly similar strength of the identified spatial relationship. According to these papers, an increase in debt in a given municipality by 1 EUR translates into a debt higher, on average, by 0.16–0.33 EUR in neighbouring municipalities. As for non-European research samples, Han et al. (2022) investigate spatial interdependencies in bond issuance among Chinese prefectural-level cities'. The estimate for the respective spatial coefficient is far below those determined for European municipalities, as it amounts to 0.08. Another study on Chinese subnational government units is that by Liu et al. (2022), who investigated provincial debt in China in the period 1999–2016. In contrast to previously mentioned studies, in their paper a log-log model is adopted. It is estimated that an increase in per-capita debt by 1% causes per-capita debt in neighbouring provinces to increase by 0.1–0.5%.

It is also worth mentioning a preliminary study in this field conducted by Kopańska and Kopyt (2018). As in the current paper, their analysis encompasses all Polish municipalities, albeit over a shorter time span (the years 2006–2016 versus the years 2005–2020). The analytical tools employed by Kopańska and Kopyt (2018) are static and descriptive, including cartograms, Moran I statistics and the identification of hot/cold spots. The research results can be summarized as follows: there is a positive spatial correlation in municipal debt; hot-hot spots are located mainly in western and northern Poland; cold-cold spots—in central and eastern Poland.

The bottom-line result emerging from the existing literature is that municipalities follow their neighbours in debt issuance. At the same time, one should not lose sight of a wide array of other possible drivers of local public debt originating from both a given subnational government and its neighbours.

2. Institutional background

Municipalities are fundamental to the functioning of three-tier local government in Poland[2]. Just to illustrate, they hold an 80% share in overall local government spending. They are responsible for numerous services crucial for the everyday life of their inhabitants, such as water supply, primary schooling and local roads.

Polish municipalities are allowed to incur debt for the sake of their investment projects. At the same time, they cannot go bankrupt. Debt which cannot be paid back by a local government unit is taken over by the State Treasury.

[2] As of 2023, there are 16 voivodeships, 314 counties and 2,477 municipalities.

This creates a clear incentive to neglect revenue collection, overspend and incur excessive municipal debt (Kornai et al., 2003). Hence, there are centrally mandated limits on municipal deficit and debt. They fall into two main categories: quantitative and qualitative. As for the former group, in the period 1999–2013, all local government units were subject to uniform thresholds: debt-to-revenues ratio not exceeding 60% and debt-repayments-and-debt--service-to-revenues ratio no higher than 15%. Since 2014, they have been replaced with an individual indebtedness limit, which serves as proxy for debt repayment capacity. The scope for borrowing has been linked to the ratio of current surplus to municipal revenues in the past. Initially, the individual indebtedness limit was based on three-year budgetary averages, and starting from 2020, this period has been prolonged to seven years.

There are also a few qualitative rules: the golden fiscal rule (which has become binding in 2011), the obligation to service debt at least once a year, the ban on foreign currency debt (with some exemptions), the rule that discounts on debt instruments cannot exceed 5% of their nominal value, and the ban on interest capitalization. Supervision of debt issuance and adherence to relevant fiscal rules is performed by specialised central government bodies (the Regional Audit Chambers) (Act, 2009; Banaszewska, 2018; Galiński, 2015).

The consequences of breaching deficit and debt rules are varied. In the first step, the municipality is obliged to prepare and execute a restructuring program. If misconduct prolongs and there is no hope for debt recovery, more severe actions take place. The municipal council and/or mayor may be dismissed. The utmost penalty is the dissolution of an excessively indebted municipality[3]. In general, the fiscal rules imposed on Polish sub-national governments are assessed highly and meet the standards outlined in the OECD Recommendation on Budgetary Governance (OECD, 2021). The current paper will provide empirical contribution to the discussion whether debt rules faced by Polish municipalities effectively mitigate the problem of soft budget constraints. As such, it can be of interest for policymakers in other countries.

3. Data, methods and research hypothesis

This paper seeks to verify the existence of spatial interaction with respect to local government units in Poland. The research sample consists of 2,442 out of 2,479 municipalities. The research method necessitates a strictly balanced panel so that some units are dropped due to missing data. The period under

[3] These sanctions are not only *de iure*. As a clear example, one municipality (Ostrowice) was liquidated due to excessive indebtedness (Wichowska, 2019).

research spans from 2005 to 2020. The beginning of this period is consistent with the implementation of local government finance reform.

Building on the existing literature on fiscal and yardstick competition, it is hypothesized that there are positive spatial interactions with respect to debt among Polish municipalities. Additionally, in line with the previous research, a set of demographic, socio-economic, fiscal and political control variables is introduced. This includes population size, squared population size, the share of young inhabitants, the share of old inhabitants, unemployment, revenue capacity, previous vote share and average salary. A description of these variables, along with data sources, is presented in Table 1. Their descriptive statistics and correlation matrix are shown in Table A1 and Table A2 in the Appendix.

Due to an arguable time persistence in debt levels, the regressions control for time-lagged dependent variable. As regards the impact of population size, it is expected that up to a certain population size a municipality benefits from economics of scale and beyond this size congestion costs start to prevail. In order to capture this non-linear relationship, both population size and its squared term are included in the regressions. The high share of young population signals favourable development conditions. In such circumstances, municipal

Table 1. Variable description and data sources

Variable name	Description	Source
Dependent variable		
Debt per capita	per capita municipal debt as of the end of year in constant 2020 prices	Ministry of Finance database
Independent variables		
Population size	the number of inhabitants	Statistics Poland Local Data Bank
Share of young	the share of people under 18 years old in total population	Statistics Poland Local Data Bank
Share of old	the share of people above 60/65 years old (women/men) in total population	Statistics Poland Local Data Bank
Unemployment	the ratio of the unemployed to working-age population	Statistics Poland Local Data Bank
Revenue capacity	revenue index utilized for the sake of vertical and horizontal equalization	Ministry of Finance database
Previous vote share	the share of votes obtained by incumbent mayor in 1st round of previous elections	National Electoral Commission database
Average salary	average monthly gross wages and salary in constant 2020 prices (at county level)	Statistics Poland Local Data Bank

Source: own work.

debt issuance is not only acceptable but even desirable if it finances socially-beneficial investments, for instance, the construction of new kindergartens and the extension of water supply lines. The opposite (negative) relationship with municipal debt is expected with respect to the share of old inhabitants. The logic of an individual indebtedness limit at local level in Poland is that the better is the fiscal stance of a given municipality (its so-called debt repayment capacity), the higher is its permitted debt. Therefore, one may predict that municipal debt per capita increases with municipal revenue capacity. The other two economic variables that indirectly point to the local fiscal situation are unemployment and average salary. The expected relationship between local public debt and unemployment (average salary) is negative (positive). Finally, the empirical model controls for a political variable: the share of votes on the incumbent mayor in the first round of previous elections. It is expected that the incumbent that enjoys higher voted support is less inclined to compete for votes with the use of lax budgetary policy which points to a negative coefficient on the respective control.

The fiscal variables presented in Table 1 were retrieved from the Ministry of Finance database (Ministry of Finance, n.a.), demographic and socio-economic data come from the Statistics Poland Local Data Bank (Statistics Poland, n.a.) and the political variable is taken from the National Electoral Commission dataset (National Electoral Commission, n.a.). As Table 1 shows, for the sake of comparability across units and over time, the dependent variable (debt) is expressed as per capita municipal debt (in PLN) at the end of year in constant

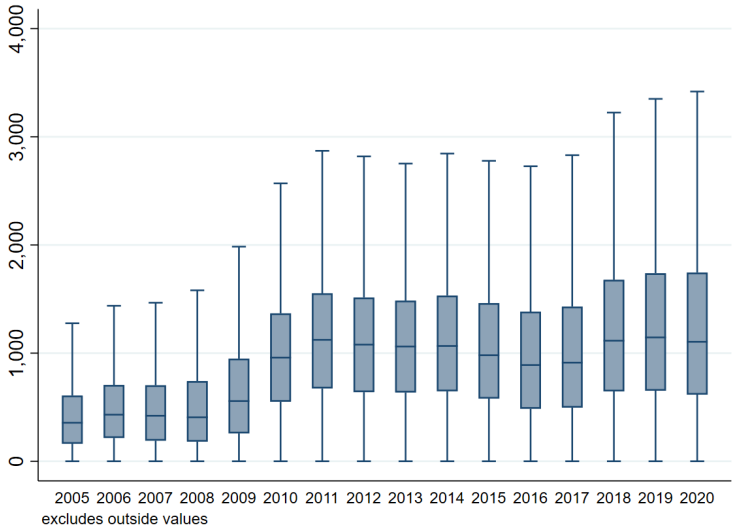

Figure 2. Municipal debt per capita in the years 2005–2020 (in PLN, in constant 2020 prices)

Source: own work.

2020 prices. The correction for inflation also applies to the average salary. It is the sole variable that varies only at county level.

As can be seen in Figure 2, the years 2005–2020 saw a general upward trend with respect to debt per capita (in constant 2020 prices) over the period under analysis. Along with the growing average indebtedness level, there was an increase in its dispersion. Figure 2 also points to disproportionate hikes in debt per capita in the years 2010 and 2018. The political economy explanation for these hikes is not fully credible, as municipal elections took place not only in 2010 and 2018 but also in 2006 and 2014.

In order to get a spatial overview, Figure 3 presents an average municipal debt per capita in the years 2005–2020. There is a considerable spatial variation with respect to the variable of interest. The incidence of relatively highly indebted municipalities is disproportionately high in north-western Poland. The visual inspection of Figure 3 also suggests the existence of some cold-cold and hot-hot spots, which are identified analytically by Kopańska and Kopyt (2018). On average, municipalities in north-western Poland are relatively rich so that, in line with the logic of individual indebtedness limit, they are allowed to incur more debt. It seems that richer municipalities make use of the extra fiscal space mandated by law. This tentative claim finds support also in correlations between municipal debt per capita and proxies of its budget (economic) stance (i.e. revenue capacity, unemployment, average salary). As can be seen in Table A2, municipal debt is positively related to revenue capacity and average salary. The opposite sign is documented for a correlation with the share of the unemployed in working-age population.

The dynamic spatial Durbin model with fixed effects is employed to make it possible to simultaneously account for spatial and time lags in the dependent variable, spatial lags in the independent variables, and also unobserved individual and time effects. The data is transformed according to the method described by Lee and Yu (2010). Dynamic model is preferred to the static version since debt is a stock variable. Its value in a given year depends heavily on the previous year's level. Estimations are performed with the use of the Stata xsmle command. The empirical model has the following form:

$$y_{it} = \tau\, y_{it-1} + \lambda \sum_{j=1}^{N} w_{ij} y_{jt} + \beta\, x_{it} + \theta \sum_{j+1}^{N} w_{ij} x_{jt} + u_i + \varphi_t + \varepsilon_{it}$$

where:

y_{it-1} – time-lagged dependent variable,

w_{ij} – elements of weight matrix,

$\sum_{j=1}^{N} w_{ij} y_{jt}$ – linear combinations of space-lagged dependent variable,

x_{it} – vector of independent variables,

$\sum_{j+1}^{N} w_{ij} x_{jt}$ – linear combinations of space-lagged independent variables
u_i – individual fixed effects,
φ_t – time-fixed effects,
ε_{it} – error term.

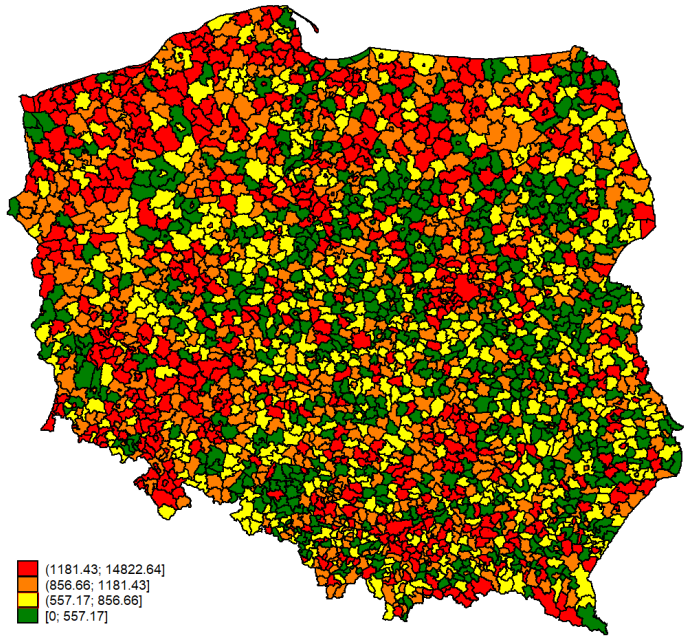

Figure 3. Average municipal debt per capita in the years 2005–2020 (in PLN, in constant 2020 prices)

Source: own work.

The key element of any spatial regression analysis is to define neighbouring municipalities. In the baseline approach, municipalities sharing a common border are treated as neighbours. In the alternative approach, the distance between the centroids of neighbours should not exceed a given threshold. In the current paper, three forms of spatial weight matrices are employed:

- contiguity binary row-normalized weight matrix,
- inverse-distance row-normalized weight matrix with a cut-off of 20 km,
- inverse-distance row-normalized weight matrix with cut-off of 25 km.

In the first spatial weight matrix (contiguity binary weight matrix), all neighbours are given equal weights. The weights in the second and third type of spatial weight matrix (inverse-distance weight matrix) are inversely related to the distance between municipal centroids. If this distance exceeds the 20 (25) km

threshold, the weight equal to zero is assigned. As a result of row-normalization, the sum of weights for given municipality's neighbours equals 1.

4. Results and discussion

The spatial Durbin model nests the spatial autoregressive model (SAR) and spatial error (SEM) models. Likelihood ratio (LR) tests are utilized to determine the most appropriate specification among the three models mentioned. They verify as to whether the spatial Durbin model can be simplified to the spatial autoregressive model (H_0: $\theta = 0$; H_1: $\theta \neq 0$) or spatial error model (H_0: $\theta + \rho\beta = 0$; H_1: $\theta + \rho\beta \neq 0$) (Elhorst, 2010; LeSage & Pace, 2009). The results of these tests are displayed in Table 2.

Table 2. Comparisons between SAR, SEM and SDM model specifications

Comparison	Test statistics	Choice
Contiguity binary row-normalized weight matrix		
SAR vs. SDM H_0: $\theta = 0$; H_1: $\theta \neq 0$	$\chi^2 = 24.19^{***}$ (0.001)	SDM is preferred
SEM vs. SDM H_0: $\theta + \rho\beta = 0$; H_1: $\theta + \rho\beta \neq 0$	$\chi^2 = 25.22^{***}$ (0.001)	SDM is preferred
Inverse-distance row-normalized weight matrix (cut-off: 20 km)		
SAR vs. SDM H_0: $\theta = 0$; H_1: $\theta \neq 0$	$\chi^2 = 26.49^{***}$ (0.000)	SDM is preferred
SEM vs. SDM H_0: $\theta + \rho\beta = 0$; H_1: $\theta + \rho\beta \neq 0$	$\chi^2 = 28.90^{***}$ (0.000)	SDM is preferred
Inverse-distance row-normalized weight matrix (cut-off: 25 km)		
SAR vs. SDM H_0: $\theta = 0$; H_1: $\theta \neq 0$	$\chi^2 = 30.89^{***}$ (0.000)	SDM is preferred
SEM vs. SDM H_0: $\theta + \rho\beta = 0$; H_1: $\theta + \rho\beta \neq 0$	$\chi^2 = 33.24^{***}$ (0.000)	SDM is preferred

Notes: Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Number of codes: 2,442. Number of observations: 36,630.

SAR – spatial autoregressive model; SEM – spatial error model; SDM – spatial Durbin model.

Source: own work.

First, it was checked whether any of coefficients on spatially lagged independent variables differs from zero. Since the null hypothesis was rejected,

SDM is preferred to SAR. In the second step, it was verified whether spatial relationships are identified only with respect to the error term. Again, the null hypothesis was rejected. It implies the superiority of SDM over SEM. As can be seen in Table 2, the choice of SDM does not change if the contiguity binary weight matrix is replaced with an inverse-distance one, with a 20- and 25-kilometer cut-off, respectively. Summing up, all tests unequivocally point to SDM as the preferable model specification.

The results from baseline regressions are compiled in Table 3. Each row represents estimations of the coefficients on time- and spatially lagged debt per capita with the use of a given specification of spatial weight matrix, respectively: contiguity-binary, inverse-distance with a 20-km cut-off, inverse-distance with a 25-km cut-off. Several observations can be made on the basis of Table 3. First, no matter which spatial weight matrix is employed, there is evidence of strong time persistence in municipal debt. The respective coefficients are statistically significant and slightly smaller than 1. This corroborates the relevance of dynamic specification. Second, the coefficients on space-lagged dependent variables are much lower in absolute values, as they do not exceed 0.1. Still, in all regressions they turn out to be statistically significant. This result supports our research hypothesis, according to which there is a spatial interaction with respect to debt among municipalities in Poland. Third, the estimated regressions explain the vast majority (approximately 70%) of variations in municipal debt per capita in the years 2005–2020.

Table 3. Main regression results for municipal debt per capita

Spatial weight matrix	Time lagged debt per capita	Space lagged debt per capita	Controls	Year FE	Unit FE	*R* squared
Contiguity binary row-normalized	0.902*** (0.00771)	0.0765*** (0.0107)	YES	YES	YES	0.737
Inverse-distance row-normalized (cut-off: 20 km)	0.902*** (0.00768)	0.0770*** (0.0150)	YES	YES	YES	0.745
Inverse-distance row-normalized (cut-off: 25 km)	0.901*** (0.00771)	0.0978*** (0.0166)	YES	YES	YES	0.736

Notes: Robust standard errors in parentheses. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Number of codes: 2,442. Number of observations: 36,630.

Source: own work.

Control variables also deserve a comment. It is important to stress that the coefficients on spatially and time-lagged control variables cannot be interpreted directly. Therefore, a set of simulations was run to determine respective long-run, short-run, direct, indirect and total effects in the model em-

ploying the contiguity weights matrix. The results are summarised in Table 4. Surprisingly, the significant effects are identified only in a few instances.

Table 4. Short-run and long-run effects of control variables on municipal debt per capita

Variables	Short-run direct effect	Short-run indirect effect	Short-run total effect	Long-run direct effect	Long-run indirect effect	Long-run total effect
Population size	–0.00428 (0.00440)	0.000202 (0.00436)	–0.00408 (0.00563)	–0.0515 (0.0542)	–0.136 (0.354)	–0.187 (0.388)
Squared population size	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Share of young	7.994* (4.178)	3.290 (5.633)	11.28* (5.812)	103.5** (47.60)	392.5 (401.8)	496.0 (423.8)
Share of old	0.546 (2.789)	–14.28*** (4.712)	–13.73*** (4.948)	–26.16 (35.79)	–579.0 (558.2)	–605.1 (578.4)
Unemployment	1.145 (3.347)	0.414 (4.525)	1.559 (2.287)	14.56 (33.21)	44.08 (248.2)	58.64 (254.8)
Revenue capacity	0.0113 (0.0112)	0.0229** (0.0112)	0.0342** (0.0150)	0.186 (0.140)	1.233 (1.272)	1.418 (1.354)
Previous vote share	0.0383 (0.228)	–0.494 (0.318)	–0.455 (0.308)	–0.578 (2.603)	–16.86 (28.07)	–17.44 (29.23)
Average salary	0.0622 (0.0395)	–0.0682 (0.0469)	–0.00600 (0.0216)	0.590 (0.381)	–0.806 (1.615)	–0.215 (1.580)

Notes: Robust standard errors in parentheses. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Number of codes: 2,442. Number of observations: 36,630.

SR – short-run; LR – long-run.

Source: own work.

As can be seen in Table 4, in the short run both the share of young inhabitants and revenue capacity are found to increase the level of municipal debt. The opposite is true for the share of old inhabitants. This implies that municipalities in an area characterised by favourable fiscal and demographic conditions are more willing to cover their expenditures with the use of debt. This observation indicates that local fiscal rules in Poland serve their purpose. In line with the logic of individual indebtedness index, there is a positive correlation between debt issuance and debt repayment capacity.

In contrast to the share of young population, the total effects of the share of old population and revenue capacity are driven by spill-over effects. Moreover, the positive impact of the share of young population sustains in the long run, albeit only with respect to a direct effect. In general, it was fo-

und that the socio-economic, demographic, fiscal and political controls does not exert a significant long-run effects on municipal debt.

Conclusions

The paper analyses spatial interactions among Polish municipalities. The research hypothesis of the existence of spatial local debt interactions has found empirical support. It has been documented that spatial interactions in Poland are not limited to tax policies. The empirical analysis shows that debt spatial interactions are statistically significant. It is estimated that increasing debt per capita in a given municipality by PLN 100 is related to an increase in the debt per capita in neighbouring municipalities by PLN 8–10. This result remains relatively stable, no matter which form of spatial weights matrix is employed (contiguity vs. inverse-distance with a cut-off). Spatial coefficients are comparable to those estimated by Han et al. (2022) for the debt of cities in China, and by Banaszewska (2022) with respect to car tax in Poland, although this is smaller than those estimated for debt in their German or Spanish counterparts, respectively: (Borck et al., 2015) and (Balaguer Coll & Toneva, 2019). There are at least two plausible explanations for this cross-country difference. First, Polish voters are more critical towards the idea of municipal authorities incurring debt. Second, local debt rules in Poland are more effective in curbing excessive municipal spending and/or overly lenient local tax policies. No matter which mechanism is in place, the result is that the risk of widespread municipal debt default is mitigated. Therefore, the institutional framework in Poland can serve as a benchmark for policy makers in other developing countries.

There is also evidence of a strong persistence in debt levels. In addition, the empirical results point to the positive short-run indirect impact of the share of young inhabitants, as well as revenue capacity and the negative impact of the share of old inhabitants. This observation supports the argument that municipal debt in Poland serves as an instrument of local development policies.

The current study is limited in the sense that it does not encompass debt incurred by municipally owned companies. Their indebtedness plays a significant role in some larger municipalities (Białek-Jaworska, 2022). A promising avenue for further research is harnessing spatial methods to analyse other fields of local government activities, such as the diffusion of environmental policies.

Appendix

Table A1. Descriptive statistics

Variable	Number of observations	Mean	Standard deviation	Minimum	Maximum
Debt per capita	39072	949.453	851.889	0	42015.84
Population size	39072	15502.95	50990.81	1286	1790000
Squared population size	39072	2.84e+09	6.41e+10	1650000	3.22e+12
Share of young	39072	20.005	2.756	9.744	34
Share of old	39072	17.525	3.58	6	43.6
Unemployment	39072	8.281	4.343	0.6	35.345
Revenue capacity	39072	1005.378	927.427	163.08	38483.64
Previous vote share	39072	56.82	17.165	12.526	97.14
Average salary	39072	3655.309	681.977	2034.895	8920.41

Source: own work.

Table A2. Correlation matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Debt per capita (1)	1.000								
Population size (2)	0.166	1.000							
Squared population size (3)	0.089	0.852	1.000						
Share of young (4)	–0.208	–0.147	–0.060	1.000					
Share of old (5)	0.116	0.078	0.047	–0.721	1.000				
Unemployment (6)	–0.113	–0.091	–0.039	0.238	–0.233	1.000			
Revenue capacity (7)	0.196	0.095	0.051	–0.177	0.090	–0.253	1.000		
Previous vote share (8)	0.015	–0.091	–0.026	0.107	–0.034	–0.086	–0.007	1.000	
Average salary (9)	0.277	0.152	0.096	–0.426	0.379	–0.501	0.406	0.015	1.000

Source: own work.

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Fertility, fiscal deficit and sustainability of public debt in an endogenous growth model

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Abstract

This aim of this study is to construct a model which overlaps generations to clear the effects of fiscal deficit on fertility. The relationship between fiscal deficit and fertility is revealed and the mechanism of fiscal deficit and its effect in reducing fertility is clarified. Empirical evidence shows that an increase in debt-GDP ratio decreases fertility. The model indicates that fiscal deficit has positive and negative effects on fertility through the change of the income tax rate. Numerical simulation shows that an increase in fiscal deficit reduces fertility. Therefore, this result is consistent with the empirical evidence. In addition, this study demonstrates that a steady state would not exist if the child allowance for child-rearing costs exceeds the critical level. This result indicated that an expansion of the child allowance aimed as a countermeasure to the falling birthrate can make the sustainability of public debt unstable. Thus, countermeasures should be formulated to address the falling birthrate depending on the fiscal situation.

Keywords

- fertility
- fiscal deficit
- sustainability of public debt
- child allowance

JEL codes: H63, J13, O40

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Introduction

Public debt has increased whereas fertility has decreased in developed countries. The relationship between public debt and fertility is an important concern in the discussion of economic policy and fiscal sustainability. An increase in fertility influences bond issuances through the increase in the labour force and the provision of child allowances.[3] Additionally, there is a close relationship between high public debt and households' fertility choices as higher tax rates associated with bond redemption reduce household disposable income. Therefore, fertility and public debt are interdependent and it is crucial to theoretically clarify these relationships in order to examine policies that can enhance economic growth, fertility and fiscal sustainability. However, few studies have analyzed the relationship. This study aims to clarify such a relationship in an endogenous growth model.

Numerous studies analyse the effects of public debt on economic growth (Futagami et al., 2008; Greiner, 2013; Saint-Paul, 1992; Ueshina, 2018). For recent empirical analyses of the relationship between economic growth and public debt, see Gómez-Puig et al. (2022), Onofrei et al. (2022) and Heimberger (2023). Research on public debt and economic growth includes the seminal work of Bruninger (2005) which analyzes the relationship between fiscal deficit, economic growth and fiscal sustainability. Using an endogenous growth model Bruninger (2005) shows that an increase in fiscal deficit to GDP ratio decreases economic growth and deteriorates fiscal sustainability. Yakita (2008) and Arai (2011) analyse the effect of government investment in public capital or public service as the engine of economic growth. Constructing a model with demographic change, Kamiguchi and Tamai (2019) show that population aging increases the public debt to GDP ratio and the growth-maximizing tax rate.

Many studies have focused on the relationship between public debt, economic growth and population aging. On the other hand, the relationship between public debt and fertility is also a significantly important issue for developed countries. Several studies have theoretically analyzed the relationship between public debt and fertility. For example, Zhang (2003) shows that an increase in public debt with increasing educational subsidies promotes human capital investment but reduces fertility in a dynastic model. Ueshina (2020) utilized Blanchard's (1985) continuous-time overlapping generations model to analyze the impacts of increasing life expectancy and decreasing fertility on the ratio of public debt to GDP. Additionally, and by using numerical calculations, he examined the impact of demographic changes on the tax

[3] An increase in the labour force decreases bond issuance as it increases tax revenue. Moreover, increases in child allowance and the concomitant increasing fertility promote bond issuance which may lead to a deterioration in fiscal sustainability.

rate that maximizes the rate of economic growth. Sun (2023) estimates the optimal level of public debt under changing demographics in China by constructing an overlapping generations model with endogenous growth as assumed by Yakita (2008). Sun (2023) shows that the optimal level of public debt depends on the number of children, the subsidy policy for rearing the children, and so on. Fanti and Spataro (2013) and Spataro et al. (2019) demonstrate the condition under which the effect of public debt on fertility can be positive or negative. Specifically, an increase in public debt tends to reduce fertility when the capital share representing the fraction of Gross Domestic Product (GDP) allocated to capital income is sufficiently large in the economy. Moreover, an increase in public debt tends to increase fertility, when the labour share, representing the fraction of GDP allocated to labour income, is sufficiently large. Their study is consistent with Sun (2019) who provides empirical evidence that indicates the negative relationship between the public debt to GDP ratio and fertility. Previous studies clearly show the effects of fiscal deficit on fertility using a simple model without endogenous economic growth and sustainability of public debt.

This study constructs an endogenous growth model with sustainability of public debt and endogenous fertility. Using the model it clarifies another mechanism of the effects of fiscal deficit on fertility, economic growth and the sustainability of public debt and shows the interactions among them. It also shows that the effect of fiscal deficit on fertility depends on two effects: one is a positive effect that raises government revenue and the other is a negative effect that raises interest payment by increasing the ratio of public debt to private capital. Using numerical analysis, the negative effect is larger than the positive effect is clarified that is, an increase in fiscal deficit decreases fertility. This result is consistent with the empirical study of Sun (2019). In addition, it is shown that a steady state would not exist if the child allowance costs exceed the critical level. Therefore, an increase in the child allowance raises fertility but may not guarantee the sustainability of public debt in the economy when the size of the fiscal deficit is large. Thus, in countries largely depending on public debt the government should reduce the fiscal deficit rather than increase the child allowance to increase fertility. Although Maeda (2017) also incorporates fertility into the model of Bräuninger (2005) Maeda does not analyse the effects of fiscal deficit on fertility or consider child allowance as government expenditure.

This study contributes to the existing literature in three ways. First, it clarifies the interaction between fertility and public debt which has been overlooked in previous theoretical studies. Second, it demonstrates that an increase in child allowances promotes fertility and influences government budget constraints, undermining fiscal sustainability and economic growth. Third, this study suggests that an increase in the fiscal deficit leads to a decline in fertility in the long run and aligning with the findings of Sun (2019).

The remainder of this paper is organized as follows. Section 1 sets up the proposed model. Section 2 analyses the equilibrium in the economy and Section 3 investigates the effects of the fiscal deficit on fertility. The final Section concludes the paper.

1. The model

This section describes the setup of the model to be analysed. This study considers an endogenous growth model with public debt. Although the analysis is based on Bräuninger's (2005) model, it introduces endogenous fertility and child allowance as new elements. The economy here consists of three agents: individuals, firms and the government. The agents and their role in the economy are described in sections 1.1–1.3, respectively.

1.1. Individuals

In this economy, it is assumed that individuals live for two periods namely, young and old. Each individual consumes, works and has children in their young period. The lifetime utility of an individual born in period t is given by

$$u_t = \ln c_{1,t} + \rho \ln c_{2,t+1} + \gamma \ln n_t \tag{1}$$

where $c_{1,t}$ and $c_{2,t+1}$ stand for consumption in period t and $t+1$, respectively. The subscripts 1 and 2 in $c_{1,t}$ and $c_{2,t+1}$ represent the young and old periods, respectively. n_t denotes the number of children. $\rho \in (0, 1)$ is the subjective discount rate and $\gamma \in (0, 1)$ is the subjective discount rate and is the weight attached to the utility from having a certain number of children. In the young period, individuals earn income from labour which is divided into consumption, savings and tax payments. As in Stauvermann and Kumar (2018), this study assumes that the government provides a child allowance (e.g., expansion of childcare). Therefore, individuals substantially receive the benefits in the form of subsidies towards the costs of child rearing. Taking the above into account the budget constraints for a young and old period are given by

$$[(1 - \tau_t) + (q - \phi)\, n_t]\, w_t = c_{1,t} + s_t \tag{2}$$

$$[1 + (1 - \tau_{t+1})\, r_{t+1}]\, s_t = c_{2,t+1} \tag{3}$$

where w_t and r_{t+1} stand for wage income in period t and the interest rate in period $t+1$, respectively. s_t are savings in period t. $\tau_t(0, 1)$ is the income tax rate,

which is endogenously determined in this model. $qn_t w_t$ and $\phi n_t w_t$ denote the child allowance for child-rearing costs and child-rearing costs, respectively. It is assumed that there is the following parameter constraint: $0 < q < \phi < 1$. Solving the optimization of the individual the following equations on the savings function and number of children are obtained:

$$s_t = \frac{\rho(1-\tau_t)}{1+\rho+\gamma} w_t \tag{4}$$

$$n_t = \frac{\gamma(1-\tau_t)}{(1+\rho+\gamma)(\phi-q)} \tag{5}$$

1.2. Firms

Following Bräuninger (2005) the production function of the Cobb-Douglas type was assumed:

$$Y_{it} = AK_{it}^{\alpha} (E_t N_{it})^{\beta} \tag{6}$$

where Y_{it}, K_{it} and N_{it} stand for output, capital and labour of a firm i in period t. $A > 0$, E_t, $\alpha > 0$, and $\beta > 0$ are the technology parameter, index of labour efficiency, and elasticity of output to capital and labour, respectively. This study assumes that $\alpha + \beta = 1$ and labour efficiency E_t is equal to capital per labour $E_t = K_t / N_t$. Thus, the aggregate product function is given by

$$Y_t = AK_t \tag{7}$$

Under perfect competition, the marginal products of the capital and labour of a firm are equal to the interest and wage rates, respectively:

$$r_t = \partial Y_t / \partial K_t = \alpha A \tag{8}$$

$$w_t = \partial Y_t / \partial N_t = \beta Y_t / N_t \tag{9}$$

1.3. Government

A government levies taxes on the income of individuals and issues bonds to finance government expenditure. The tax revenue T_t can be shown as:

$$T_t = \tau_t (Y_t + r_t D_t) \tag{10}$$

where D_t denotes total government debt and $r_t D_t$ interest payment. In addition, the government makes the interest payments on public debt and provides child allowance as expenditure. The child allowance is given by $qn_t w_t N_t$. The government issues bonds for a constant rate $b(>0)$ of output[4]:

$$B_t = bY_t \tag{11}$$

Therefore, public debt accumulates as follows:

$$D_{t+1} = D_t + bY_t \tag{12}$$

The government budget constraint is:

$$B_t + T_t = r_t D_t + qn_t w_t N_t \tag{13}$$

From equations (10) and (11), equation (13) could be rewritten as:

$$bY_t + \tau_t (Y_t + rD_t) = rD_t + qn_t w_t N_t \tag{14}$$

It is possible to rewrite equation (14) to find the per capita government budget constraint, as:

$$y_t + \tau_t (y_t + r_t d_t) = r_t d_t + qn_t w_t \tag{15}$$

where $y_t \equiv Y_t / N_t$ and $d_t \equiv D_t / N_t$.

The tax rate τ_t can be obtained by solving equation (14):[5]

$$1 - \tau_t = \frac{(1+b)(1+\rho+\gamma)(\phi - q)}{(1+\alpha x_t)(1+\rho+\gamma)(\phi - q) + \beta q \gamma} \tag{16}$$

where x_t stands for the ratio of public debt to private capital: $x_t \equiv D_t / K_t$.

[4] This fiscal rule is expressed as a formula based on the Maastricht Treaty, which stipulates that the budget deficit-GDP ratio be kept at 3%.

[5] In this study, the tax rate is endogenously determined to satisfy the government's budget constraint. This assumption is introduced in Bräuninger (2005) and various other studies such as Yakita (2008), Arai (2011), Kamiguchi and Hiraga (2019), and Maebayashi and Konishi (2021). While distinguishing between taxing labour income capital income aligns with reality it is assumed that both tax rates are equal due to the endogenous nature of the tax rate, as described above.

2. Equilibrium

From equations (12) and (14), it is possible to obtain the gross growth rate of public debt and private capital:

$$\frac{D_{t+1}}{D_t} = 1 + \frac{bA}{x_t} \tag{17}$$

$$\frac{K_{t+1}}{K_t} = \left(\frac{\rho}{1+\rho+\gamma} \cdot \frac{(1+b)(1+\rho+\gamma)(\phi-q)}{\left[(1+\alpha x_t)(1+\rho+\gamma)(\phi-q)+\beta q\gamma\right]} \beta - b \right) A - x_t \tag{18}$$

Substituting equation (16) into equation (5) forms:

$$n_t = \frac{\gamma(1+b)}{(1+\rho+\gamma)(\phi-q)(1+\alpha x_t)+\gamma q\beta} \tag{19}$$

Next the steady state in the economy is considered. When the ratio public debt to private capital is constant, public debt and private capital grow at a constant rate: $D_{t+1}/D_t = K_{t+1}/K_t$. Therefore, taking equations (17) and (18) into account and rearranging their components yields

$$1 + \frac{bA}{x^*} + x^* = \left(\frac{\rho}{1+\rho+\gamma} \cdot \frac{(1+b)(1+\rho+\gamma)(\phi-q)}{\left[(1+\alpha x^*)(1+\rho+\gamma)(\phi-q)+\beta q\gamma\right]} \beta - b \right) A \tag{20}$$

where x^* stands for the ratio of public debt to private capital in the steady states. Regarding the existence of a steady state, the following proposition is formulated.

Proposition 1. *(a) There exists critical deficit ratio b' and child allowance share q'. (b) If the deficit ratio and child allowance share are below the critical level, $b < b'$ and $q < q'$, there are two steady states. (c) If the deficit ratio and child allowance shares are above the critical level, $b > b'$ and $q > q'$, the economy has no steady state.*

The result in which there exists critical deficit ratio b' is the same as in Bräuninger (2005). The result in which there exists a critical child allowance share q' implies that an excessive increase in child allowance may lead to the situation where there is no steady state.

Next, this study analyses the stability of the steady state and sets following proposition.[6]

[6] For the proof, see Appendix.

Proposition 2. *Assuming that two steady states exist the steady state with a low ratio of public debt to private capital $x_L^\star$ is locally stable. The steady state with a high ratio of public debt to private capital $x_H^\star$ is unstable*.

Numerical examples with respect to the existence of steady states are considered. As for parameter values, they are set as follows $A = 12$, $\alpha = 0.3$. Regarding the subjective discount rate preference for children and time spent on child rearing, this study adopts $\rho = 0.6$, $\gamma = 0.3$, and $\phi = 0.1$, respectively.[7] Table 1 presents the values of the steady states for b from 0.01 to 0.03 in 0.01 increments.[8] As shown in Table 1, an increase in the fiscal deficit ratio raises the ratio of public debt to private capital of stable steady state $x_L^\star$. For $q = 0.01$ and $q = 0.03$, no steady state is found when the fiscal deficit rate is set to 0.03. This implies the existence of a critical level of fiscal deficit ratio, b'. For $q = 0.05$, this critical level of fiscal deficit ratio declines given the absence of steady state with a fiscal deficit ratio of 0.02. In other words, a critical level of child allowance share, q' is identified.

Table 1. Values of steady states and fiscal deficit ratio for $q = 0.01, 0.03, 0.05$

$q = 0.01$			$q = 0.03$			$q = 0.05$		
b	$x_L^\star$	$x_H^\star$	b	$x_L^\star$	$x_H^\star$	b	$x_L^\star$	$x_H^\star$
0.01	0.0874	0.8522	0.01	0.0940	0.0886	0.01	0.1074	0.7306
0.02	0.2340	0.6314	0.02	0.2706	0.5570	0.02	–	–
0.03	–	–	0.03	–	–	0.03	–	–

Source: own compilation.

3. Effect of fiscal deficit on fertility

To analyse the effect of fiscal deficit on fertility, it was necessary to clarify the effect of fiscal deficit on the ratio of public debt to private capital $x_L^\star$. This focuses on the steady state with a low ratio of public debt to private capital given the locally stable steady state. The left and right-hand sides of equation (20) as LHS and RHS, respectively are defined:

$$LHS \equiv 1 + \frac{bA}{x^\star} + x^\star \tag{21a}$$

[7] The results remain unchanged even with a relatively lower or higher value of subjective discount rate ρ. In addition, this study refers to Fanti and Gori (2012) for γ and ϕ.

[8] For example, the Maastricht criteria provide that the ratio of fiscal deficit to GDP be limited to 0.03.

$$RHS \equiv \left(\frac{\rho}{1+\rho+\gamma} \cdot \frac{(1+b)(1+\rho+\gamma)(\phi-q)}{\left[(1+\alpha x^*)(1+\rho+\gamma)(\phi-q)+\beta q\gamma\right]} \beta - b \right) A \quad (21b)$$

By differentiating equations (21a) and (21b) with respect to fiscal deficit ratio b, this study obtained:

$$\frac{dLHS}{db} = \frac{A}{x^*} > 0 \quad (22a)$$

$$\frac{dRHS}{db} = -\left(\frac{(\phi-q)\left\{\rho\left[(1+\alpha x^*)-\beta\right]+(1+\alpha x^*)(1+\gamma)\right\}+\beta q\gamma}{(1+\alpha x^*)(1+\rho+\gamma)(\phi-q)+\beta q\gamma} \right) A < 0 \quad (22b)$$

As shown in Figure 1, an increase in fiscal deficit ratio raises the ratio of public debt to private capital x with a locally stable steady state: $dx/db > 0$.

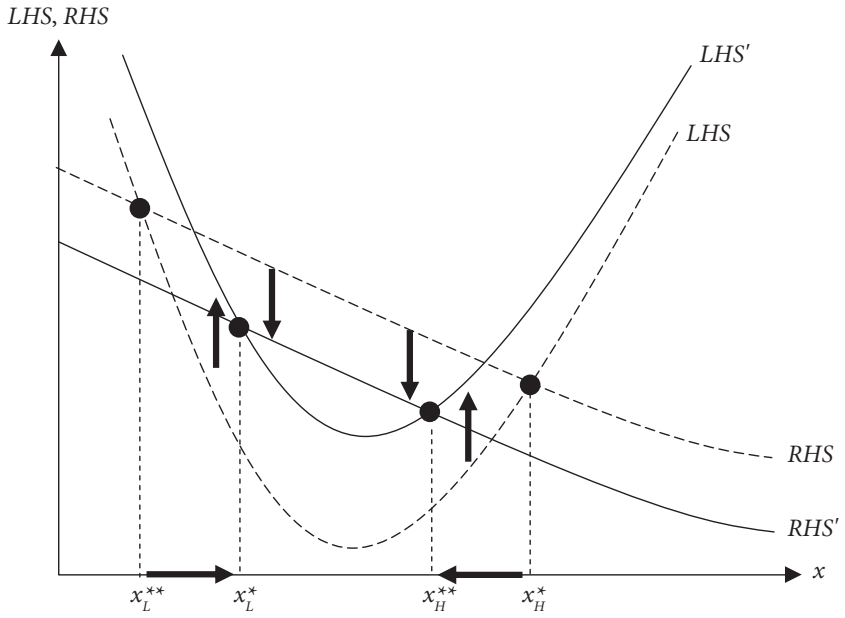

Figure 1. Effect of fiscal deficit on the ratio of public debt to private capital

Source: own compilation.

The study then considers the effect of the ratio of public debt to private capital on fertility. By differentiating equation (19) with respect to b, the following equation is obtained.

$$\frac{d\overline{n}}{db}=\frac{\gamma}{(1+\alpha x^{*})(1+\rho+\gamma)(\phi-q)+\beta q\gamma}\cdot \cdot\left\{1-\frac{(1+b)(1+\rho+\gamma)(\phi-q)\alpha}{(1+\alpha x^{*})(1+\rho+\gamma)(\phi-q)+\beta q\gamma}\cdot\frac{dx^{*}}{db}\right\} \tag{23}$$

where $\overline{n}$ stands for the fertility in the steady state. dx^{*}/db is positive. Regarding this result the following proposition is formulated:

Proposition 3. *The effect of fiscal deficit on fertility is*

$$\frac{d\overline{n}}{db}\gtreqless 0 \quad \text{when} \quad 1\gtreqless\frac{(1+b)(1+\rho+\gamma)(\phi-q)\alpha}{(1+\alpha x^{*})(1+\rho+\gamma)(\phi-q)+\beta q\gamma}\cdot\frac{dx^{*}}{db}$$

An implication of this proposition is that an increase in fiscal deficit may raise or lower fertility under certain conditions. From equation (23), this study categorizes the effects of fiscal deficit on fertility as positive and negative effects. The positive effect is when an increase in the fiscal deficit directly eases the budget constraints of individuals. An increase in fiscal deficit lowers the tax rate through higher government revenue; therefore, a decrease in tax rate raises the disposable income of individuals. Consequently, fertility rises because individuals can allocate more of their budget to child rearing. The negative effect is when an increase in the fiscal deficit raises the tax rate through accumulating public debt in the long term. Therefore, whether an increase in fiscal deficit raises or lowers fertility absolutely depends on the effect on the tax rate which has an impact on the disposable income of individuals. However, whether the positive effect exceeds the negative effect is difficult to reveal analytically.

Finally, this study conducts a numerical simulation to clear the effect of fiscal deficit on fertility. Table 2 shows that an increase in fiscal deficit lowers fertility for $q=0.01, 0.03, 0.05$. As for the parameter values, this study uses the values used in section 2. The results show that an increase in deficit ratio b reduces fertility. This study obtains the same results even after adopting other parameter values: $\gamma=0.2, 0.4$, $\phi=0.05, 0.2$. Therefore, under plausible parameters an increase in deficit ratio reduces fertility through lowered disposable income. This result is consistent with the empirical evidence provided by Sun (2019).

Figure 2 shows the simulation results: the time path of the ratio of public debt to fertility n_t (Panel (a)), tax rate τ_t (Panel (b)) and private capital x_t (Panel (c)) when fiscal deficit ratio b increases from 0.01 to 0.02.[9] As mentioned any increase in fiscal deficit reduces the income tax rate leading to the rise in fertility in the short term. However, fertility tends to decline in the long term

[9] This study assumes the case of $q=0.01$. As to the other parameters the values in Section 2 are used.

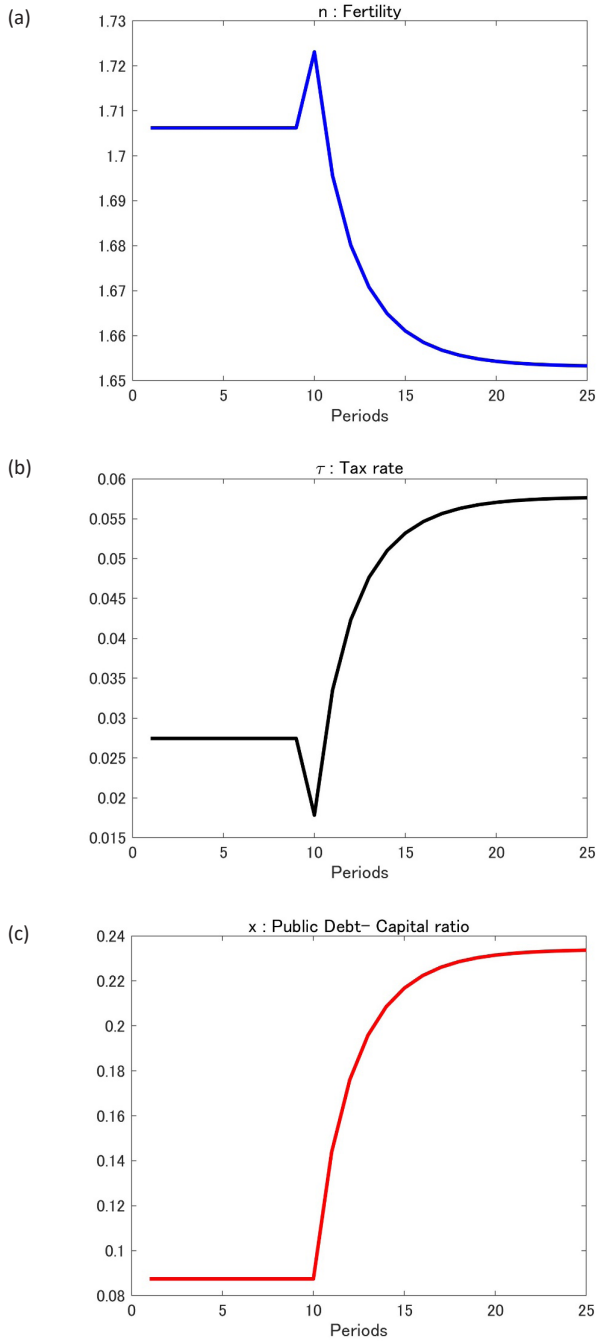

Figure 2. The effect of fiscal deficit on endogenous variables. (a) Transition dynamics of fertility, n_t. (b) Transition dynamics of tax rate, τ_t. (c) Transition dynamics of the ratio of public debt to private capital, x_t

Source: own compilation.

with the increase in the income tax rate rises over time as a result of an increase in the ratio of public debt to private capital.

Table 2. Effect of fiscal deficit on fertility

$q = 0.01$		$q = 0.03$		$q = 0.05$	
b	n	b	n	b	n
0	2.0581	0	2.5574	0	3.3768
0.01	1.7062	0.01	2.1181	0.01	2.7910
0.02	1.6531	0.02	2.0387	0.02	–
0.03	–	0.03	–	0.03	–

Source: own compilation.

As regards counter measures to the falling birthrate, these results provide an important implication. As shown in Tables 1 and 2, the higher the fiscal deficit ratio b is the lower the implementable child allowance q, in the sense that balanced growth path exists.[10] This implies that the government has to select a policy aimed at increasing fertility depending on the financial situation. Under the situation where the size of the budget deficit is large and from the point of view of fiscal sustainability, the government should reduce the fiscal deficit instead of increasing the child allowance to increase fertility.

Conclusions

This study constructs an endogenous growth model with public debt to analyze the effect of fiscal deficit on fertility and sustainability of public debt. According to the empirical evidence, public debt has a negative impact on fertility. This paper provides a more realistic model for the empirical relationship and a mechanism for the reduction in fertility owing to an increase in fiscal deficit. The main findings are as follows. First, a rising fiscal deficit exerts opposite effects on fertility through changing the disposable income of individuals: one is a positive effect, which raises government revenue and the other is a negative effect, which raises the interest payment by increasing the ratio of public debt to private capital. Under plausible parameters, this numerical example demonstrates that the negative effect exceeds the positive effect.

[10] For example, the government can implement a child allowance for $q = \{0.01, 0.03, 0.05\}$ if fiscal deficit ratio b is set to 0.01. However, the government cannot implement the child allowance for $q = 0.05$ once fiscal deficit ratio b rises to 0.02.

That is, an increase in fiscal deficit reduces fertility through lowering disposable income. Second, critical levels for the deficit ratio and child allowance share are identified: the economy does not converge to the stable steady state if these values exceed the critical level. This implies that an increase in the child allowance share raises fertility but may not guarantee the sustainability of public debt under the situation where the size of the fiscal deficit is large. Thus, to remedy declining fertility countries relying on their fiscal deficit should reduce the fiscal deficit instead of increasing the child allowance they offer.

One limitation of this study is that government expenditures other than child allowances were considered in our model. Incorporating other government expenditures such as public investment and public healthcare is important for deriving additional policy implications. Therefore, considering other government expenditures is an issue for future research.

Appendix

This study confirms the existence and stability of the steady states using equation (21a) and (21b), displayed in Figure 2.

Figure A1 presents the U-shaped LHS and upward sloping RHS. Considering the properties of equations (21a) and (21b), this study identified two steady states: x_L^* and x_H^* in case of $RHS\big|_{x=\sqrt{bA}} > 1+2\sqrt{bA}$.

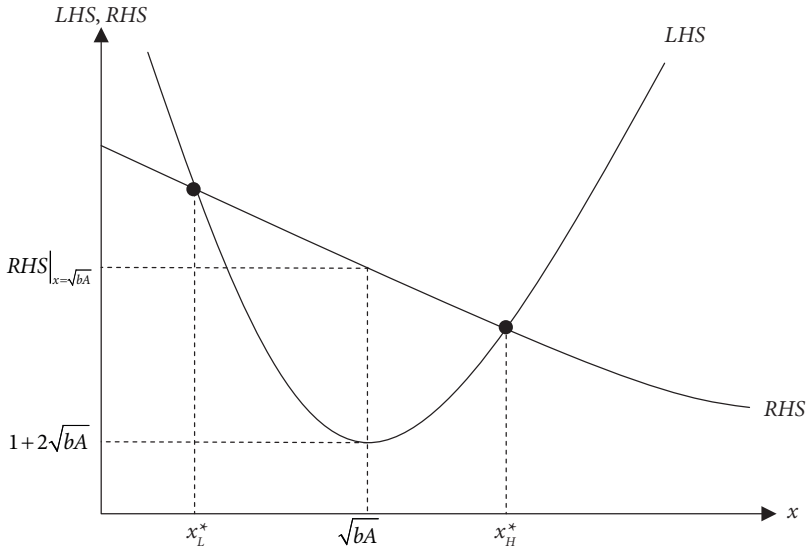

Figure A1. Existence of steady states

Source: own compilation.

Next, this study confirms the stability of the steady states. From the definition of x, this study obtains the dynamic equation of x:

$$\frac{x_{t+1}}{x_t} = \frac{D_{t+1}/K_{t+1}}{D_t/K_t} = \frac{g_D}{g_K} \tag{A1}$$

where g_D and g_K stand for the gross growth rate of public debt and private capital, respectively. By differentiating x_{t+1} with respect to x_t, this study obtains:

$$\left.\frac{dx_{t+1}}{dx_t}\right|_{x_t=x^*} = 1 + \frac{1}{g_K}\left(-\frac{bA}{x^*} + \frac{\rho(1+b)(1+\rho+\gamma)(\phi-q)^2\beta A\alpha}{\left[(1+\alpha x^*)(1+\rho+\gamma)(\phi-q)+\beta q\gamma\right]^2}x^* + x^* \right) \tag{A2}$$

Regarding equation (A2), this study obtains following properties:

$$\left.\frac{dx_{t+1}}{dx_t}\right|_{x^*\to 0} = -\infty, \quad \left.\frac{dx_{t+1}}{dx_t}\right|_{x^*\to\infty} = \infty$$

Thus, $dx_{t+1}/dx_{t>1}$ holds for a high value of x^*, whereas dx_{t+1}/dx_t holds for a low value of x^*. Therefore, x_L^* is a locally stable steady state and x_H^* is an unstable steady state.

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Does regional trade integration reinforce or weaken capital mobility? New evidence from four free trade areas

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Abstract

The study aims to empirically determine whether a higher level of trade openness and the presence of better legal protection for investors enhances the impact of trade bloc membership on capital mobility based on four trading blocs: Eurasian Economic Union (EAEU), Central American and Dominican Republic Free Trade Agreement (CAFTA-DR), Central European Free Trade Agreement (CEFTA), and the Pacific Alliance. This study employs the fully modified and dynamic ordinary least squares estimators and a panel quantile regression cointegration estimator. The study finds that a country's affiliation with a trade bloc improves capital mobility in the whole group and EAEU region, low capital mobility in the Pacific Alliance region and moderate low capital mobility in the CAFTA-DR region. The legal protection system alone provided for the investors does not improve the level of capital mobility unless its interaction with investment is included. Also the study reveals that high trade openness does not necessarily lead to better capital mobility for the studied trade blocs.

Keywords

- regional integration
- capital mobility
- trading blocs
- panel cointegration estimators

JEL codes: C23, F21, O55

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Introduction

The world economy has undergone significant changes in both its structure and nature. The change from trade interactions as the engine of the world economy to cross-border capital movements playing a more dominating role is one major transition. This change in dynamics has led to increased interconnectivity and interdependence among national economies, affecting various aspects of the global economic landscape (Ganić, 2020). In recent decades the number of regional trade blocs has risen while the deepening of existing trade integrations was followed by capital flow liberalization. Capital mobility holds immense importance for any economy and particularly within trading blocs as it expedites investment and fosters economic growth. It highlights the role of enhanced capital mobility in facilitating the flow of funds across countries thereby creating favourable conditions for investment opportunities contributing to economic growth. There is still no general consensus about the role of the many channels through which various determinants can have an impact on capital mobility. Referring to the increasing capital mobility and the possibility of covering domestic savings deficits it would be interesting to explore whether deepening regionally based trade integration increases capital mobility. Markusen (1983) investigated the complementarity between trade and capital flows. He concludes that capital mobility can increase gross trade flows in a variety of models where comparative advantage is not driven by differences in capital-labour ratios across countries. Also Cavallo and Frankel (2008) examined trade openness as a determinant of capital vulnerabilities concluding that economies that trade less with other countries are more prone to capital inflows and currency crises. The rationale for examining the link between trade integration and capital mobility assumes that a country's affiliation in a trading bloc is followed with the lowering of trade barriers. This reduction in trade barriers is expected to facilitate an increase in capital mobility within these countries. For example, it is anticipated that the deployment of digital technology will result in a large decrease in trade costs, increased transparency, and simpler access to foreign markets. This will make it possible for more businesses and people to engage in international trade (Rymarczyk, 2021).

The measurement of capital mobility levels and the factors that encourage investment growth has served as a motivation for numerous authors to conduct various empirical studies. These studies have made both theoretical and empirical contributions for developed, less developed and underdeveloped countries.

The debate over saving and the investment link in the context of capital mobility inspired this research and brought up the idea of conducting empirical tests which would prove or disapprove the existence of positive role deepening in regionally based trade integration on rise of capital mobility.

There are plenty of studies addressing investment-savings correlation in the European Union (EU), the OECD (Organization for Economic Cooperation and Development) and developing countries but less to address the impact of regional economic integration on capital mobility with the mediation role of level trade openness and legal protection of the investor.

The purpose of this study is to make a contribution to the ongoing debate on saving and investment. More precisely a case study of four trade blocs is conducted using the available data between 2000 and 2020 to determine if a higher level of trade openness and the presence of better legal protection of the investor enhances the impact of trading bloc membership on capital mobility. The rationale of this proposition and the study's contributions within that context are as follows. First, increasing trade openness promotes regional trade integration by facilitating trade and investment between trade bloc member countries and augments economic growth (Kumar et al., 2014; Matthews, 2003). Second, as part of their reform processes many countries have started the process of strengthening the legal protection of investors. The aim of these activities is to increase the inflow of capital and enhance efficiency and productivity in the national economy by strengthening the legal protection of investors thus enhancing investor confidence for both beneficiary countries and the relevant sub-region (Collier, 1991).

The study employs methodologies such as the FMOLS estimator, the DOLS estimator and a panel quantile regression cointegration estimator to analyze data. Although some aspects of these aims have been assessed partially, others have been ignored while in the areas of FTAs where the findings differed across studies. This study aims to answer the following questions:

1. Does a country's affiliation with a trade bloc improve capital mobility?
2. Does the effect of a country's affiliation with a trade bloc on increasing capital mobility is amplified in the presence of higher level trade openness?
3. Does the effect of a country's affiliation with a trade bloc on increasing capital mobility increase in the presence of legal protection of investor?

In investigating the research questions above three hypotheses will be tested:

H1: There is increased capital mobility after country's affiliation with a trade bloc.

H2: The effect of a country's affiliation with a trade bloc on increasing capital mobility is amplified in the presence of higher level trade openness, and

H3: The effect of a country's affiliation with a trade bloc on increasing capital mobility is amplified in the presence of better legal protection of the investor.

The findings of this paper contribute to the existing literature the on capital mobility and trade integration because the previous related studies (Kumar,

2015; Kumar et al. 2014) that address the relationship between trade integration and capital mobility are limited especially to four trade blocs it this study. Also the data set covers the last two decades where capital controls were abolished and where some new countries joined FTAs. It gives interesting views for the current saving and investment debate and examination of the existence of a positive role of regionally based trade integration on the rise of capital mobility. In comparison with other similar empirical studies this study explores whether regional trade integration with the presence of high-level trade openness and legal protection of the investor increases capital mobility for a group of four trade blocs (EAEU, CAFTA-DR, CEFTA, and the Pacific Alliance). To the best of the authors' knowledge there has been no such study implemented in the other trade blocs. In addition, this study makes another contribution to the existing literature by investigating the importance of regional savings in the financing of investments in four trade blocs (EAEU, CAFTA-DR, CEFTA, and the Pacific Alliance) providing additional evidence on the role of trade regionalism in capital market integration. These findings can be extended to the other trade blocs as they share many common features such as proximity to each other and a similar pattern of economic development

Additionally, the contribution of research can be visible in the econometric approach applied to examine some cases where domestic savings and investment might vary from one to another by depending on quantile, a characteristic that is neglected in most previous empirical studies.

The article is organised as follows: Section 1 reviews the literature on trade integration and capital mobility. Section 2 presents the research data and method. In Section 3 research results are depicted. Section 4 discusses empirical results. The last section concludes the article.

1. Literature review

Analyzing the six major puzzles in International Macroeconomics, Obstfeld and Rogoff (2000) identified the Feldstein and Horioka (F-H) puzzle as one of the most robust highlighting its valuable contribution to the understanding of international capital mobility. For instance, Obstfeld and Rogoff (2000) revealed that most studies appeared to confirm theoretical arguments of the F-H hypothesis but they are empirically inadequate. In fact, solving one puzzle comes at the expense of creating others. The authors suggest that the F-H regularity becomes unpredictable if intranational regional data is used implying that factors inherent in trade between different nations are at work.

The most widely used method in assessing a link between gross domestic investments and gross domestic savings is the method developed by the F-H (Feldstein & Horioka, 1980). While the F-H (1980) hypothesis has been veri-

fied by some researchers some others struggled to attain equivalent results. Contrary to expectations of increased capital flows Feldstein and Horioka (1980) obtained perplexing findings in terms of savings and investment relationship in sixteen OECD countries between 1960 and 1974. The authors find low capital mobility among OECD countries indicating that domestic investment was primarily determined by domestic savings.

This approach for measurement of capital mobility is not without its critics. Research that demonstrated substantial correlation between savings and investment in OECD countries suggested that international capital mobility is relatively low. Indeed, the debate about capital mobility in the context of the Feldstein and Horioka hypothesis has raised questions about the validity of assumptions of their analysis.

It implies that in a world of complete capital mobility savings and investment tendencies should not be correlated. It is true that there are arguments to support the use of the correlation between savings and investment as an indicator for measuring international capital mobility. Dornbusch (1989), concluded that even if international markets are highly integrated, if domestic capital markets are segmented it may result in low levels of international capital mobility.

Obstfeld (1986) and Tesar (1991) presented models in which there is a high correlation between savings and investment even in the presence of high capital mobility. These models suggest that while capital mobility may be unrestricted there are some other factors that may affect the relationship between savings and investment. For example, these factors include tax policies, institutional constraints or information asymmetries. On the other hand, Frankel (1991) highlighted that holding the F-H hypothesis requires certain demanding assumptions. The F-H hypothesis suggests that if a strong correlation between domestic savings and domestic investment exists there is a high correlation between domestic savings and domestic investment implying low international capital mobility. Frankel (1991) argued that this hypothesis holds good only under certain conditions and assumptions such as fixed exchange rates, capital flow restrictions or high adjustment costs. In fact, the ongoing debate raises the question as to whether the F-H puzzle leads to a contradiction between empirical research and the theoretical framework when it comes to the relationship between the savings rate and investment.

The studies validating the F-H results are existent but not very prevalent. Some authors such as: Sinn (1992), Obstfeld and Rogoff (1995), Coakley et al. (1996), Jansen (2000), indicate that for the presence of a long-term relationship (cointegration) between domestic savings and investments require the existence of long-term solvency of the local economy. The model with transaction costs for international trade in goods developed by Obstfeld and Rogoff (2000) indicates that the mere existence of frictions in commodity markets can prevent capital mobility between countries.

Following the example of these studies in OECD countries substantial efforts were directed at applying similar methodology for various markets around the world. Some contributors such as Payne and Kumazawa (2005), Yildirim and Yildirim (2020) found low capital mobility in emerging economies, Murthy and Ketenci (2020) in Latin America countries while Holmes (2005) and Midagu et al. (2020) found increased capital mobility.

From the research conducted by Sobański (2019), it follows that the U.S. has a privileged position in terms of foreign income from international investments compared to the group of 18 economies included in his research. This means that the U.S. achieves relatively higher rates of return on its foreign assets compared to other countries in the reference group. Also, the costs arising from its foreign obligations are relatively lower.

Besides the OECD and the developing countries there are studies on capital mobility specifically in the EU. For example, Syssoyeva-Masson and Sousa Andrade (2015), Ketenci (2014) investigated high capital mobility in EU countries while Masud-Alam and Rafiqul-Islam (2010) found that the savings-investment correlation varies between the old and new EU members.

Those studies are performed in various sets of countries over different time periods.

Taylor (1996) found substantial cross-country heterogeneity and towards the 1970s the group studied showed improved capital mobility.

Next Padawassou (2012) explored capital mobility in twenty-two countries in Africa suggesting that there exist both low and high capital mobility which challenges the previous results obtained for developing countries. Rocha (2006) concluded that the effect of savings on investment is small in the presence of some degree of capital mobility. However, out of the twenty-nine countries studied only nine have experienced capital immobility resulting in mixed results.

Ketenci (2014) examines existence of capital mobility in the OECD, EU-15, NAFTA, and G7 countries between 1970 and 2008. The obtained results indicate that the G7 countries are the only ones with low capital mobility. Bilas (2007) examines capital mobility among members of EU-15, ASEAN, MERCOSUR and NAFTA between 1960 and 2003. The findings are intriguing as the most mobile capital is in MERCOSUR, while ASEAN experiences the lowest capital mobility.

Kumar (2015) examines the relationship between investment and savings alongside FTAs between 1960 and 2012 using the sample of the following FTAs: AFTA (ASEAN FTA), EU, CARTAGENA, MERCOSUR and NAFTA. It indicates that capital mobility is similar in most countries and tends to increase in the post-integration period. In another study Kumar et al. (2014) found that the trade agreements slightly improved capital mobility by exploring twenty-five African member countries of different FTAs (COMESA, ECOWAS, SACU and UEMOA).

For the purposes of this study a saving-investment correlation framework was been adopted by using recent advances in panel data econometrics for long run analysis and quantile regression estimates to avoid the data and estimation problems outlined above. The goal of the study is to obtain a more accurate and efficient estimate of the savings-investment relationship for a group that covers four regionally based free trade agreements (FTAs). Therefore, the literature review section concludes that there is a gap in the literature and this paper contributes to this area.

2. Research data and method

In his research Frankel (1995) highlights four main theories for measuring capital mobility (using the Feldstein-Horioka definition, real interest rate parity, uncovered interest parity and covered interest rate parity). Initially this study utilizes the F-H definition of capital mobility which is considered to be the most widely of the methods for measuring capital mobility out of the four available. Decisions about variables which should be included in the model variance across different articles. The formal definition of gross domestic investment and gross domestic saving were clarified and sourced from the World Development Indicators through the World Bank database.

In line with a similar empirical analysis conducted by Feldstein and Bacchetta (1991), Payne and Kumawaza (2005), Kumar et al. (2014) and Kumar (2015) this study slightly extended the model to control for the degree of trade openness and the legal protection of investors. It aims to explain variations in capital mobility by examining the implications of a country's affiliation in FTAs, trade openness and the legal protection of investors. Equation (1) incorporates the set of variables as follows:

$$\left(\frac{I}{Y}\right)_{it} = \beta_0 + \beta_1\left(\frac{S}{Y}\right)_{it} + TRO_{it} + ROL_{it} + DA_{it} + I \times ROL_{it} + I \times TRO_{it} + \varepsilon_{it} \quad (1)$$

where: $\left(\frac{I}{Y}\right)$ – Gross domestic investment to GDP of a country i at time t, $\left(\frac{S}{Y}\right)$ – Gross domestic saving to GDP of a country i at time t, β_0 refers to the constant of equation; β_1 represents saving retention coefficient (with $\beta = 0$ for perfect capital mobility, $\beta = 1$ for perfect capital immobility and $0 < \beta < 1$ for imperfect capital mobility); TRO – measure trade openness of a country i at time t; to measure legal protection of investors Rule of Law (ROL) of a country i at time t is proxied; interaction variables: $I \times ROL$ (sum of I and ROL), $I \times TRO$ (sum of I and TRO) are introduced into the model in interac-

tion with investment (I) variable to capture their impact on the investment retention coefficient; D_{Ait} – dummy variable that takes the value of 0 in times when a country i had not joined the FTA and takes the value of 1 in times when a country is part of the FTA, while i and t stand for country specific and time specific, ε_{it} satysfing $N(0, \sigma)$ for all i and t.

Equation (1) assumes a long-term relationship between investment, savings and the control variables. Accordingly, it is necessary to ensure that the individual time series for all variables in equation (1) are nonstationary and integrated in the same order to form a cointegrated model.

The econometric tests are performed to understand what kind of model would suit this kind of data best. To examine cross-sectional dependency, the study employs the LM test by Breusch and Pagan (1980), bias-adjusted LM test by Pesaran et al. (2008), Pesaran (2004) CD test and slope homogeneity by Pesaran and Yamagata (2008). Then several unit root tests are employed to examine stationarity variables as follows: ADF (LLC) proposed by Levin, Lin and Chu (2002), Im, Pesaran and Shin W-stat (Im et al., 2003) as well as ADF-Fisher Chi-square and the PP-Fisher Chi-square tests that consider the heterogeneity across units. The null hypothesis assumes that the time series contains a unit root while the alternative hypothesis assumes that the time series are stationary.

The long run relationship among variables will be examined by employing three panel cointegration tests: the Johansen- Fisher panel Co integration Test (1988), the Pedroni Residual Cointegration Test (1999), and the Kao Residual Cointegration Test (1999).

To address endogeneity and serial correlation in cointegrating regressions and to ensure unbiased estimates of cointegration coefficients this study employs two methods: FMOLS (Phillips & Hansen, 1990) and DOLS (Stock & Watson, 1993). The reason for using the FMOLS method is to address deviations in standard fixed effect estimators. On the other hand, the DOLS method is used to solve endogeneity problems by introducing dynamic elements of the models and assessing the robustness of the FMOLS estimator. In addition, the Pairwise Dumitrescu-Hurlin panel causality tests (2012) are employed to examine causality between savings and investments where the null hypothesis of no causal relationship between savings and investment is tested. It excludes capital immobility if a causal relationship exists between investments and savings. The Pairwise Dumitrescu-Hurlin panel causality procedure (2012) is employed to account for heterogeneity in the cross-sections.

The panel quantile regression is utilized to examine the heterogeneity of impacts and run robustness checks of the models. The study compares the magnitude of the impact of trade regional integration, trade openness and legal protection on the level of capital mobility across different quantile distributions specifically the first quantile (q.25), second quantile (q.5) and third quantile (q.75). This type of empirical analysis provides information on the impact of

changes in independent variables on the interquartile difference and specifically on the distribution of the dependent variable. For robustness of the panel results the quantile regression developed by Koenker (2005), Koenker and Hallock (2001) is used. This approach allows the estimation of the effects that are heterogeneous across the conditional distribution of the response variable while also controlling for both individual and time-specific confounders.

The dataset used for the analysis consists of 483 observations between 2000 and 2020. All the data for the variables included in the model are sourced from the World Bank databases (2022). The study focuses on the following four regionally based free trade agreements (FTAs): EAEU (Eurasian Economic Union: Belarus, Kazakhstan, Russia, Armenia, Kyrgyzstan), CAFTA-DR (Central American and Dominican Republic Free Trade Agreement: United States of America, Dominican Republic, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua), CEFTA (Central European Free Trade Agreement: Albania, Bosnia and Herzegovina, North Macedonia, Moldova, Montenegro, Kosovo, Serbia), and the Pacific Alliance (Chile, Colombia, Mexico, and Peru).

To measure capital mobility, the empirical model should estimate the difference between savings rates and investment rates because capital is considered internationally mobile if foreign savings are used to finance domestic investments and vice versa. In this study for the measurement of the dependent variable of investment (I) the study deploys a proxy variable of gross capital formation. There are several different ways to measure a variable of investment (I) but this study employs gross capital formation as a proxy. It is referred to as fixed asset purchase minus the disposals made by inhabitant producers. The rationale to deploy this variable comes from the explanation that gross capital formation tends to behave less procyclically because it excludes the procyclical nature of inventories. The studies conducted by Bayoumi (1990), Isaksson (2001), Sinha and Sinha (2004), Payne and Kumazawa (2005) used the same proxy variable.

According to standard economic theory and in the absence of state regulation in the movement of international capital savings are expected to flow to the countries with the best investment opportunities seeking higher returns. More specifically the savings variable is included in the model due to its importance for financing investments in fixed capital which are necessary for countries to achieve a sustainable growth path. To measure savings (S) the study adopts a definition of saving as the difference between gross domestic product and final consumption expenditure. This variable has been one of the original variables used in many empirical models in interaction with investments to measure level of capital mobility (Feldstein & Bacchetta, 1991; Giannone & Lenza, 2004; Isaksson, 2001; Ketenci, 2014; Payne & Kumazawa, 2005; Taylor, 1996; Tesar, 1991; Yildirim & Yildirim, 2020).

Another variable widely accepted to play a role in the determination of capital mobility is trade openness. A theoretical background suggests that

capital mobility can be explained by the level of trade openness (Feldstein & Bacchetta, 1991; Giannone & Lenza, 2004; Isaksson, 2001; Ketenci, 2014; Payne & Kumazawa, 2005; Taylor, 1996; Tesar, 1991; Yildirim & Yildirim, 2020). The trade openness variable is specified as the sum of total trade to GDP to measure how changes in level of openness affect capital mobility. The above review of studies applied to the regions and countries suggest that if a country is more open to trade it stimulates capital mobility, attracts investors and promotes economic development. It is expected that the openness to international trade will have a positive impact on investment rates.

The rationale for the inclusion of a country's affiliation with FTAs as a dummy variable in the model is based on the complementarity between trade and capital flows as proposed by Markusen (1983). It is a fact that regional trade integration involving lowering of trade barriers could have spurred capital mobility in these countries. It assumes that when a country becomes a member of a trade bloc there is reduction in trade barriers that could support an increase in capital mobility. Matthews (2003) highlights several advantages with the pursuit of integration such as potential for investment and production growth, elimination of regulatory barriers, the exploiting of economies of scale and the emergence of intra-industry trade. Some of the previous research done by Kumar (2015), Kumar et al. (2014), Yersh (2022) confirmed the effects of a rise of post-integration flows on capital mobility.

The literature attributes positive effect of legal system protection to capital mobility. Inclusion of a Rule of Law (ROL) to be a proxy for legal protection system in the model is based on evidence related to a strong link between finance and law (La Porta et al., 1998) and better investment protection. It believes that a robust rule of law promotes better implementation of laws providing legal protection the investors and improves capital mobility. The complexity and dynamics of the legal system, including property rights, often create tensions between predictability and uncertainty. Institutional frameworks and the rule of law play a key role in balancing these two aspects in order to ensure the fairness and effectiveness of the legal system (Behar-Villegas, 2022). According to the study conducted by Shleifer and Wolfenzon (2002), countries with stronger investor protection have a larger share of investment capital generated from the foreign sources and a smaller share originates from internal funds. Accordingly, a variable of ROL is used as a proxy for the legal protection of investors. In addition, research done by Midagu et al. (2020) and Drakos et al. (2018) suggest that legal protection of investors promotes capital mobility.

Alongside the key variables of interest, the Rule of Law or (ROL) and Trade openness variables are included into the model in interaction with the investment (I) variable to capture their impact on the investment retention coefficient.

3. Research results

One of the first steps in the empirical analysis is the examination of multicollinearity issues in the upcoming regression. The results of correlation matrix are presented in Table 1.

Table 1. Correlation matrix

	I	S	DALL	ROL	TRO
I	1				
S	0.0483	1			
DALL	0.0227	–0.1361	1		
ROL	–0.1379	0.1414	0.1001	1	
TRO	0.5062	–0.2228	0.0421	–0.3192	1

Source: authors' calculations.

A variable of savings has a positive relationship with a variable of investments. A variable of the rule of law is negatively correlated to a variable of investment while trade openness is positively correlated to investment. The higher the magnitude of investment the lower the rule of law which is puzzling. The dummy variable of a country's affiliation with an FTA negatively correlated to savings while the rule of law is positively correlated. The rule of law is positively correlated to the dummy variable while positive and low correlation of trade openness is found. Lastly trade openness is negatively associated with the rule of law, indicating that as the rule of law increases trade openness decreases.

The LM test by Breusch and Pagan (1980) and the bias-adjusted LM test by Pesaran et al. (2008), Pesaran (2004) CD test are employed to examine cross-sectional dependency (Table 2). In the case of the LM test the null hypothesis of no cross-section dependence is rejected at 5% significance level. In the case of bias-adjusted LM test the null hypothesis is also rejected at 5% whereas CD LM the null hypothesis of cross-sectional independence is rejected at 1%. When it comes to data homogeneity the null hypothesis of homogeneity is rejected at 5% significance level indicating the presence of heterogeneity (Table 2).

Table 3 displays the results for the variables considered in the level and first difference. The study was not able to reject the null hypothesis for the variables in level: TRO and I × TRO for ADF – Fisher test, I × TRO for PP – Fisher test, I for LLC test and TRO for IPS test. However, when taken after the first difference the test statistics reject the null of non-stationarity in all specifica-

Table 2. Cross-sectional dependency and slope homogeneity tests

Cross-sectional dependency tests (H0: Cov(uit,ujt) = 0 for all t and i! = j)		
Test	**Statistics**	***p*-value**
LM (Breusch & Pagan, 1980)	517.5	0.0000
Bias-adjusted LM adj (Pesaran et al., 2008)	18.32	0.0000
Pesaran CD LM (Pesaran, 2004)	7.23	0.0000
Slope Homogeneity tests (Pesaran & Yamagata, 2008)		
Test	**Statistics**	***p*-value**
$\hat{\Delta}$ test	12.78	0.000
$\hat{\Delta}$ adj	15.13	0.000

Source: authors' calculations.

tions implying stationarity of all variables and integrated of an order one (I) at the 1% significance level.

After the examination of stationarity variables in the model the presence of long run relationships among variables is tested. Accordingly, the study employs three panel co-integration tests: Johansen-Fisher panel cointegration test (1988), Pedroni Residual Cointegration Test (Pedroni, 1999) and Kao Residual Co integration Test (Kao, 1999) to verify the (non) stationarity of the residuals and estimate the parameters of the long run relationship within the variables (Table 4).

Referring to the above mentioned tests the research finds that all four of the Pedroni's statistics including the Kao's statistic and Johansen Fisher trace and maximum eingevalue cointegration tests reject the null hypothesis of no cointegration between variables. It implies the presence of long run panel cointegration between the observed variables in the model.

Moreover, the study explores the long-run relationship by using the DOLS and the FMOLS estimators.

The findings from Table 5 reveal that an increase in savings positively affects investments in the long run while a one-unit increase in savings will lead to a 0.29-unit increase to investment in the long run. The closeness of values for the saving retention coefficients in the case of FMOLS (0.294) and DOLS (0.292) models confirming the robustness of the findings. This implies that a low correlation between savings and investments can provide evidence of high capital mobility. Similarly, both the dummy variable and the TRO have positive and significant (at 1% and 5% level) effects on investments.

In fact, it implies that membership in the FTA led to an increase in the level of investments. On the contrary a variable of ROL does not have long run

Table 3. Unit root tests

	I (0)				I(1) First difference			
	ADF – Fisher	**PP – Fisher**	**LLC**	**IPS**	**ADF – Fisher**	**PP – Fisher**	**LLC**	**IPS**
I	57.9679	70.1571**	–1.21363	–1.45341*	170.067***	366.453***	–8.04502***	–8.9408***
S	62.0962*	64.0505**	–1.63352*	–1.66533**	145.500***	253.148***	–4.71103***	–7.6958***
ROL	444.621***	224.040***	–18.791***	–12.586***	440.253***	1064.20***	–9.39083***	–21.151***
TRO	54.6791	60.6829*	–1.61833*	–0.74830	182.511***	361.760***	–7.37885***	–9.7485***
I*ROL	155.400***	165.563***	–8.9074***	–7.3962***	272.67***	776.52***	–4.9532***	–14.446***
I* TRO	57.5795	57.5219	–1.65684*	–1.20791	184.727***	498.304***	–9.00506***	–9.7931***

Note: ***, **, * signify 1%, 5% and 10% significance levels, respectively.

Source: authors' calculations.

Table 4. Panel cointegration tests results

Test	Null hypothesis		Name of the statistic		The values
Pedroni residual cointegration test	no cointegration	within dimension	panel ADF-statistic (0.0000)		–5.079369 0.0000
			panel PP-statistic (0.0041)		–2.642071 0.0000
		group dimension	group ADF-statistic (0.0000)		–5.101673 0.0000
			group PP-statistic (0.0000)		–5.35388 0.0000
Kao residual cointegration test	no cointegration		panel ADF-statistic 0.0000		–6.346513 (*t*-Statistic) 0.0000
Johansen-Fisher panel cointegration test	hypothesized	trace test	*p*-value	maximum eigenvalue test	*p*-value
	none	594.3	0.0000	525.8	0.0000
	at most 1	223.9	0.0000	149.2	0.0000
	at most 2	107	0.0000	77.18	0.0027
	at most 3	54.41	0.1850	29.42	0.9728

Source: authors' calculations.

statistically significant effect on level of investment but is significant in the panel quantile regression. Moving on to the interactive effect of investment on trade openness ($I \times$ TRO) in the long run the findings indicate that this variable is significant (1%) and improves the given level of investments. The legal protection system for the whole provided for the investors did not impact on the level of capital mobility.

In the models of Q1, Q2, Q3 pseudo-R squared in the quantile's regressions of 0.5936, 0.6825, and 0.7688 respectively are adequate (Table 5). The results of *F*-statistics are significant by rejecting equality of the estimated coefficients for the three quantiles (q.25, q.50, and q75). Moreover, the results show that the FTA members with a better ROL and higher trade openness can influence capital mobility within the region. On the contrary a dummy variable of DALL does not have significant effect across quantiles (q.25, q.50, and q.75).

The results presented in Table 6 for the CEFTA region reveal that the saving retention coefficients in the case of FMOLS and DOLS estimators are statistically insignificant with values of 0.05 and 0.08 respectively. Estimated dummy variable of CEFTA and trade openness are significant at 1% indicating that the current level of trade openness and country's affiliation with CEFTA incre-

Table 5. Whole sample – results for long run analysis and quantile regression estimates

Variables	Long run analysis		Panel quantile regression		
	FMOLS	DOLS	Q1 Regress	Q2 Regress	Q3 Regress
S	0.294895	0.292205	0.0246534	–0.0097317	0.0002501
	0.033843)***	(0.034069)***	(0.0146464)*	(0.0049331)**	(–0.003206)
DALL	4.701773	4.315180	0.4733129	0.1018105	0.0481084
	0.889482)***	(0.889448)***	(–0.3813246)	(–0.1088265)	(–0.0967001)
ROL	2.704918	2.837177	8.259125	7.205589	7.872.612
	(3.372560)	(3.335086)	(2.838906)***	(2.175663)***	(2.334127)***
TRO	0.084237	0.087171	–0.152853	–0.2211035	–0.2376273
	(0.033478)**	(0.033761)**	(0.0207234)***	(0.0155172)***	(0.0150562)***
I × ROL	–0.119643	–0.120895	–0.387814	–0.3230305	–0.3428673
	(0.152331)	(0.151094)	(0.1393505)***	(0.1003833)***	(0.1010295)***
I × TRO	0.004842	0.004958	0.0069799	0.0093848	0.0100619
	(0.001306)***	(0.001324)***	(0.0009104)***	(0.000626)***	(0.0006205)***
Observations	483	483	483	483	483
Pseudo R^2	–		0.5936	0.6825	0.7688

Note: ***, **, * signify 1%, 5% and 10% significance levels, respectively. Test for equality of Q1, Q2 and Q3 estimated coefficients: *I* × ROL – *F*-statistics = 0.27; *I* × EO – *F*-statistics = 14.37***; in the brackets are standards errors.

Source: authors' calculations.

ases investment. The variable of savings is shown as statistically insignificant in the long run and across the quantiles. Moreover the variables of $I \times$ ROL and $I \times$ TRO are statistically significant at 1% and have different effects on *I*. More precisely the interactive effect between investment and rule of law has an inverse relationship with *I*. The interactive effect between investment and trade openness has a positive effect on the level of investment. Moving onto quantile regression results in model Q1 variables are significant at 1%, except for variable of S which is insignificant.

In the low quantile regression, the dummy variable of CEFTA, ROL, $I \times$ ROL and $I \times$ EO have a significant positive correlation with a given level of investments. In the middle and upper quantiles the dummy variable of CEFTA is not shown as statistically significant. As the quantile increases the positive correlation of the interactive effect of investment and trade openness to level of investment has strengthened. The variables interaction of investment and rule of law and trade openness have an inverse relationship with investment level. It means when investments are low there is no significant sign of

Table 6. CEFTA – results for long run analysis and quantile regression estimates

Variables	Long run analysis		Panel quantile regression		
	FMOLS	DOLS	Q1 Regress	Q2 Regress	Q3 Regress
S	0.049319	0.086562	–0.0132286	0.0038773	97945
	(0.082202	(0.084970)	(–0.020174)	(–0.008381)	(–0.0084051)
DCEFTA	3.338500	2.895589	1.428416	0.9419655	0.083378
	(1.044133)***	(1.055864)***	(0.511297)***	(–0.629475)	(–0.1599487)
ROL	1.347629	2.173026	20.74062	2.372.839	1.439.134
	(2.799475)	(2.711077)	(2.41182)***	(3.859715)***	(1.223829)***
TRO	0.058880	0.066507	–0.0975525	–0.1324982	–0.201596
	(0.024943)**	(0.025797)**	(0.0257582)***	(0.0331056)***	(0.0110065)***
I × ROL	–0.734517	–0.624539	–0.9972873	–1.036915	–0.6179306
	(0.117947)***	(0.117771)***	(0.0658559)***	(0.1665304)***	(0.0517424)***
I × TRO	0.004822	0.005013	0.0058564	0.0065575	0.0088124
	(0.000936)***	(0.000979)***	(0.00072)***	(0.000787)***	(0.000275)***
Observations	147	147	147	147	147
Pseudo R^2	–	–	0.7333	0.764	0.8054

Note: ***, **, * signify 1%, 5% and 10% significance levels, respectively. Test for equality of Q1, Q2 and Q3 estimated coefficients: *I* × ROL – *F*-statistics = 3.73; *I* × EO – *F*-statistics = 4.17***; in the brackets are standards errors.

Source: authors' calculations.

a relationship between investment interaction, rule of law, trade openness and the level of investments (Table 6).

Over the period between 2000 and 2020 for the CAFTA-DR region the saving retention coefficients were 0.51 for FMOLS and 0.50 for the DOLS model at 1% level. It is higher than for the whole sample indicating that half of domestic savings stays in the region where the level of capital mobility is moderate for the sample of CAFTA-DR countries (Table 7). The variable of ROL is shown to have an inverse relationship with investment. The interactive effect of investment on trade openness (*I* × TRO) and rule of law (*I* × ROL) in the long run have a positive association with the investment. Estimated post integration effect measured by country's affiliation with DCAFTA-DR is seen as statistically significant in the determination of investments. As expected in the case of the models: panel quantile regression of Q1, Q2, and Q3 a variable of savings is statistically significant at 10% and 5% and has a positive relationship with investments. Next a dummy variable of DCAFTA-DR is only statistically significant at 5% in a model of Q3 and has an inverse relationship with investment indicating that is it not constant across all three quantiles.

Table 7. CAFTA-DR – results for long run analysis and quantile regression estimates

Variables	Long run analysis		Panel quantile regression		
	FMOLS	DOLS	Q1 Regress	Q2 Regress	Q3 Regress
S	0.515018	0.500512	0.0425873	0.0494812	0.0309193
	(0.083870)***	(0.084970)**	(0.0233087)*	(0.020128)**	(0.0163936)*
DCAFTA-DR	4.471846	3.587975	–0.5131176	–0.4725462	–0.6984027
	(1.130571)***	(1.189604)***	(–0.3941724)	(–0.202846)	(0.3437636)**
ROL	–12.36142	–9.890712	9.357.295	2.887.319	–0.8069263
	(6.054177)**	6.432136)	(4.132765)**	(3.69832)**	(–2.001092)
TRO	0.020339	0.032876	–0.1867322	–0.1713857	0.0076081
	(0.061577)	(0.066124)	(0.0360501)***	(–0.1787828)	(–0.0959669)
I × ROL	0.619964	0.508499	–0.4865366	–0.2391571	–0.2723696
	(0.293884)**	0.310588	(0.2140351)**	(0.02377)***	(0.014340)***
I × TRO	0.007173	0.007167	0.0074999	0.0098938	0.0116064
	(0.002694)***	(0.002884)**	(0.0018121)***	(0.0012794)***	(0.0008796)***
Observations	105	105	105	105	105
Pseudo R^2	–	–	0.7114	0.7648	0.8049

Note: ***, **, * signify 1%, 5% and 10% significance levels, respectively. Test for equality of Q1, Q2 and Q3 estimated coefficients: *I* × ROL – *F*-statistics = 4.96; *I* × EO – *F*-statistics = 3.54***; in the brackets are standards errors.

Source: authors' calculations.

The next two interaction variables: *I* × ROL and *I* × TRO are shown as statistically significant at 1% and 5%. The relationship is inverse in the case of effect interaction between investment and rule of law on investment (*ROL) and positive in the case of *TRO. Pseudo-R-squared indicate that the models were estimated correctly across quantiles (q.25, q.50, and q.75).

The coefficient of interactive effect between investment and TRO is positive and higher for the lower quantile (0.0009104) than the upper quantile (0.0006205).

The saving retention coefficients at level of 0.18 (FMOLS) and 0.20 (DOLS) obtained for the EAEU trade bloc indicate high capital mobility in the region. The estimated coefficients show that a one-unit increase in savings will lead to 0.18 units increase in investment for FMOLS estimator and 0.2 units increase in investment for DOLS estimator. However, the current level of trade openness, rule of law and country's affiliation are not shown as statistically significant in determination of investments (Table 8).

Table 8. EAEU – results for long run analysis and quantile regression estimates

Variables	Long run analysis		Panel quantile regression		
	FMOLS	DOLS	Q1 Regress	Q2 Regress	Q3 Regress
S	0.187230	0.202474	–0.0006036	0.001628	–0.0172063
	(0.073856)**	(0.073021)***	(0.022761)	(0.0133307)	(0.0206903)
DEAEU	3.935183	3.942861	0.2208101	–0.328866	–0.5335434
	(2.818292)	(2.798093)	(0.5484321)	(0.469809	(0.6649705)
ROL	–13.67277	–1.136111	3.525.208	3.110.738	0.0564676
	(23.92898)	(23.27081)	(5.831258)	(6.038325)	(4.827666)
TRO	–0.066221	0.015926	–0.2110758	–0.243353	–0.3043739
	(0.201267)	(0.198457)	(0.068566)***	(0.0732398***	(0.0674097)***
I × ROL	0.376859	–0.112584	0.1489065	–0.0946831	444937
	(0.993861)	(0.971853)	(0.2662965)	(0.2600997)	(0.2160978)
I × TRO	0.009622	0.006193	0.0082277	0.0095711	0.0116592
	(0.008298)	(0.008202)	(0.0027205)***	(0.0027603)***	(0.0025434)***
Observations	105	105	105	105	105
Pseudo R^2	–	–	0.7385	0.751	0.7682

Note: ***, **, * signify 1%, 5% and 10% significance levels, respectively. Test for equality of Q1, Q2 and Q3 estimated coefficients: *I* × ROL – *F*-statistics = 0.32; *I* × EO – *F*-statistics = 0.3036***; in the brackets are standards errors.

Source: authors' calculations.

As shown in Table 9 the saving retention coefficients estimated for Pacific Alliance (PA) countries were 0.92 (FMOLS) and 0.86 (DOLS) indicating low capital mobility. In the long run the results indicate that the current level of rule of law in the region is statistically significant but trade openness insignificant in long run. In the panel quantile regression two variables of TRO and ROL have statistically significance but an inverse relationship with investments.

The regression results for the Pacific Alliance imply that investments depend on savings as well as the rule of law. Accession to the Pacific Alliance improved capital mobility as the relationship between the dummy variable and investments is positive but capital mobility still remins very low. This is in line with Kumar (2015) who studied effect of trade integration on capital mobility.

Moreover, Dumitrescu-Hurlin (2012) panel causality tests are employed to examine the directions of causal relationship among the variables for causality (Table 10). The null hypothesis related to existence of no causality between investment and saving is rejected for both directions at 1% level in the case of the whole sample and unidirectional causality in the CAFTA-DR region at 10% level, the EAEU region at 1% level and the Pacific Alliance region at 1%

Table 9. Pacific Alliance—results for long run analysis and quantile regression estimates

Variables	Long run analysis		Panel quantile regression		
	FMOLS	DOLS	Q1 Regress	Q2 Regress	Q3 Regress
S	0.929878	0.862338	424139	0.0382598	261172
	(0.137460)***	(0.144683)***	(–0.0463217)	(0.0155418)**	(0.0188886)
DPA	2.364638	2.383942	1909649	0.060186	0.1662889
	(1.079790)**	(1.123671)**	(–0.2924877)	(0.1130958)	(0.1402758)
ROL	–15.11215	–10.97406	6.518.015	5.858.636	4.100.585
	(7.072987)**	6.796278	(1.629981)***	(1.248575)***	1.248888***
TRO	–0.158058	–0.160420	–0.4446159	–0.4506119	–0.4133085
	(0.124786)	0.129851	(0.0343008)***	(0.0289297)***	(0.0304873)***
I × ROL	0.562835	0.388293	–0.2857091	–0.2597289	–0.1846442
	(0.314502)*	(0.303685)	(0.0694499)***	(0.0547198)***	(0.0548466)***
I × TRO	0.006555	0.007860	0.0193579	0.0197796	0.0184963
	(0.004765)	0.004924	(–0.0013576)	(0.0010559)***	(0.0011234)***
Observations	84	84	84	84	84
Pseudo R^2	–	–	0.8334	0.8378	0.8347

Note: ***, **, * signify 1%, 5% and 10% significance levels, respectively. Test for equality of Q1, Q2 and Q3 estimated coefficients: *I* × ROL – *F*-statistics = 2.88; *I* × EO – *F*-statistics = 1.83***; in the brackets are standards errors.

Source: authors' calculations.

level. This implies that there is significant relationship between investment and savings. No causality relationship between investment and savings was found for the CEFTA region. A unidirectional causality was found between country affiliation in FTAs and investment in the whole sample, in the CEFTA region and the CAFTA-DR region, but no causal relationship was found for the EAEU and the Pacific Alliance regions. Furthemore, changes in trade openess significantly result in variations in investments in all the considered regions except in the EAEU while the rule of law does cause investment.

4. Discussion

The results for capital mobility presented in this study show that there are some variations in the savings-investment relationship for the group that covers four trade blocs. Generally, the saving retention coefficient is positive as

Table 10. Results of Pairwise Dumitrescu-Hurlin panel causality tests

Null Hypothesis	Zbar-Stat	Effect	Null Hypothesis	Zbar-Stat	Effect
Whole sample			**CEFTA**		
S ⇒ I	1.83081*	Bidirectional causality	S ⇒ I	1.31388	No causality
I ⇒ S	2.12007**		I ⇒ S	–0.49985	
DALL ⇒ I	31.5979***	Unidirectional causality	DCEFTA ⇒ I	51.0099***	Unidirectional causality
I ⇒ DALL	–0.39639		I ⇒ DCEFTA	–0.78377	
ROL ⇒ I	–0.76084	Unidirectional causality	ROL ⇒ I	–1.04357	Unidirectional causality
I ⇒ ROL	12.6083***		I ⇒ ROL	8.29498***	
DALL ⇒ S	2.65874***	Unidirectional causality	DCEFTA ⇒ S	51.0099***	Unidirectional causality
S ⇒ DALL	–1.01226		S ⇒ DCEFTA	–0.78377	
TRO ⇒ I	3.23303***	Bidirectional causality	EO ⇒ I	2.28080**	Unidirectional causality
I ⇒ TRO	7.70626***		I ⇒ EO	0.21801	
ROL ⇒ S	1.06690	Unidirectional causality	ROL ⇒ S	8.77506***	Unidirectional causality
S ⇒ ROL	9.95233***		S ⇒ ROL	–1.04357	
TRO ⇒ S	1.35397	Unidirectional causality	EO ⇒ S	–0.46627	Unidirectional causality
S ⇒ TRO	7.24785***		S ⇒ EO	8.29498***	
CAFTA DR			**EAEU**		
S ⇒ I	–0.47111	Unidirectional causality	S ⇒ I	–0.08832	Unidirectional causality
I ⇒ S	1.69729*		I ⇒ S	2.83770***	
DCAFTADR ⇒ I	7.59659***	Unidirectional causality	DEAEU ⇒ I	–1.30746	No causality
I ⇒ DCAFTADR	0.76346		I ⇒ DEAEU	–0.15231	
ROL ⇒I	–0.81541	No causality	ROL ⇒ I	0.58647	Unidirectional causality
I ⇒ ROL	0.66241		I ⇒ ROL	6.60390***	
DCAFTADR ⇒ S	1.97480**	Unidirectional causality	DEAEU ⇒ S	–0.81639**	Unidirectional causality
S ⇒ DCAFTADR	–0.84099		S ⇒ DEAEU	–0.76357	
TRO ⇒ I	3.35534***	Unidirectional causality	EO ⇒ I	2.01345	Unidirectional causality
I ⇒ EO	1.12592		I ⇒ EO	1.63219***	
ROL ⇒ S	–1.07895	No causality	ROL ⇒ S	–0.81068**	Bidirectional causality
S ⇒ ROL	2.77811		S ⇒ ROL	14.6089***	
TRO ⇒ S	2.07062	No causality	EO ⇒ S	4.78656*	Unidirectional causality
S ⇒ TRO	3.58546		S ⇒ EO	1.66324	

Null Hypothesis	Zbar-Stat	Effect
PACIFIC ALLIANCE		
S ⇒ I	3.37399***	Unidirectional causality
I ⇒ S	0.32705	
DPA⇒ I	–0.29820	No causality
I ⇒ DPA	–0.75334	
ROL ⇒I	–0.02093	Unidirectional causality
I ⇒ ROL	10.3657***	
DPA ⇒ S	1.65857*	Unidirectional causality
S ⇒ DPA	–0.74949	
TRO ⇒ I	1.67955	Bidirectional causality
I ⇒ TRO	4.19142***	
ROL ⇒ S	1.84308*	Bidirectional causality
S ⇒ ROL	7.73833***	
TRO ⇒ S	1.00175	Unidirectional causality
S ⇒ TRO	9.59438***	

Note: ***, **, * signify 1%, 5% and 10% significance levels, respectively.

Source: authors' calculations.

expected. The null of zero slope coefficients is rejected in the CAFTA-DR, the Pacific Alliance and the EAEU member countries except in the CEFTA region due to the slow capital liberalization in the transition period that affected their exchange rate regimes and financial systems. In the EAEU countries capital is more mobile than in the rest of considered regions implying that the region depends on foreign capital. The high correlation between saving and investment and low capital mobility is observed in the Pacific Alliance region where a high percentage of domestic savings turned into domestic investments. The results obtained in DOLS estimator are similar those obtained by FMOLS estimator confirming robustness of results. For the whole sample the study finds that most investments are financed by foreign savings implying high capital mobility. In addition, the findings provide evidence supporting the effect of trade integration on the savings-investment link.

The high value of β coefficient for Pacific Alliance region shows that countries from that region have better economic development by generating more domestic savings for financing domestic investments. On the contrary some considered trade blocs such as: CEFTA, EAEU and CAFTA-DR still use more foreign than domestic savings for financing domestic investments. This can be

explained by the fact that these are underdeveloped economies with insufficient savings available for domestic investment. In the CEFTA trade bloc the results show that the countries of the region do not have enough savings to finance investments while the relationship between savings and investments is not unique. The low level of the national savings rate amongst CEFTA members is the result of low economic growth during the transition period and stagnant productivity. The region suffers from a history of economic and political instability that has had a negative impact on investment opportunities discouraging local savings. Furthermore, the study suggests that a country's affiliation with a trade bloc contributes to an increase in capital mobility. In the EAEU region, the study finds an increase in capital mobility after the country-'s affiliation while the role of trade openness and the legal protection system in an increase in capital mobility is very limited. For the sample of CAFTA-DR trade bloc the findings indicate increase of capital mobility after a country's affiliation with a trade bloc while a positive interactive effect of investment on trade openness and the rule of law is found. The regression results for the Pacific Alliance imply that a country's affiliation with the trade bloc slightly improved capital mobility which still remins very low in the region.

Except for the EAEU region the statistical significance of the value of the dummy variable shows that a country's affiliation with a FTAs leads to an increased level of investments in the considered trade blocs. It is in the line with the study done by Kumar (2015). In the case of the other control variables: openness and legal protection system the study finds limited significance implying that both variables can have some limited impact on the saving – investment link.

The obtained results remain comparable for some transition and developing countries except for Pacific Alliance countries. The findings of the study confirm previous researches done by Kumar (2015), Kumar et al. (2014) for the most developing countries where a country's affiliation with a FTAs improved capital mobility. Thus there is capital mobility for the whole sample, CAFTA-DR members and EAEU members while there is a little evidence of this for the Pacific Alliance. Unidirectional causality between a country's affiliation with a FTAs and investment indicates that this affiliation tends to encourage investments.

Conclusions

Based on four trading blocs—the Eurasian Economic Union (EAEU), Central American and Dominican Republic Free Trade Agreement (CAFTA-DR), Central European Free Trade Agreement (CEFTA), and the Pacific Alliance—the study

seeks to empirically determine whether a higher level of trade openness and the presence of better legal protection for investors enhances the impact of trade bloc membership on capital mobility. The 483 observations made between the years 2000 and 2020 make up the dataset used for the analysis. In the majority of these trading blocs, there is statistical support for the idea that trade integration has a favourable impact on the link between saving and investment. The degree of capital mobility within them varies somewhat, though. It shows that establishing regional integration does not result in an equivalent degree of capital mobility among participating nations. According to Hypothesis 1, the study's findings statistically support that a country's affiliation with a trade bloc improves capital mobility in the whole group and the EAEU region and low capital mobility in the Pacific Alliance region and moderate to low capital mobility in the CAFTA-DR region but not in the CEFTA region.

Referring to the testing of Hypothesis 2 the study reveals that higher trade openness enhances the impact of a country's affiliation with a trade bloc on capital mobility in interaction with investment only in the CEFTA and CAFTA-DR regions but not in the EAEU region and the Pacific Alliance. It might be concluded that high trade openness alone does not necessarily lead to better capital mobility for the trading blocs studied.

In the case of hypothesis H3 the study demonstrates that better legal protection of the investor enhances the impact of trade bloc membership on capital mobility in interaction with investment in most of trading blocs except in the EAEU. The legal protection system alone for the whole group the CEFTA and EAEU trade blocs does not improve the level of capital mobility unless its interaction with investment is included.

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