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FORUM SCIENTIAE OECONOMIA



**Miguel Angel Alonso-Neira, Antonio Sanchez-Bayon,
Marcos Castro-Oliva**

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of Economics analysis of boom & bust

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An heterodox History of Spanish Economy into the Eurozone: Austrian School of Economics analysis of boom & bust

MIGUEL ANGEL ALONSO-NEIRA, ANTONIO SANCHEZ-BAYON,
MARCOS CASTRO-OLIVA

Abstract

This is a heterodox Economic History on Political Economy, Macroeconomics and Applied Economics, based on the Austrian Economics theory of business cycles, applied to the case of the Spanish Economy during the boom-bust cycle (2002-2014). Attention is focused on the endemic problem of business cycles, such as successive and distorting periods of boom and bust that modern economies suffer, as with the Spanish economy. This work reviews the analysis of the Austrian School of Economics' theory and its development, with attention to the empirical renewal line (into the school), which used econometric support, to help the communication with other economic schools. Consequently, there is a review of the main econometric literature on the Austrian cycle, followed with an illustration of the case of Spain in the Eurozone. In this way, it is possible to better understand the cycle of boom and bust by means of new currency emission and how to help econometric tools to illustrate economic principles.

Key words

economic cycle; monetary policy; capital-based Macroeconomics; Austrian School of Economics; heterodox approaches.

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Introduction

The aim of this study is to apply the Austrian Business Cycle Theory (ABCT) to the Spanish Economy case, during the

period 2002-2014: between the boom, following the introduction of the Euro (€), and the bust following the Great

Recession in 2008. The originality of this Austrian School of Economics review consists in the illustration of the theory with an empirical case (Alonso et al, 2013 & 2023). This means that, although the explanation of ABCT has traditionally been literary (Mises, 1912, 1949; Hayek, 1929, 1931), on this occasion real data and econometric methods will be used, as Machlup (1936, reviewed by Hutchinson, 1956, and Garrison, 2001) had already suggested, and other Austrian School authors have continued (i.e. Fekete, Alonso, Cachanosky, Padilla, Rallo, Ravier, Sánchez-Bayón & Castro-Oliva, 2022). It is hoped that this study will provide a better understanding of ABCT and updates thereto, in addition to building bridges with other economic approaches, the theories and models thereof (Sánchez-Bayón, 2020 & 2021; Sánchez-Bayón et al., 2022).

ABCT is part of the so-called monetary cycle theories, which reject the assumption of neutrality of money (either in the short run or in both the short and long run). However, unlike other approaches (Friedman, 1993; Lucas, 1972), it is characterised as an endogenous, disaggregated and capital-based theory of the disequilibrium cycle (Alonso, 2005; Alonso et al., 2011). ABCT states that an increase in the money supply, either by the Central Bank (through the so-called open market operations) or by commercial banks with fractional reserve banking (which expand credit via the bank multiplier), could reduce the interest rate (with an artificial expansion of credit and the origin of a financial boom). The interest rate of the economy (the so-called money or bank interest rate) is thus lowered below its natural level as a result of the “liquidity effect”

(Garrison, 2001)¹. This study, therefore, offers a review of ABCT development, with attention paid to empirical research based on econometric methods (after Garrison’s model of capital-based macroeconomics). Also, it illustrates the ABCT using a specific historical episode: the economic cycle in Spain between 2002 and 2014 (i.e. boom, recession and recovery). The aim is to test whether ABCT serves to illustrate the Spanish economic cycle during the cited period.

1. Theoretical background review

1.1. ABCT foundations

The artificial reduction in interest rates is caused by the increase in the supply of loanable funds resulting from the expansion of bank credit, which moves entrepreneurs, who can now finance themselves more cheaply, to take on newly created loans and invest in long-term production processes (more time and capital-intensive and therefore more sensitive to interest rate variations), located in the stages furthest away from consumption, induced by the increase in the prices of capital goods given the decrease in interest rates

$$(a_n = (1 + i)^n - 1 / i(1 + i)^n).$$

On the other hand, the decrease in interest rates leads economic agents to save less and increase their present consumption. This increase in consumption may also be caused in part by the greater monetary availabilities resulting from credit expansion.

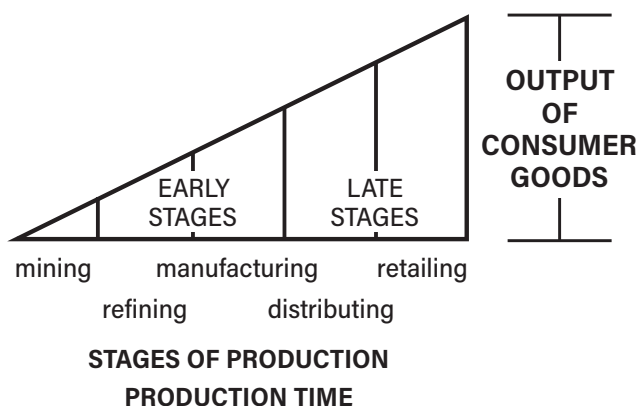
¹ The term ‘natural rate of interest’ comes from Wicksell (1898), who took it from Böhm-Bawerk (1884, 1888), corresponding to the Austrian theory of the long-term rate of return on capital, which in turn is a reflection of the rate of time preference of economic variables; therefore, it is not affected by monetary factors (Garrison, 2006). It is important to note that ABCT is based on the existence and empirical importance of the “liquidity effect” (Keeler, 2021).

This situation causes serious perception issues for economic agents (Alonso, 2004), since the production structure tends to become more time and capital-intensive, while the demand for goods for immediate consumption increases. So, with more indirect production processes financed under artificially low interest rates, without any prior increase in real savings, there is a distortion of the production process, thanks to wrong signals. The situation seems to be a panacea, as the abundance of cheap money induces entrepreneurs to take out new loans and further lengthen the production structure, while households increase their consumption by borrowing as well. However, intervention in the loanable funds market creates an unsustainable situation in the long run, as there is an inter-temporal misalignment between savings and investment decisions. In other words, entrepreneurs invest in long-term production projects by paying for them with loans obtained at low interest rates, while consumer-savers do not lower their rate of time preference (therefore they do not postpone their present consumption in order to increase their future consumption capacity). On the contrary, in the context of low interest rates, consumers decide to save less and increase their present consumption by borrowing. The mismatch between savings and investment decisions leads to a scenario of unsustainable monetarily-induced growth.

The first economic symptoms that reveal the unsustainability of the situation created by the monetarily-induced inter-temporal mismatch between savings and investment decisions are:

- First, there is an increase in the price of labour and raw materials. Entrepreneurs who finance themselves with arbitrarily cheap credit require labour to implement their productive processes in the stages furthest away from consumption, which are more profitable in the short term because of the increase in the price of capital goods resulting from the artificial decrease in the monetary interest rate. Since we start from a situation of full employment of production resources², the only way for entrepreneurs to attract workers from the stages closer to consumption to those further away from it is to offer higher wages, which raises the costs of the new productive processes put in place (Machlup, 1931).
- Secondly, there is an increase in the price of consumer goods as a result of a decrease in supply, since labour has been taken away from the production processes closer to consumption and displaced to those located at more distant stages (Hayek, 1931). In addition, the latter have lengthened and new production processes (even further away from final consumption) which are more time- and capital-intensive due to the readjustment effect (Sánchez-Bayón et al., 2021), financed by the expansion of bank credit, have emerged. This results in an increasingly complex capital structure. The combination of all the above causes' consumer goods to reach the market more slowly, the supply to decrease and the price to increase due to the time discount effect (Garrison, 2001).

² Theoretically, "production" means an objective view (what it is changed with the application of labour to satisfy necessities) and "productive" a subjective view (what it is expected to generate profits or more welfare).

Figure 0: Hayek's triangle (stages of production/production time)

Source: own elaboration based on Hayek (1931)

- Third, there is a relative increase in the accounting profits of companies closer to final consumption. Since the price of consumer goods increases in relative terms more than the price of labour and raw materials, and yet the price of intermediate products (capital goods) generated in the stages further away from consumption remain unchanged, the profits of firms which are closer to final consumption will tend to rise with respect to those of firms farther away. This fact goes to show entrepreneurs that they have erred in investing in production processes farther away from final consumption, since the highest profits are now to be found in companies producing goods for immediate consumption.
- Fourth, the so-called “Ricardo effect” (Hayek, 1929, reviewed as the readjustment effect, Sánchez-Bayón, 2021) is verified, but in the opposite direction. As the price of consumer goods rises above nominal wages, real wages fall. This sends a new market signal for businessmen to substitute capital equipment for labour factor at the margin (Huerta de Soto, 1998), which worsens the situation, because as the demand for capital goods decreases, the price falls, and the accounting profits of companies located in the stages furthest away from consumption continue to suffer.
- Fifth, there is an increase in interest rates. This rise is the result of three distinct causes. The first cause is because commercial banks will tend to add a premium for the inflation generated. The second is that there will be many production processes that, because of the above, will need to be refinanced, resulting in a scramble for additional loans and credit to save production processes. This will increase demand for loans and credits, making them more expensive. Finally, the third cause has to do with the actions of the Central Bank, since it is likely that in the final phases of the upward cycle, close to the financial crisis phase, in the expectation of an inflationary process, the monetary authorities will decide to raise the reference interest rates. Historical evidence shows that interest rates resulting from the market adjustment process derived from an expansion of bank credit can be even higher than the initial ones (Rothbard, 1963).
- Finally, as a result of the effects, accounting losses begin to appear in many companies located furthest away

from final consumption in the production process which, compared to the profits of the closest companies, reflect poor business investments induced by the artificial reduction of interest rates resulting from the processes of credit expansion without the prior backing of voluntary savings.

It is at this point that the expansionary phase of the cycle gives way to a recession and a financial crisis. With new higher interest rates, lower capital goods prices and higher wages, many companies in debt during the credit boom phase do not make profits and become unprofitable. This causes the assets of commercial banks to contract (as a result of delinquency), while their liabilities, made up of the deposits they created through the bank multiplier, remain the same, leading to a problem of insolvency in the banking system leading to the financial crisis phase of the business cycle.

The financial crisis phase, and the consequent tightening of bank credit, is quickly transmitted to the real economy in the form of an economic recession, when the inter-temporal misalignment between savings and investment decisions is discovered, leading to a spontaneous market adjustment process. This adjustment involves the paralysis of the refinancing activity of a multitude of projects undertaken during the credit expansion phase in the stages furthest away from consumption, and the transfer of labour from these stages (in which investment errors have accumulated) to others more in line with agents' preferences. The supply of credit contracts to a level consistent with the supply of savings (which in turn reflects the rate of time preference of the consumer-savers in a given economy). On the other hand, commercial banks, with a more precarious solvency-liquidity ratio, are much more restrained in granting new loans and credit lines. The tightening of the supply of bank

credit leads to a rise in interest rates, which in turn leads to a decline in investment, which also falls below its initial level.

In the long run, this process leads to the destruction of a myriad of productive processes, resulting in a less capital-intensive production structure with fewer stages, which will provide smaller quantities of consumer goods in the future. As markets adjust, the economy shows negative growth rates, declining real wages and rising unemployment (Hülsmann, 2001).

Once the malinvestments undertaken in the early stages of the productive structure have been purged, the economy will only return to a sustainable growth path if it is based on technological advances or increases in savings by economic agents (Garrison, 2001). Moreover, ABCT does not end at this point, but also differentiates between "short recessions" in which the government does not interfere in the reallocation of misinvested capital, and "recessions that are prolonged in time" as a consequence of fiscal and monetary expansion policies driven by governments to perpetuate the employment levels resulting from the preceding man-made boom phase. These policies hinder a rapid and efficient liquidation of bad investment processes and the early reallocation of resources to other productive stages and sectors of the production structure.

Finding empirical illustrations of ABCT would allow us to distinguish them from alternative approaches that seek to explain the origin, the propagation mechanisms and the persistence of cyclical oscillations (Young, 2011).

1.2. Literature review

Although it is true that the academic literature in this line of research is limited, some papers can be found that use econometric methods to analyse ABCT in different historical periods. The aim of this section is to review a good part of them, with the aim

of discovering what type of data and econometric methods can be most useful. The most relevant contributions will be analysed in chronological order.

The first study is by Wainhouse (1984), who used Granger causality tests (1969) to analyse the impact of credit expansion on interest rates and the production structure of the United States of America using monthly data between 1959 and 1981. He concluded that the business cycle is the result of a process of credit expansion, as he established that fluctuations in the supply of credit lead to alterations in interest rates and, in turn, verifies the “time discount” effect by finding that changes in the rate at which credit is granted stimulate entrepreneurs to invest in the stages furthest away from consumption. In addition, it shows that the ratio of capital goods prices to consumer goods prices behaves according to the ABCT explanations, i.e. it increases in boom phases and decreases as the market adjusts.

Subsequently, Le Roux and Levin (1998), in line with Wainhouse’s study, used monthly data for the South African economy between 1980 and 1996, reaching similar conclusions; that is, the South African Central Bank’s monetary policy induced an expansion of bank credit unsupported by voluntary savings, which led to strong distortions in interest rates and in the structure of the productive process, giving rise to the “forced savings” effect.

Following this work, Keeler (2001) used standardised quarterly data for the United States of America (USA/U.S.), between 1950 and 1991, on money supply growth (measured by M1), with the slope of the yield curve (the spread between the ten-year and three-month federal bond rates) as a proxy. Between 1950 and 1991 of money supply growth (measured by M1), the slope of the yield curve (spread between the 10-year and three-month federal bond rates) as a proxy for the natural or Wicksellian

rate of interest and the money interest rate in the short-term credit market, the allocation of resources within the production structure (for which the proxy is the ratio between the capacity utilisation of primary processing industries and the capacity utilisation of advanced processing industries), and output deviations (measured by the ratio between real GDP and natural real GDP). This author questioned whether Austrian explanations of the impact of monetary policy shocks can characterise eight cycles of the U.S. economy since the post-war period. Through the study of cross-correlations between variables with different lags, he concluded that fluctuations in the money supply have an immediate effect on the yield curve, and that changes in the latter positively affect both the inter-temporal allocation of production resources and cyclical deviations in output with some lag. These results are consistent with ABCT in that a decline in the interest rate induced by monetary expansion stimulates the shift of production resources from the productive stages which are closer to final consumption to the more distant stages. In the same way, it shows that the fact that the correlations between the allocation of resources within the productive structure of the economy and the cyclical deviations of production are positive until the fifth quarter and negative thereafter goes to show that the processes of allocation (in the boom phase) and reallocation (in the recessionary phase) of productive resources in the capital structure have an influence on the cyclical behaviour of economic activity.

Mulligan (2002) deviated from previous studies, evaluating the U.S. production structure between 1959 and 2000 by means of the Hayek triangle, using interest rate data with different maturities and employment data from nine productive sectors (manufacturing, construction, finance, insurance and real estate, the government sector, mining, services, transportation

and utilities, the retail trade industry, and the wholesale trade industry). This author used cointegration techniques and error correction vector models (ECVM) to conclude that, if labour is taken as the productive resource under analysis instead of capital (since the latter is much more complex to measure), the study presents very strong empirical evidence of co-integration between changes in sectorial employment and changes in interest rates. That is, employment in different productive sectors responds strongly and differentially to changes in interest rates over the business cycle. The author concludes that expansionary phases, when interest rates fall, they are marked by a redistribution of employment towards the productive stages furthest away from final consumption, while at the beginning of the recession, which is usually preceded by an increase in interest rates and followed by a reallocation of employment towards the productive stages, closer to final consumption (Hayek, 1931). According to ABCT, since interest rates signal which production processes are profitable and which are not, generating movements of productive factors between the different stages of the capital structure, with an impact in the economic system.

In the same sense, while conducting a study similar to that of Mulligan (2002), Young (2005) used quarterly data on job reallocation within the production structure and federal funds interest rates (as a proxy for monetary policy behaviour) for the U.S. between 1972 and 1993. He employed a dynamic panel data model and finds a statistically significant "Hayekian channel" for monetary policy. Specifically, he concluded that episodes of job reallocation occur in the production structure in response to monetary policy management as predicted by ABCT. However, although he found that the "Hayekian channel" is statistically significant, he also determined that monetary shocks only explain little more than

10% of the variability of job reallocation in the U.S. production structure, so that the contribution of monetary policy is quite modest.

In turn, Mulligan (2006) used monthly data on real consumable output, 10-year federal bond interest rates and three-month U.S. Treasury bills between January 1959 and March 2003 to determine the existence of cointegrating relationships between personal consumption expenditure and the "long-run-short-run" rate differential through an ECVM. The author concluded that an increase in the interest rate differential has a positive impact on all stages of the production structure, although this effect is greater in the stages which are furthest away from final consumption (producing capital goods) than in the stages closer to it (producing consumer goods). Furthermore, he concluded that this effect tends to dilute over time, although it ends earlier in the stages closer to consumption than in those farther away. Finally, he stated that this effect not only disappears over time, but also tends to reverse, the reversal being more intense in the stages farther away from consumption than in those closer to it. Therefore, these results are consistent with the postulates of ABCT.

Carilli and Dempster (2008) followed in the footsteps of Keeler (2001). Using quarterly data on personal consumption and savings, short-term interest rates, central bank (or Federal Reserve 'Fed') reserves, and U.S. GDP between the first quarter of 1959 and the second quarter of 2007, they established Granger (1969) causality contrasts between the growth rate of reserves and the interest differential (conceived as the spread between the natural rate of interest approximated by the savings-consumption ratio and the short-term credit market interest rate), and between the interest differential and the growth rate of real GDP. They concluded that the rate of growth of reserves causes the interest rate differential

in the Granger sense, and that the interest rate differential itself causes the rate of growth of real GDP in the Granger sense (Rothbard, 1993). These results are consistent with ABCT. In addition, they estimated a polynomial lagged Almon (1965) model with the real GDP growth rate as the dependent variable and different lags of the interest rate differential as explanatory variables. Based on this model, they presented the existence of “endogenous” turning points which show that an increase in the interest rate differential has a positive impact on the real GDP growth rate in the short run, and a negative impact in later periods. Again, this result would be consistent with ABCT, as the initial positive effect would tend to reverse as the market discovers bad investment processes undertaken in projects that require more time to mature than the market is willing to wait.

In a paper published in 2009, Bismans and Mougeot used a panel data model with fixed effects to estimate the relationship between the interest rate differential (using the long-term interest rate as a proxy for the natural rate of interest) and the cyclical deviations of real GDP, the ratio between consumption and investment expenditures and the ratio by quotient between the prices of consumption goods and the prices of production goods. They concluded that an increase in the interest differential generates an acceleration of real GDP. However, they also found that this acceleration tends to abate and reverse as the short-term interest rate converges to the long-term interest rate (i.e. as the interest rate differential narrows). These findings represent an empirical illustration of ABCT.

With a methodology that differs from previous studies, Young (2011) proposed an innovative analysis. Using TIOR data (i.e. the total industrial production requirement of a productive sector, as an approximation of the concept of indirect production) of 65 industries of the U.S. production structure

and the effective federal funds rate between 2002 and 2009, he measured the degree of complexity of the capital structure of the U.S. economy throughout the period under consideration and how it was altered by the expansionary monetary policy of the Federal Reserve, concluding that the capital structure expanded because of the monetary expansions that began in 2002 and then contracted during the 2007-2008 recession. This research represents a good empirical illustration of ABCT, mainly in terms of the initially positive and subsequently negative effects that monetary inflation policies had on the U.S. production structure.

Following in the footsteps of Keeler (2001), Carilli and Dempster (2008), and Bismans and Mougeot (2009), Alonso et al. (2013) used quarterly data on the monetary base, long-term and short-term interest rates, the industrial production of different productive sectors and the aggregate industrial production in the U.S.A. between 1988 and 2010, to carry out a Granger (1969) causality test between the cyclical behaviour of the monetary aggregate MZM (money zero maturity) and the slope of the yield curve, between the yield curve and various ratios that represent the cyclical evolution of the U.S. production structure, and between the yield curve and the cyclical behaviour of aggregate industrial activity. They concluded that the cyclical fluctuations of the MZM cause the interest rate differential in the Granger sense, and that this, in turn, causes the cyclical variations of the ratios that reflect the production structure and the cyclical behaviour of the industrial aggregate activity. Furthermore, using polynomial distributed lag models that add the ratios that approximate the cyclical behaviour of the production structure and the variable that represents the cyclical behaviour of industrial activity as dependent variables, and a set of lags of the slope of the yield curve as explanatory variables, they found endogenous inflection points

whereby an increase in the interest rate differential has a positive impact on the ratios of the production structure and on industrial aggregate activity in the short term, and a negative impact in later periods. Both findings provide empirical evidence in favour of ABCT, since, as the authors themselves argued, they would confirm both the impulse and propagation mechanisms of the Austrian cycle.

In a 2013 paper, Fisher extended the work of Mulligan (2006) by integrating and evaluating the role of monetary policy in determining interest rates and consumption. Using quarterly data on monetary aggregate M1, real personal consumption expenditures, the effective federal funds rate, and real asset yields, for which the spread between the 10-year federal bond rate and three-month treasury bills between the first quarter of 1963 and the second quarter of 2012 functions as a proxy. There were co-integrating relationships and resorts to error correction models for different periods (the full sample, February 1982 to February 2012, and January 1980 to January 2009), in order to analyse the long-run relationships among monetary policy, interest rates and real consumption. So, it was concluded that Federal Reserve intervention in the loanable funds market lowers short-term interest rates through the management of the effective federal funds rate, which distorts the value of the slope of the yield curve. Furthermore, he argued that an increase in the money supply tends to destabilise short-term real personal consumption expenditures. These results suggest that the Fed's short-term actions disrupt long-term monetary, interest rate, consumption and investment expectations, findings which are consistent with ABCT.

Lester and Wolf (2013) dismissed the use of production, consumption and investment data from the U.S. National Income and Production Accounts (NIPA) as too aggregated and not particularly illuminating

of the sequential process of the production structure. They argued that the available U.S. data on the stages of the production process accurately capture the Austrian notion of a production structure. They measured industrial production in three stages (early, intermediate and late) with the industrial production indexes of raw, primary and finished products, and the average prices of goods produced in the early, intermediate and late stages with the producer price indexes of raw, intermediate and finished goods (based on data obtained from the Bureau of Economic Analysis (BEA) and Bureau of Labor Statistics (BLS)). Subsequently, they estimated a structural vector autoregressive (VAR) model to determine the short-run changes in the productive structure as a result of monetary expansion processes (using the effective federal funds rate as an indicator of monetary policy). These authors argued that if ABCT is empirically relevant, a monetary expansion should increase the output and prices of goods in the early and late stages relative to the output and prices of goods corresponding to the intermediate stage. They found that while monetary expansions are followed by statistically significant changes in aggregate output, the magnitude of the changes in the productive structure and prices of the various stages is moderate, statistically insignificant, and sometimes bears the opposite sign to that predicted by ABCT. The work of Lester and Wolf (2013) represents a clear challenge to ABCT, having found no clear empirical evidence for it. However, it is possible that these authors used a monetary policy indicator that is not entirely consistent with ABCT.

In this regard, Luther and Cohen (2014) applied the same method as Lester and Wolf (2013). However, they criticised their use of the federal funds rate as an indicator of monetary policy, since, in their opinion, it fails to distinguish a low market interest rate from a market interest rate that is low

compared to the natural interest rate. These authors preferred to use the estimate of the natural rate of interest proposed by Selgin, Beckworth and Bahadir (2011) to record, using the same econometric methods as Lester and Wolf, that the market interest rate falls below its natural level as a result of a process of monetary expansion orchestrated by the Federal Reserve. However, their efforts to improve on Lester and Wolf's study do not substantially modify the results obtained since, similarly, they found little empirical evidence in favour of ABCT regarding the fact that a monetary expansion alters the production structure. Considering that other previous research did find empirical evidence that a monetary expansion produces distortions in the production structure, the results contrary to ABCT in the latter work may be due to the fact that the data set does not provide a good approximation of the production structure of an economy.

1.3. A brief graphical and mathematical illustration of ABCT

In this section, a brief mathematical and graphical demonstration of the theoretical development of ABCT will be carried out. For this purpose, this study is based on the works of Garrison (1978, 1989 and 2001) and Cachanosky and Padilla (2016), in which ABCT is illustrated in a more formal way. Firstly, the mathematical development of ABCT implemented by Cachanosky and Padilla (2016) provides an innovative view of the cycle theory, as it is the first and only mathematical version of Austrian theories on record to date. Secondly, the mathematical model of Cachanosky and Padilla (2016) is mainly based on the graphical model of Garrison (2001), which characterises the Austrian cycle by interconnecting three main graphs. The first of these is a loanable funds market, where we have the economy's interest rate on the vertical axis, and the economy's investment and savings on the

horizontal axis, the levels of these two variables being determined by the interconnection of an increasing demand for funds and a decreasing supply of funds. The second is a production possibilities frontier, understood as a trade-off between sustainable combinations of monetary units spent on consumption (vertical axis) and monetary units spent on investment (horizontal axis). Finally, the third is the intertemporal structure of production, colloquially known as the Hayekian triangle, in which consumption is on the vertical axis and the period of production is on the horizontal axis. This graph reflects the concept of roundaboutness or indirect production introduced by Böhm-Bawerk (1888), which is defined as the process by which capital goods are first produced; goods for final consumption are subsequently produced through the combination thereof. These graphs interrelate with each other on the basis of their common axes; that is, the loanable funds market is related to the PPF on the basis of their common axis on which investment and savings are determined, the PPF is related to the Hayekian triangle on the basis of their common axis on which consumption is determined, and finally, the loanable funds market is related to the Hayekian triangle through the interest rate, since the slope of the Hayekian triangle represents the return on capital, which coincides with the interest rate determined in the loanable funds market.

The equations defining this model of stationary equilibrium with full employment of resources (capital and labour) are shown below. For mathematical simplicity, it is assumed that there is no long-run growth, being defined as a closed economy with no public sector (an issue that has raised the Salerno-Young-Engelhardt-Murphy controversy over Garrison's theory of long-run growth: Salerno, 2001; Young, 2009a, 2009b; Engelhardt, 2009; Murphy, 2017; Cachanosky, 2017):

$$I^D = A - \alpha i \text{ (Demand for loanable funds)} \quad (1)$$

$$I^S = B + \beta i \text{ (Supply for loanable funds)} \quad (2)$$

$$\bar{Y} = C + I \text{ (Production Possibilities Frontier)} \quad (3)$$

$$C = i\tau \text{ (Hayekian triangle slope)} \quad (4)$$

Therefore, the equations that define the main variables of the model in the balance with full use of resources are as follows:

$$i^* = (A - B) / (\alpha + \beta) \text{ (Rate of interest)} \quad (5)$$

$$I^* = (\beta A + \alpha B) / (\alpha + \beta) \text{ (Investment)} \quad (6)$$

$$C^* = [(\alpha + \beta)\bar{Y} - (\beta A + \alpha B)] / (\alpha + \beta) \text{ (Consumption)} \quad (7)$$

$$\tau^* = [(\alpha + \beta)\bar{Y} - (\beta A + \alpha B)] / (A - B) \text{ (Production period)} \quad (8)$$

We will now move directly to define how ABCT, understood as a process of credit expansion, followed by a boom and subsequent recession, it could be mathematized in the Macroeconomic capital-based model. This credit expansion injects as a ΔM that adds to the autonomous credit supply in the credit supply function, which causes it to shift; hence, the new credit supply is as follows: $S^I = B + \Delta M + \beta i$. Consequently, attention should be paid to three different sets

of points: first, the initial state of balance without credit expansion, which has already been defined above; second, how the main variables of the model are left after the increase in credit supply resulting from monetary expansion; and third, the value taken by the main variables of the model after the market reaction to an artificially low interest rate and the final situation.

The main variables of the model after credit expansion:

$$i_m^* = (A - B - M) / (\alpha + \beta) \quad (9)$$

$$I_m^* = [(\beta A + \alpha B) + \alpha M] / (\alpha + \beta) \quad (10)$$

$$C_m^* = [(\alpha + \beta)\bar{Y} - (\beta A + \alpha B) - \alpha M] / (\alpha + \beta) \quad (11)$$

$$\tau_m^* = [(\alpha + \beta)\bar{Y} - (\alpha B + \beta A) - \alpha M] / (A - B - M) \quad (12)$$

Difference from the initial situation:

$$i_m^* - i^* = [-1/(\alpha + \beta)]M < 0 \quad (13)$$

$$I_m^* - I^* = [\alpha/(\alpha + \beta)]M > 0 \quad (14)$$

$$C_m^* - C^* = [-\alpha/(\alpha + \beta)]M < 0 \quad (15)$$

$$\tau_m^* - \tau^* = [(\alpha + \beta)(\bar{Y} - A)M] / [(A - B)(A - B - M)] > 0 \quad (16)$$

The market reaction to an artificially low interest rate:

$$i_p^* = [(A - B)\alpha + \beta M] / [\alpha(\alpha + \beta)] \quad (17)$$

$$I_p^* = [(\beta A + \alpha B) - \beta M] / (\alpha + \beta) \quad (18)$$

$$C_p^* = [(\alpha + \beta)\bar{Y} - (\beta A + \alpha B) + \beta M] / (\alpha + \beta) \quad (19)$$

$$\tau_p^* = \frac{\alpha[(\alpha + \beta)\bar{Y} - (\beta A + \alpha B) + \beta M]}{(A - B)\alpha + \beta M} \quad (20)$$

Difference from the initial situation:

$$i_p^* - i^* = \beta M / [\alpha(\alpha + \beta)] > 0 \quad (21)$$

$$I_p^* - I^* = [-\beta/(\alpha + \beta)]M < 0 \quad (22)$$

$$C_p^* - C^* = [\beta/(\alpha + \beta)]M > 0 \quad (23)$$

$$\tau_p^* - \tau^* = \frac{(A - B) - (\alpha + \beta)\bar{Y} + (\beta A + \alpha B)}{(A - B)^2\alpha + (A - B)\beta M} < 0 \quad (24)$$

Credit expansion ΔM puts the economy above FPP and is distributed between the deviation of consumption and investment:

$$Y_m = \bar{Y} + M \quad (25)$$

$$(I_m^* - I^*) + (C_p^* - C^*) = M \quad (26)$$

Moreover, it becomes necessary to know the differences that occur between the variables affected by credit expansion and the

value of the variables after the natural reaction of the market to an artificially low interest rate:

$$i_m^* - i_p^* = (-1/\alpha)M < 0 \quad (27)$$

$$I_m^* - I_p^* = M > 0 \quad (28)$$

$$C_m^* - C_p^* = -M < 0 \quad (29)$$

$$\tau_m^* - \tau_p^* = \frac{(\alpha + \beta)((\alpha + \beta)\bar{Y} - \alpha(A - B - M)) + (\beta A + \alpha B) - 2\alpha\beta M}{(A - B - M)(\alpha(A - B) + \beta M)} M > 0 \quad (30)$$

There are two interest rates at the same time in the market: a) i_m^* defines the slope of the hypotenuse of the Hayekian triangle for the stages furthest away from consumption; b) i_p^* fixes the slope for the stages closer to consumption. This verifies the breakage of the Hayekian triangle after credit expansion and the economic mismatch of

increasing consumption and investment at the same time, with no savings to support it.

In addition, it is possible to calculate an approximation of how the variables would be after the process of capital restructuring in the economy through the intercept between the two hypotenuses mentioned above:

$$C_B^* = (\tau_m^* - \tau_B^*)i_m^* \quad (31)$$

$$C_B^* = (\tau_p^* - \tau_B^*)i_p^* \quad (32)$$

$$\tau_B^* = (\tau_p^* i_p^* - \tau_m^* i_m^*) / (i_p^* - i_m^*) \quad (33)$$

$$C_B^* = [(\alpha + \beta)(\bar{Y} - A) - (\beta A + \alpha B)] / (\alpha + \beta) < C_m^* < C^* < C_p^* \quad (34)$$

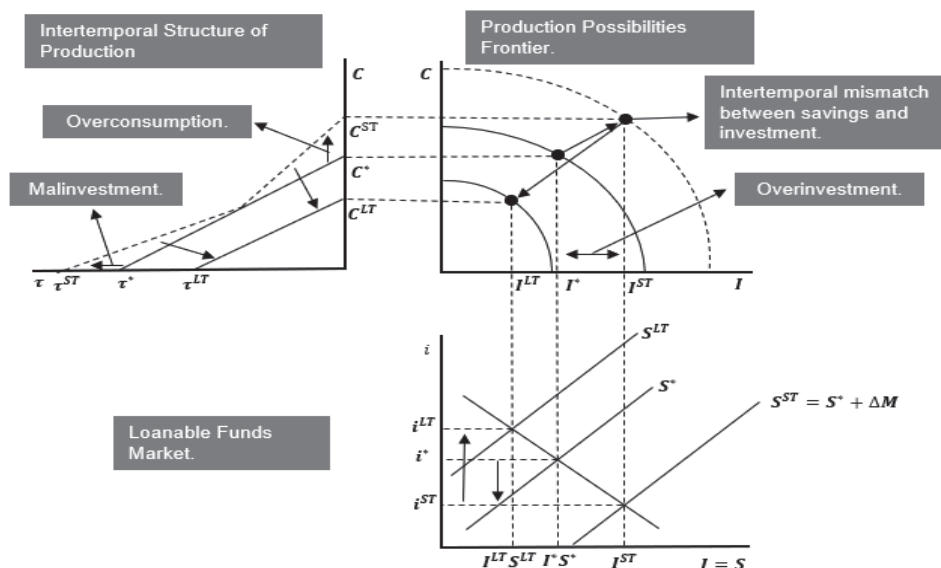
Figure 1 represents Garrison's (1978, 1989, 2001) ABCT model, where the main peculiarity with respect to the usual macroeconomic models is that while the latter are based on labour, the Austrian model

is based on capital (Ebeling, 2001). In this representation it is assumed, as in the previous mathematical illustration, that there is no sequential growth, i.e. the starting point is from a steady state situation. On the

other hand, it is assumed that the economy is closed, with no public sector (Ravier and Cachanosky, 2015) and is in a full employment equilibrium (Ravier, 2011). One may

contrast this graphical demonstration with the mathematical demonstration above to ensure consistency and clarity of the developments.

Figure 1. Unsustainable economic growth
(Austrian theory of the endogenous monetary cycle)



Source: own elaboration based on Garrison (2001)

2. Methodology and problems encountered

2.1. Overview

This paper proposes an empirical study based on the use of econometric methods of time series, the main objective of which is to characterise a specific historical episode: the economic cycle in Spain between 2002 and 2014 (i.e. boom, recession and recovery). The aim is to test whether ABCT serves to illustrate the Spanish economic cycle during the period. The econometric packages chosen to perform the calculations and estimations were STATA and R.

This study encounters a main problem which, in turn, generates another secondary problem. The initial obstacle derives from the non-econometric vision of the Austrian

School, which was especially popularised by the “Rothbardian” approach or extreme apriorism (Rothbard, 1957), attributing to it an opposition to the application of quantitative methods in economics. However, this is not exactly the case, as from the very beginning, the Austrian School paid special attention to the methodological question, claiming the differentiation of methods in economics with respect to the natural sciences and engineering (Menger, 1883). Traditionally, Austrians are in favour of the aprioristic-deductive or logical-deductive research method, based on the genetic-causal study of human action; therefore, they reject the abuse of quantitative methods without theoretical or real support, or the Friedmanian error (Sánchez-Bayón, 2022), since it gives rise to circular reasoning which is incompatible

with the progress of economic theory and cannot be used to construct laws of tendency (Mises, 1949). This methodological rejection extends to the abuse of mathematical economics and econometrics, as they are understood as predictive tools of social engineering, and not as instruments by means of which to illustrate theory (Keeler, 2001, p. 331; Alonso et al., 2013, p. 45). In the social sciences, projections, forecasts or conjectures (not predictions) are the norm, especially in economics due to its dynamic and creative processes (Huerta de Soto, 2009).

Regarding ABCT, Carilli and Dempster (2008), Luther and Cohen (2014), and Alonso et al. (2013) point out the lack of empirical studies in favour of a monetary expansion orchestrated by any central bank which causes distortions in the productive structure of the economy. This is precisely the motivation of the present study: to illustrate ABCT while characterising a specific historical episode. Its objective is to determine whether, using econometric methods, ABCT contributes to an explanation of the observable historical economic data during the Spanish business cycle between 2002 and 2014. Therefore, this study should be viewed as providing a historical research method as an alternative to the techniques, which are also historical, that were traditionally used by the authors of the Austrian School in order to explain the scenarios of expansion and recession. Thus, Rothbard (1963) resorted to historical techniques to characterise the Great Depression of 1929 as a result of the distortions caused by the expansion of bank credit in the 1920s. He also showed that the New Deal frustrated the early liquidation of malinvestment, resulting in a prolonged secondary contraction (Mulligan, 2006).

Powell (2002) used the same techniques to find historical evidence that the Japanese crisis of 1990 reflected ABCT. He concluded that fiscal and monetary policies aimed at stimulating recovery prolonged

the recession in Japan. Similarly, Callahan and Garrison (2003) asked whether the historical evidence allows one to explain the business cycle caused by the dotcom bubble through ABCT.

In addition to the methodological problems and the lack of previous literature, Young (2011) argued that this type of study may encounter a third problem derived from the difficulty of obtaining data that is consistent with Austrian theory, since a theory that is based on the disaggregated nature of the production structure and the concept of indirect production is not easily verifiable through the aggregate data available in the main institutional organisations which lack a measure of the temporal structure of production.

In conclusion, considering these problems, this study attempts to find, through the application of appropriate econometric techniques, distinctive empirical evidence in favour of ABCT in relation to other competing theories of the business cycle (along the lines already inaugurated by Morgenstern or Machlup, updated by Garrison or Cachanosky, and continued here). A good part of the aforementioned contributions have been taken into account for the purposes of this study; however, its originality stands out, not only for its vocation of dialogue between currents and its evolutionary synthesis in this respect, but also for being the first to approach the Spanish cycle of the period 2008-2014 econometrically according to the Austrian tradition.

2.2. Suggested hypotheses

This section mainly follows the contributions of Keeler (2001), Carilli and Dempster (2008), Bismans and Mougeot (2009) and Alonso et al. (2013) in establishing two categories of hypotheses in the study of the Spanish expansionary-recessionary cycle between 2002 and 2014. The first category of hypotheses would refer to the Austrian business cycle impulse mechanisms, which

would involve contrasting the three following hypotheses:

1. The monetary and credit expansion processes (ΔM) carried out by the European Central Bank caused a divergence between the natural rate of interest and the prevailing interest rate in the short-term credit market in Spain.
2. This divergence caused, with a certain delay of between six and 18 months (Friedman, 1968; Froyen, 1997), an artificial alteration of the production structure of the Spanish economy. This led to an increase in investment in the stages furthest away from final consumption (intermediate goods, capital goods and consumer durables, which would include construction), which are more time- and capital-intensive, to the detriment of the stages closer to final consumption (consumer goods), which are less time- and capital-intensive.
3. This divergence between the natural rate of interest (approximated by the 10-year bond rate) and the prevailing interest rate in the short-term credit market (approximated by the three-month treasury bill rate) also caused, with some delay, an artificial alteration in aggregate industrial activity.

The second category of hypotheses would refer to the propagation mechanisms of the Austrian expansionary-recessionary cycle that influence the volatility of the observed cyclical variations and their persistence over time. ABCT warns that the initial positive effect on the productive structure and aggregate economic activity caused by the divergence between the natural rate of interest and the interest rate of the credit market will tend to revert as the market's spontaneous adjustment process uncovers the bad investment processes induced by credit expansion (Huerta de Soto, 1998). This requires testing two additional hypotheses:

4. The divergence between the natural interest rate and the short-term credit

market interest rate had a positive impact on the productive structure of the Spanish economy; however, as the market discovered the massive investment errors induced by the abundance of cheap credit, this positive effect tended to recede and reverse until the European Central Bank (ECB) again expanded the money supply. Therefore, after an initial correction process, a new positive impact on the productive structure should be observed and, therefore, the beginning of a new phase of an artificially induced boom. This implies, therefore, that the effect of the interest rate differential on Spain's production structure is first positive, then negative and then positive again.

5. The divergence between the natural interest rate and the short-term credit market interest rate caused a positive effect on aggregate industrial activity in Spain; however, as the market detected the massive investment errors induced by the abundance of cheap credit, this effect tended to reverse until the ECB started a new phase of monetary expansion, so that a new positive effect on aggregate industrial activity should be observed and, therefore, the beginning of a new phase of an induced boom. This would imply that the effect of the interest rate differential on Spain's aggregate industrial production is first positive, then negative and then positive again.

2.3. Data presentation and construction of variables

Following the premises, processes and results of the studies analysed in section 4, in order to test the hypotheses of the preceding section it will be necessary to define four variables: 1) a measure of the degree of laxity of the ECB's monetary policy, 2) a measure that reveals the impact of

monetary policy on the term structure of interest rates, 3) a measure that represents the productive structure of the Spanish economy, and 4) a measure of aggregate economic activity.

1. Regarding the first variable, the cyclical behaviour of the monetary aggregate M3 is taken as a measure of the degree of laxity of the ECB's monetary policy. For this

$$\Delta M3_t = \ln \left(M3_t / \text{trend} M3_t \right) \quad (35)$$

2. Research on the ABCT usually uses the differential between the natural interest rate, which is defined as a real economic variable that responds to the agents' time preference rate and not to the implementation of monetary policy, and the short-term credit market rate (or money rate), which does depend on the degree of laxity inherent in the monetary policy.

purpose, we use the monthly data of the M3 between January 2002 and December 2014 (data extracted from the ECB's Statistical Data Warehouse) in deviations from its trend calculated by means of the Hodrick-Prescott filter (1997). This process allows us to determine the cyclical behaviour of the M3:

However, there is no historical data available for the natural rate of interest, so it is necessary to estimate it. The authors of the Austrian School use two different approximations for the natural rate of interest. On the one hand, they use the savings-consumption ratio proposed by Rothbard (1993). In this sense, Carilli and Dempster (2008, p. 275) argue that:

According to most mainstream analysts, the natural rate is determined primarily by the growth prospects of the economy, while Austrians prefer to think of the natural rate as reflecting the underlying time preferences of economic actors. Indeed, Rothbard (1993) suggests the savings-consumption ratio as the appropriate interest rate proxy based on the relationship between this ratio and the level of time preference (see Rothbard 1993, p. 342).

On the other hand, authors such as Keeler (2001), Mulligan (2006), Bismans and Mougeot (2009), Alonso et al. (2013), or Fisher (2013), prefer to use the long-term interest rate (10-year government bonds) as a proxy for the natural rate of interest.

They resort to the slope of the yield curve as a proxy for the spread between the natural rate of interest and the prevailing money interest in the short-term credit market. In this sense, Keeler (2001) points out that:

A monetary expansion will have a liquidity effect that will reduce short-term interest rates to a greater extent than long-term interest rates (Romer 1996, pp. 395-396). Long-term interest rates are affected since they are an average of short-term rates, but the effect is moderate. The contrast in the behaviors of short-term and long-term interest rates supports the notion that observed long-term rates are a good representation of natural interest rates, and in particular that the slope of the yield curve represents the Wicksellian idea of the differential between market and natural rates. The slope of the yield curve shows more regularity over business cycles in the magnitude of the slope and in the patterns of change than the levels of interest rates.

In the same way, Mulligan (2006, p. 78) uses the same approach, arguing that:

The term spread is computed as the ten-year constant maturity rate minus the three-month secondary-market rate. Usually, the term spread falls as the central bank pursues expansionary monetary policy. When a large price premium dominates short-term interest rates, as often occurs in the late stages of monetary expansion, the term spread becomes negative. The term spread rises with tight monetary policy. The term spread is often used as a measure of the real interest rate (Keeler 2001, pp. 338–40).

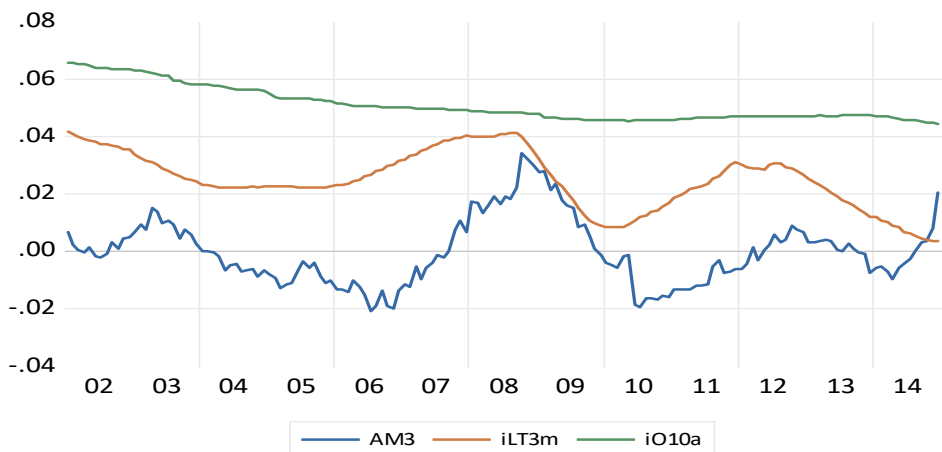
This study uses the yield on 10-year bonds as an approximation of the natural interest rate (long-term interest rate that reflects the agents' time preference rate and does not respond to monetary phenomena), while using the yield on three-month Treasury bills as an approximation of the interest rate prevailing in the short-term credit market (based on data from the Spanish Treasury). Before constructing the spread, it is necessary to check that the yield on 10-year bonds does not respond to monetary phenomena, for which purpose the yield on 10-year bonds, the yield on three-month Treasury bills and the

cyclical behaviour of the ECB's M3 monetary aggregate are plotted.

Figure 2 shows how the yield on three-month Treasury bills clearly responds to the cyclical behaviour of M3. However, the yield on 10-year bonds seems to be out of sync with the stance and intensity of monetary policy.

Another way to examine the link between short- and long-term interest rates and the tone of monetary policy is to calculate the correlations between the cyclical behaviour of M3 and the yield on three-month Treasury bills, the value of which is 0.62, and between the cyclical behaviour of M3 and the yield on 10-year bonds, the value of which is 0.05.

Figure 2. 10-year bond yields (iB10a), three-month Treasury bill yields (iTB3m) and the cyclical pattern of the ECB's M3 monetary aggregate (AM3)



Source: own elaboration

Once it has been proven that the yield on 10-year bonds can be considered a good approximation of the natural rate of interest, since it does not respond to the tone and orientation of the ECB's monetary policy, the

spread between the yield on 10-year bonds and the yield on three-month Treasury bills is used as an approximation of the spread between the natural rate of interest and the monetary interest rate in the short-term credit market.

$$SPR_t = \ln \left[\frac{(1 + i_{10y})_t}{(1 + i_{3m})_t} \right] \quad (36)$$

3. Obtaining a measure of a country's production structure is no easy task given the aggregate nature of most historical production series. However, in order to represent a relationship between the stages furthest away from final consumption and the stages closer to it, and to show how the former, which are more intensive in time and capital, expand in the early stages of the monetary expansion cycle at the expense of the latter, dedicated to the production of final consumption goods, and how this relationship ends up reversing over time, this paper resorts to the production indexes of capital goods, consumer durables and intermediate goods (which would represent the stages furthest away from final consumption), and the production index of consumer goods extracted from the National Institute of Statistics (INE)

(which would represent the stages closer to final consumption) (Alonso et al., 2013).

It is assumed, in line with ABCT, that changes in the interest rate differential will influence three ratios constructed from these indices, namely capital goods/consumer goods, consumer durables (which in Spain includes construction)/consumer goods, and intermediate goods/consumer goods. Thus, if empirical evidence in favour of ABCT is found, it should be possible to verify that an increase in the interest rate differential would cause these ratios to rise, and that a decrease in the interest rate differential would tend to reduce these ratios.

Therefore, in order to reflect the cyclical behaviour of the production structure, as next step, there are constructed the some ratios based on deviations (using the filters of Hodrick and Prescott, 1997):

$$\Delta PE_{1t} = \ln \left[\frac{(\text{Capital goods} / \text{Consumer goods})_t}{\text{trend}(\text{Capital goods} / \text{Consumer goods})_t} \right] \quad (37)$$

$$\Delta PE_{2t} = \ln \left[\frac{(\text{Consumer durables} / \text{Consumer goods})_t}{\text{trend}(\text{Consumer durables} / \text{Consumer goods})_t} \right] \quad (38)$$

$$\Delta PE_{3t} = \ln \left[\frac{(\text{Intermediate goods} / \text{Consumer goods})_t}{\text{trend}(\text{Intermediate goods} / \text{Consumer goods})_t} \right] \quad (39)$$

4. On the other hand, the industrial production index (IPI) is used to incorporate a measure of aggregate economic activity.
- In this case, fluctuations in aggregate economic activity are measured based on deviations of the IPI from its trend:

$$\Delta IPI_t = \ln \left(\frac{IPI_t}{trend IPI_t} \right)$$

(40)

For information purposes, Table 1 presents a description of the statistical analysis of the variables included in the study.

Table 1. Descriptive statistics of the variables included in the study

	$\Delta M3_t$	SPR_t	ΔPE_{1t}	ΔPE_{2t}	ΔPE_{3t}	ΔIPI_t
Mean	-0.000210	0.025041	-0.006719	-0.007845	-0.015952	-0.005514
Median	-0.001088	0.026404	0.027932	0.026049	-0.033919	0.020176
Maximum	0.034194	0.040149	0.135588	0.134412	0.666318	0.143688
Minimum	-0.020761	0.006699	-0.462416	-0.523590	-0.425986	-0.378886
Standard dev	0.011402	0.008760	0.118275	0.126432	0.161449	0.104998
Obliquity	0.660852	-0.444955	-2.316027	-2.407351	1.010099	-1.665102
Kurtosis	3.245550	2.267851	7.830418	8.527041	5.207727	5.837847

Source: own elaboration

3. Results and discussion

3.1. Impulse mechanisms of the business cycle

Following Wainhouse (1984), Carilli and Dempster (2008) and Alonso et al. (2013), this section uses Granger (1969) causality tests to test the hypotheses regarding the Austrian business cycle impulse mechanisms. Given the variables defined in the previous section, verifying the first three hypotheses stated in section 5 would imply the need to verify the following hypotheses:

1. $\Delta M3_t$ Granger-causes .
2. SPR_t Granger-causes ΔPE_{jt} ($j=1,2,3$).
3. SPR_t Granger-causes ΔIPI_t .

Before testing the hypotheses corresponding to the impulse mechanisms of the business cycle, the stationarity of the variables under study is determined by means of the augmented Dickey-Fuller test (used to verify whether a time series is stationary or not, where stationarity means that the variances and covariances of the means of the time series are constant over time). Based on the Akaike information criterion, a maximum of 13 lags are used. Table 2 shows that all variables are stationary at least at the 5% significance level, except the variable $\Delta M3_t$, which is stationary at the 10% significance level. However, the 10% significance level is accepted so that all the variables analysed are zero-order integrated ($I(0)$) and therefore stationary.

Table 2. Augmented Dickey-Fuller test

Null hypothesis	t-statistic and p-value	Result
A unit root is present in $\Delta M3_t$	-2.655328 [0.0844]*	Reject the null hypothesis
A unit root is present in SPR_t	-4.058279 [0.0402]**	Reject the null hypothesis
A unit root is present in ΔPE_{1t}	-3.179530 [0.0233]**	Reject the null hypothesis
A unit root is present in ΔPE_{2t}	-3.067758 [0.0313]**	Reject the null hypothesis
A unit root is present in ΔPE_{3t}	-3.638692 [0.0061]***	Reject the null hypothesis
A unit root is present in ΔIPI_t	-4.394998 [0.0005]***	Reject the null hypothesis

*** 1%, ** 5%, * 10%

Source: own elaboration

The next step is to perform the Granger causality tests. The goal consists in the determination of the optimal order of lags in each tests performed to solve the possible problems of autocorrelation, derived from establishing too few lags, and multicollinearity. Information criteria and other

mechanisms are taken from Akaike (AIC), Hannan-Quinn (HQ), Schwarz (SC), the likelihood-ratio test (LR) and the final prediction error method (FPE), the search procedures for the optimal number of lags chosen following the Vector Autoregressive (VAR) methodology.

Table 3. Determination of the optimal order of lags

	LR	FPE	AIC	SC	HQ
$\Delta M3_t - SPR_t$	11.17444* [7]	4.62e ¹² * [3]	-20.42480* [3]	-20.20641* [2]	-20.33542* [2]
$SPR_t - \Delta PE_{1t}$	59.57691* [12]	6.34e ¹⁰ * [12]	-15.51448* [12]	-14.34096* [12]	-15.03761* [12]
$SPR_t - \Delta PE_{2t}$	11.98364* [14]	7.00e ¹⁰ * [15]	-15.42185* [15]	-14.19469* [12]	-14.89282* [14]
$SPR_t - \Delta PE_{3t}$	9.596704* [16]	3.87e ¹⁰ * [16]	-16.01724* [16]	-14.80071* [12]	-15.49739* [12]
$SPR_t - \Delta IPI_t$	25.93219* [15]	7.55e ¹⁰ * [15]	-15.35224* [18]	-14.06767* [12]	-14.79889* [15]

Source: own elaboration

Normally, in the econometric literature, the Granger causality tests are usually established for a number of specific lags; however, in the present study the decision was made to carry out the causality tests for all the sets of optimal lags obtained through the selection criteria selected in the previous paragraph in order to ensure the consistency of the results.

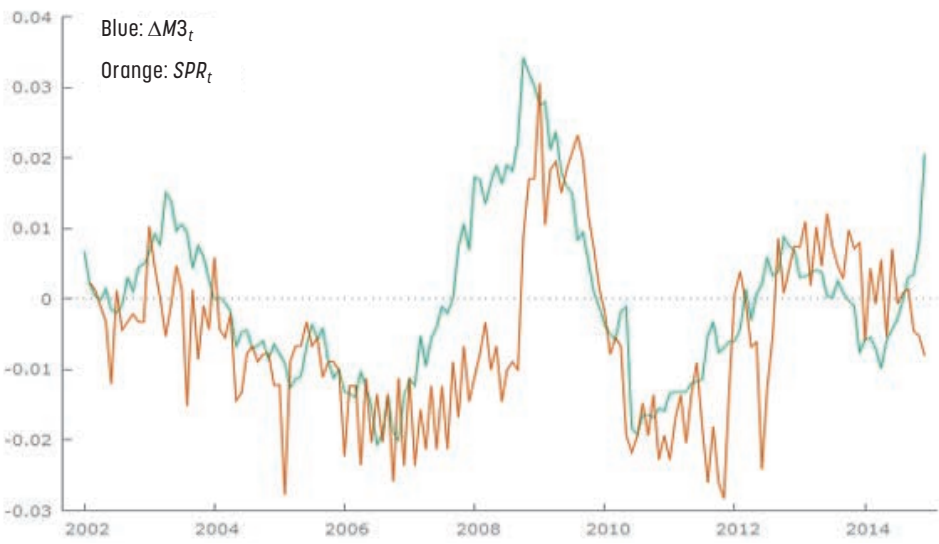
The first three rows of Table 4 present the results of the Granger causality test between $\Delta M3_t$ and SPR_t for the optimal lags chosen using the selection criteria shown in Table 3. It can be seen that $\Delta M3_t$

Granger-causes SPR_t at least at the 5% level of significance. However, SPR_t does not Granger-cause $\Delta M3_t$. These results provide empirical evidence that the cyclical behaviour of the monetary aggregate M3 Granger-causes changes in the interest rate differential with a lag period between two and seven months, implying that the ECB monetary policy stance caused changes in the slope of the Spanish yield curve for the period analysed.

It may be relevant to chart the impact of the cyclical behaviour of the monetary aggregate M3 on the interest rate differential,

especially when the observed correlation between the monetary policy tone and the interest rate differential over the period 2002-2014 is 0.67.

Figure 3. The impact of the cyclical behaviour of the monetary aggregate M3 on the interest rate differential.



Source: own elaboration

The fourth row of Table 4 shows the result of the Granger causality test between SPR_t and ΔPE_{1t} for the number of lags chosen using the selection criteria indicated. It can be seen that SPR_t Granger-causes ΔPE_{1t} at least at the 5% level of significance. However, ΔPE_{1t} does not Granger-cause SPR_t .

The fifth, sixth and seventh rows of Table 4 show the results of the Granger causality tests between SPR_t and ΔPE_{2t} for the optimal lags chosen using the defined selection criteria. They show that in two of the tests SPR_t Granger-causes ΔPE_{2t} at least at the 5% level of significance. On the other hand, ΔPE_{2t} does not Granger-cause SPR_t .

The eighth and ninth rows of Table 4 present the results of the Granger causality tests between SPR_t and ΔPE_{3t} for the optimal lags chosen using the defined selection criteria. It may be observed that in one of the two tests SPR_t Granger-causes ΔPE_{3t} at least

at the 5% level of significance. Nonetheless, ΔPE_{3t} does not Granger-cause SPR_t .

These results provide empirical evidence that variations in the interest rate differential Granger-cause cyclical deviations in the production structure with a lag period between 12 and 16 months (Friedman and Schwartz, 1963; Friedman, 1968, 1993), which implies, for the specific case of Spain between 2002 and 2014, that variations in the slope of the Spanish yield curve caused alterations in the production structure of the Spanish economy.

The 10th, 11th and 12th rows of Table 4 show the results of the Granger causality tests between SPR_t and ΔIPI_t for the sets of optimal lags chosen using the above-mentioned selection criteria. They show how, at least at a 5% significance level, SPR_t Granger-causes ΔIPI_t ; moreover, in two of the tests, ΔIPI_t also Granger-causes SPR_t . Therefore, there is a bidirectional causality

between the variables, which may be due to the marked countercyclical nature of the ECB's monetary policy between 2007 and 2014. The results obtained provide empirical evidence that changes in the interest rate differential Granger-cause cyclical swings in industrial aggregate activity with

a lag period between 12 and 18 months. This implies, as far as this paper is concerned, that changes in the slope of Spain's yield curve (as an indicator of the tone and stance of monetary policy) caused changes in the country's aggregate economic activity and its production structure.

Table 4. Granger causality tests (the null hypothesis of non-causality is rejected at the 5% level of significance)

		$H_0: \Delta M3_t$ does not Granger-cause SPR_t	$H_0: SPR_t$ does not Granger-cause $\Delta M3_t$
Observations	Lags	F statistic and p-value	F statistic and p-value
154	2	8.43415 [0.0003]***	1.74026 [0.1790]
153	3	5.67040 [0.0011]***	2.58956 [0.0552]*
149	7	2.92522 [0.0070]***	1.54715 [0.1568]
		$H_0: SPR_t$ does not Granger-cause ΔPE_{1t}	$H_0: \Delta PE_{1t}$ does not Granger-cause SPR_t
Observations	Lags	F statistic and p-value	F statistic and p-value
144	12	3.09620 [0.0008]***	0.90799 [0.5413]
		$H_0: SPR_t$ does not Granger-cause ΔPE_{2t}	$H_0: \Delta PE_{2t}$ does not Granger-cause SPR_t
Observations	Lags	F statistic and p-value	F statistic and p-value
144	12	6.28511 [0.0000]***	1.36861 [0.1906]
142	14	1.02489 [0.4343]	1.21383 [0.2753]
141	15	2.74101 [0.0220]**	1.29841 [0.2156]
		$H_0: SPR_t$ does not Granger-cause ΔPE_{3t}	$H_0: \Delta PE_{3t}$ does not Granger-cause SPR_t
Observations	Lags	F statistic and p-value	F statistic and p-value
144	12	5.02607 [0.0000]***	1.09195 [0.3732]
140	16	1.62056 [0.0757]*	1.38734 [0.1620]
		$H_0: SPR_t$ does not Granger-cause ΔIPI_t	$H_0: \Delta IPI_t$ does not Granger-cause SPR_t
Observations	Lags	F statistic and p-value	F statistic and p-value
144	12	3.63485 [0.0001]***	2.15950 [0.0180]**
141	15	2.44848 [0.0040]***	1.24612 [0.2495]
138	18	1.85638 [0.0284]**	2.25169 [0.0059]***

Source: own elaboration. *** 1%, ** 5%, * 10%

In summary, the Granger causality tests in Table 4 illustrate the first three hypotheses of Section 5 and, therefore, provide empirical evidence in favour of the Austrian cycle impulse mechanisms, since they show that the ECB's monetary policy course affected the slope of the Spanish yield curve, and that this in turn caused alterations in the productive structure of the economy, causing the initial monetary shock to be transmitted to the entire productive process represented by the industrial production index.

3.2. Propagation mechanisms of the business cycle

Having analysed the driving mechanisms of the Austrian business cycle, we now turn to test the fourth and fifth hypotheses put forward in section 5, which refer to the propagation mechanisms of the Austrian expansionary-recessionary cycle. The ABCT warns that an artificial increase in the interest rate differential caused by a process of monetary and credit expansion can have only positive effects on the production structure and aggregate economic activity in the short-term. As time goes on, the artificial distortions induced in the production structure and the resulting real resource constraints will cause the initial boom to turn into a recession as the spontaneous market adjustment process uncovers the malinvestments caused by the excess of inexpensive credit.

In the case of Spain between 2002 and 2014, looking at the evolution of the interest rate differential, it is clear that it increases from 2002, and then starts to decrease at the dawn of the recession (i.e. before 2007-2008). However, the differential increases again in the following years as a consequence of the

orchestration of a new monetary expansion by the ECB. In this sense, if the Spanish economy responds to the story of the Austrian theory of the endogenous expansionary-recessionary cycle, it should be observed that the ratios of output ΔPE_{1t} , ΔPE_{2t} and ΔPE_{3t} and aggregate economic activity (as defined by the IPI) increase when the interest rate differential increases, and decrease when it decreases. However, after the initial expansionary-recessive movement, a new increase in output ratios and aggregate output should be observed as a consequence of a new countercyclical monetary expansion executed by the ECB, leading to a new distortion of the production structure and the beginning of a new phase of unsustainable boom (or expansionary-recessive business cycle).

One way of contrasting the above would be to locate endogenous turning points in the effect of the interest rate differential on the three ratios that represent Spain's production structure and on the industrial production index. Finding these endogenous turning points would reveal the existence of recurrent economic cycles that are self-perpetuating in line with the contributions of the Austrian approach (Alonso et al., 2013).

To account for this process, and following the contributions of Carilli and Dempster (2008) and Alonso et al. (2013), four polynomial distributed lag (PDL) models (Almon, 1965) are estimated, in which the dependent variables are the three ratios representing the Spanish production structure (ΔPE_{1t} , ΔPE_{2t} and ΔPE_{3t}) and the variable that accounts for aggregate economic activity (Industrial production index, IPI), while the explanatory variables incorporate n lags of the interest rate differential. The four models are represented as follows:

$$\Delta PE_{1t} = \alpha + \sum_{i=0}^n \beta_i SPR_{t-i} + \varepsilon_i \quad (41)$$

$$\Delta PE_{2t} = \alpha + \sum_{i=0}^n \beta_i SPR_{t-i} + \varepsilon_i \quad (42)$$

$$\Delta PE_{3t} = \alpha + \sum_{i=0}^n \beta_i SPR_{t-i} + \varepsilon_i \quad (43)$$

$$\Delta IPI_t = \alpha + \sum_{i=0}^n \beta_i SPR_{t-i} + \varepsilon_i \quad (44)$$

$$\text{Where } \beta_i = a_0 + \sum_{j=1}^m a_j i^j \quad (45)$$

If ABCT explains the Spanish case, the estimates of the regression coefficients (β_i) should initially increase up to a given number of lags, subsequently decreasing (also up to a specific number of lags), and finally show increasing values again. This evolution would outline a process of boom, recession, recovery and new boom, induced by the ECB's monetary policy stance and intensity.

Polynomial distributed lag (PDL) models require the determination of two unknowns: the length of the delays (n) and the degree of the polynomial (m) used to estimate the value of the betas. The logic of the historical data collected and of the ABCT suggests that it would be appropriate to apply a third-degree polynomial, in order to contemplate the process of an unsustainable boom, recession and recovery and a new induced boom. After several tests, the best values of Akaike and Schwartz criteria and adjusted R^2 are obtained from $n = 45$ y $m = 3$. Therefore, four third-degree polynomial distributed lag models with 45 lags are established.

Once the four models have been established, it is necessary to check the assumptions of homoscedasticity, as well as for the absence of multicollinearity and autocorrelation, in order to ensure the robustness

and consistency of the results. The Breusch-Pagan-Godfrey heteroscedasticity tests ensure that the four models meet the homoscedasticity assumption. On the other hand, the variance inflation factors (VIF) ensure that all models comply with the assumption of non-multicollinearity. However, the Durbin-Watson statistics and the LM tests for serial correlation provide evidence that there is autocorrelation in the residuals. Therefore, it is necessary to introduce certain adjustments to avoid the problems derived from the existence of residual autocorrelation. In order to homogenise the results of the four models, an autoregressive variable AR(12) was introduced to solve the problems derived from the existence of autocorrelation. Once introduced, the result of the Durbin-Watson statistic allows us to accept the null hypothesis of absence of autocorrelation.

Columns 2 to 4 of Table 5 show the relationship between the three ratios that represent the cyclical behaviour of the Spanish production structure and the lagged changes in the interest rate differential. These columns reveal that the effect of an increase in the interest rate differential on these ratios is initially positive but becomes negative when

the interest rate differential decreases during the market's spontaneous adjustment process. Subsequently, it returns to positive values when the ECB initiates a new monetary expansion and generates a new increase in the interest rate differential. Thus, it can be observed that the betas show increasing values up to 12-16 lags (months) of the interest rate differential, which represents the boom phase of the Austrian cycle (in which the stages of the production structure furthest away from final consumption expand to the detriment of those closer to it). However, from that moment on, the estimates of the betas decrease until 31-34 lags (months), which characterises the deceleration and recession phase of the Austrian cycle (in which the stages of the production structure farther away from final consumption deteriorate more intensely than those closer to final consumption). Finally, the estimated values of the betas again show increasing values up to 45 lags (months), which implies that the economy enters a new phase of artificial boom induced by a new process of monetary expansion (which again raises the slope of the yield curve) orchestrated by the ECB.

It should be noted that the fit of the model is especially good for the cyclical behaviour of the ratio ΔPE_{2t} (consumer durables/consumer goods), with an adjusted R^2 greater than 0.90, which is consistent with the economic reality, since it should be remembered that the Spanish consumer durables index includes construction, for which the bubble and the subsequent bursting thereof in 2007-2008 marked the beginning of the economic and financial crisis. The fact that the goodness of fit is higher for this ratio implies that the effect of variations in the yield

curve is especially significant on the construction sector, which is entirely predictable, since a large part of the newly created loans and credits were channelled at artificially low rates to this sector.

Similarly, column 5 reveals the relationship between the cyclical behaviour of aggregate industrial activity and lagged changes in the interest rate differential. The effect that the slope of the yield curve has on industrial aggregate activity is represented by the values of the betas. The regression coefficients show increasing values up to 13 lags (months) of the interest rate differential, reflecting the unsustainable growth phase of the Austrian cycle. However, thereafter the estimates decrease up to 33 lags (months), which is the deceleration and recession phase of the Austrian cycle. Finally, the betas return to increasing values up to 45 lags (months) of the rate differential, implying a new phase of unsustainable boom orchestrated by the new monetary inflation processes of the ECB.

Figure 4 represents the lagged effects of the interest rate differential on the three ratios that approximate the productive structure of the Spanish economy and on aggregate industrial activity. The figure allows us to visualise the existence of endogenous turning points in both the lagged impact of the slope of the yield curve on the production structure and on aggregate industrial activity. Thus, the evolution of the Spanish productive structure between 2012 and 2014 allows us to confirm the fourth and fifth hypotheses set out in section 5, since it has been possible to verify that the Spanish case responds to the concept of the expansionary-recessionary cycle set out by ABCT.

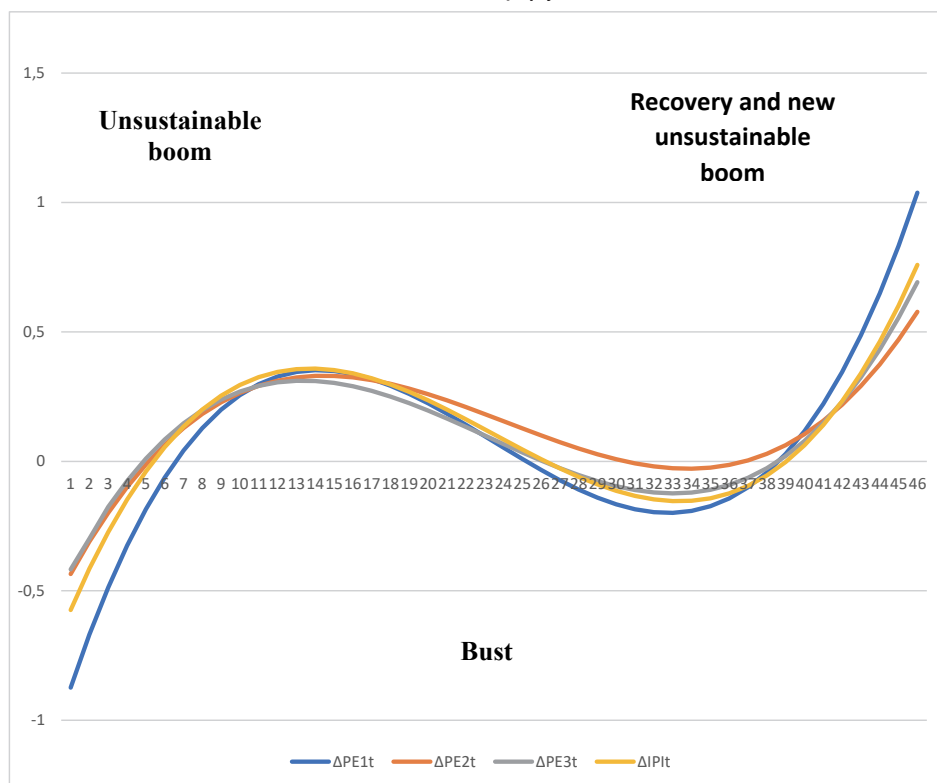
Table 5. Lagged effects of the interest rate differential on the three ratios that approximate the productive structure of the Spanish economy and on aggregate industrial activity

Coefficient β_i	ΔPE_{1t}	ΔPE_{2t}	ΔPE_{3t}	$\Delta IPEI_t$
SPR_t	-0.87381***	-0.43508**	-0.4171**	-0.57391**
SPR_{t-1}	-0.66934***	-0.31018*	-0.29911*	-0.41462*
SPR_{t-2}	-0.487***	-0.19847	-0.17564*	-0.27291*
SPR_{t-3}	-0.32578***	-0.09936	-0.076	-0.14798
SPR_{t-4}	-0.18464***	-0.01225	0.0105	-0.039
SPR_{t-5}	-0.06255	0.06347	0.08453	0.05484
SPR_{t-6}	0.04152	0.12837*	0.14678***	0.13435**
SPR_{t-7}	0.12861***	0.18306***	0.19794***	0.20035***
SPR_{t-8}	0.19974***	0.22814***	0.23869***	0.25366***
SPR_{t-9}	0.25595***	0.26419***	0.26973***	0.2951***
SPR_{t-10}	0.29826***	0.29182***	0.29172***	0.32547***
SPR_{t-11}	0.32771***	0.31162***	0.30536***	0.34559***
SPR_{t-12}	0.34533***	0.32419***	0.31134***	0.35629***
SPR_{t-13}	0.35215***	0.33011***	0.31034***	0.35838***
SPR_{t-14}	0.3492***	0.32999***	0.30304***	0.35266***
SPR_{t-15}	0.33752***	0.32443***	0.29013***	0.33996***
SPR_{t-16}	0.31812***	0.31401***	0.27229***	0.3211***
SPR_{t-17}	0.29205***	0.29934***	0.25021***	0.29689***
SPR_{t-18}	0.26034***	0.281***	0.22458***	0.26814***
SPR_{t-19}	0.22401***	0.2596***	0.19608***	0.23568***
SPR_{t-20}	0.1841***	0.23573***	0.16539***	0.20031***
SPR_{t-21}	0.14164***	0.20998***	0.13321***	0.16285***
SPR_{t-22}	0.09766***	0.18296***	0.10021***	0.12413**
SPR_{t-23}	0.05319	0.15525***	0.06708*	0.08495*
SPR_{t-24}	0.00926	0.12745**	0.0345	0.04613

Coefficient β_i	ΔPE_{1t}	ΔPE_{2t}	ΔPE_{3t}	$\Delta IPEI_t$
$SPR_t - 25$	-0.03309	0.10016*	0.00317	0.00848
$SPR_t - 26$	-0.07284	0.07397	-0.02624	-0.02717
$SPR_t - 27$	-0.10896*	0.04949*	-0.05304	-0.06001*
$SPR_t - 28$	-0.14041**	0.02729*	-0.07654*	-0.08923*
$SPR_t - 29$	-0.16615**	0.00799*	-0.09605**	-0.11401**
$SPR_t - 30$	-0.18518**	-0.00783**	-0.11091**	-0.13353***
$SPR_t - 31$	-0.19644***	-0.01957**	-0.1204***	-0.14698***
$SPR_t - 32$	-0.19891***	-0.02664**	-0.12387***	-0.15355***
$SPR_t - 33$	-0.19155***	-0.02843**	-0.12061***	-0.15241**
$SPR_t - 34$	-0.17335**	-0.02435**	-0.10994**	-0.14275**
$SPR_t - 35$	-0.14325**	-0.01382**	-0.09118**	-0.12376**
$SPR_t - 36$	-0.10025*	0.00378*	-0.06364*	-0.09461**
$SPR_t - 37$	-0.04329	0.02903*	-0.02663	-0.0545*
$SPR_t - 38$	0.02864	0.06253	0.02052	-0.00261*
$SPR_t - 39$	0.11658**	0.10487	0.0785	0.06189
$SPR_t - 40$	0.22156***	0.15665*	0.148*	0.13979*
$SPR_t - 41$	0.34461***	0.21847*	0.22971**	0.23193*
$SPR_t - 42$	0.48677***	0.29092*	0.3243***	0.33912**
$SPR_t - 43$	0.64906***	0.3746**	0.43247***	0.46216**
$SPR_t - 44$	0.83251***	0.4701**	0.5549***	0.60188**
$SPR_t - 45$	1.03816***	0.57802**	0.69228***	0.7591**
$AR(12)$	0.936023***	0.899012***	0.713064***	0.824977***
Constant	-0.099335*	-0.160972***	-0.114378***	-0.118905***
Adjusted R^2	0.858081	0.910486	0.552995	0.672717
F statistic	111.8482	129.4053	23.68041	38.68347
p-value (F)	0.0000	0.0000	0.0000	0.0000
Log-likelihood	181.1145	213.2275	188.4084	156.6701

Source: own elaboration

Figure 4. Lagged effects of the interest rate differential on the three ratios that approximate the productive structure of the Spanish economy and on aggregate industrial activity (β_i values)



Source: own elaboration

Conclusions

This research has analysed the theory of investment errors induced by monetary and credit expansion processes without the prior support of real voluntary savings (only supported by political decisions). The ABCT establishes that a monetary expansion orchestrated by the central bank has only positive effects on the production structure and on aggregate economic activity in the short term (and not always). However, in the medium and long term, the constraints of real resource (associated with the unsustainable growth phase) and the intertemporal mismatch (between savings and investment

decisions), it will cause the reverse of that kind of positive effect, when the spontaneous adjustment process of the market uncovers and purifies the massive investment errors in productive processes undertaken in the stages of the productive structure furthest away from final consumption. These stages produce capital goods and consumer durables that require more time to mature than consumer-savers are willing to wait. As a result, a good part of the production of these sectors will not be absorbed by the markets, resulting in a strong and undesirable accumulation of stock.

The aim was to review the ABCT and to transfer it to the field of Applied

Economics, using econometric techniques, in order to illustrate it through the characterisation of a specific historical episode: the Spanish cycle of the period 2002-2014. Resorting to the use of Granger causality tests and Almon's polynomial distributed lag models, it has been possible to empirically prove that ABCT helps to explain the observable historical data from the Spanish cycle of 2002-2014. Granger causality tests have found that the cyclical behaviour of the ECB's monetary aggregate M3 Granger-causes the variations in the slope of the Spanish yield curve. According to Granger-causes for cyclical fluctuations of the production structure and aggregate industrial activity, it is confirming the impulse mechanisms of the Austrian cycle. With the polynomial distributed lags models applied, endogenous inflection points have been identified in the effect that the Spanish yield curve has on the cyclical behaviour of the productive structure and industrial aggregate activity, thus showing that the cycle of the Spanish economy between 2002 and 2014 could respond to the concept of the expansionary-recessionary cycle as proposed by the Austrian School. Likewise, the propagation mechanisms of the Austrian cycle would also have been verified, whereby a monetary shock from the ECB would have been transmitted, with a certain delay, to the entire real economy, causing distortions in the productive structure of the Spanish economy and cyclical oscillations in its aggregate industrial activity.

This study may have interpretative limitations, because according to the statistical literature, Granger causality tests imply incremental predictability rather than direct causality. However, although Granger causality tests do not infallibly assume a causal relationship between variables, they do provide some empirical evidence thereof. Similarly, care should be taken when interpreting the magnitudes obtained through polynomial distributed lag models.

Nevertheless, both the significance and the signs of the estimates obtained provide strong evidence that the endogenous boom and bust characteristics of ABCT are present in the data.

Therefore, by means of applying econometric techniques (contributed by the Austrian School renewal) to the case of the Spanish business cycle between 2002 and 2014 (i.e. boom, recession and recovery), the present research does find empirical evidence in favour of ABCT in this particular historical episode. In this sense, and as a guideline for future lines of research, the results obtained may help to deepen further studies of this type (i.e. comparisons with other Eurozone countries) or encourage the application of econometric methods based on previous non-econometric studies (i.e. Rothbard, 1963; Powell, 2002; Callahan & Garrison, 2003). Furthermore, it may help to emphasise the unique features of the Austrian Business cycle theory in relation to competing business cycle theories (socialist theories, Keynesian and neo-Keynesian theories, modern monetary theory or new-classical theories of the real cycle, among others).

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Reasons for potential bankruptcy: evidence from the construction industry in Slovakia

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Abstract

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Small and medium-sized enterprises are seen as a source of growth, new ideas, and the competitiveness of the economy, as they can flexibly respond to changing conditions through their rapid launch and activities; on the other hand, these entities are associated with a relatively high failure rate. The purpose of the paper is to analyse the overall dynamics in the construction industry in Slovakia with the focus on the failure rate of companies due to bankruptcy, and to identify the reasons for and specifics of bankruptcy in the construction sector in Slovakia. A Slovak dataset of critical events, used for the identification of bankrupt companies, was paired with a dataset containing the financial statements of 162 companies which went bankrupt in the Slovak construction sector during the period of 2016-2020 and whose bankruptcy proceedings have been completed. Data from the Statistical Office of the Slovak Republic were presented to provide a deeper understanding of the size of the industry and its development over time. Selected reasons for bankruptcy (overindebtedness, insolvency, age of the company, and region) were analysed by means of descriptive statistics and correlations to the duration of bankruptcies. The research confirmed that simple signals indicating potential financial problems could be captured well in advance of bankruptcy. The majority of bankrupt entities reacted to such signals and prepared for bankruptcy, while the regional aspect was insignificant. The results of the research constitute a contribution to the identification of the specific reasons that lead to bankruptcy among companies in the construction industry in Slovakia.

Keywords

bankrupt, crisis indicators, construction industry, failure of business, Slovakia.

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Introduction

The business lifecycle is usually described by identifying several stages of the duration of the company on the market. Research on entrepreneurship differs between stages that can be described as the shiny side of economic activity (business creation, but mostly growth and market expansion) and stages (such as failure with a subsequent exit from the market) perceived as the dark side of entrepreneurial ventures when risks become reality and bring about failure (Levratto, 2013). Pawełek et al. (2017) opined that the establishment of new companies and the closure of some existing companies are natural phenomena occurring in a free-market economy. However, according to Levratto (2013), “the exit rate of new entrants barely decreases below 50% before their fifth birthday”. This means that this problem is an important issue in the economic sciences, and it is important to determine the characteristics of company failure and exit from the market.

Most companies in each economy are small and medium-sized enterprises (SMEs), which are usually described as the backbone of the economy (Eggers, 2020). SMEs have specific features and fulfil important tasks in the economic system (Belás et al., 2014). Their importance is not only due to the number thereof, but also to their essential contributions, e.g. to the level of employment and new job creation, as well as economic stability and growth (Hyder and Lussier, 2016). Unfortunately, this sector is also known for its especially high company mortality rates (Mayr et al., 2017).

Business failure is a term that is sometimes used in the literature together with other terms such as financial distress, bankruptcy, insolvency, or default (Yigit, 2018). Although they are all related to unsuccessful business enterprises, these terms also have some distinguishing features. In this study, the focus will be on company bankruptcy,

which is considered to be a disruptive process that can influence not only the company itself, but also other companies. According to Fedorova, Dovzhenko, and Fedorov (2016), more than 95% of enterprises experience significant losses due to bankruptcy. The theoretical framework focuses on bankruptcy and the costs thereof, together with the identification of the reasons for bankruptcy. The main analysis was conducted on bankrupt construction companies in the Slovak Republic with the aim of identifying their reasons for entering bankruptcy and the process itself. Slovak legislation considers bankruptcy an irrevocable process leading to the termination of business activity and distinguishes the two stages (and reasons) thereof: 1. a warning signal via the imbalance between equity and liabilities (Act No. 513/1991, 2020); and 2. the bankruptcy process itself initiated via overindebtedness or insolvency (Act No. 7/2005 Coll., 2016).

The aim of the paper is to analyse the overall dynamics in the construction industry in Slovakia with a focus on the failure rate of companies due to bankruptcy and to identify the reasons and specifics of the bankruptcy in the construction sector in Slovakia. The paper offers added value in the form of the analysis of the bankruptcy process in the Slovak construction industry with an emphasis on three areas: the age of bankrupt companies, the behaviour of managers during the two-year period before the bankruptcy, and the verification of whether the indicator of the crisis (recommended in the Commercial Code) is functional. There are various existing investigations on bankruptcy prediction models among enterprises in different countries and sectors of the economy. The paper fills the gap in the classification of the reasons behind bankruptcies in the Slovak construction industry into shared and specific ones, as well as the evaluation of the crisis/failure. e research has led to the following conclusions: economic results in the Slovak construction industry

are influenced by several factors such as economic cycles, seasonal fluctuations, and sectoral foundations. A strong connection and dependence among enterprises in this sector is proven – in the case of problems in some enterprises, they would also most likely be identified in other cooperating enterprises. The research has also shown that descriptive statistics can be used as a tool to discover early signals of potential bankruptcy; on the other hand, the decision about how to solve this situation is entirely in the hands of company representatives.

The following section of the paper introduces the theoretical background for the bankruptcy of enterprises with an emphasis on the identified external and internal causes of this process. The paper continues with the research methodology section. The next section and subsections introduce the microeconomic situation in the construction industry in Slovakia, the development of bankruptcies in this sector and selected economic and financial indicators of the analysed companies. It analyses and discusses the findings as they relate to specific (industry) and general causes of bankruptcy and to regional stratification of bankrupted companies in Slovakia. The conclusion indicates the current and future challenges faced by the Slovak construction industry and presents the limitations of the investigation.

1. Literature review

Yigit (2018) defines failure as a situation in which the capital costs are higher than the approximate return on investment. According to the aforementioned author, a company may experience economic failure over a long period of time, but never fail to satisfy its financial obligations due to the lack of any debt that is enforceable by law. Financial distress differs from operational distress, and several causes of operational distress are identified (such as the departure of key employees or management, changes in

the availability or quality of raw materials, or a change in the demand for company products / services) (Yigit, 2018). They usually result in a decline in market share or revenues, increased operating expenses, and liquidity constraints. If the company cannot react to these negative situations, it soon inevitably experiences financial stress and possibly insolvency. On the other hand, financial distress is related to a situation where there is excessive leverage in the company and in companies that use short-term lines of credit to finance their long-term assets. These two types of distress are not mutually exclusive; that is, a company with strong operating activity may be struggling financially, and a company in a strong financial position may be struggling operationally. However, troubled companies can use certain techniques and tools to solve these situations and avoid having to immediately file for bankruptcy. Among the most powerful such activities are (Ratner et al., 2009):

- the sale of part of the company,
- strategic acquisitions by the company,
- new equity investments in the company,
- a tender offer for debt,
- the recapitalisation of the business,
- interim forbearance by lenders, and
- exchange offers, either debt for debt, debt for equity, or debt for debt and equity.

The terms ‘bankruptcy’ and ‘insolvency’ are often confused, but there is a subtle difference between them. According to Boratyńska (2016), bankruptcy refers to an economic process, while insolvency is basically a legal category with the purpose of satisfying all the creditors of a given debtor. A bankrupt company is not able to settle its debts and the value of its assets is not sufficient to cover all liabilities; bankruptcy represents one possible solution to insolvency. Bankruptcy can be identified as either formal or material (Moravec, 2013). The former relates to the court that declares bankruptcy; the latter means fulfilling the legal assumption of bankruptcy and the obligation

to file a bankruptcy petition. Insolvency can arise when the total liabilities of a company surpass its total assets; this is considered a greater danger of possible bankruptcy (Altman and Hotchkiss, 2006). The relationship between the debtor company and its creditors is also represented by default, usually differentiated in a legal and/or technical manner. A debtor missing a scheduled payment can cause legal default, whilst technical default occurs when a debtor violates the agreement with a creditor (Yigit, 2018).

“Bankruptcy represents a legal process that allows creditors to have control over the assets of the debtor” (Yigit, 2018). According to Bryan et al. (2013), bankruptcy occurs when the company is unable to meet its obligations. Financial distress is generally considered a reason that may lead to bankruptcy and is generally evident before the event. Early indicators of bankruptcy include losses in multiple consecutive years, dry cash flows, and declining sales (Bryan et al., 2013). Bankruptcy also represents a financial and legal consequence of a personal or organisational failure to pay outstanding debts. It has become a highly prevalent phenomenon throughout the world due to rapid economic growth and the serious problems caused by this new economic condition. Bankruptcy is considered disruptive and costly, not only for owners, but also for various stakeholders such as employees, creditors, suppliers, and customers (Baixauli and Mónica-Milo, 2010). Also, in the case of the bankruptcy of small and medium-sized enterprises, consideration of the position of their stakeholders, who would be affected directly by the failure of such SMEs, is essential (Crutzen and Van Caillie, 2008).

As mentioned above, bankruptcy brings costs for the economy as a whole, as many procedures in this process are expensive and last for an extended period of time (Levratto, 2013). Weiss (1990) found that the average cost of bankruptcy is around 3% of total book assets and 20% of the market value of equity

in the year prior to bankruptcy. Authors tend to differentiate between the direct and indirect costs of bankruptcy. Direct costs are represented by fees paid to lawyers, accountants, consultants, and other professionals involved in the bankruptcy process; a substantial part of these costs is fixed (Yigit, 2018). LoPucki and Doherty (2003) characterise direct costs as high because procedures are complex and involve many creditors, and due to the information asymmetry between the company and lenders. These costs usually represent 15% of the company’s assets according to the Doing Business Index (García-Posada and Mora-Sanguinetti, 2014). Indirect costs can be characterised as economic losses incurred during the bankruptcy process and relate to a wide range of unobservable opportunity costs (including loss of profits, loss of sales, and the inability of companies to issue securities or obtain credit). The loss of important suppliers, customers, and key employees are other examples of indirect costs; companies in bankruptcy usually have a weaker position when trading with suppliers. The measurement of indirect costs is nearly impossible to perform; therefore, it is very difficult to calculate the total costs of bankruptcy (Yigit, 2018).

A complete picture of the possible causes of bankruptcy is provided by Bradley and Rubach (2002), who offer a reminder of the different types of factors identified as the causes of insolvency in a survey commissioned by the Small Business Administration. Management, marketing or financial reasons are the main ones, but additional elements should also be stated, such as the following:

- external business conditions: include increased competition, insurance, and general costs of doing business,
- financing: includes loss of capital, inability to secure new capital, and high debt,
- internal business conditions: include management errors, location, loss of clients, and trade credit problems,

- tax: includes problems with the tax administration,
- disputes with a particular creditor: include foreclosures, lawsuits, and contract disputes,
- personal: includes illness and divorce,
- calamities: include fraud, theft, natural disasters, and accidents, and
- other: includes delaying and involuntary bankruptcy filings.

Other authors (Ooghe and Prijcker, 2008) have identified five different groups of factors that can cause the failure of a company; moreover, they also stress that these groups are linked. First, the general environment (composed of factors such as politics, technology, economics, social factors, foreign countries, etc.) affects the motivation of managers, the usefulness of their skills, and therefore corporate policy, in addition to the relationship with stakeholders in their immediate environment (e.g. customers, suppliers, competitors, banks and credit institutions, and stockholders). The immediate environment is seen as the second group of factors because the interactions between a company and its stakeholders determine corporate development. Ruinous competition, but also mutual projects with stakeholders, are well-known examples of these interactions. Third, the characteristics of management (or the entrepreneur) – motivation, skills, qualities, and personal characteristics – also have an important effect on company performance. Together with these factors, corporate policy (such as company strategy and investments, personnel, finance and administration, and corporate governance) can negatively influence the wellbeing of the company in the case of certain errors. Finally, company characteristics (e.g. maturity, size, industry, and flexibility) must also be considered – for example, young companies are very vulnerable because they must build up stable relationships with stakeholders. Moreover, even companies with similar financial profiles but in

different industries have a different probability of failure.

Some authors (Collett et al., 2014; Lukason and Hofman, 2015) differentiate between the internal (or intra-organisational) and external (or extra-organisational) causes of bankruptcy; sometimes there is a combination of causes from both groups (Qeidari et al., 2020).

The most important extra-organisational reasons for bankruptcy are competition, business fluctuations, rapid technological advancement, and the characteristics of many other companies attempting to obtain a competitive advantage and gain customers, all of which can significantly increase the risk of bankruptcy. On the other hand, enterprises should ensure to dispose of the ineffective management of the company, and thus to reduce this risk. The irrationality of some investors can cause business fluctuations that can result in the bankruptcy of some enterprises; factors such as a reduction in price of goods or a sudden increase in prices and a reduction in sales, along with other similar factors, also increase the risk of bankruptcy. Rapid technological progress is also a significant factor in causing bankruptcy because it may render certain production processes and products obsolete. If entrepreneurs do not use modern methods and quickly identify consumer demands, they will experience failure. Some economic systems are unstable and still developing, and enterprises in these economies are at greater risk of bankruptcy compared to more stable economic systems. However, in unstable economies there is also an opportunity for entrepreneurs to be successful, albeit this is mostly dependent on effective management that must predict changes in the economic structure and reduce risk accordingly (Bikas and Saponaitė, 2018).

On the other hand, intra-organisational reasons for businesses going bankrupt are those that could be prevented by taking the proper measures. Most of these factors are

the result of poor decision making, and responsibility for this lies directly with management (Qeidari et al., 2020), including general managerial inefficiency, insufficient sales, or improper pricing. The inefficiency of CEOs is one of the most important reasons for bankruptcy, and success or failure is directly affected by executive measures and decisions. A lack of education and experience affects managerial ability and innovation in the field of competition and technology. Insufficient sales result from an unsuitable location, an inefficient marketing department, insignificant measures to improve sales, and the offer of low-quality services and products. In other words, an entrepreneur does not earn enough income to continue his activities. Considering manufacturing costs, a product priced improperly, sold for extremely low prices, will lead to minimal profits or even a loss on said product (Newton, 2009).

The current literature deals mainly with bankruptcy in general and models that predict future problems in companies and assess their financial health (Shetty et al., 2022; Voda et al., 2021; Bateni et al., 2020; Kováčová et al., 2020). Many studies (Ďurica et al., 2021; Klieštík et al., 2020; Khan et al., 2020; Kováčová et al., 2019) emphasise that these models need to be constructed for a specific country or industry because of their specificities and differences, but it is also possible to construct a bankruptcy model for a group of countries with similar features or for neighbouring countries (Sponerová, 2021). According to Khan et al. (2020), the perception of bankruptcy in Slovak enterprises and those in the Czech Republic is different – Slovak entrepreneurs perceive bankruptcy as a natural part of business. Another study (Bič, 2022) confirms that in both countries certain interventions in the business environment are needed to help entrepreneurs in this unfortunate situation. Rybářová et al. (2016), who performed research on a sample of

companies from the construction sector, analysing the efficiency of the Altman Z-score bankruptcy model, confirmed that this model is also suitable for Slovak construction businesses. Our study also focuses on the construction sector, but with the emphasis on the identification of the potential reasons for bankruptcy in these companies.

2. Methodological approach

In order to investigate the reasons behind bankruptcies of business entities in Slovakia, the construction sector was chosen (SK NACE Section F) as it represents a traditional – in terms of economic development – and important industry in Slovakia (measured by the value produced on domestic and foreign markets, the number of employees, the number of business entities, etc.), with long-term growth potential, but also one that is highly sensitive to economic cycles and public spending. From a geographical point of view, bankruptcies in the construction sector were scaled according to NUTS III regions and the period of filing for bankruptcy. In line with the objective, three research questions were formulated:

- The status of crisis is the first step towards bankruptcy, but its warning function may fail – the status of crisis introduced by legislation (Slovak Act No. 513/1991 Coll., as amended, Commercial Code) helps to identify companies which are dangerously close to overindebtedness. It expects a crisis to have begun if the debt to equity ratio falls below 8% (Commercial Code). The potential of such an indicator to identify failure is based on the fact that small and medium-sized enterprises with limited resources can quickly become overindebted after an unsuccessful business venture if their losses suddenly exceed this value. As small companies are prevalent in the Slovak construction industry, this warning is less relevant. Before

the conditions of the Commercial Code were tightened, the limit of 8% was less strict before 2018, but with the effort to ensure mutual comparability between periods, the same and most rigorous 8% limit is used for all companies.

- Subsidies from owners can save liquidity and offer additional financial sources – as the median values of loans-to-assets indicators suggest, construction companies in Slovakia are seldom financed by bank loans, and only large companies rely on this financial instrument (Finstat, 2019). It does not mean that smaller companies never utilise debt financing, but it includes sources gained from common supplier-customer relations. Therefore, companies (mostly in the early stages of their activity) are somewhat dependent on the private resources of owners. It is common practice, then, that apart from direct equity contributions, companies also utilise indirect subsidies from their owners, because said process is faster, simpler, and bears lower risk. In line with this, the article answers the question of how owners behave before bankruptcy.
- The length of the bankruptcy process depends on the age of companies – the causes of failure of younger companies clearly differ from those of mature ones, mostly due to a lack of quality or capital (Kücher et al., 2020). Moreover, Ooghe and Prijcker (2008) consider new companies to be candidates for bankruptcy primarily because of limited managerial and industry-related experience and a weak financial and administrative structure. As all these factors have an impact on potential profit and thus even on the structure of capital, it raises the question of whether the age of a company influences the duration of the bankruptcy process as a whole, or whether there are other factors which have a significant effect.

The research sample consisted of all bankrupt business units identified via the Dataset of Critical Events administrated by the Finstat commercial data register (Finstat, 2020). The availability of their financial statements in the Slovak register of accounting statements was a necessary precondition, owing to which three companies were eliminated from the 165 previously identified bankrupt organisations. So as to measure the proper characteristics of the bankruptcy process, only those companies whose process was closed and their legal existence terminated were chosen. The secondary reason for the construction of such a sample was the legislative exemption by which a company in bankruptcy does not submit the regular closure of accounts within the process of bankruptcy; thus, there is no information about the financial background of bankrupt companies except for the information published by the administrator of the bankruptcy assets. In total, 138 business entities from the construction sector which went bankrupt during the observation period of 2016-2020 and whose bankruptcy was fully completed were analysed. The decision was made to conduct the research based on data covering a five-year period including the newest available data for 2020. Sole proprietors were excluded, as their financial data is not publicly available, is confidential in character, and is partially subject to different legal regulations. Furthermore, companies with an unknown bankruptcy start date were omitted, as the bankruptcy process might have been initiated in conditions which differed from those in the evaluation period. Thus, we consider the research to be applied on the above-defined parent population of bankrupt companies. The robustness of the sample (in terms of representativeness) allows one to apply the conclusions to all bankrupt companies in the construction sector.

Specific attention was devoted to the development of warning signals in time. This “time effect” was considered twice, once

to see whether the value of the selected indicators differed according to the year in which the companies entered bankruptcy, and secondly to understand the degree to which the indicators worsened one or two years before bankruptcy, the latter also in connection with the region and the intensity of construction activity therein. The crucial indicators were split into two categories: legal indicators given by the legislation and relevant in the case of internal or external start of bankruptcy (crisis leading to overindebtedness or insolvency) and financial indicators relevant in the case of obvious (liquidity, debt) or hidden (sales, assets change, asset sellout, internal borrowings) problems. Therefore, the choice of measures was partially inspired by the Bankruptcy and Restructuring Act (legal rules) and other

studies (Djankov et al., 2008; Boratyńska, 2016; Ooghe and Prijcker, 2008), although those indicated more or less complex insight into the topic (Djankov et al., 2008) or were more general in focus without exact data (Boratyńska, 2016); thus, the measures were selectively chosen with respect to the aim of the investigation. Macroeconomic or broader qualitative characteristics of the industry were not considered. The number of measures was limited, since the intention was not to prepare financial predictions or distress models, as the number of failed companies is not sufficiently robust in the mid-term period, their activities are heterogeneous and seasonal, and they declare variable financial results according to size, which requires a separate approach (Pervan, Pervan and Kuvek, 2018).

Table 1. Absolute and relative measures

Legal indicators	Financial indicators	Hidden proofs
Equity-to-liabilities (crisis)	Acid test (liquidity)	Change in sales and assets
Equity-to-assets (debt)	Loans-to-assets (debt)	Sellout of assets
Mature liabilities (insolvency)	Daily sales in payables (debt)	Internal borrowings
	Return on assets (profit)	

Source: own elaboration

In addition to the descriptive statistics (absolute and relative indicators) used for the profile of each individual legal entity in the sample, all bankrupt companies were evaluated through the median values for the entire sample (we preferred the median instead of the mean due to its greater accuracy and lower sensitivity to the expected outlying values in the sample). The Pearson correlation coefficient was used to measure the potential dependability of the entire bankruptcy process. The duration of bankruptcy was correlated with debt (the greater the debt, the shorter the process), asset size (the more it owns, the longer it takes to process), and company age (older companies with complex relationships may have a large number of creditors).

Apart from the literature review and other research results, two financial databases were used as primary information sources, both administrated by the Finstat register. The dataset with critical situations was used to identify bankrupt companies (specifically, the start and completion date of bankruptcy). These companies were paired with the dataset containing financial statements used for data processing and evaluation. Data from the Statistical Office of the Slovak Republic were presented to understand the size of the industry and its development over time. The Cribis register offered median values of selected relative indicators that described the entire construction industry in Slovakia.

To infer specific reasons for bankruptcy in the Slovak construction sector, we used a narrative literature review with purposive sampling, as we were interested in respondents who had the most knowledge regarding the reasons for bankruptcy.

3. Research results and discussion

The following text is divided into three sections. The first section is focused on the characteristics of the construction industry in the Slovak Republic through selected indicators (e.g. number of entities, territorial location of business entities, number of employees, average nominal wage, value of production, number of bankruptcies entered). The second part is focused on the analysis of the economic situation in construction companies with a more detailed orientation towards bankrupt construction companies. The last section is dedicated to the analysis of the bankruptcy process and its consequences for construction companies.

The construction industry and the development of bankruptcies in the construction sector in Slovakia

Construction is one of the most important sectors of the Slovak economy. Its annual share in gross domestic product (GDP) is approximately 7%, and it constitutes a significant share of private sector output (Statistical Office of the Slovak Republic, 2020a). Construction contributes significantly to the growth of the Slovak economy and in many ways is comparable to the level of construction in other EU countries (especially in terms of technical, technological, and architectural standards of buildings, quality of construction work and speed of construction, range of materials and products used, etc.). Table 2 presents the development of the number of legal entities in the construction sector during the period of 2016-2020 and the share of legal entities in the construction sector in the total population of legal entities in Slovakia.

Table 2. Number of legal entities in the construction sector and their share in the economy

Year	Legal entities in the construction sector	Share of total entities in construction	Share of legal entities in construction in the total population of Slovakia
2016	16,439	18.05%	6.52%
2017	18,688	19.97%	6.84%
2018	19,831	21.17%	6.79%
2019	21,468	20.72%	6.98%
2020	22,954	21.21%	7.09%
relative change 2016-2020	1.39		
absolute change 2016-2020	6515		

Source: own elaboration according to the Statistical Office of the Slovak Republic, 2020a

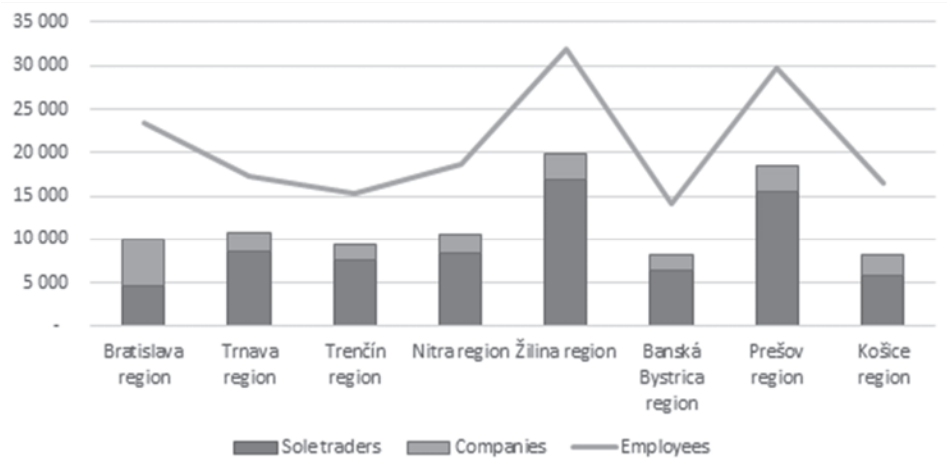
During the observed period, an increase in the number of legal entities was recorded in the construction sector in Slovakia (by

39% in total). Legal entities also increased their share of the total number of entities in the construction sector (by 3.16 percentage

points). A similar change was recorded as a 0.57 percentage point increase in the share of legal entities in the total number of legal entities in Slovakia.

Figure 1 illustrates the geographical dispersion of business entities in the Slovak construction sector and the number of employees.

Figure 1. Number and structure of construction business entities in the regions of Slovakia (2020)



Source: own elaboration

The data in Figure 1 presents the number of companies and people actively working in the Slovak construction sector in 2020. The data can be interpreted from two points of view; the first indicates that the number of sole proprietors was much higher than the number of companies, being predominant in all regions except the Bratislava region. The second interpretation would be that the companies held a dominant position in terms

of number of people involved (employees). The number of employees was highest in the Žilina, Prešov and Bratislava regions.

The increasing economic importance of the construction sector in Slovakia was also confirmed by the growth in the value of production since 2016. The construction sector achieved an increase in the value produced of almost 9% in 2020 compared to 2016 (Table 3).

Table 3. Value of production in the construction sector in Slovakia

	2016	2017	2018	2019	2020
Value of production (mil. €)	4866	5174	5801	5807	5290
Domestic construction (mil. €)	4622.7	4863.56	5452.94	5458.58	4622.7
Foreign construction (mil. €)	243.3	310.44	348.06	348.42	317.4
Domestic construction (%)	0.95	0.94	0.94	0.94	0.94
Foreign construction (%)	0.05	0.06	0.06	0.06	0.06

Source: own elaboration according to the Statistical Office of the Slovak Republic, 2020

In the long run, the share of domestic production in the construction sector was around 94%, while the rest (6%) constituted Slovak companies in other countries. This also implies that if there was a loss of production in this sector, it would be reflected primarily in the domestic market (through the number of people employed, products and services purchased, as well as the value created for domestic customers).

The decisive factors for the development of the construction sector in Slovakia are mainly the qualifications, expertise, and experience of the workers. However, there has been a long-term lack of a qualified workforce in this sector, which could threaten the competitiveness of construction companies on the Slovak and European markets.

Although employment in the construction sector has been on an upward trend since 2016 (Table 4), there are too few skilled workers available (especially in the manual and craft professions), and it is estimated that this situation will further worsen. The reason for this is probably the low average wage within the sector, long-distance work, and the general unattractiveness of the technical fields of study, which lag significantly behind the humanities. Slovakia is solving this problem by supporting secondary vocational education through the introduction of a dual education system. At the same time, there is a need to promote technical education, intensify cooperation between schools and businesses, and adapt the content of education to the needs of practice.

Table 4. Number of employees and average nominal wage in the construction sector

	2016	2017	2018	2019	2020
Number of employees	157,236	162,631	166,864	176,914	166,336
Average nominal wage (€)	639	646	713	746	751
Standard deviation of nominal wage (€)	153	192	210	268	169

Source: own elaboration according to the Statistical Office of the Slovak Republic, 2020

In 2020, the largest number of employees were employed in companies based in the Bratislava, Žilina and Prešov regions (51% of all employees working in the Slovak construction sector), while the lowest level of employment was in the Banská Bystrica (8.5%) and Trenčín (9%) regions. There were also large regional differences in the nominal wages of the employees. While in 2020, the wages of employees in almost all regions were at the level of 90% or less of the average wage in the construction sector (and as little as 74% in the Prešov region), in the Bratislava region, the capital city paradox had a visible effect, and the nominal wage was up to 167% of the average wage in the sector. The standard deviation of

the average wage in the construction sector suggests a deeper regional inequality in this area as well.

Table 5 presents the number of bankruptcies entered in the construction industry in Slovakia in the period 2015-2020. The share of bankruptcies among sole proprietors (measured from the average number of sole proprietors during 2015-2020) was approximately three times higher than the share of bankruptcies among companies in the construction industry. Unfortunately, the data pertaining to sole proprietors was not available due to its confidential character, so the only objects of investigation were companies (legal entities) which closed the bankruptcy process within this period.

Table 5. Number of bankruptcies entered in the construction sector

	Total 2015–2020	Closed 2015–2020	Closed 2021–2022
Total	3999	2178	352
• Legal entities	239	141	29
• Sole proprietors	3760	2037	323

Source: own elaboration according to Finstat, 2022

The economic situation and the reasons behind bankruptcies

Generally, the economic conditions (or financial health) of construction companies in Slovakia were quite variable (compared to other industries in the period analysed) but developed rather positively in the last five years (Table 6). Liquidity was built on a lower share of inventories, thus contributing to better coverage of liabilities. The relationship between receivables and payables was standard and slightly in favour of a shorter payable turnover period, and both indicators were proportionally lower over time, each by almost 10 days. On the other hand, the pandemic worsened all indicators as a rule, especially in the case of profitability. The overall money cycle was faster, but companies paid trade debts sooner than they

collected trade claims. Lower trade debt partially influenced the size of total liabilities, with a debt-to-assets ratio of almost 58% in 2020, while contributing to the improvement of the debt-to-equity ratio (crisis ratio) that was increased to 0.88 in 2019 (in contrast to the significant crisis found in bankrupted companies). The development of profitability was not as positive, as the return on assets fell below 1% in 2020. The median value of loans-to-assets was equal to zero (the same in the upper-quartile companies) in each year. This indicates that construction companies are not regularly financed by financial institutions, although the value of debt is partly based on the size of the company; in the upper quartile the value of loans to assets increased (10% in medium companies, 17% in large companies identified through the size of assets).

Table 6. Median values of key indicators in the construction sector and their development over time

Indicator	2015	2016	2017	2018	2019	2020
Acid Test Liquidity (coef.)	1.24	1.29	1.60	1.58	1.67	1.56
Daily Sales in Receivables (days)	39.87	34.96	34.02	30.17	28.88	30.69
Daily Sales in Trade Payables (days)	30.37	24.35	21.83	20.78	16.95	20.05
Debt-to-Equity (crisis; coef.)	0.47	0.56	0.81	0.76	0.88	0.74
Debt-to-Assets (%)	68.51	34.32	55.34	56.85	53.30	57.67
Loans-to-Assets (%)	0	0	0	0	0	0
ROA (%)	2.18	3.10	1.76	1.18	1.14	0.43

Source: own elaboration and Cribis.sk

The economic situation in bankrupt companies was significantly different. The legal reasons why companies go bankrupt are usually focused on the capital structure (share and structure of debt) and cash situation (how the obligations are satisfied). Bankruptcy legislation in Slovakia follows similar principles that were also added to the research as a crucial criterion for the identification of causalities in bankruptcy. These are focused on the legislative reasons why companies went bankrupt (although with a degree of modification, as certain company data may not be disclosed in detail due to the privacy of statements) and other financial reasons that preceded the ultimate situation in which the bankruptcy was inevitable from the legislative point of view. It is obvious that none of the factors was the one and only cause of bankruptcy, as they usually collide or go hand-in-hand. Thus, bankruptcy is considered the result of an ultimate chain effect brought about by several economic and financial issues.

Many authors focus their research on the compilation of different country- or industry-specific distress models. Specific models for the construction industry are not very common (e.g. Chen, 2009; Ho and Lin, 2004), mostly due to the unique characteristics of this industry (highly diversified, very seasonal). Our research focused primarily on the causes; therefore, individual characteristics and ratios were crucial, not the eventual result itself (failed vs. not failed). Many of the ratios used were confirmed in the existing literature (e.g. Kováčová et al., 2019) as being predominant in Central Europe, while others came directly (negative

equity period, debt-to-equity) or indirectly (daily sales in trade payables) from the legislation, and thus are specific to Slovak conditions.

Sales development

53% of companies in the construction industry went without sales two years before entering bankruptcy (period X-2) and 80% one year before bankruptcy (period x-1). This opens the question of a potential speculative approach of their owners (zero sales as a delaying strategy or as a consequence of the crisis). The fact that only 8% of companies had no employees within a year of bankruptcy indicated that the purpose was not necessarily only speculative. All companies without sales two years before bankruptcy no longer had employees, so the bankruptcy in their case was quite expected and planned.

The median value of the decline in sales (in companies which continued to generate sales) was 57%, thus creating potential threats to later cash generation and payable compensation (after 90% winsorisation, the median value increased to 59%). Approximately 6% of companies generated increased sales before filing for bankruptcy. The best companies in the upper quartile increased their sales by more than 121%, but it should be stated that there were many extreme outlier values due to the lower initial sales before their sudden growth. The development of sales indicated that companies either prepared themselves for bankruptcy or remained inactive for a period of time and potentially utilised economic and tax allowances.

Table 7. Development of key causalities of bankruptcy in bankrupt construction companies

		Assets change	Negative equity period	Crisis _(x-1) (Debt-to-Equity)	Crisis _(x-2) (Debt-to-Equity)	Sales change	Equity-to-Assets _(x-1)	Equity-to-Assets _(x-2)	Sales-to-Assets _(x-1)	Sales-to-Assets _(x-2)
N	Valid	62	111	80	60	87	110	106	96	86
	Missing	100	51	82	102	75	52	56	66	76
Median		.86	2.00	-.69	-.61	.57	-.77	-.26	.55	.91
Std. Deviation		13.20	1.96	2.01	2.31	21.49	264.19	88.90	99.39	6.95
Percentile	25	.46	1.00	-.86	-.71	.15	-5.94	-1.68	.00	.00
	50	.86	2.00	-.69	-.61	.57	-.77	-.26	.55	.91
	75	1.009	4.00	-.046	-.032	1.21	.01	.11	2.59	1.91

Source: own elaboration

Sales generation problems were also documented by the share of sales in total assets (Table 7). While in period X-2 this share (or turnover) was 91% (median value), in period X-1 it was a mere 55%, so even in the case of lowered assets (covered in more detail in the next paragraph) the development of sales was disproportional. Only the best companies (upper quartile) succeeded, as their share of sales on total assets increased (from 191% to 259%). All indicators in Table 7 were calculated from unmodified financial statements from the extraordinary closure of accounts made due to the start of bankruptcy (Act No. 431/2002 Coll.). Missing observations are registered due to missing data in statements, either in period X-1 or X-2.

The fact that companies did not have sales one or two years before entering bankruptcy may be the result of strong competition, lost projects, lack of employees, or a pure consequence of poor management. These findings confirmed the results of Bryan et al. (2013), specifically the role of sales in prediction. The fact that some companies had no employees seems to be a result of planned activity, and there was also evidence that many companies

intentionally sold their property in advance, while they also simultaneously settled preferred claims, mostly those of owners instead of other business partners. The size of negative equity (overindebtedness) showed that many times companies went beyond extreme loss tolerance, and thus potentially brought their lenders to secondary insolvency with a very limited likelihood of even the partial recovery of their claims (albeit this is not only the case in the construction industry). Similarly, Altman and Hotchkiss (2006) pointed to the crucial role of liabilities prevailing over assets in the probability of bankruptcy, although the examples given above support the idea of distinguishing between the types of liability and also the important role of management (both competence and ethics).

Assets represent a necessary precondition of sales; moreover, in the case of the construction industry, they significantly affect production capacity, although some minor activities such as electrical, plumbing, and other installations or building completion and finishing (suitable rather for micro- and small enterprises) do not need a great deal of property. Increased assets can potentially

be considered proof of the growth of the company (reflecting the power of capital, although sales are also relevant), although they can be devalued in the case of abandoned claims. Additionally, extreme growth in property, plant, and equipment, which is not actively used in sales generation, may be ineffective in financial health (including potential debt financing and the ensuing consequences). But it needs to be said that newly built capacities require sufficient time to reflect their value in sales (it depends on the purchase value, expected return, annual sales potential, depreciation policy, etc.); on the other hand, some ratios may seem extremely efficient in the case of rented long-term assets generating a significant portion of sales (rather than assets owned).

The loss of assets may, on the other hand, offer warnings similar to those of sales development. A certain decrease is natural due to depreciation, although missing fixed investments in the long run may point to a lower level of liquidity, problems with external financing (theoretically, as the simple operations not based on technological infrastructure do not require as much investment, nor as often), or general managerial dysfunction. The gradual and intentional decrease in fixed assets also signals the potential sale of PPE, indicating that bankruptcy is expected or even planned. It may also demonstrate speculative reasons and the effort to eliminate the responsibility to settle liabilities as companies enter bankruptcy.

Approximately 5% of companies in the construction industry had no assets two years before bankruptcy and 21% a year later. Only the upper quartile companies increased the value of assets (median value +0.9%), while the decrease in assets in the lower quartile companies reached 46%. The value of sales of long-term assets was used as a dummy variable (although it was generally accepted that it is not automatically connected with the sale of assets and preparation for bankruptcy). Almost one quarter of all companies had certain income

from the sale of long-term assets in both years (26% two years before entering bankruptcy and 21% one year beforehand).

Status of crisis and capital structure

The status of crisis was introduced into the Slovakian Commercial Code in order to create warning signals before potential failure and, most of all, to protect companies and their creditors from privileged claims compensation and potentially unfair acts of statutory bodies. The crisis ratio directly points to a low level of equity, and when the company enters this crisis state, it is threatened by the start of potential bankruptcy, and should announce this fact in its financial statements. The company is considered to be in crisis when the relationship between equity and debt falls below 8%.

The analysed companies had already signalled significant problems two years before bankruptcy. The median value of the equity-to-debt relationship was -0.31 in period X-2 and -0.69 in period X-1. Thus, even in the case of active businesses, problems with capital structure deepened. The negative value of this indicator reflected still more negative equity (due to increased losses); more precisely, such extreme indebtedness (with higher levels of debt than assets) is one of the two conditions for potentially commencing the bankruptcy process (Act No. 7/2005 Coll.). Moreover, while the crisis detects potential future problems, the analysed companies directly became bankruptcy candidates as the values of equity fell significantly. The Act on bankruptcy and restructuring expects that company authorities should do their best to avoid the crisis and/or indebtedness and insolvency in the case of the detection of warning signals, but the results showed that companies were bankruptcy candidates more than two years before bankruptcy started in practice. Only 6.5% of the companies were in crisis two years before bankruptcy and only two of them became overindebted afterward. This goes to answer

the first research question about the partial failure of this indication of a crisis.

69% of all active companies had negative equity in period X-2 and 73% in period X-1, despite the fact that the law cited above expects immediate action in the case of detection (primarily due to losses generated). The average period for which companies were indebted was two years, but the worst quartile of companies remained in this situation for more than four years. In terms of certain solutions to this problem (taking immediate action), both additional equity (although no company did so) or provisions given by related parties (usually owners) may be considered. Only 15% of companies provided additional funds for company liquidity purposes, although in fact increasing the already extreme portion of debt financing at that time by doing so. It seems that a direct contribution to equity may be too risky, leading to the prevalence of owners' subsidies.

Fundamentally, contact with related parties is one of the limitations that the status of crisis rule has introduced. All provisions provided by the owner, shareholders, statutory bodies, or other related entities could not be refunded during the crisis, but only after they had perished. This protection "helps" to designate all necessary funds to cover claims against other creditors (state, employees, banks, suppliers, etc.). Despite this, 21% of companies repaid those funds back to related parties, although they were already in crisis. This does not mean that they broke the law (since part of the research sample comes from the 2015 period preceding the force of this legislation), but it emphasises the fact that they preferred their own interests rather than paying back the "real" debts they had previously collected. Therefore, the second research question about the behaviour of owners before the start of bankruptcy was thus answered.

The second rule in filing for bankruptcy is insolvency. A company is deemed illiquid if it is unable to pay its debts that are in arrears

for more than 30 days and if it has more than one creditor. 55% of the companies claimed to have no overdue debts, while the remaining companies in the sample recorded significant debts (as indicated also by the negative equity above). The median value of the debt-to-asset ratio was 115% in period X-2 and 162% in period X-1. Furthermore, the average share of debts due on assets was 51%.

Although insolvency is usually initiated by creditors, indebtedness is based primarily on the initiative of each company (its representatives and statutory bodies). The situation in the construction industry showed that both legislation tests prove the expectation of incoming bankruptcy, although insolvency generally seemed to be a more intensive threat (as it pertained to the start of bankruptcy), because creditors lose patience sooner (short-term effect) and indebtedness is a more complex topic also due to its spread over time (long-term effect; moreover, it can be quite successfully hidden).

Boratyńska (2016) considers bankruptcy to be an economic process and insolvency to be a legal category. According to the Slovak legal system, it may suggest that insolvency (as specified in legislation) is rather the opposite – an economic category with reversible status – while bankruptcy is a legal category, as Yigit (2018) also mentions, irreversibly heading towards the cancellation of the company's legal status; moreover, it is strictly under the control of the court and supposes at least an effort to partially settle the claims of creditors. Significant international differences in the framework of bankruptcy exist, in terms of its procedures, an understanding of the consequences, or in enforcements of insolvency (Merovach, 2021). Moreover, although bankruptcy solves economic and legal issues, it not only has an economic or financial background, but takes place because of many more or less visible causes.

The reasons that lead companies to experience financial problems and ultimately cause their default may be split into two categories

(Table 8) (Belás et al., 2020; CEEC Research, 2020; CEEC Research, 2021; EUROSTAV, 2018; Statistical Office of the Slovak Republic, 2019; Statistical Office of the Slovak Republic 2020b; Krokoš, 2019; CRIF Slovak Credit Bureau, 2015; European Construction Sector Observatory, 2021; European Construction Sector Observatory, 2020).

Table 8. Reasons for bankruptcy in the Slovak construction sector

Shared reasons	Specific reasons
Demand crisis / Public procurement	Construction legislation
Law enforceability (general)	Power of key players in the sector
Corruption	Cascade effect of problems in a chain
Lowered liquidity / Insolvency	Minimal wage pressures
Poor management	Material availability / Price pressures
	Low quality
	Availability of workforce
	Decrease of new constructions / Increased recovery and maintenance

Source: own elaboration

As Levrato (2013) states, the causes of bankruptcy can be as numerous and complex as the factors leading to growth, which can make each company a unique case suffering from specific and partial failures, albeit such a candidate for bankruptcy may suffer from general economic problems/collapse (shared reasons) or industry recession (specific) as well. Reasons in the first category may be shared with other industries; thus, we do not consider them unique to the construction sector. At the beginning of the analysis period, it was quite common to designate lower public investments as a cause of the crisis in the industry. The government / regional governments were blamed for lower investments in public infrastructure or public procurement. The latter was considered too static, bureaucratic and unclear as regards the criteria evaluated in public tenders. Specifically, in the case of housing and road infrastructure, or those generally financed by EU funds (such deals are considered by construction companies to be partially manipulated and extremely risky including price shocks). As the majority of

construction activities occurred in the western Slovak regions (both infrastructural and housing), it also intensified the quite significant differences between regions with the consequent economic deviations (Table 9).

It was not only the public procurement process that prolonged the entire process and frequently hindered the financial flows within the industry (compensation, complaints, etc.). Many companies and stakeholders, including the Slovak Chamber of Construction Engineers, blame the entire construction law for the extremely long preparation of new constructions and the long closing phase of finished ones. The excessive number of amendments made it unclear and created space for both bureaucratic and economic interventions and the occurrence of illegal constructions that are legalised afterwards.

The status and extent of certain construction activities (specifically highway or railway reconstruction) suit only a very few key players, while they simultaneously create long list of small suppliers dependable on their success. Several public projects showed how a failure (whether an economic one or

a physical accident) in the case of one company threatens the existence of its suppliers and pushes them to bankruptcy. Moreover, the opacity of such relations threatens safety in terms of the final construction and spreads the responsibility for potential failure over an excessive number of unidentified subjects/suppliers (who officially were not considered in case of construction approval). As the price is usually the most important factor in a tender, the low quality of the materials used or the work provided intensifies the overall effect in the case of safety.

The abovementioned facts are why many companies are reluctant to take part in certain construction projects (due to their duration, the way of financing, of the potential cooperation partners) or why they are vulnerable during participation. This is also proven by the fact that sales from maintenance and recovery deals grew faster than new constructions in recent years. On one hand, it may give small companies an opportunity to benefit; on the other hand, they are less

beneficial for larger companies due to lower added value (in the case of prevailing fixed costs) and beset with inherent economic risk.

**The bankruptcy process
and the consequences thereof –
the regional point of view**

Differences in values from a geographical point of view proved a certain heterogeneity of bankruptcy. Table 9 shows how the values of indicators were scaled in all Slovak regions. The worst values in each criterion are in black, while the better values (in terms of the data spread, not in terms of the optimum) are in white. Generally, the Košice (KE) and Bratislava (BA) regions were ranked among the better percentiles (lighter background), although they represented the highest shares in total bankruptcies. On the other hand, the Prešov (PO), Trenčín (TN), and Trnava (TT) regions represented the worst percentiles (due to the scaling of the values from better to worse), in their case displayed against a somewhat dark background.

Table 9. Regional stratification of indicators (medians)

Regions	BB	BA	KE	NR	PO	TN	TT	ZA
Regional share of total bankruptcies in the sector (%)	11	25	17	9	14	5	9	10
Debt-to-assets _{x-2}	2.340	1.126	0.970	1.226	1.355	1.652	3.123	0.999
Debt-to-assets _{x-1}	3.210	1.580	1.014	2.790	5.649	5.310	4.350	1.467
Mature liabilities (coef.)	0.410	0.183	0.356	0.419	0.360	0.999	0.056	0.502
Crisis status _{x-2}	-0.573	-0.268	-0.007	-0.164	-0.529	-0.552	-0.729	-0.066
Crisis status _{x-1}	-0.688	-0.695	-0.035	-0.427	-0.895	-0.902	-0.965	-0.582
Life cycle (years)	7.826	11.833	11.871	12.205	11.556	12.140	12.474	8.037
Bankruptcy duration (years)	0.392	0.518	0.786	1.403	0.945	0.575	0.684	0.759

Source: own elaboration

The majority of the indebted companies were in the Banská Bystrica (BB) and Trenčín (TN) regions in period X-2. A year later, the situation had worsened significantly in Prešov (PO) and Trenčín (TN), thus demonstrating a sudden increase in debts compared

to assets (partly due to significant losses). In the Bratislava (BA), Košice (KE) and Žilina (ZA) regions, the increase in debt was not as dramatic. Incoming threats of overindebtedness and insolvency were also identified through the crisis status. In Trnava (TT),

Trenčín (TN) and Prešov (PO) the crisis was the most intensive, and in Košice (KE) the least. In all regions, due to negative equity, companies were (generally) over-indebted. The highest share of overdue payables on total debt (mature liabilities) was in Trenčín (TN), while in Trnava (TT) and Bratislava (BA) the solvency of the construction companies was better. Of course, ex-post analysis deals with bankruptcies which have already been completed, after the terminal situation had already arisen. Within the life cycle, it is very difficult to identify the proper breaking point, especially in situations where companies accrue an increasing amount of debt and fall into secondary insolvency due to the active receivables (which are overdue).

Although young companies appear to be more vulnerable due to lower capital, lower economies of scale, or less developed relationships with key stakeholders, the results showed that only two companies went bankrupt before the second year of their existence. This finding is in line with research by Levrato (2013) suggesting lower failure rates among young businesses. On the other hand, in our research 18% of companies had been operating for longer than 20 years. The oldest bankrupt companies are in Trnava (TT) region and the youngest in Banská Bystrica (BB), but other factors making age more or less relevant that had not yet been researched in the Slovakian context (e.g. regional intensity of competition, local or national business focus, etc.) might also exist. Specifically, younger companies frequently fail due to inexperience (Headd, 2003), underestimation of equity, cost calculation, or ignorance of accounting, while older ones fail due to resistance to changes or preference of routine activities (Kücher et al., 2020).

The distribution of bankruptcies in all regions was shown to have a normal distribution (Elexa, Hvolková, Knapková, 2019), notwithstanding the fact that construction was one of the most bankruptcy-prone industries in Slovakia. On average, according to the

Doing Business survey (The World Bank, 2020), Slovakia was 46th in terms of insolvency proceedings (compared to the Czech Republic being much higher in 16th place), recovering just 46 cents of each 1 EUR of debt, lasting for years, and incurring a total cost of 18% of property. There were only two countries with higher bankruptcy costs and eight with lower satisfaction measures (among OECD countries). On the other hand, general data from the Slovak Insolvency Register (2021) without specification of the particular industry suggested an almost 27.06% median cost in 2018, thus proving a certain underestimation, as was also claimed by Staszkievicz and Morawska (2019) in the case of Poland.

The duration of the bankruptcy process in construction companies was considerably shorter than in the above-cited Doing Business report, lasting for approximately nine months. The reason may be found in the characteristics of bankrupt companies presented above, mainly in assets (or the absence thereof), and in the fact that those companies were economically in bankruptcy (in terms of overindebtedness) a long time prior, although legally the bankruptcy process had not yet been initiated. In 38% of bankruptcies, the process was halted due to insufficient property and even in the case of some assets recorded on the company's balance sheet, their value was recorded at historical prices, including receivables that cannot be fully sold (or collected), all of which limited the level of recovery.

The Pearson correlation coefficient proved the existence of a significant but not especially strong relationship between the length of bankruptcy and the size of the debt (0.11, $p = 0.046$). It was supposed that, in accordance with Slovakian legislation, increasing debt leading to overindebtedness and insufficient asset value stops bankruptcy. Other factors (e.g. insolvency, the administrative burden, and judicial factors) were found to have a potentially more significant influence. Unfortunately, for creditors, it confirmed

that in many cases the bankruptcy occurred in a situation for which the debtor had been preparing. It was also partially proved by continually lowering sales and the sudden compensation of the owner's borrowings, followed by an accelerated sell-off of assets that were analysed separately. In their case, the effect (correlation coefficient 0.14; $p = 0.62$) indicates that the evidence is not sufficiently strong to suggest an effect exists in the population of bankrupt companies. It could also be an outcome of the abovementioned bankruptcy preparation (sell-off of assets or lacking assets at the time of bankruptcy). Thus, it also made a very weak contribution to the prolongation of the bankruptcy process. An even higher, albeit still quite weak, correlation was found in the case of company age (0.28; $p = 0.001$), very prudently claiming that the more mature the company, the longer the bankruptcy process will last, perhaps due to more complex relations with many partners, a potentially more complicated process, and a longer time period required for the inspection and acknowledgment of all debts (although it is expected that after so many years of successful cooperation, business partners are well known and the cumulation of debts is not an intentionally fraudulent process). The bankruptcy process in the Nitra and Prešov regions lasted the longest, whereby the oldest companies were bankrupt with rather higher debt-to-asset ratios one year before bankruptcy. On the other hand, the shortest bankruptcies were in the Banská Bystrica and Bratislava regions, both with quite a significant share of total bankruptcies across regions, but very different economic situations (more indebted companies and mature liabilities in Banská Bystrica; almost equal in terms of crisis intensity; older companies in Bratislava). This meant that, in the case of the third research question, it is not possible to identify the primary factor that prolongs the bankruptcy process. Although in the case of age the correlation was stronger, it is still too weak to have significant implications.

This is also supported by one other finding, namely that owners (or administrators) still have sufficient time and measures before bankruptcy to either prolong the crisis or prepare for bankruptcy.

Conclusions

The construction sector in Slovakia suffered for both cyclical/seasonal and fundamental/sectoral reasons. There are between three and five large companies that are somewhat dependent on public expenditures and public projects. Currently, construction of the northern and southern highways have slowed down; thus, railroad reconstruction has become relatively more important instead. The concentration of activities among a relatively small number of companies emphasized the dependability of the sector on its performance (the 10 largest companies had a 12% share of total sales in the industry and 1% of the total population had a 41.5% share in sales in 2019). It is visible even in the supply chain in the case of many small and medium-sized enterprises, which suffer every time some of the key players have financial problems. This is also one of the problems that brought the highway projects to a halt. Private investments in construction were dependent on economic conditions, which worsened in the last two years (including the pandemic-induced slowdown). Since the beginning of 2019, there were 17 months in which the sales in the sector had decreased compared to the previous year (Statistical Office of the Slovak Republic, 2020a), although in some of them companies paid the price for seasonal activities.

Another problem that has occurred in recent years is the development of the labour market, specifically the lack of workers. The qualifications, expertise, and experience of workers are considered the decisive factors for this state of affairs. However, there has been a long-term lack of a qualified workforce in this sector. This situation could threaten the

competitiveness of construction companies on the Slovak and European markets. Although employment in the construction sector has been on an upward trend since 2015, the availability of skilled workers (especially in manual and craft professions) is insufficient, and it is estimated that this situation will worsen in the future. The most likely reasons for this are the low average wage within the sector, long-distance work, and the overall weak attractiveness of technical fields of study, which lag significantly behind other fields among young people. Slovakia is solving this problem by supporting secondary vocational education through the introduction of a dual education system. At the same time, there is an effort to promote technical education, intensify cooperation between schools and businesses, and parallel adaptation of the content of education to the needs of practice. Moreover, the share of foreign workers in construction is next to automotive sector the highest, although in this case it is more or less seasonal.

Descriptive statistics showed that early signals of potential bankruptcy could be very simple and warn the company of the threat of bankruptcy long before real problems occur. On the other hand, it also showed that the statutory bodies of threatened companies are aware of those problems and can do a great deal to avoid terminal closure (or meet company obligations). At the same time, they may undertake many unethical actions that can hinder even the partial satisfaction of claims, as happened in case of bankruptcy processes stopped because of the insufficient assets of bankrupt companies.

It should be mentioned that this research suffered from certain limitations given by the sample construction and publicly available data. The sample was built from bankrupt companies which had already completed the process and been removed from the business register. The fact that some companies entered bankruptcy before the research period, and that those bankruptcies are still ongoing,

generally prolongs the estimated duration of the process and supports the measures offered by the World Bank (2020). On the other hand, it also points out that, for some companies (or owners), it is advantageous to remain in the bankruptcy process for a period of time. Publicly available data is considered a limitation due to several facts. First, it is not able to detect seasonal changes, and any annual financial summary may come too late for lenders to check the potential threat. Second, from a regional point of view, the distribution of companies was given according to their place of registration. This does not always correspond to the place of their economic activity, and as such their potential failure cannot automatically be linked to a local economic boom or crisis. Finally, the companies are highly heterogeneous, having specific expertise, portfolio and customer structure. Therefore, the research relied less on macro-economic cyclical data and instead looked at internal financial measures as reflections of external influences. Measuring the probability of failure among Slovak companies as Lesáková, Gundová and Vinczeová (2020) did, or comparing flourishing and bankrupt companies as Malakauskas and Lakstutiene (2021) or Mihalovič (2016) did using different analytical methods or modelling techniques, was not part of the research framework. Instead, the research focused only on bankrupt companies and followed their path before entering bankruptcy.

As the state is not only an administrator of the entire reporting system, but simultaneously also a referee when it comes to the legal recovery of debts, it is odd that so many companies can continue to operate freely for so long under the threat of extreme debts, especially in a situation where the state itself is one of the most affected stakeholders/lenders with a very low recovery rate. Economic stagnation or crisis and weaker business activity during the pandemic has brought and will continue to bring new candidates for bankruptcy; therefore, it would

be necessary to look for potential changes in warning signs, but also to study in detail the potential cross-industrial transmission of problems from one industry to another.

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Determinants of debt for local governments in Europe – panel data research

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Abstract

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In local government, debt is a key factor determining long-term solvency, stability and the level of fiscal strain. The indebtedness of this sector may affect the quality of life and private businesses alike. Thus, the aim of the article is to examine financial, economic and demographic determinants of local government debt in Europe, as well as to identify the associations between the debt burden and certain spending categories. The study concerns 27 European countries in the period 2007–2020. Therefore, panel data regression models were estimated, namely the fixed effects model and the random effects model. The survey showed that in the context of local government, the growth in debt per capita is positively affected by the decentralisation of expenditure and investment activity. However, an increase in the share of expenditure on housing and economic affairs in the budget decreases the debt burden, whereas an increase in the share of expenditure on education, health and social protection positively stimulates the level of indebtedness. In addition, local authorities should promote the growth of the working age population to mitigate the effects of urbanisation on the growth of debt and take advantage of periods of low interest rates to restructure the debt portfolio.

Key words

local government, Europe, debt, panel data models, determinants.

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Introduction

The processes of decentralisation of public authorities in Europe have resulted in the delegation of public tasks and opportunities

to raise certain funds. The growing needs of the local communities and insufficient revenues have resulted in the increasing of

debt as an instrument used to carry out new responsibilities (Bellot et al., 2017, 52). This mainly concerns the development of the infrastructure by means of which to deliver public goods and services, and to attract inhabitants and investors. Pinardon-Touati (2022, 1–4) shows that local debt may adversely affect private businesses. Further loans from the banking sector reduce both investment and wages. This crowding-out effect would undermine the stimulus effect of the debt-financed spending policy of the local government. Thus, an increase in debt results in underinvestment in business (Cao et al., 2022, 17). In addition, when the scale of this debt exceeds a certain level, economic growth could be suppressed by the crowding-out of private investment and a decline in public expenditure (Zhao et al., 2019, 19). Certain authors (Standar and Kozera, 2020, 2) envisage that the excessive indebtedness of local governments may lead to the deterioration of financial liquidity or, in extreme cases, cause a debt spiral. In turn, Micheli (2020, 1034) found that an increase in local governments' indebtedness per capita lowers apartment prices. Moreover, the effects of debt competition between levels of government are surveyed. Greer (2015, 763) shows that a growing amount of debt at a lower level of government increases the cost of interest at higher levels of government. Aghón and Letelier (1996, 82) highlight that whilst the bulk of local debt is geared to finance investment activity, access to these funds might be essentially fungible and result in fiscal troubles that are likely to cause pressure on central authorities. This indebtedness also stimulates long-term solvency (Gorina et al., 2018, 79–85).

However, greater debt transparency along with better debt management can mitigate certain costs tied to growing indebtedness or political and economic pressures for increased debt (Kose et al., 2020, 17). Thus, economies may benefit from debt, which is one of the sources of financing capital

formation to advance the development of infrastructure (urbanisation processes), education, or healthcare (Zhao et al., 2019). Debt accumulation enables local governments to capture the benefits of capital investments immediately, rather than waiting until sufficient savings from current income can be accumulated to cover this activity (Canuto and Liu, 2013, 1). Nevertheless, the findings of Chen and Li (2019, 350) show that this influence can differ within the country due to the size of the debt. Debt-financed expenses may increase growth prospects in sound fiscal conditions, where policy is aimed at maintaining long-term sustainability and a proper cyclical position (Kose et al., 2020, 17). Therefore, in a number of countries, 'golden rule' restrictions are implemented which imply that current local government revenues must finance current spending, and debt is aimed at capital expenditure (Lotz, 2006, 243). This solution contributes to a lower risk of fiscal distress brought upon by a failure to meet standards in the area of debt over successive years (Kloha et al., 2005, 314).

Simultaneously, empirical studies focus mainly on the debt predictors in a chosen country. This results in the specificity of the applied variables which in many cases cannot be compared from an international perspective. In addition, there is a dearth of survey data presenting the impact of the structure of expenditures on local borrowing. However, the perception that these relations could reduce fiscal distress has resulted in the improper delegation of tasks set against a background of fiscal policy. This sphere is crucial due to aspects of further administrative, financial and political decentralisation. Therefore, the aim of the article is to examine certain determinants of financial, economic and demographic debt in local government in Europe using longitudinal data. In addition, the goal of this article is to show the associations between debt and the share of certain spending categories,

with due consideration given to the financial factors. In this context, the research question relates to how the structure of expenditure along with other financial and socio-economic factors affects the debt burden of the local government.

The estimated empirical models could be applied in the debt prediction processes. As a result of the research procedure and the applied data concerning the situation in 27 European countries (Table 1) in the period 2007–2020, panel data regression models were estimated, i.e. the fixed effects model and the random effects model. Therefore, the author reviewed the literature on the indebtedness factors of local governments, taking into account common determinants in the regressions with the structure of expenditure, which is omitted in many surveys. Due to the different findings of studies based on the separate states, the results of the estimation in this paper could be a benchmark for further analysis. Thus, the novelty value of the article is the examination of the debt determinants from an international perspective. It is worth adding that the chosen countries have signed and ratified the European Charter of Local Self-Government, which has contributed to the implementation of certain common regulations in the field of financial management and the governance of the local public sector.

1. Literature review

In the literature, there are research studies which examine both the internal and external determinants of public debt. Fisher and Wassmer (2014, 146–147) show that the demand for public services and the financing of the infrastructure used to provide such services is the fundamental reason behind long-term borrowing by states and local governments in the USA. Therefore, the more populous states exhibit a higher level of borrowing *per person*, whereas Gross State Product (income) *per capita* is

associated with greater borrowing *per capita*. Even though a severe recession occurred, states and local units continued to incur debt to address public infrastructure demands, consistent with their earlier policy. Additionally, a larger fraction of the population being enrolled in public schools is associated with greater *per capita* borrowing.

In turn, the econometric models of Derycke and Gilbert (1985, 397) confirm the crucial impact of three types of variables upon the borrowing behaviour of the largest French local governments. Firstly, there are internal determinants, associated with needs for local public investment resulting from urbanisation, local housing development, and self-financing capacities (savings and grants). Secondly, there are external factors tied to the financial resources of lenders and the level of interest rates. Thirdly, the analysis also considers the macroeconomic policy measures imposed by the central government, which affect the level of borrowing of these units.

Poniatowicz et al. (2017, 100–101) underline the fact that economic doctrine distinguishes the following premises that justify the growing indebtedness of local governments, i.e. insufficient revenues, the aspects of cost- and time-effectiveness of infrastructure investments, or the necessity to comply with the concept of intergenerational equity.

Nevertheless, there are certain factors that may result in the higher indebtedness of the local units, such as:

- the inappropriate structure of public spending, i.e. the relatively high shares of rigid components (wages, pensions and interests), often under strict regulations. Budget rigidities constrain the ability to modify the size and structure of the public budget, especially in the short term, and may contribute to fiscal distress (Muñoz and Olaberria, 2019, 9–30);
- aspects of moral hazard, which encourages spending beyond revenue capacity,

safe in the knowledge that the higher tier of government will cover the indebtedness (Williams, 2020; 4). Shi and Hendrick underscore (2020, 138) that when multiple local governments receive funding from the state government, having the capacity to impose taxes and issue debt independent of the state fiscal base, they may be prompted to borrow excessively;

- a deficit bias causing an adverse incentive to overspend, undertax or borrow excessively, which poses a threat to fiscal discipline. Therefore, it manifests in the tendency to push the burden of fiscal discipline to future authorities and generations (Turley et al., 2021, 28);
- the problem of free-riding, resulting from the fact that the interests of individual local governments may diverge from the common national interest, e.g. due to electoral pressures and unsustainable fiscal policy. Finally some units would bear only part of the cost of mismanagement (Canuto and Liu, 2013, 3);
- the common pool problem, which arises when the costs of an activity that benefits a small community are shared among a larger group (Jordahl and Liang, 2010, 157). Fritz and Feld (2020, 90) found that during the process of amalgamation at the local level, higher debt dynamics appear when more municipalities take part in an amalgamation. In addition, forced amalgamations exploit the common pool created by amalgamation more than those conducted voluntarily by the units.

Tang (2022, 4) presents reasons for the active borrowing of local governments. Firstly, they tend to stimulate demand and production through loan consumption to boost local development, especially in an economic downturn, which leads to a decline in local tax revenues. Jalles and Medas (2022) show that the relationship between debt surges and economic growth are complex in the public sector. Debt surges tend to be followed

by weaker economic growth and persistently lower output. However, this negative relationship does not always hold. Thus, during periods of fiscal austerity, local governments may wish to issue more debt to increase the resources currently available for operating budgets (Greer and Denison, 2016, 116). The second reason for debt growth, as indicated by Tang (2020), is due to the competition among local governments to attract new entrepreneurs, which requires additional investment activity in conditions of limited amounts of one's own resources. Moreover, the decrease in the tax burden for local entrepreneurs raises the pressure on local finances, and the scale of indebtedness expands. Thirdly, the incentive of the 'soft constraint' of a budget and the separation of local government authority to borrow from responsibility for the debt also encourages these units to increase indebtedness.

Research findings have also indicated that inter-jurisdictional competition could be a driving force of excessive borrowing by local government. This is due to fiscal decentralisation and political centralisation, which pushes local governments to compete with each other to achieve better economic performance (Pan et al., 2017, 899–900). In the context of these studies, Yan et al. (2021, 13–14) found that urban expansion also affects local government debt. This results from two principal aspects: low density leads to the reduction of land output efficiency or the expansion of construction infrastructure.

Scholars also cite political factors as determinants of debt. This is recognised by the concept of the Political Budget Cycle (PBC), which argues that politicians seek to synchronise the timing of economic benefits and government profligacy with the elections calendar (Geys, 2007, 238). The PBC suggests that there is a debt expansion by the ruling party immediately before elections in an intent to promote its re-election (Benito et al., 2021, 2).

To sum up, debt determinants are usually discussed under two broad categories: financial and non-financial (Ehalaiye et al., 2017, 515). Thus, when investigating the financial determinants of local government debt, Ehalaiye et al. (2017, 519) included the following as independent variables in the econometric model (panel data analysis): capital expenditures and investment in infrastructural assets; rates revenues; the net surplus (operating income less operating expenses); other assets apart from infrastructural assets; other income generated apart from rates revenues; control variables related to the effects of the type of council; and the effects of global financial crises. A vast catalogue of factors is included in the research of Bellot et al. (2017, 55–57), characterising political, demographic, geographical, fiscal and financial, economic and budgetary issues. In turn, Balaguer-Coll et al. (2016, 518–519) included certain financial variables concerning capital expenditures, net savings, a non-financial deficit in a non-financial surplus, one's own fiscal capacity and expenditure commitments, as well as socioeconomic (level of tourism, level of economic activity) and political (type of governing party, kind of region, scope of decentralisation) factors. A disparate approach was applied by Feld et al. (2011, 58), who assumed that the debt per taxpayer might be a function of average net income, unemployment rate, the tax rate of the media taxpayer, the share of own revenues, the number of taxpayers, average income to median income ratio, the number of political parties in the executive body, the proportion of some type of parties in the executive body, the strong role of the Minister of Finance in the budget process, and an institutional factor (an existence of a fiscal referendum). In contrast, Benito and Bastida (2004, 504), in examining (the panel data regression) factors influencing changes in an annual debt stock to total revenues, applied dummy variables for the geographical

location, economic level, level of population and political ideology as well as continuous variables in the sphere of capital expenditures and capital revenues independence ratio and a non-financial surplus or deficit. Moreover, Alińska et al. (2021, 121) emphasised the financial variable in the field of revenues and expenditures to estimate (by means of ordinary least squares regression) the factors of total liabilities in local government. Similarly, Serbes et al. (2020, 145), in their study (using the quantile regression) of debt *per capita*, introduced mainly financial predictors, i.e. expenditures *per capita*, capital expenditures *per capita*, share of rigid expenditures, the relationship between non-interest budget expenditures and non-interest budget revenues, tax revenues *per capita*, and the population. A different procedure was applied in the research of Delgado-Téllez and Pérez (2020, 232–239), who examined economic, political, and institutional factors on the change in the debt-to-Gross Domestic Product (GDP) ratio. They emphasised that the economic cycle as a fundamental determinant of budget balances is mainly responsible for debt growth, whereas political variables and the strength of fiscal regulations do not seem to have a noteworthy effect on debt. This is also dependent on the previous stock of the debt, market discipline, or aspects of fiscal decentralisation. Thus, some studies include macroeconomic and institutional factors that influence debt, such as level of GDP or GDP growth, the unemployment rate, the share of people of post-working age, miscellaneous political issues, certain territorial aspects or the income situation of residents (Veiga and Veiga, 2014, 31; Costa and Morais, 2021, 91; Yared, 2019, 117; Medve-Bálint and Bohle, 2016, 14–22; Chatterjee et al., 2019, 350). Navarro-Galera et al. (2015, 398) show that population density, immigration, economic level and the political orientation of the governing party are applied in some studies as variables affecting local government debt.

2. Methodology

The paper examined the available data in the fields of finance, economy and demography concerning 27 European countries (the members of the Organisation for Economic Co-operation and Development (OECD) plus Romania; Table 1), that characterises the financial situation and the fiscal position of the local government in these countries between 2007 and 2020 (for Iceland the debt level was available for the period 2007–2013). The data was extracted from the

databases of the OECD, the World Bank and the International Monetary Fund (IMF).

Due to the aim of the article and the data, panel models were applied. The simplest estimator for this kind of data is the pooled OLS (ordinary least squares) model, in which all entities are assumed to be homogeneous (Das, 2019, 501). In most cases this is unlikely to be adequate, but it does provide a baseline for comparison with more complex estimators (Cottrell and Lucchetti, 2022, 204). The pooled OLS model takes the form:

$$y_{it} = x_{it}\beta + u_{it},$$

where y_{it} is the dependent variable for the cross-sectional unit i (country in this research) in the period t , x_{it} is a $1 \times k$ vector of independent variables observed for unit i in the period t , β is a $k \times 1$ vector of the parameters, and u_{it} is an error or disturbance term specific to unit i in period t .

Considering the differences between the observations (i.e. countries), the fixed effects

model (FEM) and the random effects model (REM) might be applied, which decompose the unitary pooled error term, u_{it} . For the FEM, u_{it} is decomposed into a unit-specific and time-invariant constant coefficient, α_i , and an observation specific error, ε_{it} , and takes the form:

$$y_{it} = x_{it}\beta + \alpha_i + \varepsilon_{it}.$$

In the REM, u_{it} is the sum of the individual specific random component (v_i) and ε_{it} .

Thus, this model is as follows (Cottrell and Lucchetti, 2022, 205):

$$y_{it} = x_{it}\beta + v_i + \varepsilon_{it}.$$

The choice of the type of panel data regression model results from the Wald test (the F statistic), the Breusch-Pagan test (the χ^2 statistic), as well as the Hausman test (the χ^2 statistic). Using the Wald test, the joint significance of the individual effects of the analysed observations is verified. In this test, the null hypothesis is that there are no specific individual effects (Das, 2019, 503–505). In turn, in the Breusch-Pagan test, the null hypothesis is that the variance of v_i in the REM equation equals zero. If this hypothesis is not rejected, then it is concluded that the pooled model is adequate (Cottrell and Lucchetti, 2022, 208). The Hausman test is applied when choosing between the FEM and the REM. The null

hypothesis here is that individual effects are uncorrelated with any regressor in the model. In other words, the null hypothesis in the Hausman test is that the preferred model is the REM rather than the FEM (Das, 2019, 508). In the model estimation, heteroscedasticity (the Modified Wald test, χ^2 statistic) and the autocorrelation (the Wooldridge test, the F statistic) are also checked. Therefore, a failure to meet the assumptions of the distribution of residuals results in the use of clustered standard errors (Hoechle, 2007, 285). Moreover, multicollinearity was also controlled using the absolute value of correlation coefficients with a threshold of 0.7 (Dormann et al., 2013, 32; Reddy and Balasubramanyam,

2021, 39). For the estimated models, a goodness of fit measure is presented: within R^2 .

In the paper, the debt *per capita* (table 1) of the local government, as a measure of the debt burden, was applied as the dependent variable in the models. Simultaneously, the debt-to-GDP ratio (%) was also considered. However, in this case the available data was only for the period 2009–2020, in which the correlation coefficient between this ratio and the debt *per capita* was 0.9144 and between the debt-to GDP-(%) and the natural log of the debt *per capita* was 0.8861. Finally, in attempting to examine the entire period, i.e. 2007–2020, and including the strong relationships between the aforementioned ratios, the debt *per capita* (table 1) was chosen as the dependent variable. It is worth adding that the application of debt to revenues (%) or debt to expenditures (%) as a dependent variable was also considered, but from the point of view of the aim of the article and the set of independent variables, it would have constrained the scope of the study and the likelihood of achieving the research goals.

In order to identify the factors affecting the dependent variable, a certain set of

variables was investigated (table 1). These variables were selected from the literature review as determinants of local government indebtedness that could be applied in international comparisons. It is worth adding that some scholars suggest not including an excessive number of regressors, and consequently to focus only on the most relevant ones (Benito and Bastida, 2004, 503). First, the single-factor models for each variable were estimated to check and control potential reverses of the coefficient sign in the final model. In this way the confounding was limited, which is perceived as a mixing of effects of the exposure being studied with the effect of another variable (Checkoway et al., 2004, 89). It may even reverse the apparent direction of an effect. Secondly, the author estimated seven models with different combinations of debt determinants. However, each variable appears in at least two regressions. This approach was an attempt to avoid misleading results and conclusions and confirm the stability of the results. Thus, the applied methodology takes aspects of the robustness check into account.

Table 1. Definition of the relevant variables and the countries applied in the estimations

Label	Definition/ Calculation	Source	Validity and specificity of debt predictors; examples of application	Expected sign
Dependent Variable				
Debt <i>per capita</i>	Total debt ÷ Population (natural log)	OECD, World Bank	Hildreth and Miller (2002, 107) suggest that if the economic base is diversified, the debt burden can realistically be viewed by outstanding debt <i>per capita</i> . This is also a ratio of fiscal strain (McKinney, 2004, 498). This kind of variable was applied in research by Martell et al. (2021, 58) and Balaguer-Coll et al. (2016, 518). Debt issued <i>per capita</i> was used in the regression of Fisher and Wassmer (2014, 127) and Serbes et al. (2020, 145). Debt in US dollars, current PPPs.	not applicable

Label	Definition/ Calculation	Source	Validity and specificity of debt predictors; examples of application	Expected sign
Independent Variables				
Financial				
Decentrali- sation	Local expendi- tures ÷ GDP (%)	OECD, World Bank	The variable represents the size of local finances in the economy (Hanif et al., 2020, 5) and thus fiscal decentralisa- tion. Some authors revealed that fiscal expenditure decen- tralisation increases the default risk of local government debts (Ouyang and Li, 2021, 644, 663).	(+)
Fiscal Exp. Decentr.	Local expendi- tures ÷ general government expenditures (%)	OECD	Higher fiscal expenditure decentralisation (Fiscal Exp. Decentr.) results in additional responsibilities of local gov- ernments and tends to enhance an incentive to spend and borrow more to stimulate local growth (Ouyang and Li, 2021, 654). Definition of local government and general govern- ment according to the OECD.	(+)
Invest- ment	Investment expenditures ÷ Population (natural log)	OECD	Expenditure on infrastructure expansion puts pressure on debt growth. The borrowing behaviour may be affect- ed by the needs for local public investment resulting from urbanisation and local housing development (Derycke and Gilbert, 1985, 397). Capital expenditures <i>per capita</i> were included in the model of Serbes et al. (2020, 145). Capital spending was included in the models of Balagu- er-Coll et al. (2016, 519), Ehalaiye et al. (2017, 519), Veiga and Veiga (2014, 11), Delgado-Téllez and Pérez (2020, 232). However, in the quantile regressions in the study of Ser- bes et al. (2020, 139), concerning units in Turkey, capital expenditures per capita were insignificant. Investment expenditures in US dollars, current PPPs.	(+)
Social Protection	Exp. on social protection in total (%)	OECD	Variables showing the significance of some core tasks (ex- penditures (exp.)) of local governments on their indebted- ness. Jin et al. (2019, 6, 11-18) indicate that many countries are facing large fiscal pressures from high levels of public debt and competing spending needs from infrastructure, health and social protection. Local governments play a major role in managing some public functions, i.e. education or healthcare, which are typically provided through munic- ipally-owned facilities. However, local units are constrained by legislation which sets out the framework, especially in the field of education, healthcare or distribution of social as- sistance. In other functions, i.e. economic affairs or housing and community amenities, local governments may be more flexible in terms of policymaking. Thus, certain functions, i.e. education or health, might increase the pressure to search for debt instruments to meet the needs. These functions, i.e. education or health, determine the quality of life (Iamtrakul et al. 2022, 347).	(+)/(-)
Education	Exp. on educa- tion in total (%)			
Health	Exp. on health in total (%)			
Economic Affairs	Exp. on eco- nomic affairs in total (%)			
Housing	Exp. on Housing and community amenities in total (%)			

Label	Definition/ Calculation	Source	Validity and specificity of debt predictors; examples of application	Expected sign
Demographic				
Population	Number of inhabitants (natural log)	World Bank	The demand for public goods, influenced by the size of the population, may affect the growth of local debt (Hájek and Hájková, 2009, 36–42). Population captures the demands for service and social policy pressures (Martell et al., 2021, 56) and is a proxy for market size (Fahmi et al., 2016, 70). This is included in the model of Serbes et al. (2020, 145).	(+)
Working Age	Population aged 15–64 as % of the total population	World Bank	Honda and Miyamoto (2020, p. 8) indicate that population aging is positively associated with high public debt resulting from increased fiscal spending (e.g. health care).	(-)
Urban Population	People living in urban areas as % of the total population	World Bank	Yan et al. (2021, 1) show that the scale of local government debt increases significantly with a rise in urban expansion.	(+)
Economic				
GDP	Gross Domestic Product (natural log)	World Bank	The variable reflecting the size of the economy that could hypothetically generate excessive expenditures by public services (Bellot et al., 2017, 57). Bellot et al. (2017) included the size of the “entity”, measured in GDP terms relative to the mean, and revealed its significance, as well as both direct and inverse relationships in certain cases.	(+)
GDP per capita	Gross Domestic Product per capita (natural log)	World Bank	This is an indicator of human development and welfare (Fikri and Zhu, 2015, 20). The factor considered in the study of Bellot et al. (2017, 55–57), which shows that relationship the between GDP <i>per capita</i> and debt is not always positive. Delgado-Téllez and Pérez (2020, 232–239) revealed that regions in Spain that have a higher GDP <i>per capita</i> tend to have less accumulation of debt. In turn, Yan et al. (2021) revealed that GDP <i>per capita</i> , as a proxy for urbanisation, is highly and positively correlated with local government debt. GDP in current US dollars.	(+)
GDP growth	GDP growth (annual %)	World Bank	This variable was included in the research of Bellot et al. (2017, 57). These authors argued that this shows whether there is a countercyclical budget.	(-)
Unemployment	Unemployment, total (% of total labour force)	World Bank	Unemployment rates indicate whether local government capital-financing policies respond to social burdens (Martell et al., 2021, 56). A higher unemployment rate might result in higher expenditures in the field of social protection and lower tax revenues. Veiga and Veiga (2014, 11, 31) included unemployment as a determinant of the gross municipal debt and revealed the significant and positive sign of the coefficient. This variable was also used in the estimation of Greer and Denison (2016, 125) and considered in the research of Feld et al. (2011, 58–60).	(+)

Label	Definition/ Calculation	Source	Validity and specificity of debt predictors; examples of application	Expected sign
Interest Rate	Long Term Interest Rates (%)	OECD, IMF	According to the safe asset provision theory, public debt should rise in response to increasing income risk, due to the fact that households and businesses facing greater income risk develop a stronger precautionary motive to save, driving down interest rates (Yared, 2019, 121). The level of the interest rates indicated in the estimation of Derycke and Gilbert (1985, 397) and in the research of Galiński (2015, 379–381). For Estonia the following were applied for the period 2011–2020: Harmonised Euro Area Rates, Loans, Non-Financial Corporations (IMF).	(-)
Codes of the 27 countries included in the research				
AUT, BEL, CZE, DNK, EST, FIN, FRA, DEU, GRC, HUN, ISL, IRE, ITA, LTU, LVA, LUX, NLD, NOR, POL, PRT, SVK, SVN, ESP, SWE, CHE, GBR, ROU				

Note: Due to the availability of the data for the construction of the variables, absolute values of budgetary categories are in US dollars, current PPP, while the absolute value of GDP is in current US dollars

Source: own study based on databases of the OECD, the World Bank and the IMF

3. Research results and Discussion

The European countries studied herein differ from each other in terms of the fiscal situation of the local government and its place and role in the economy and public finance (Table 2). Furthermore, they operate in different financial, economic and demographic conditions that affect their financial decisions, especially with respect to the scope of the expenditures. Thus, there are disparities

in the field of the levels of debt *per capita* and the debt-to-GDP ratio (%) (Table 2).

According to the characterised methodology, nine models with different sets of variables were estimated (Table 3), i.e. six fixed-effects models (FEM) and three random-effects models (REM). Tests for heteroskedasticity (the Modified Wald test, χ^2 statistic) and autocorrelation (the Wooldridge test, the F statistic) (Table 4) resulted in the use of clustered standard errors.

Table 2. Descriptive statistics

Variable	Mean	Standard deviation	Min	Max
Debt per capita (log)	7.65	0.85	5.16	9.49
Debt per capita	2,913.77	2,345.72	173.98	13,264.11
Decentralisation (%)	13.04	6.69	2.30	33.94
Fiscal Exp. Decentr. (%)	23.92	12.19	5.66	64.68
Investment (log)	6.27	0.52	4.87	7.63
Investment	607.25	335.01	129.68	2058.19
Social Protection (%)	18.24	11.01	2.56	57.06
Education (%)	21.78	11.07	0.39	41.15

Variable	Mean	Standard deviation	Min	Max
Economic Affairs (%)	13.95	5.18	3.27	28.53
Health (%)	10.64	11.42	-0.05	49.34
Housing (%)	5.19	3.64	0.12	26.13
Population (log)	16.05	1.45	12.65	18.67
Working Age (%)	66.36	2.13	61.58	72.22
Urban Population (%)	74.03	12.42	51.98	98.08
Unemployment (%)	8.02	4.47	2.01	27.47
GDP (log)	26.37	1.44	23.30	29.01
GDP per capita (log)	10.42	0.64	9.01	11.73
GDP growth (%)	1.25	3.89	-14.84	25.18
Interest Rate (%)	3.11	2.74	-0.52	22.50
Debt to GDP (%)	6.84	4.10	0.65	21.33

Note: Statistics for the period 2007-2020, apart from Debt to GDP (%), which, due to the availability of the data, includes only the years 2009-2020.

Source: own study based on the OECD, World Bank and IMF databases

In each model the debt determinants are statistically significant (Table 3). An increase in *Investment* affected a rise in *Debt per capita*. According to Model 1, a 1% growth in capital expenditures *per capita* resulted in an

increase in debt *per capita* by 0.2270%. In addition, the growth of *Decentralisation* resulted in higher *Debt per capita*. The importance of fiscal expenditure decentralisation was confirmed by Models 5 and 6.

Table 3. Determinants of *Debt per capita* in local government in Europe in 2007–2020 –fixed effects model (FEM) and random effects model (REM) estimation

Variable/ Model (type)	Model 1 (FEM)	Model 2 (FEM)	Model 3 (FEM)	Model 4 (FEM)	Model 5 (FEM)	Model 6 (FEM)	Model 7 (REM)	Model 8 (REM)	Model 9 (REM)
Intercept	9.9872*** (1.0086)	6.0236*** (0.1698)	-10.9871* (3.5675)	-0.0208 (1.3180)	14.0359*** (1.2913)	13.2719*** (1.0584)	-3.7607 (2.8495)	-4.8734 (1.3527)	4.9901** (2.1495)
Decentrali- sation	-	0.0610*** (0.0086)	-	0.0745 (0.0084)	-	-	-	0.0674*** (0.0104)	-
Fiscal Exp. Decentr.	-	-	-	-	0.0337*** (0.0105)	0.0256** (0.0115)	-	-	-
Investment	0.2270*** (0.0673)	-	0.3141** (0.1130)	-	-	-	0.2107** (0.0826)	-	0.3226*** (0.0801)
Social Protection	0.0238** (0.0094)	0.0178*** (0.0063)	-	-	-	-	-	-	-
Education	0.0218*** (0.0060)	0.0102** (0.0039)	-	-	-	-	0.0220*** (0.0077)	-	-

Variable/ Model (type)	Model 1 (FEM)	Model 2 (FEM)	Model 3 (FEM)	Model 4 (FEM)	Model 5 (FEM)	Model 6 (FEM)	Model 7 (REM)	Model 8 (REM)	Model 9 (REM)
Health	0.0361*** (0.0084)	0.0264*** (0.0078)	-	-	0.0266*** (0.0087)	0.0299*** (0.0104)	0.0345*** (0.0102)	-	-
Economic Affairs	-	-	-0.0404*** (0.0118)	-0.0166** (0.0060)	-	-	-	-0.0139** (0.0061)	-0.0356*** (0.0085)
Housing	-	-	-	-0.0213** (0.0100)	-	-	-	-	-0.0284* (0.0151)
Working Age	-0.0760*** (0.0133)	-	-	-	-0.1154*** (0.0219)	-0.0988*** (0.0172)	-	-	-0.0607*** (0.0177)
Urban Popu- lation	-	-	0.0444** (0.0204)	-	-	-	0.0349*** (0.0096)	-	-
Unemploy- ment	-	-	0.0206** (0.0079)	-	0.0222** (0.0104)	-	-	0.0323*** (0.0064)	0.0344*** (0.0088)
GDP	-	-	0.5226 (0.2179)	-	-	-	0.2559*** (0.0959)	-	-
GDP per capita	-	-	-	0.6766*** (0.1310)	-	-	-	1.1196*** (0.1235)	0.4920*** (0.1504)
GDP growth	-0.0077*** (0.0018)	-	-0.0064* (0.0032)	-	-	-	-	-0.0058** (0.0027)	-0.0094*** (0.0029)
Interest Rate	-	-	-	-	-	-	-0.0243* (0.0127)	-0.0185** (0.0091)	-0.0220** (0.0111)
No. obs.	371	371	371	371	371	371	371	371	371
Within R ²	0.4551	0.4464	0.2803	0.5046	0.4118	0.3574	0.3048	0.5686	0.4977

Note: 1) ***, ** and * denotes statistical significance at the 1%, 5% and 10% levels respectively, 2) clustered standard errors in parentheses (...), 3) p-value in brackets [...]

Source: own study

In contrast, Model 2 indicates that an increase of the expenditures in GDP by one percentage point affected the growth of debt *per capita* by 6.10%. The structure of the expenditures was also significant for the level of the indebtedness of local governments in European countries. Therefore, an increase of the share of the expenditures on a) social protection, b) health, and c) education influenced the growth of *Debt per capita*. The growth of the shares of these types of expenditures lends their structure more rigidity. Simultaneously, there is less room for manoeuvre during a recession. In turn, the higher the share of expenditures on a) economic affairs and b) housing, the lower the *Debt per capita*. These types of spending form the basis for the development of local governments

and are crucial in the process of attracting new residents and entrepreneurs.

As far as demography is concerned, the log of the population did not reveal its significance (either as a variable in the single-factor models or as an additional factor in the estimated models). Nevertheless, the growth of the *Working age* population influenced the decline in *Debt per capita*. The one percentage point increase of the *Working Age* population in the total population resulted in the drop of the debt *per capita* by 7.60% (Model 1). This could contribute to higher tax revenues and finally the greater capability to finance investment activity from one's own resources. It is worth noting that Maličká et al. (2023, 9–10) revealed that the growth of the share of the population

aged 14–65 in the total population positively affected the importance of real estate tax in total tax revenues in the analysed municipalities. In addition, the growing population of working age may enhance local financial autonomy (Jemna et al., 2013, 46–58).

In addition, an increase in *Unemployment* by 1% drove a rise in *Debt per capita* by 2.06% (Model 3). Simultaneously, unemployment can directly affect quality of life (Seed and Lloyd, 1997, 91). Therefore, the growth in the number of people falling into the *Working age* category and the decline in the *Unemployment* numbers might also be predictors of the quality of life in the localities as well as the situation on the labour market. It is worth adding that quality of life is determined by social, economic and environmental factors (Šuljová and Kubina, 2022, 10). In contrast, a rise in the share of the *Urban population* affected the increase in *Debt per capita*. The one percentage point growth of the population in urban areas corresponded with an increase of the debt per capita by 4.44% (Model 3). Areas that are more urbanised require more investment to compete, a requirement which in

many cases is financed through borrowing. Furthermore, the larger the economy (GDP) and the *GDP per capita*, the higher the *Debt per capita*. This means that the development of the country along with the process of the decentralisation of public finance influence the growth of local government indebtedness. On the other hand, an increase in *GDP growth* resulted in the lower debt burden in local governments. Thus, the local government sector benefits from economic development that positively affects the sustainability of their finances. The cost of raising external capital was also significant with respect to the indebtedness of local governments. As a consequence, a one percentage point decrease in the *Interest Rate* resulted in *Debt per capita* growing by 1.85% (Model 8) in local government. Thus, the public finance sector took advantage of low interest rates, in particular to finance investment activity or restructure the debt portfolio. However, Postuła et al. (2019, 218) revealed that in the process of financial planning, local government entities are unable to effectively take advantage of the availability of low and ultra-low interest rates.

Table 4. Diagnostic tests for the estimated models

Test/ Model (type)	Model 1 (FEM)	Model 2 (FEM)	Model 3 (FEM)	Model 4 (FEM)	Model 5 (FEM)	Model 6 (FEM)	Model 7 (REM)	Model 8 (REM)	Model 9 (REM)
Wald test	118.882 [< 0.001]	184.320 [0.001]	61.650 [< 0.001]	89.928 [< 0.001]	148.558 [< 0.001]	145.143 [< 0.001]	70.484 [< 0.001]	99.421 [< 0.001]	86.789 [< 0.001]
Breusch-Pagan test	1,534.05 [< 0.001]	1,727.00 [< 0.001]	1,252.23 [< 0.001]	1,670.25 [< 0.001]	1563.66 [< 0.001]	1,858.07 [< 0.001]	1,314.02 [< 0.001]	1,654.73 [< 0.001]	1,490.12 [< 0.001]
Hausman Test	18.87 [0.004]	21.38 [0.001]	15.93 [0.014]	13.80 [0.008]	21.02 [< 0.001]	9.38 [0.025]	9.35 [0.155]	7.09 [0.313]	8.88 [0.352]
Modified Wald test for Heteros.	6,154.00 [< 0.001]	1,147.43 [< 0.001]	18,492.81 [< 0.001]	3,704.13 [< 0.001]	5487.63 [< 0.001]	8,557.49 [< 0.001]	4,885.59 [< 0.001]	1,193.14 [< 0.001]	2,849.31 [< 0.001]
Wooldridge test for Aurocorr.	71.515 [< 0.001]	75.553 [< 0.001]	80.246 [< 0.001]	68.701 [< 0.001]	66.905 [< 0.001]	103.553 [< 0.001]	105.620 [< 0.001]	60.397 [< 0.001]	52.782 [< 0.001]

Note: 1) under the level of the statistic is the *p*-value in brackets [...]

Source: own study

The inclusion of each variable in at least two models and in certain cases in both the

fixed effects (FEM) and the random effects (REM) regressions (based on the Hausman

test) shows the stability of the empirical results. None of the variables reveal a high change in level or in the coefficient sign (Table 3).

Conclusions

The indebtedness of local government is the key aspect of the sound fiscal position thereof. The debt burden determines both the possibility of delivering public goods and services and the risk of fiscal distress. Borrowing may increase the development of the local economy or create dysfunction in business. The level of debt per inhabitant can be also a proxy for fiscal strain. Therefore, this can affect the quality of life in the localities.

The findings revealed that variables concerning the fiscal position and the financial situation of local government and the economic conditions in the states affect the level of the debt *per capita* of the public finance sector. The more decentralised the state, the greater the burden of local government debt on its inhabitants. Therefore, this complies with the findings of Ouyang and Li (2021) that growing fiscal expenditure decentralisation leads to a higher risk of default. The delegation of tasks increases the awareness of local authorities of the need to improve infrastructure to meet the requirements of the communities in a competitive environment. The intensified investment activity results in a larger debt burden. Furthermore, the larger the population in urbanised areas, the higher the debt per capita, although the size of the population is not the key debt determinant. Therefore, this confirms the findings of Yan et al. (2021) that urban expansion is tied to local government debt. Hence, the policy supporting an increase of the share of the working age population might mitigate the pressure on the growth of indebtedness. The estimation showed that the debt burden is affected by the expenditure structure. As consequence, the direction of spending

influences the debt per capita in the local government. Higher expenditure on health, education and social protection affect the growth of local levels of indebtedness. Thus, in line with the conclusion of Jin et al. (2019), expenditure on health and social protection contribute to larger fiscal pressure. In addition, these types of expenditures are dependent on the legal framework and thus make the structure of the local budgets more rigid. In the short run, they are less flexible in terms of the process of adjusting them to the prevailing economic conditions. Local governments with high levels of expenditure on education, healthcare, and social protection might be particularly vulnerable to the fiscal strain. These categories of expenditure also require significant capital outlays to maintain and improve their quality. Thus, delegating tasks in education, healthcare and social protection to local government should include funding to cover additional operations. Moreover, in formulating the strategy of the local development, policy-makers should be aware that the potential increase of these services puts pressure on debt growth. Thus, it can be mitigated by policies promoting the growth of the working age population to enhance tax revenues.

The paper confirms that local government takes advantage of economic growth to decrease the level of debt per inhabitant. The survey also revealed that an increase of expenditure on economic affairs and housing reduces local government debt per capita. Expenditure in these budget categories stimulates the basis for further development and attracts inflows of people of working age and entrepreneurs, which in turn might increase fiscal capacity. They also improve the quality of life in the localities. Therefore, local governments which can do more than perform only administrative functions and which possess greater capability to stimulate development tend to be less indebted. Hence, the process of fiscal decentralisation should include the transfer of competences in the

field of economic affairs along with granting financial independence.

Greater levels of indebtedness of the local governments are visible in larger economies, possibly because of intensified capital expenditures and, as indicated by Yan et al. (2021), urban economic development along with the processes of urbanisation. This also results from greater fiscal expenditure decentralisation, which is in line with the results of Ouyang and Li (2021). In addition, lower interest rates lead to higher debt per capita. This influences the lower costs of the debt service and, given the conditions of the 'golden rule' restrictions, contributes to higher capital expenditure. Therefore, where possible, local government should take advantage of low interest rates to restructure its debt portfolio, which is not common practice.

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Is ChatGPT better at business consulting than an experienced human analyst? An experimental comparison of solutions to a strategic business problem

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Abstract

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Given the level of continued technological progress, AI language models have been the subject of enormous media attention. The popularity of such models skyrocketed in November 2022 with the introduction of the ChatGPT application. The impact of AI language models on areas such as research, healthcare and business is constantly being evaluated. However, an issue in which there is a clear research gap is the use of ChatGPT for business decision-making purposes. The aim of this article is, therefore, to investigate whether ChatGPT can be leveraged to make strategic business decisions. The methodology compares three paths towards a case for a strategic business decision by means of a checklist-based score: one conducted by a human alone; the second taken purely by ChatGPT with as little human interaction as possible; and third, the centaur model, where a human actively interacts with ChatGPT and asks critical questions. The findings were twofold. Firstly, ChatGPT is still far from being considered a quality business consultant in itself. Secondly, however, AI turned out to be extremely helpful in terms of creating a decision-making path. Hence, humans may leverage the information provided by ChatGPT to gain helpful insights for better business decision making.

Key words

decision making, management, ChatGPT, AI, LLM, financial analysis.

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Introduction

The business decision-making process has been the subject of myriad discussions over a period of many years. Considerable research progress on this topic occurred in the second half of the 20th century due to advances in operations research (Simon, 1987; Tung and Miller, 1990; Eisenhardt and Zbaracki, 1992). It was then when major management strategies evolved and when the decision-making process was cascaded down to understand which factors affect it the most (e.g. Duncan, 1972; Tung, 1979; Jauch and Kraft, 1986). Yet even given those meaningful findings, there remains one area in which bias continues to effect the decisions made by even the most experienced and educated managers: uncertainty about the future (Gorry and Scott Morton, 1971; Walker et al., 2003). Although the future – by definition – remains uncertain even today, executives have substantially better tools and resources by means of which to foresee what is coming next and act accordingly (Pelissari et al., 2021).

One such resource is data itself, which is often nowadays referred to as Big Data due to its size, complexity and potential for growth. Adding tools that make it possible to process this data renders certain past decision-making problems obsolete. As an example, one may consider operative data, which can be measured with Internet of Things (IoT) solutions. In the past, productivity figures were measured manually by humans, but now those are transferred automatically in real time, for example, in agriculture (Astill et al., 2020). To take this one step further, one may imagine a multinational American restaurant chain wishing to acquire a brand of smaller restaurants in Europe. The inherent risks may include the potentially poor reputation of the smaller player. Today, to obtain a general idea of the risks involved, a simple check of reviews on Google Maps, which was not

previously possible, would suffice (Wang, Kim and Kim, 2021).

As revealed in this paper, executives have superior tools for managing their business than they had 30, 20 or even 10 years ago. These are not limited to the examples listed above, but may include more complex solutions such as business intelligence reporting (Niu et al., 2021; Bordeleau et al., 2020), globally connected enterprise resource planning systems (Lee, 2021), and many more (Varriale et al., 2021).

There is, however, another tool that may potentially assist managers in the decision-making process, but it is still a novelty for most practitioners and a largely unexplored area for researchers (Van Dis et al., 2023). This solution is known as ChatGPT and has been the most popular artificial intelligence language model (AI language models) to date. The aim of AI language models such as ChatGPT is to provide accurate and helpful responses to users' questions (Doshi, Bajaj and Krumholz, 2023; Korzynski et al., 2023a). Such questions may be related to education, research, general knowledge and even business consulting. This solution exhibits a great deal of potential in the context of strategic business decision making.

Hence, the above introduction leads to the following research question:

- **RQ1:** Can ChatGPT support managers in making strategic business decisions?

Of course, the formulated RQ1 is very generic, and at first glance the answer seems to be yes; however, from experience it is clear that unqualified or underperforming consultants may not only leave an existing problem unresolved, but also considerably worsen the outlook for a given company. A well-suited example could be an inexperienced consultant suggesting lay-offs for a strategically important product with

a negative margin. The EBIT would increase in the short term, but the product may turn out to have been crucial to cross-selling opportunities. As a result, income will increase in the short run, but in the long-term the company will go on to lose customers and perhaps even fail. Therefore, consultants and strategic managers are expected to have a holistic view of the entire business.

It is exactly such a case which will be the subject of consideration in this paper. If ChatGPT suggestions could lead to negative or neutral effects on the company, then the answer to RQ1 would be a clear “no”, or rather – considering the level of technological progress – “not yet”. If ChatGPT turns out to be helpful and/or asks further questions leading to a holistic approach, then we may answer in the affirmative. Regardless, the path towards an answer may have multiple solutions; therefore, the following research hypotheses were formulated:

- **H1:** An experienced human analyst is able to provide an optimal solution to the business problem presented, albeit over a long period of time.
- **H2:** AI by itself – ChatGPT – is not able to provide an optimal holistic solution to the business problem presented.
- **H3:** The centaur model – collaboration between ChatGPT and an experienced human – is the optimal means by which to solve the business problem presented.

The aim of this paper, therefore, is to compare the strategic business decision-making process of a human to those of an AI language model and the centaur model, which we define as collaboration between AI and humans.

The paper is structured as follows. Section one includes the literature overview of AI supporting the business decision-making process; section two describes the methodology; section three presents the results; and finally, section four concludes the paper.

1. Literature Review

The human fascination with AI has a long history in popular culture, ranging from visions of its positive effect on our world as in the Star Wars franchise, to dystopian scenarios as seen in the popular Matrix or Battle Star Galactica series. Most recently, engineers have made a great deal of progress on AI modelling, one result of which is the popular language platform ChatGPT. This language model has received a great deal of attention across multiple media for various reasons. On the one hand, users have been impressed by the AI’s ability to solve complex problems and provide information on coding, engineering, or even write essays on its own (Vanian, 2022). On the other hand, certain groups of people were negatively affected by the AI, where the language model behaved in a racist manner, told untruths, and even suggested people commit suicide (Davey, 2022; Wach et al., 2023).

Unfortunately, scientific research on AI is not as popular as media-driven discussions, but it may be surprising to note that one of the first major publications was published as early as in 1961. Minsky (1961) stated that although computers can only do what they are told to (programmed to do), they may be taught how to search through various databases and “learn by themselves”. Of course, this concept is highly simplified and does not accurately describe the complexity behind the production of the AIs that we are accustomed to today. It does, however, provide a significant insight into how AI works, as without human input, AI would not exist at all. Since then, technological progress has allowed us to create superior computers and machines that can easily outperform humans and have the potential for further growth, even in areas such as quantum mechanics (Saffman, 2016) or AI (Grace et al., 2018).

Hardware has been subject to enormous progress as well. For example, one may consider the famous statement by the co-founder of Intel, Gordon Moore, that the number of transistors in integrated circuits are likely to double every two years (later referred as Moore's Law). Proof of this theory may be found in the fact that the Intel 4004 from 1971 had 2300 transistors while the latest Apple M1 Ultra computer has 114 billion of them (Apple Press Release, 2022).

Notwithstanding this tremendous technological progress, the general concept of AI has not changed dramatically and can be described as a machine or software able to understand and learn new algorithms. Bini (2018) has summarised the evolution of AI aptly. The learning part is crucial here, because this is where substantial progress in software development has been made. To see an obvious difference, one may consider two different processes - one requiring few decisions, as in checkers, and another that requires a chain of decisions, as in chess. AI models were initially programmed to evaluate every single possible solution; hence, there was a different code for each move. Later, however, the concept of machine learning (ML) was introduced. This is where AI receives a sample data set and finds relevant patterns to create more of them; basically the machine learns from the "past" by itself and recodes itself, hence the term "machine learning". This method unfortunately has certain restrictions related to the amount, or rather the structure, of the data. With ML, software has to receive and structure the data in a specific manner in order to understand it, which requires a great deal of preparation and calculation. To overcome these limits, the concept of deep learning (DL) comes into play. With DL, machines use statistical models called Artificial Neural Networks (ANN) that process information in a similar way to the human brain

to develop a very deep understanding of such information.

This theoretical background brings us to the application of modern AI models which are part of everyday life. Nowadays AI is supportive in a variety of fields related to research (Scholarcy, Adept), images (Bria, Evoto), video (Vidyo.ai, Tavus), design (Galileo AI, PhotoRoom), spreadsheets (Sheet+, Ajelix) and even text production (Notion AI or ChatGPT). The latter, namely text or language models, are particularly relevant to the scope of this paper because the user may have an actual conversation with them.

Language models (LM) became popular at the beginning of the 21st century when a number of scientific papers were published, mostly related to translation. For example, Brants et al. (2007) described mathematical models that may be utilised to improve text translation. Those methods relied on the "training dataset"; the bigger it was, the higher the quality of the translation. The way language models work is not especially difficult to understand when using the concept of statistics. Fundamentally, they find the sequence of words with the highest probability of occurring.

A solid overview of the current language model architecture, including ChatGPT 3, was compiled by Brown et al. (2020). The authors dove deeply into technical specifications related to Language Models, testing a variety of questions in an attempt to evaluate the performance and limitations of multiple software models. The main point of interest of this research is the outlined problems that may be related to language models. ChatGPT 3 has been beset by various difficulties when dealing with topics such as religion, gender or race. To offer an example, misuse may occur as there are frequently used terms associated with a specific religion, race or gender. Hence, ChatGPT has developed some "favourite" words indicating stereotypes related

to religion (e.g. Christianity – Attend and Ignorant; Hinduism – Cast and Cows; Islam – Pillars and Terrorism, etc.), gender (e.g. male – large, mostly, lazy; female – optimistic, bubbly, naughty). Finally, it is becoming increasingly difficult to distinguish texts created by ChatGPT from those created by humans.

Based on the review above, AI language models such as ChatGPT can be considered a powerful tool, assisting humans in multiple ways (Korzyński et al., 2023b). But can it ultimately be used for strategic business decisions? Although papers like that of Duan et al. (2019) describe the use of AI for managerial decision making, literature on ChatGPT remains rare. As an example, as of April 2023 there were no results for documents indexed in Scopus after searching for “ChatGPT” and “decision” and “management”. The search was expanded to include “ChatGPT” and “management” only, at which point 10 documents were found, most of them related to healthcare and general ChatGPT challenges. The only article that may be seen as somehow related to the decision-making process was written by Wesendrup and Hellingrath (2023), who undertook a case study to see whether proximal policy optimisation (PPO) can be helpful for production planning and control purposes. It turned out that models utilising PPC are supportive of production-related decisions. This may be considered relevant in the context of this paper because ChatGPT uses the PPO method as reinforced learning.

As the next step in this review, a search on Google Scholar for the keywords “ChatGPT”, “decision”, “making”, and “management” was performed. Although more fruitful than Scopus, the results were still minimal. Again, many papers were related to healthcare. The results which were identified as being helpful for management science included papers by Wang et al. (2023) and Burger et al. (2023). The

former is rather a summary of a conference where the authors investigated ChatGPT’s knowledge of Industry 5.0. It turned out that ChatGPT was able to provide detailed information around the topic, but some of the concepts lacked creativity. On the other hand, the latter paper investigated whether ChatGPT can be used as a tool to support the research in the management sphere. Although not purely related to the issue tackled in this paper, the conclusion of the authors was in line with H3: Although ChatGPT will not replace humans, humans using ChatGPT can perform better with the help of AI.

As may clearly be seen, the limits and quality of the literature indicate a clear research gap. In the next section, the authors attempt to solve a holistic business problem with the help of ChatGPT.

2. Methodology

Using an experimental technique, this study compares the performance of humans, AI (ChatGPT), and the centaur decision-making model in a strategic business setting. A medium-sized food manufacturing company experiencing financial performance issues served as the basis for the design of the experiment (Yin, 2014). The controlled experimental design, reproducibility, and quantitative and qualitative analyses evaluate the scientific rigor of the study (Creswell, 2014). The research must display methodological awareness, which is accomplished by identifying the inherent limitations, upholding consistency, and addressing potential biases (Bryman, 2016). All research must take ethics into account. While avoiding the use of ChatGPT in the literature review, discussion, results, and conclusions, this experiment restricts such usage to the experimental goals, focusing on decision-making situations. By doing this, the AI tool is used sensibly, offering insightful information about its possible uses in managerial decision making. In this

study, the methodological triangulation is accomplished by combining quantitative and qualitative data and examining several decision-making situations involving humans, artificial intelligence, and centaur models.

The paper uses an experiment and a checklist-based score to compare three strategically important business decision making scenarios:

- 1. Human scenario (scenario 1): An analyst offers suggestions and proposes a solution to the business problem without the help of AI.
- 2. AI scenario (scenario 2): ChatGPT offers suggestions and proposes a solution to the business problem with the minimum possible amount of human assistance.
- 3. Centaur scenario (scenario 3): Humans and AI collaborate to make a decision, with the human having the relevant business acumen and asking critical questions.

In order to verify the stated hypotheses, a strategic business case was formulated which related to a medium-sized food

manufacturing company called Snacks Company faced with the challenge of decreasing EBIT. The three-year financial data (Figure 2) was prepared in such a way that one business unit (Nacho Chips) had a negative margin, while the second (Salsa Dip) was highly profitable and drove the company's EBIT.

To avoid a purely qualitative comparison of the three scenarios, a checklist-based scale with weighted grading was proposed as per Figure 1. The checklist is divided into two main areas, the first of which included nine crucial criteria by means of which to solve the formulated business case, and the second of which included three that were helpful in the overall business decision-making process (Elbanna, 2006). The scores were allocated based on their importance to solving this particular case (5 highly material, 1 not material). Additional criteria that were helpful received an average score of 3. For each scenario, we checked whether the specific criteria were present. Subsequently, the respective scores were applied, and the sum resulted in the total score.

Figure 1. Checklist with scores on a scale from 1 to 5

Area	Criteria	Wage
Decision making problem	Gather qualitative data (ask questions)	5
	Interpret the qualitative data	2
	Gather quantitative information (data)	5
	Interpret the quantitative data	3
	Discover product complementariness	5
	Find the root cause (margin)	5
	Propose a pricing strategy	5
	Propose other solutions (material)	5
	Propose other solutions (non-material)	1
Add. Criteria	Speed	3
	Independence	3
	Holistic view	3

Source: own elaboration

For an overview of the situation at Snacks Company, the following simplified Profit

and Loss Statement (P&L) was prepared as shown in Figure 1.

Figure 2. Simplified Profit and Loss Statement for the scenario

Simplified Profit and Loss Statement									
kUSD	Snacks Company Total			Nacho Chips			Salsa Dip		
	2020	2021	2022	2020	2021	2022	2020	2021	2022
Unit Price		n/a		5	5	5	2	2	2
Sales				100	110	120	100	110	120
Revenue	700	770	840	500	550	600	200	220	240
Unit variable cost		n/a		4	5	5.5	0.2	0.2	0.2
Total variable cost	420	572	684	400	550	660	20	22	24
Margin 1	280	198	156	100	0	-60	180	198	216
Fixed Cost	60	60	60	50	50	50	10	10	10
EBIT	220	138	96	50	-50	-110	170	188	206

Source: own elaboration

As shown, the issue of declining EBIT is related to increased variable costs for nacho chips from 2021 onwards, while the sales price and fixed costs remained constant. The most straightforward solution based on the numbers would be to exit the nacho chips business to improve the company's overall EBIT. But to test the AI, the scenario was based on a "holistic" assumption: the catch is that salsa dip is a complementary product to nacho chips and without the sale of nachos, no sales of salsa will be made. This correlation may be clearly visible for a human, but difficult for AI.

To avoid potential bias, in the case of scenarios 1 and 2, another assumption was added: The owner of the Snacks Company asking for assistance possesses neither broad business acumen nor AI acumen, and rather than volunteering information freely he provides it on request (if available).

The most popular freely available version of ChatGPT 3.5 at the current point in time was utilised to perform the comparison. All the content generated by the AI is related purely to the business decision-making process, and the two conversations were included in their entirety in the appendix. The AI was not involved in generating any of the textual content of this article itself. The results are described in detail in the subsequent section of the paper.

3. Results and Discussion

The discussion of the three scenarios from the methodology section will hereby proceed one by one. The steps involved in Scenario 1, the human business decision-making process, are shown in Figure 3 below.

Figure 3. Human business decision-making process

Source: own elaboration

First, the analyst asked the owner whether he has an idea of where the problem may

lie, to which the owner replied negatively (the assumption was that no assistance would be

forthcoming). Later, the available financials were provided; hence, step 1 may be categorised as information gathering. Immediately after looking at the financials, the analyst was able to see that the Nacho Chips business unit incurred losses due to variable costs having increased since 2021. The analyst also interpreted the data to investigate whether the products are sold jointly (complementariness). It did not take long for the human analyst to highlight the increasing variable costs and suggest that those may be related to the COVID-19 pandemic and supply chain problems. The analyst did not even consider shutting down the Nacho Chips business unit, but instead proposed a two-step solution:

- Step 1: Evaluating the root cause of the increase in variable costs. If these are seasonal due to the COVID-19 pandemic, then the EBIT problems should be resolved after such a shock. If not, Step 2 is not only optional, but also a requirement to maintain the business as a going concern.
- Step 2: Implementation of a sustainable pricing strategy. The human

analyst indicated that EBIT may not only be improved through cost optimisation, but through revenue effects. Those are clearly problematic because, even considering the increasing inflation, the price of nacho chips did not rise. Moreover, salsa dip may soon be faced with these same problems as well. The pricing strategy should consider the competition, market analysis, and more importantly the production costs.

- Optional suggestion: rolling budgeting/forecasting was proposed as a process by which to avoid such problems in the future.

Considering the interview with the analyst, the scale for Scenario 1 can be summarised as per Figure 4. As one may see, the analyst registered scores in all categories except for the interpretation of qualitative data. Also, although the answer came after approximately two hours and could be considered fast, it was necessary to plan a meeting with the analyst one week in advance.

Figure 4. Human checklist score

Area	Criteria	Wage	Checked? Human	Final Points Human
Decision making problem	Gather qualitative data (ask questions)	5	yes	5
	Interpret the qualitative data	2	no	0
	Gather quantitative information (data)	5	yes	5
	Interpret the quantitative data	3	yes	3
	Discover product complementariness	5	yes	5
	Find the root cause (margin)	5	yes	5
	Propose a pricing strategy	5	yes	5
	Propose other solutions (material)	5	yes	5
	Propose other solutions (non-material)	1	yes	1
Add. Criteria	Speed	3	no	0
	Independence	3	yes	3
	Holistic view	3	yes	3
# of affirmative responses and total score			10	40

Source: own elaboration

Looking at the abovementioned solution, H1 can be confirmed positively. The next step, then, was to repeat the process with

AI as the decision-making tool. The decision-making process for Scenario 2 can be summarised as in Figure 5 below.

Figure 5. ChatGPT business decision making process



Source: own elaboration

The amount of information and ideas received from the AI is impressive. However, obtaining the information involved responses that required solid business acumen. For example, immediately after providing the general Snack Company background, ChatGPT asked questions about revenue, market demand, competitors, environment/regulatory changes, the main cost drivers, and (similarly to the human analyst) the marketing and sales strategy. Since we assumed that the owner did not have a great deal of business acumen, advanced questions were answered “I don’t know”. Hence, we may consider the possibility of ChatGPT asking for qualitative data.

In general, after providing the information, the AI was able to offer five suggestions:

1. Cost structure analysis
2. Pricing strategy improvement
3. Sales channel increases
4. Marketing strategy improvement
5. Understanding the customers

Further, ChatGPT provided a detailed description of the suggestions above, which may be considered as interpretation of qualitative data on the created scale. Unfortunately, ChatGPT did not ask for any financial statements by itself; hence, no points were awarded for gathering financial data. However, in order to test the AI further, we insisted on providing additional information and fed the ChatGPT the financial data – a simple copy/paste manoeuvre from MS Excel. Surprisingly, the AI was able to read and interpret said data to draw

conclusions about decreasing margins and problems in the Nacho Chips business unit. Its conclusion was to optimise the cost, expand sales channels and consider additional sales in the profitable Salsa Dip business unit. For the next test, the owner asked the AI whether it might be worth closing the Nacho Chips business unit, to which the AI replied negatively. The entire conversation can be found in the appendix to this paper. Due to the high level of business knowledge required and the follow-up questions, the AI was able to provide clear suggestions, albeit not completely independently of human assistance. A person without solid business acumen and eagerness to learn the terminology would not benefit from a great deal of help on this topic. The solutions were also helpful, although very “generic”.

The summary of the scale can be found in Figure 6. It is important to mention that although the pricing strategy was indicated, no particular strategy was proposed by AI, in contrast to the human analysts. The same occurred in the context of information gathering. If the business owner did not provide additional information by himself, the AI did not ask for it. The speed of the AI response was surprising, and indeed an area in which AI performance can be considered significantly superior to that of the human. ChatGPT answered the questions within seconds. Overall, ChatGPT achieved a low score of 24 points in total. However, this is not sufficient to definitely reject H2. Further research is needed.

Figure 6. ChatGPT checklist score

Area	Criteria	Wage	Checked? Final Points	
			AI	AI
Decision making problem	Gather qualitative data (ask questions)	5	yes	5
	Interpret the qualitative data	2	yes	2
	Gather quantitative information (data)	5	no	0
	Interpret the quantitative data	3	yes	3
	Discover product complementarity	5	no	0
	Find the root cause (margin)	5	yes	5
	Propose a pricing strategy	5	no	0
	Propose other solutions (material)	5	yes	5
	Propose other solutions (non-material)	1	yes	1
Add. Criteria	Speed	3	yes	3
	Independence	3	no	0
	Holistic view	3	no	0
# of affirmative responses and total score			7	24

Source: own elaboration

Lastly, we investigated the centaur model (Scenario 3) and asked the analyst to work

together with AI. The process can be summarised as per Figure 7:

Figure 7. Centaur business decision-making process



Source: own elaboration

One may immediately note that the process is slightly different and longer than the one in Scenario 1, but there are multiple similarities. In this scenario, rather than having a conversation, the analyst utilised AI in a professional way, giving commands and assumptions. Hence, as part of step 1, the input and assumption section were required. After receiving the data together with the assumptions, the AI provided three potential business solutions:

1. Cost-benefit analysis
2. Pricing strategy
3. Product expansion

Surprisingly, the first two options are exactly in line with what the analyst initially

suggested during Scenario 1. After receiving the options, the human analyst investigated the steps for each of the proposals in more detail. The analyst confirmed that he was unaware of all the details and mentioned that those were highly informative, albeit not a factor in decision making for this particular case. AI was able to provide detailed strategies around those issues. The analyst would not consider product expansion in the end because of the risks inherent in the current environment, suggesting a holistic view. All in all, the collaboration was useful, fast and in line with the human decision-making process. The human analyst definitely drove the conversation and

the decision-making process, while the AI remained very supportive. The analyst also admitted that the problem of his limited knowledge of the literature on multiple topics was negated when working in cooperation with AI, hence increasing the speed of the process even further. The AI was also able to provide multiple interpretations

on every indicator or strategy after the human asked questions (qualitative/quantitative interpretation). Not only did the centaur model score the most points as per Figure 8, but H3 can be confirmed positively. The entire conversation can be found in Appendix 2.

Figure 8. Centaur checklist score

Area	Criteria	Wage	Checked? Centaur	Final Points Centaur
Decision making problem	Gather qualitative data (ask questions)	5	yes	5
	Interpret the qualitative data	2	yes	2
	Gather quantitative information (data)	5	yes	5
	Interpret the quantitative data	3	yes	3
	Discover product complementariness	5	yes	5
	Find the root cause (margin)	5	yes	5
	Propose a pricing strategy	5	yes	5
	Propose other solutions (material)	5	yes	5
	Propose other solutions (non-material)	1	yes	1
Add. Criteria	Speed	3	yes	3
	Independence	3	yes	3
	Holistic view	3	yes	3
# of affirmative responses and total score			12	45

Source: own elaboration

Conclusions

This article leverages an experimental technique to investigate three scenarios that offer solutions to a strategic business issue. A checklist with weighted scoring was developed to compare the performance of the three scenarios. The research problem was related to profits decreasing over a two-year period at a manufacturing company. All three scenarios were categorised depending on the involvement of the AI language model ChatGPT, as listed below:

- Human scenario (Scenario 1)
- AI scenario (Scenario 2)
- Centaur scenario (Scenario 3)

Scenario 1 involved purely human work and investigated the decision-making process of a human analyst. Scenario 2, by contrast, used a person referred to as a “business owner” who did not have a great deal of business acumen (apart from information on a simplified profit and loss statement) and interacted with the AI as he would converse with another human. Lastly, Scenario 3 involved a human analyst who had solid business acumen and was able to effectively leverage the language model (with commands rather than a conversation). The scores and final results of all three scenarios are shown in Figure 9 below:

Figure 9. Summary checklist score of all scenarios

Area	Criteria	Wage	Checked?			Final Points		
			Human	AI	Centaur	Human	AI	Centaur
Decision making problem	Gather qualitative data (ask questions)	5	yes	yes	yes	5	5	5
	Interpret the qualitative data	2	no	yes	yes	0	2	2
	Gather quantitative information (data)	5	yes	no	yes	5	0	5
	Interpret the quantitative data	3	yes	yes	yes	3	3	3
	Discover product complementarity	5	yes	no	yes	5	0	5
	Find the root cause (margin)	5	yes	yes	yes	5	5	5
	Propose a pricing strategy	5	yes	no	yes	5	0	5
	Propose other solutions (material)	5	yes	yes	yes	5	5	5
Add. Criteria	Propose other solutions (non-material)	1	yes	yes	yes	1	1	1
	Speed	3	no	yes	yes	0	3	3
	Independence	3	yes	no	yes	3	0	3
	Holistic view	3	yes	no	yes	3	0	3
# of affirmative responses and total score			10	7	12	40	24	45

Source: own elaboration

Ultimately, the worst scenario, although still impressive, was Scenario 2, purely based on AI. The AI programme was able to provide a number of insights and proposals, but human input would be required to ask additional questions and have at least an average understanding of business. The outcome of Scenario 3 could be described as similar to “Wikipedia” providing up-to-date information.

In general, the results of Scenario 1 and Scenario 3 were very similar. In fact, the AI programme offered the same first two proposals as the human (cost evaluation and pricing strategy). In addition, it was able to provide helpful information about business theories that the analyst was not aware of or had not considered.

This research can be considered valuable for a number of reasons. Managers can use AI to get additional insights on their business performance or the related theories. The AI user should bear in mind that general knowledge of a particular topic is helpful. Also, providing ChatGPT with clear commands, data and assumptions substantially helps with the business decision-making process.

The study was, however, beset by certain limitations. One included the paucity of available literature on the utilisation of AI language models for business decision making. Secondly, the methodology, which involved an experiment and the qualitative comparison of three scenarios and one analyst, could definitely be expanded. Lastly, the rapid technological progress with respect to AI language model training may make this research obsolete in a mere few years, if not months.

The limitations, however, can be considered the next step for further research. Scientists may develop specific methodologies to compare AI with managers and undertake further research when new versions of AI language models become available.

Disclosures on AI-Generated Content

The article was generated entirely by the authors without assistance from an AI-based system. The AI conversations in the Appendix were used purely for methodological purposes to compare the business decision-making process of a human with that of an AI language model.

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Appendix

Appendix 1: Conversation with AI, Scenario 2.



I need some advice on the performance of my business. Can you help out?



Of course, I'd be happy to help! Please provide me with some more details about your business and the specific areas you would like to improve upon. This will enable me to give you more targeted advice.



I do not have a lot of business acumen, so please feel free to ask questions. My business is called Snacks Company and is structured into two business units. Nacho Chips and Salsa Dip. We are running the production since couple of years but encountered EBIT decreases from 2021 onwards.



I understand. Here are some questions that will help me get a better understanding of your business:

1. What is the current size of your business in terms of revenue, number of employees, and market share?
2. What is the current market demand for nacho chips and salsa dip, and how does your business unit compare to your competitors in terms of product quality, price, and distribution?
3. Have there been any recent changes in your business environment, such as new regulations, changes in consumer preferences, or disruptions in the supply chain that may have contributed to the decrease in EBIT?
4. What are the main cost drivers for your business, and have there been any changes in these costs that have affected your profitability?
5. What marketing and sales strategies are you currently employing to promote your products, and how effective have they been in generating sales?

Once I have a better understanding of your business, I can provide more targeted advice on how to improve your performance.



I will answer what I know and have.

1. The total revenue ranges from 700k USD in 2020 to 840k USD in 2022.
2. Sales increases from 100k units to 120k units from 2020 to 2022.
3. I don't know.
4. Fixed costs are stable, but variable cost increased from 420k USD to 684k USD (2020 vs
5. I don't know.



Based on the information you provided, here are some initial suggestions to improve the performance of your business:

1. **Analyze your cost structure:** Your variable costs have significantly increased, which could be impacting your EBIT. It would be helpful to understand the reasons behind this increase and whether it can be reduced or optimized. Conducting a detailed analysis of your cost structure, including material costs, labor costs, and overheads, can help you identify areas where you can save costs without compromising on quality.
2. **Improve your pricing strategy:** If your competitors are offering similar products at a lower price, you may want to consider adjusting your pricing strategy. You could also explore offering promotions and discounts to attract more customers.
3. **Increase your sales channels:** Consider expanding your sales channels to reach a wider customer base. For example, you could explore selling your products online, through third-party retailers, or by partnering with other businesses that complement your products.
4. **Improve your marketing strategy:** It's important to have an effective marketing strategy to promote your products and increase brand awareness. This could include social media participating in trade shows or sponsoring events to increase visibility.
5. **Understand your customers:** It's important to understand your customers' preferences and needs to develop products that meet their expectations. Conducting market research, customer surveys, and focus groups can help you gather feedback and insights to improve your products and services.

I hope these suggestions are helpful. Remember that improving the performance of a business is an ongoing process that requires continuous effort and evaluation. Good luck with your business!



Thank you. I have a detailed cost analysis for two of my business units, would this help you?



Yes, a detailed cost analysis for your business units would be helpful in identifying areas where you can optimize your costs and improve your profitability. Please provide me with the cost analysis, and I will do my best to analyze the information and provide you with more targeted advice.



I have this table, is it helpful?

kUSD	Snacks Company Total			Nacho Chips			Salsa Dip		
	2020	2021	2022	2020	2021	2022	2020	2021	2022
Unit Price	n/a	5	5	2	2	2			
Sales	100	110	120	100	110	120			
Revenue	700	770	840	500	550	600	200	220	240
Unit variable cost	n/a	4	5	5.5	0.2	0.2	0.2		
Total variable cost	420	572	684	400	550	660	20	22	24
Margin 1	280	198	156	100	0	-60	180	198	216
Fixed Cost	60	60	60	50	50	50	10	10	10
EBIT	220	138	96	50	-50	-110	170	188	206



Thank you for providing this information. Based on the table, here are some observations and suggestions to improve the performance of your business:

1. Margins: The margin for the Nacho Chips business unit decreased significantly from 2020 to 2022, which is contributing to the overall decrease in EBIT. This could be due to the increase in variable costs, as the unit price remained constant. It would be helpful to understand the reasons behind the increase in variable costs and whether there are any opportunities to optimize these costs.
2. Fixed Costs: Your fixed costs remained stable over the years, which is a positive sign. However, it would be helpful to review your fixed costs to see if there are any opportunities to reduce them without compromising on quality or productivity.
3. EBIT: Your overall EBIT decreased from 2020 to 2022, which is a concerning trend. To improve your EBIT, you could consider increasing your revenue by expanding your sales channels, improving your pricing strategy, and enhancing your marketing efforts. Additionally, you could review your cost structure to optimize your variable and fixed costs.
4. Salsa Dip: The Salsa Dip business unit has a higher margin compared to the Nacho Chips business unit. It may be worthwhile to focus on expanding this business unit or introducing new products in this category to increase revenue and improve overall profitability.

In summary, to improve the performance of your business, it would be helpful to focus on optimizing your cost structure, expanding your sales channels, and enhancing your marketing efforts. Additionally, you may want to consider focusing on the Salsa Dip business unit or introducing new products in this category to increase revenue and profitability.



Would it be worth to shut down the nacho chips business unit to use the resources for the salsa dip business unit?



Based on the information provided, it is difficult to determine whether it would be worth shutting down the Nacho Chips business unit and redirecting resources towards the Salsa Dip business unit.



While the Nacho Chips business unit is currently not as profitable as the Salsa Dip business unit, it still generates a significant amount of revenue for your company. Additionally, shutting down the Nacho Chips business unit would likely result in the loss of customers who prefer this product, which could negatively impact your overall revenue.

Before making a decision to shut down the Nacho Chips business unit, it would be helpful to analyze the long-term potential of this product category and identify opportunities to optimize its cost structure and increase its profitability. You may also want to consider exploring new markets or distribution channels to expand your customer base and increase your revenue.

In summary, while it is important to focus on optimizing your resources and maximizing profitability, it may not be advisable to shut down a business unit without conducting a thorough analysis of its potential and exploring all possible opportunities for improvement.

Appendix 2: Conversation of an analyst with AI, Centaur Scenario (Scenario 3).



Act as a business consultant and help with a strategic problem



Of course, I'm here to help. What specific strategic problem are you facing in your business?



Assume the following. The company is in the FMCG manufacturing business. Turnover is around 800K USD per year. There are two business units, Nacho Chips and Salsa Dip. Products are sold complementary but have different profitability. Let me feed you with the financials in the next step.



Great, please provide me with the financials for both business units so I can better understand the situation and provide more targeted advice.



This is information for 3 years, from 2020 to 2022 for two business units. Can you read it?

kUSD	Nacho Chips			Salsa Dip		
	2020	2021	2022	2020	2021	2022
Unit Price	5	5	5	2	2	2
Sales	100	110	120	100	110	120
Revenue	500	550	600	200	220	240
Unit variable cost	4	5	5.5	0.2	0.2	0.2
Total variable cost	400	550	660	20	22	24
Margin	100	0	-60	180	198	216
Fixed Cost	50	50	50	10	10	10
EBIT	50	-50	-110	170	188	206



Thank you for providing the financial information. Based on the data, it seems that the Salsa Dip business unit is significantly more profitable than the Nacho Chips unit.

One immediate suggestion would be to conduct a cost-benefit analysis of the Nacho Chips unit to identify any inefficiencies or areas of improvement that could help to increase its profitability. This analysis could include a review of the unit's manufacturing process, supply chain, and distribution channels.

Another option would be to evaluate the pricing strategy for both units. While it may not be feasible to increase the price of the Nacho Chips too much, a slight increase in price combined with a reduction in the unit variable cost could help to improve its profitability. On the other hand, since the Salsa Dip is already highly profitable, a small decrease in the unit price combined with a slight increase in the unit variable cost may be an option to increase the volume sold while maintaining profitability.

Additionally, it might be worthwhile to consider expanding the product line for the Salsa Dip unit. Since it has a strong profitability record, this could be an opportunity to leverage the existing distribution channels and increase overall revenue.

Finally, exploring potential partnerships or collaborations with other businesses in the FMCG industry could be a way to create new revenue streams and increase overall profitability. This could include partnerships with complementary businesses such as soft drink or beer manufacturers, or exploring new markets through export partnerships.

Overall, a combination of these strategies could help to improve the profitability of the Nacho Chips unit and leverage the strong profitability of the Salsa Dip unit to create new revenue streams for the business.



Give me steps for a successful cost benefit analysis.



Sure, here are some steps to follow for conducting a successful cost-benefit analysis:



1. Identify the objective: Define the goal of the cost-benefit analysis, such as identifying inefficiencies, assessing the financial feasibility of a project, or determining the economic impact of a policy change.
2. Identify the alternatives: Determine the various alternatives that could address the objective. For example, if the objective is to identify inefficiencies, alternatives could include changes in the manufacturing process, supply chain optimization, or reduction in fixed costs.
3. Identify the costs: List all costs associated with each alternative, including direct costs such as labor, materials, and overhead, as well as indirect costs such as opportunity costs and potential legal or regulatory costs.
4. Identify the benefits: Determine all benefits associated with each alternative, such as increased revenue, reduced waste, or improved customer satisfaction.
5. Assign monetary value to costs and benefits: Quantify the monetary value of each cost and benefit to ensure that they can be compared directly. For example, costs can be measured in terms of dollars spent, while benefits can be measured in terms of additional revenue or improved efficiency.
6. Calculate the net present value: Discount the future costs and benefits to the present value to account for the time value of money. This will help to determine the net present value (NPV) of each alternative.
7. Compare alternatives: Compare the NPVs of each alternative to determine the most financially feasible option.
8. Sensitivity analysis: Perform a sensitivity analysis to determine how changes in assumptions or inputs could impact the results of the cost-benefit analysis.
9. Present the findings: Finally, present the results of the cost-benefit analysis, including the NPVs of each alternative and the sensitivity analysis, to key stakeholders and decision-makers to inform their decision-making process.

By following these steps, you can conduct a thorough and effective cost-benefit analysis that can help you make informed decisions about your business strategies.



Give me proposals for a pricing strategy for this business.



Sure, here are some pricing strategy proposals for your business based on the financial information you provided:

1. Bundle pricing: Consider bundling Nacho Chips and Salsa Dip together as a combo deal at a slightly discounted price. This can incentivize customers to purchase both products and potentially increase overall sales volume.
2. Premium pricing: Since Salsa Dip is already highly profitable, you could consider slightly increasing its unit price and positioning it as a premium product. This could increase its perceived value and justify the higher price point.
3. Cost-plus pricing: You could use a cost-plus pricing strategy, where you add a markup to the total cost of production for each product. This can ensure that you are covering your costs and generating a profit on each sale.
4. Promotional pricing: Consider running promotional pricing on Nacho Chips to increase sales volume. For example, you could offer a discount for a limited time or run a "buy one, get one free" promotion to incentivize customers to try the product.
5. Dynamic pricing: Consider implementing a dynamic pricing strategy where the price of each product changes based on supply and demand. This can be particularly useful for Nacho Chips, where demand may fluctuate based on factors such as seasonality or events.
6. Value-based pricing: Finally, you could consider a value-based pricing strategy, where you price your products based on the value they provide to customers rather than just the cost of production. For example, if Nacho Chips are particularly popular with customers, you could increase the price slightly based on their perceived value.

Overall, the pricing strategy you choose will depend on a number of factors such as your target market, competition, and production costs. It's important to carefully evaluate each option and test different pricing strategies to see what works best for your business.



What to consider when expanding the profitable salsa dip business unit? Give me clear steps.



Sure, here are some steps to consider when expanding the profitable salsa dip business unit:

1. Market research: Conduct market research to determine the potential demand for the salsa dip product in new markets. This could include surveys, focus groups, and competitive analysis to identify market trends and customer preferences.
2. Financial analysis: Analyze the financial feasibility of expanding the salsa dip business unit. This could include analyzing the costs of production, distribution, and marketing as well as potential revenue streams and profitability projections.
3. Supply chain management: Ensure that the supply chain can handle the increased demand for the salsa dip product. This may involve securing additional suppliers, increasing production capacity, or optimizing distribution channels.
4. Marketing strategy: Develop a marketing strategy to promote the salsa dip product in new markets. This could include advertising, social media campaigns, and collaborations with influencers or other businesses.

5. **Distribution strategy:** Develop a distribution strategy to ensure that the salsa dip product is available in new markets. This could include partnerships with retailers or distributors, online sales channels, or opening new sales channels such as foodservice or catering.
6. **Regulatory compliance:** Ensure that the salsa dip product complies with all relevant regulatory requirements in new markets. This may involve obtaining permits or certifications, adhering to labeling and packaging requirements, or complying with food safety regulations.
7. **Launch plan:** Develop a launch plan for the expansion of the salsa dip business unit. This should include timelines, budgets, and milestones to ensure a smooth and successful launch.
8. **Performance measurement:** Develop metrics to measure the success of the expansion, such as sales volume, revenue, and profitability. Monitor these metrics regularly and adjust the strategy as needed to optimize performance.

By following these steps, you can develop a clear and comprehensive plan for expanding the profitable salsa dip business unit into new markets.



We have limited amount of resources. Where to start with the business improvement process?



When resources are limited, it's important to focus on areas of the business that will have the greatest impact on improving performance. Here are some steps you can take to prioritize where to start with the business improvement process:

1. **Identify the most pressing issues:** Start by identifying the most pressing issues facing the business. This could include issues related to production, sales, marketing, finance, or customer service. Prioritize those issues that are having the biggest impact on performance or that are causing the most frustration for customers or employees.
2. **Evaluate the potential impact:** Once you have identified the most pressing issues, evaluate the potential impact of addressing each issue. This could include analyzing the potential revenue or cost savings associated with improving a particular process or addressing a specific issue.
3. **Assess resource requirements:** Assess the resource requirements for each improvement initiative. This includes not only financial resources but also personnel, time, and equipment. Prioritize initiatives that require fewer resources or that can be implemented quickly and with minimal disruption to ongoing operations.
4. **Develop a roadmap:** Develop a roadmap for implementing the improvement initiatives, prioritizing those with the greatest potential impact and requiring the fewest resources. This roadmap should include timelines, milestones, and metrics to measure progress and success.
5. **Monitor and adjust:** Monitor progress on the improvement initiatives regularly and adjust the roadmap as needed. This may involve reallocating resources, adjusting timelines, or changing the focus of improvement initiatives based on new information or changing circumstances.

By following these steps, you can prioritize where to start with the business improvement process and develop a roadmap for addressing the most pressing issues and improving overall performance, even with limited resources.

Correlation between Agri-Market Subjects: A Case Study of Ukraine – EU vs. EU – China¹

OKSANA KIFORENKO

Abstract

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Agriculture is vitally important for the survival of mankind in both a general and individual sense, as it provides food for people and forage for domestic animals. Due to the differences in climatic conditions, the availability of water, the costs and skills of the labour force, etc. countries have diverse food security possibilities. Thereby, exporters of agricultural products gain increasing economic, and consequently political, importance either locally or globally as they have agro-produce surpluses which they can deliver to secure food availability. The local and global agricultural product markets function according to their own laws with their colossi players being related with each other, stating their game rules on the said markets. Therefore, the research problem considers whether a small country such as Ukraine, without a great deal of political influence at a global level and not being especially economically developed, has any correlation with a giant player on both the global economic and political stages such as the EU. The purpose of the research is to evaluate whether the export of agricultural products from Ukraine to the EU27 has any correlation with the export of agricultural products from the EU27 to China and, if so, how strong that correlation is. The research has been conducted using such methods and tools as comparative analysis, univariate analysis, the Pearson correlation coefficient, the Spearman rank correlation coefficient, the tabular method, as well as data visualisation tools – a line graph, bar charts, box plots and a scatter plot. The data analysed in the article are the food, drinks and tobacco (SITC 0+1) exports of Ukraine to the EU27 and of the EU27 to China, measured in millions of Euros. The timeframe of the data analysed in the article is 10 years – from 2012 to 2021 in-

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clusive. The value of the Pearson correlation coefficient points to the existence of a strong positive correlation between the analysed data sets, while the value of the Spearman correlation coefficient points to the existence of strong – indeed close to perfect – positive correlation between the data sets under research. The p-values corresponding to both the abovementioned coefficients point to the statistical significance of the results obtained and the rejection of H0. The research will contribute a great deal to all the spheres of scientific research connected with data analysis, politics and economics, international relations, international trade in general and of agricultural products in particular, etc. The research presented in this paper and the results thereof will be of interest to and highly useful for those involved in all segments of international trade, public administration officials, decision and policy makers, academic society representatives, as well as beginner and experienced data analysts alike.

Key words

agricultural product exports, correlation, China, the European Union, Ukraine, international trade.

Introduction

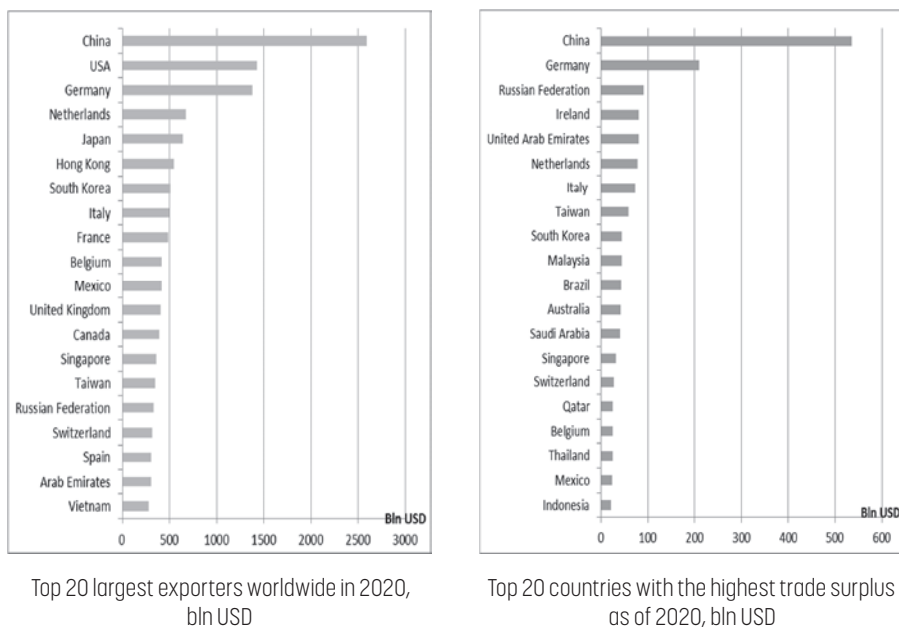
The progress of agriculture approximately 12,000 years ago changed the outline of human life, bringing about a change from the nomadic hunter-gatherer way of life to permanent settlements and farming (National Geographic, n.d.). Since those times, the way humans live has changed a great deal but agriculture has remained of vital importance to humanity in general and in terms of the individual, as well. Agriculture is a significant part of the economy in all countries, but it is especially important for the economic development of developing countries, because it is a source of either food or income and employment, especially for the rural population (Khanna & Solanki, 2014). Due to the differences in the climatic conditions, the availability of water resources, soil fertility, the costs and skills of the labour force and other factors, the availability of agricultural products is not equal in various regions/countries of the world. For that reason, the importance of trade, especially

international trade, is particularly vital in the provision of agricultural products from the regions with surplus production to those with a deficit of such products. Moreover, trade is a key factor in maintaining competitiveness in the global economy and lowering the prices of goods internationally, as it stimulates the development of innovation as well as encouraging markets on different levels to become specialised (Qurban, 2022). Countries that are open to international trade have a tendency to grow faster, implement more innovations, increase the productivity of their industries and provide more opportunities to raise the income of the population (The World Bank, 2018). If there were no trade, the constraint on the food systems, either local or national, in ensuring food security would be larger, carrying with it serious burdens on both natural resources and governmental budgets (Ash & Greenville, 2015). To prove everything stated above, the comparative analysis of the

20 countries which are the largest exporters and with the highest trade surpluses as of

2020 is to be undertaken with the help of the visualisation presented in Figure 1.

Figure 1. Top 20 largest exporters worldwide and the 20 countries with the highest trade surplus as of 2020, bln USD



Source: own elaboration based on data from Statista (2021(a), 2021(b))

According to the data presented on the left of the above Figure, the countries which are commonly perceived as being highly economically developed, and therefore in the strongest positions on the global political stage, are among the world's 10 leading exporters as of 2020. It would be naive to think those countries reached their high positions only thanks to the increased volume of their exports. It is rather a combination of many factors, such as geographical location, developed infrastructure and logistics structure, competent political leadership, etc. which played a role in leading those countries to the highest positions in the world rankings. Nonetheless, exports are considered to be a significant tool of a country's improved economic development, as an increase in exports also brings

about an influx of foreign currency, and allows for an increased volume of imports of capital goods and services, which are significant in terms of increased productivity and economic wealth (Kalaitzi & Chamberlain, 2020).

Coming back to the analysed data visualised in the figure presented above, first place among the most influential nations in terms of the volume of exports is occupied by China. In addition to being the largest exporter worldwide, China was № 2 in the world in terms of GDP, № 2 in total imports, № 68 in terms of GDP per capita and the 28th most complex economy in accordance with the Economic Complexity Index in 2020 (OECD, n.d. (b)). An explanation should be given here to better understand the analysed data – the European Union (EU) itself

is not included in this particular analysis as only individual countries are included, rather than unions or other groups thereof. Although the EU operates as a single market and conducts all negotiations as one entity on behalf of all its member countries, it is nonetheless still a union of countries, not a single country. Nevertheless, it should be stressed here that six of the 20 largest global exporters are EU member countries. It is also important to note that in 2020 China, together with the US and the EU, accounted for 43% of global trade (Eurostat, 2021).

Despite the myriad shortcomings in the export of goods and services, such as the market trade rules of one country differing from those of another, the possibility of losing a certain amount of control due to the distance inherent in business management, etc., most countries do everything possible to increase the volume of exports, since it is believed that the advantage of exports over imports, the so-called positive trade balance, makes the country more influential on the world stage, both economically and politically. Comparing the list of the 20 countries with the largest positive trade surpluses and the leading exporting countries globally in 2020, as well as the actual location of the countries in these lists, we see that in both cases China is the unchallenged leader. One more country occupies a place among the top three in both lists, namely Germany, which ranks third among the leading exporters and has the second largest trade surplus. Apart from China, there is only one country that occupies the same place in both lists, that being Singapore (15th place). All other countries either occupy different places or are completely absent from one of the lists. Thus, for example, the following countries were listed among the leading exporting countries but are not among the top 20 countries with the largest trade surpluses, namely the United States, Japan, Hong Kong, France, the United Kingdom, Canada, Spain, the Arab Emirates and Vietnam.

That is, 45% of the countries on the list of the 20 leading exporters are not among the top 20 countries in terms of the size of their trade surplus.

Both territorially large and small countries, countries with different political systems and religions, politically influential nations and those which we customarily hear very little about are included in the lists above. Nevertheless, in major scientific works and market research, the correlation, and thus the relations and the degree of influence, between the equivalent market players are computed and analysed. The term 'equivalent' is used here to mean being of a similar territory, economic development level, political influence, etc. That is, it goes without saying that a territorially small or underdeveloped or politically non-influential country cannot be considered to have any influence, either economic or political, on territorially large and either economically or politically influential global players. As such, this very gap in the scientific and market research was exactly what motivated the author of the presented research to undertake the current study. Thereby, the research problem is whether such a territorially small country, without a great deal of political influence – at least on the global level – and which is not highly economically developed, such as Ukraine, can be correlated with such a giant player on both economic and political world stages as the EU. Therefore, the purpose of the research is to evaluate whether Ukrainian agricultural exports to the EU27 are correlated with the EU27's agricultural exports to China and, if so, the strength of said correlation.

1. Literature review

Trade has always been vitally important to the development of human civilisation, as trade between countries around the world allows them to make use of raw materials, products, services and technologies which

are not accessible to them on the domestic markets (Pancenکو & Ivanova, 2018). Trade also plays a crucial role in the provision of livelihoods to all those employed along the food supply chain, because it makes a major contribution to the reduction of food insecurity in the world and gives consumers a greater choice of available goods (OECD, n.d. (a)). To be more precise, agricultural trade helps to counter food production shortages due to different reasons, contributing to the prosperity of farmers, industries and consumers (European Commission, n.d. (a)). On the other hand, taking countries' involvement in the trade of agricultural products into account, the distribution of the previously mentioned products in areas with specific or various social and natural conditions is still significant as it results in substantial regional differences in the degree and level of involvement of countries in international trade (Abrahám, Vošta, Čajka, & Rubáček, 2021). In addition, trade helps to organise a reliable, well-integrated global agricultural food system, which, in turn, will help countries withstand unexpected challenges such as the COVID-19 pandemic in the early 2020s, when the world agricultural and food markets showed remarkable resilience (Reliefweb, 2022).

Another integral part of the food system mentioned above is robust and properly functioning markets, which have the ability to:

- increase compensation for investments made in agricultural production;
- provide people who live in rural areas with the chance to specialise in the production of fewer items, which in turn will increase the total amount of goods produced and make said products more affordable;
- help supply to complement demand across regions and seasons, while increasing total sales for producers and ensuring food security, access and availability for consumers of different groups and better standards of living;
- lower food costs, which constitute the largest expenditure of the poorest population stratum (USAID, n.d.).

Due to the extreme significance of agriculture as a whole and the trade in agricultural products in particular, topics connected with either the former or the latter enjoy notable popularity among researchers. One group of academics researches agricultural market development, trends and prospects (Minakov & Nikitin, 2019); agricultural marketing and price analysis (Norwood, Lusk, Peel & Riley, 2021); the riskiness of the agricultural markets in terms of price forecasting and the necessity of intervention policies (Scandizzo, Hazell & Anderson, 2019); the transformation of the agri-food markets towards more sustainable functioning patterns (Borsellino, Schimmenti & El Bilali, 2020); the exchange of risks between the energy and agricultural product markets with the help of a dependence-switching CoVaR-copula model (Ji, Bouri, Roubaud & Shahzad, 2018); the adoption of uncertainty, learning, and technology in agriculture (Chavas & Nauges, 2020); the use of econometric modelling in the formation of optimal prices to be implemented in agricultural production (Volontyr & Zelinska, 2019); the implementation of a game theory approach in the study of the impact of governmental subsidies on agricultural production and pollution (Zhang, Ma & Liu, 2021); the study of the role of peaks and troughs in the agricultural futures market in forecasting stock market volatility (Ma, Zhang, Wahab & Lai, 2019); the study of the costs and structure of common agricultural policy (Buckwell, Harvey, Thomson & Parton, 2019); the interrelations of agricultural intensification, dietary diversity, and markets in the global food security narrative (Ickowitz, Powell, Rowland, Jones & Sunderland, 2019); future price prediction of agricultural products with the help of long-and short-term time series networks (Ouyang, Wei & Wu, 2019); the study of agricultural innovation and

inclusive value-chain development (Devaux, Torero, Donovan & Horton, 2018); research on labour, markets, and agricultural production (Van der Ploeg, 2019); the study of the heterogeneous effects of standards on agricultural product trade flows (Fiankor, Haase & Brümmer, 2021); research on market orientation, innovation, and financial performance in the agricultural value chains in emerging economies (Ho, Nguyen, Adhikari, Miles & Bonney, 2018); the study of the types of risks in agriculture (Komarek, De Pinto & Smith, 2020); the impact of the political economy on agricultural and food policies (Swinen, 2018); and others.

Other scientists concentrate on the factors influencing the way the agricultural markets function as the global impacts of future cropland expansion and intensification on the development of agricultural markets and biodiversity change (Zabel, Delzeit, Schneider et al., 2019); the potential influence of climate change and mitigation on global agriculture by 2050 (Van Meijl, Havlik, Lotze-Campen, Stehfest, Witzke, Domínguez,... & van Zeist, 2018), with a particular subgroup of the latter group containing scientific works on the impact of the COVID-19 pandemic on various aspects of the functioning of the agricultural market (Elleby, Domínguez, Adenauer et al., 2020); the social media impact of COVID-19 on agricultural prices and consumers' buying behaviour (Bansal, Chaturvedi, Saroha, Kaur, Mehra, Ahmad & Vynnychenko, 2020); how the COVID-19 pandemic has influenced agricultural exports (Lin & Zhang, 2020); an overview of lessons from China about the rising concerns over agricultural production during the spread of COVID-19 (Mingzhe & Yu, 2020); mitigation strategies and implications for practitioners in terms of agriculture supply chain risks and COVID-19 (Sharma et al., 2020); an overview of the evidence from food markets in India pertaining to COVID-19 and supply chain disruption (Mahajan & Tomar, 2021); the impact of the

COVID-19 pandemic on the agri-food system (Poppe, 2020); and others.

There are a number of articles focused on the peculiarities of the functioning of agricultural markets in particular localities/regions/countries/continents, such as governments and agricultural markets in Africa (Bates, 1988); a study of the results from pilot market channel assessments of community-supported agriculture marketing performance in Colorado (Jablonski, Sullins & Thilmany, 2019); a study of Dutch contributions to agricultural marketing in tropical Africa (Van der Laan, Dijkstra & van Tilburg, 2018); research into the high-frequency volatility of connectedness between US crude oil and Chinese agricultural commodity markets (Luo & Ji, 2018); an overview of actions taken by the government of India and agricultural policy during the COVID-19 lockdown (Narayan & Saha, 2020); an overview of the experience of Ukraine and Poland in terms of the competitive advantages of wholesale agricultural product markets as a type of entrepreneurial activity (Boiko, Kwilinski, Misiuk & Boiko, 2019); a study on the effects of the inclusion of agricultural products in the customs union between Turkey and the EU (Grethe, 2003); an overview of the empirical evidence from agricultural commodity spot and futures markets in India as related to price discovery and volatility spillover (Manogna & Mishra, 2020); a study on the issues, challenges and prospects for the agricultural sector value chain and government policy in Nigeria (Olomu, Ekperiware & Akinlo, 2020); research on the evolution of agricultural policy in Kazakhstan (Baubekova, Tikhonova & Kvasha, 2021); the assumptions pertaining to the utility of agricultural commodity prices as a predictor of Nigerian inflation (Tule, Salisu & Chiemeké, 2019); a study of the implementation of the econometric approach towards agricultural credit and productivity in Bangladesh (Islam, 2020); research on the development of the organic

farming market in Europe and the European Union (Willer, Schaack & Lernoud, 2019); a study on the resilience of agricultural value chains in the context of developing countries (Vroegindewey & Hodbod, 2018); and others. Thus, as far as one can see, there are a great deal of scientific works researching either trade in general or the agricultural products trade in particular as well as the functioning of said markets, but the lack of publications on the correlation/relations between the subjects of those markets constitutes a gap in the scientific research which the author has attempted to fill by conducting the research presented in this article.

2. Methodology

As the agricultural products trade in general and exports in particular are vitally important for the survival and functionality of mankind, the profound analysis of the present state of matters as well as the dynamics thereof and making credible projections are, in turn, very important for the successful functioning of international trade as a whole as well as the export of agricultural products in particular, as a key component of international trade. The data analysed in the article are the food, drinks and tobacco (SITC 0+1) exports of Ukraine to the EU27 and of the EU27 to China, measured in millions of Euros. The abbreviation SITC denotes the Standard International Trade Classification, which is the United Nations product classification used for external trade statistics, including export and import values as well as volumes of goods traded, making it possible to conduct international comparisons of commodities and manufactured goods (Eurostat, n.d.). The timeframe of the data analysed in the article is a period of 10 years, that is, from 2012 to 2021 inclusive.

The aim of the research, as has already been stated above, is to estimate whether such a territorially small country, without a great deal of political influence – at least

on the global level – and which is not highly economically developed, such as Ukraine, can be correlated with such a giant player on both economic and political world stages as the EU. The 27 member countries comprising the European Union are hereinafter referred to as the EU27. The novelty value of the research is the estimation of the presence/absence of correlation between one of the spheres of economic activity of a small and politically non-influential country and that of a large, economically and politically strong global player. The scientific question to be answered while conducting the research is whether the export of Ukrainian agricultural products to the EU27 is correlated with the export of EU27 agricultural products to China and, if so, to calculate the strength of said correlation.

In order to answer the scientific question mentioned above to the largest possible degree as well as to achieve the aim of the presented research, the comparative analysis of Ukrainian agricultural exports to the EU27 and from the EU27 to China, as well as the dynamics thereof, was conducted with the help of a line graph to visualise the results of said analysis. The comparative analysis of Ukrainian agricultural exports to the EU27 and from the EU27 to China with differences to previous periods is presented using bar charts to better visualise the analysed data. The visual verification of the presence/absence of the correlation between Ukrainian agricultural exports to the EU27 and similar exports from the EU27 to China was done by means of a scatter plot of the data collected. The simple statistics of both data sets were presented using the tabular method; while the Pearson correlation coefficient as well as the corresponding *p*-value of Ukrainian agricultural exports to the EU27 with those from the EU27 to China were computed and analysed in the article. It should be noted here that the Pearson correlation coefficient is used to estimate the strength of a linear association between two variables,

where the value $r = 1$ means a perfect positive correlation and the value $r = -1$ means a perfect negative correlation (Social Science

Statistics, n.d.). The Pearson correlation coefficient is calculated according to the formula presented below:

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}} \quad (1),$$

where:

r – Pearson correlation coefficient;

n – number of stock pairs (Srivastav & Vaidya, n.d.).

In order to make the analysis more credible, Ukrainian agricultural exports to the EU27 and those from the EU27 to China were tested for normality by means of univariate statistical analysis, the results of which were presented using box plots as a data visualisation tool. To be perfectly sure

of the research results and to once again verify those from the analyses, the Spearman correlation coefficient and its corresponding p -value were calculated and analysed in the article. The Spearman rank correlation coefficient (Spearman ρ) is a nonparametric measurement correlation which is used to assess the relationship between two data sets (Springerlink, n.d.). A simpler formula for the Spearman rank correlation coefficient calculation is presented below:

$$\rho = 1 - \frac{6\sum d_i^2}{n(n^2-1)} \quad (2),$$

where:

ρ – Spearman rank correlation coefficient;

d_i – difference between a pair of ranks;

n – number of observations (Cheusheva, 2022).

The Spearman rank correlation coefficient test does not require the data to be normally distributed.

3. Research results

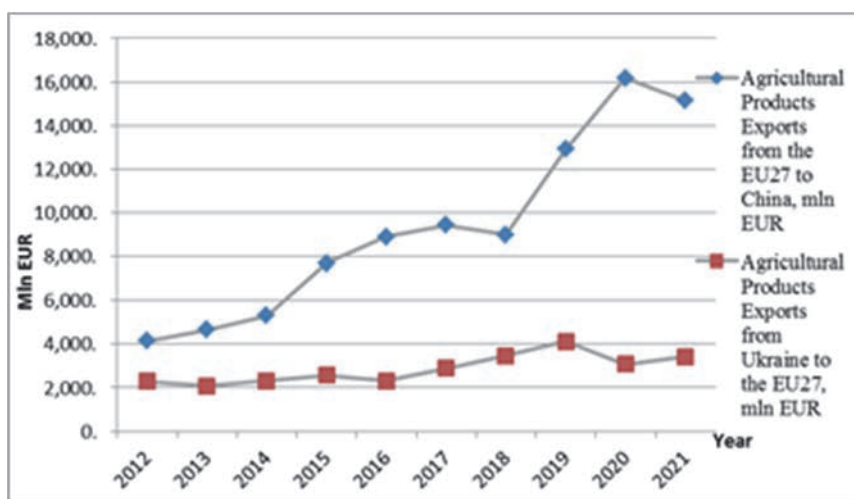
The international agri-food products trade has grown enormously during the last 20 years, expanding almost 7% annually in real terms between 2001 and 2019 on an increasingly global scale (OECD, n.d. (b)). The design and pattern of international agricultural trade is undergoing intense changes (Sun Q. et al, 2022). New players are constantly entering the lists of the top producers/exporters/importers of agricultural products, changing either the pattern of the international agri-production trade or the ranking of the global players on the agricultural products market. Countries which have recently been considered underdeveloped and not

worth paying a great deal of attention to in the context of global geopolitics have begun to ascend the world rankings of global agricultural producers/exporters/importers, meaning that nominally more powerful nations now take them into account when analysing the world agri-market, modelling, forecasting, etc. An example of such a country is Ukraine, a country situated in Eastern Europe (Britannica, 2022). In 2000 Ukraine exported only 0.47% of the world's cereals, while in 2020 the country was the third largest exporter of cereals worldwide, accounting for 8.14% of global cereal exports (OEC, n.d. (a)), behind only the USA (15.7%) and the Russian Federation (8.95%). Given such a volume, Ukraine is often referred to as the breadbasket of Europe, as approximately 25% of the world's most fertile black soil is on Ukrainian territory. The main agricultural crops of which Ukraine is known to be one of the world's top agricultural producers and exporters are grains and forage crops, including wheat, corn, barley, sunflower, sugar beet, legumes, fruits and vegetables, tobacco, etc. (DLF, 2020). Ukraine has a rather

large consumer market, an educated and cost-competitive work force, as well as rich natural resources. Ukraine's Association Agreement with the EU gives Ukraine preferential market access and is accelerating Ukraine's economic integration with the EU (U.S. Department of State, 2020). The main aim of the Association Agreement (AA) / Deep and Comprehensive Free Trade Area (DCFTA) is to increase the trade in goods and services between the EU and Ukraine by decreasing trade tariffs and gradually changing Ukraine's laws on trade, bringing

them in accordance with those of the EU. Thanks to the abovementioned agreements, the European Union is already Ukraine's largest trading partner, accounting for approximately 40% of its total trade as of 2019. In turn, Ukraine is the 18th largest trading partner of the European Union, accounting for approximately 1.1% of the EU's total trade (European Commission, 2021). The comparative analysis of Ukrainian agricultural exports to the EU27 with the same exports from the EU27 to China is the first step of the research, which is presented in Figure 2.

Figure 2. Exports of agricultural products from Ukraine to the EU27 and from the EU27 to China, mln EUR



Source: own elaboration based on data from Eurostat (2022 [c])

The visual presentation of the data which was the subject of analysis in the above image allows one to discern the differences in both the amount of exports mentioned above and the dynamics of said exports more clearly. The first difference, which seems obvious when observing the data, is the difference between the dynamics of the research data – Ukrainian agricultural exports to the EU27 are smoother than those of the EU27 to China. Although the difference between the researched export amounts is apparent from the data visualisation presented above,

the simple statistics allow one to draw more precise conclusions, namely that the mean of the exports of EU27 agricultural products to China is approximately 3.3 times higher than those from Ukraine to the EU27. The highest observation value of the data set of agricultural exports from the EU27 to China, which can be observed in 2020, is around 3.9 times higher than that of Ukraine to the EU, which was in 2019. The lowest observation value of the EU27 to China agro-exports data set, in this case from 2012, is almost twice as high than that from the data set

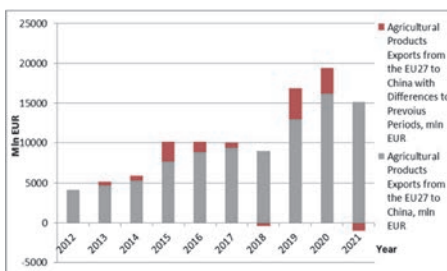
pertaining to Ukrainian agricultural product exports to the EU27, observed in the following year of 2013. This leads to another conclusion about the analysed data sets, namely that the years in which the highest and the lowest volumes of exports were observed did not coincide. The changes of the analysed data dynamics, especially during the last years of the research timeframe, may be perceived as being somewhat contradictory, and thus perhaps even more interesting. According to the conventional point of view, the COVID-19 pandemic negatively influenced the main indicators of economic activity; however, according to the data shown in Figure 2, both agro-export figures noted an increase (a relatively small one of approximately 653 mln EUR for Ukrainian exports to the EU27 and a significantly larger one of 3918 mln EUR for EU27 exports to China). In the next year, one may observe a completely different situation in terms of

changes in the dynamics of the data – another large increase in exports from the EU27 to China, and the opposite, that is, a decrease in Ukrainian agricultural exports to the EU27 of approximately 1048 mln EUR. The year 2021 was considered to be a year, in which either the global or most local economies recovered from the Covid-19 pandemics' impacts, at least according to numerous scientific and mass media publications. The change in the amount of Ukrainian agricultural products exported to the EU27 proves that, with an increase of approximately 349 mln EUR. However, a completely different picture, contradicting the conventional viewpoint, can be seen in the case of EU27 agro-exports to China, namely a decrease in the level of said exports of approximately 1037 mln EUR. Further analysis of the export of Ukrainian agricultural products to the EU27 and from the EU27 to China can be done using the data visualised in Figure 3.

Figure 3. Export of agricultural products from Ukraine to the EU27 and from the EU27 to China with differences to previous periods, mln EUR



Agricultural products exported from Ukraine to the EU27 with differences to previous periods, mln EUR



Agricultural products exported from the EU27 to China with differences to previous periods, mln EUR

Source: own elaboration based on data from Eurostat (2022 [c])

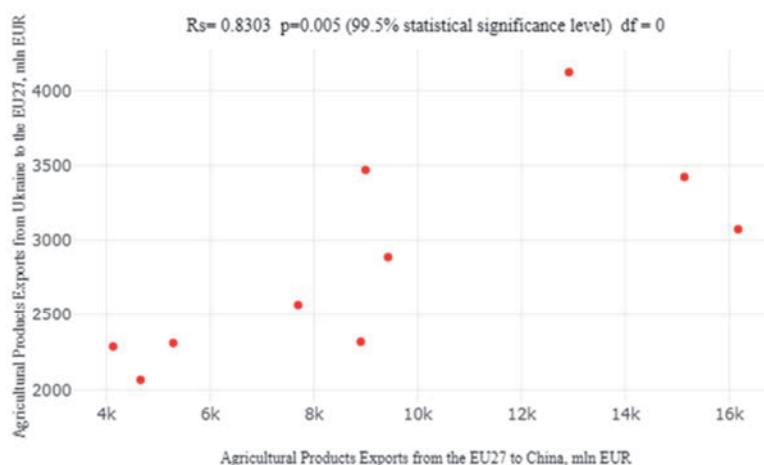
Upon further analysis of how Ukrainian agro-exports to the EU27 and those from the EU27 to China changed when compared to previous periods, it should be stated that the negative changes to said exports from Ukraine to the EU may be observed in 2013, 2016 and 2020, while a decrease in exports from the EU27 to China can be seen

in 2018 and 2021. This means that there was not a single year in which a decrease in the level of exports is observed in both data sets for that given year. The largest decline in the amount of agro-exports from Ukraine to the EU27 was in 2020, while the smallest was 2013. Furthermore, EU27 agro-exports to China decreased the least in 2018 and

the most in 2021. If Ukrainian agricultural exports to the EU27 appear smoother than those of the EU27 to China, when observing the agro-exports together with the differences to the previous periods included, the Ukrainian ones are more changeable than those of the EU27 to China. One could even mention the cyclicity in the export of Ukrainian agricultural products to the EU27 if the periods were of the same length, but the first period of year-on-year increases lasted two years (2014 and 2015), while the second such period ran for three years (2017–2019). A completely different picture was given in the case of agro-exports from the EU27

to China, that is to say the first period of constant upward trends in the data dynamics lasted from the beginning of the analysed timeframe to 2017 inclusive. It was then interrupted in 2018 by a decline in exports of approximately 433 mln EUR, followed by a second upward period in 2019, which in turn lasted only two years (2019 and 2020). It is worth noting that in all of the years 2014, 2015, 2017 and 2019, increases in both Ukraine – EU27 and EU27 – China agricultural exports could be seen. After obtaining the research results, a scatter plot was used to assist with the visual interpretation of the analysis and the results thereof (Figure 4).

Figure 4. Scatter plot of agricultural product exports from Ukraine to the EU27 vs. from the EU27 to China



Source: own elaboration with the help of Barcelona Field Studies Centre (2022) based on data from Eurostat (2022 (c))

A scatterplot, also called a scattergram or a scatter diagram, is no mere data visualisation tool as it displays a relationship between two sets of data (Texas Gateway, n.d.). Inspecting the data presented in the figure given above, we conclude that there is a medium to strong positive correlation between Ukrainian agricultural exports to the EU27 and those from the EU27 to China. Such a conclusion has been made as the dots, denoting data observations, do not form

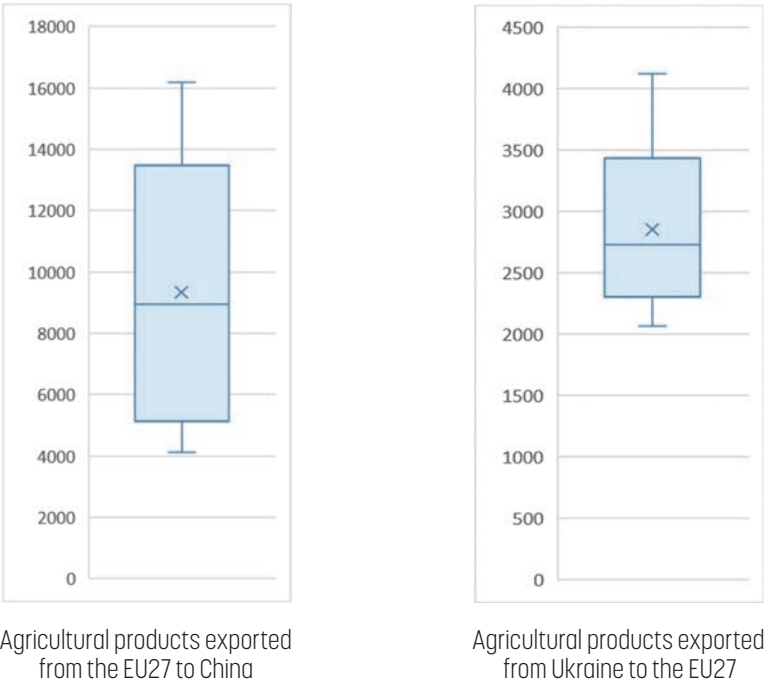
a perfect straight line in the plot; nonetheless, an upward tendency can be observed, although the dots are somewhat spread out from the imagined straight line denoting a theoretical perfect correlation. As the upward tendency of the data observations is viewed in the scatter plot, we conclude that there is evidence of the presence of a positive correlation between the analysed data sets, except for the last two observations. It is clear from the scatter plot above that

a correlation between the analysed data sets exists. Despite the fact that a scatter plot is a suitable tool by means of which to visualise the presence/absence of the correlation between the researched data sets, it does not give precise results, only an approximation. In order to obtain more robust results to reach scientifically sound conclusions, the Pearson correlation coefficient (given the H_0 of ρ equals zero) and its corresponding p -value have been computed, as the Pearson correlation coefficient measures either the strength or the direction of the linear relationship between two continuous variables, whose values can extend from -1 to +1 (Frost, n.d.). The Pearson correlation coefficient of Ukrainian agricultural product exports to the EU27 with those from the EU27 to China has a value of 0.7377 (Social Science Statistics, n.d. (a)). Such a value

indicates the existence of a strong positive correlation between the analysed data sets. To ensure that the test results are statistically significant, attention should be paid to the corresponding p -value, which in this case is 0.014877. With the confidence intervals of 95%, meaning $\alpha=0.05$, the p -value corresponding to the calculated Pearson correlation coefficient between the analysed data sets defines the abovementioned coefficient as statistically significant. Consequently, we can reject the H_0 that there is no correlation between the data sets.

As one of the assumptions of the calculation of the Pearson correlation coefficient is the need for the analysed data sets to be at least approximately normally distributed, the data sets were tested for normality. A visual presentation of the results of normality testing is displayed in Figure 5.

Figure 5. Box plots for agricultural products exported from Ukraine to the EU27 and from the EU27 to China



Source: own elaboration based on data from Eurostat (2022 (c))

A box plot is a typical way of displaying the distribution of the analysed data based on the summary of five indicators ('minimum', first quartile (Q1), median, third quartile (Q3), and 'maximum') (Galarnyk, 2018). Having observed the box plots given above, we see that the so-called 'whiskers' are not even and the median differs from

the mean, which in turn points to the fact that none of the researched data sets can be considered normally distributed, albeit the violations are relatively small. So as not to base the conclusions on the visual presentation of the data alone, the simple statistics for said data were calculated and grouped in Table 1.

Table 1. Simple statistics of the volume of agricultural products exported from the EU27 to China vs. from Ukraine to the EU27

Indicators	Agricultural products exported from the EU27 to China, mln EUR	Agricultural products exported from Ukraine to the EU27, mln EUR
Minimum	4130.9	2066.7
Q1	5289.2	2310.2
Median	8948.7	2728.45
Q3	12913.2	3423.9
Maximum	16174.4	4123
Mean	9332.46	2853.13
Skewness	0.453577	0.699958
Kurtosis	-0.970052	-0.396467
Outliers	None	None

Source: own calculations with the help of Statistics Kingdom (n.d.) based on data from Eurostat (2022 [c])

Judging by the data in the table shown above, the violations of normality are larger for the Ukraine – EU27 data set when compared to those of the EU27 – China one. In addition, both data sets are slightly skewed to the right, albeit some scientists engaged in statistical analysis consider data sets with such small violations to be almost normally distributed. Moreover, both data sets are platykurtic. Nevertheless, none of the analysed data sets have outliers, which justifies the use of Pearson correlation testing. At the same time, due to the violations of normality of the data sets under research, the above-mentioned results of the analysis cannot be considered sufficiently credible to draw definitive conclusions on the matter. For this

reason, the Spearman correlation coefficient (given a H_0 of ρ equals zero) and the corresponding p -value have been calculated, as the Spearman rank correlation coefficient is a nonparametric test measuring the correlation based on data ranks, for which approximate normal distribution for the analysed data sets are not required (Penn State, 2022). Having considered the Spearman correlation coefficient of Ukrainian agricultural exports to the EU27 with those from the EU27 to China, which amounts to 0.8303 (Social Science Statistics n.d. (b)), it should be stated that the value of said coefficient indicates the existence of strong – indeed close to perfect – positive correlation between the researched data sets. With the confidence

limits of 95%, that is, $\alpha = 0.05$, the calculated p -value corresponding to the Spearman correlation coefficient of Ukrainian agro-exports to the EU27 with those from the EU27 to China, which has a value of 0.00294, points to the statistical significance of the results obtained, allowing us to reject the H_0 of no correlation between the analysed data sets. It should, however, be stressed here that the fact that the H_0 was rejected does not automatically mean the acceptance of the alternative.

4. Discussion

The world is still adapting to a post-pandemic reality stressed by inflation shocks, energy scarcity, and geopolitical tensions in various parts thereof (McKinsey & Company, 2022). Markets in different parts of the world have continued to tumble as recession panic reoccurred with the central banks of many countries raising rates in an effort to slow down inflation (Pronina & Valero, 2022). Russia's February 2022 invasion of Ukraine appeared to be the latest in a sequence of events that have sent shockwaves through the global order and raised serious concerns about the nature and frequency of state-to-state military conflicts, the course of globalisation and technological innovation, as well as the utility and legacy of multilateral institutions (CSIS, 2022). Political and economic turbulence in one part of the world causes uncertainty/problems/distortions in another part or parts of the world, be it a small, underdeveloped country, a political/economic union of nations or an entire continent, as politics, economics, sociology, etc. are currently closely interrelated with each other in the globalised world. For example, the ongoing war in Ukraine, which affects a region vitally important to global food security, is giving rise to uncertainty and increased risk of the fragmentation of global agri-food markets, magnifying hunger threats which were already very high because of the COVID-19 pandemic, political and military conflicts in various

countries, as well as humanitarian crises in different parts of the world (Reliefweb, 2022). The abovementioned war has also had a significant effect on the global markets and food supply, because blockades of Ukrainian grain exports have worsened hunger in many vulnerable regions of the world, as Ukraine has always been a large exporter of grain, having fed 400 million people around the world in 2021 (IRC, 2022). More than that, the price of fuels has also risen as a consequence of Russia's unprovoked and unjustified aggression against Ukraine, which has also led to the rise of concerns connected with the security of the energy supply, especially in the EU (Council of the European Union, 2022).

The EU itself has experienced some political and economic turbulence including the risks of natural gas stockpiles running out in the middle of the current winter peak demand, if Russian gas supplies through critical pipelines are partially or even completely halted (Pronina & Valero, 2022). In addition, the annual inflation rate in the eurozone was 10.6% in October 2022, compared to 9.9% in September, while in the previous year, the corresponding rate was 4.1%. Annual inflation in the European Union was 11.5% in October 2022, up from 10.9% in September, while a year earlier the rate was 4.4% (Eurostat, 2022 (a)). In addition to the issues listed above, it is possible to add increased rental prices; European sugar prices – already the highest in four years – pushing up the cost of food; the corruption scandal in the European Parliament, etc.

In the midst of the strengthening geopolitical tensions and shifting political dynamics in some member states of the European Union, companies and investors with particular interest in EU – China relations could expect the bilateral relations between said parties to remain rather turbulent despite cautious re-engagement, while taking the risks of further deterioration into account (FIPRA, 2022). In China itself, neither the economic nor political situation can be

seen as cause for optimism. Three factors are largely at fault for this: the so-called zero-Covid policy, a decline in the property sector, which accounts for approximately 30% of China's GDP, and an extensive clampdown on Big Tech (Dutt, P., 2022). The new Chinese leadership elected at the 20th Communist Party Congress is viewed as more ideologically and politically oriented, while those retiring are considered to be more growth- and market-oriented; for this reason, according to Western media, China could be moving away from its decades-long trend of opening up its economy to the world (Duan, 2022). All of the above makes the author's attempt to assess the presence/absence of the correlation between such global market players, interesting from both political and economic points of view, even more interesting and useful, offering an abundance of potential directions for further research.

Conclusions

Agriculture is extremely significant to the survival and successful functioning of humanity in both a general and individual sense. Moreover, sustainable agriculture is pivotal to ensuring of food security (Rampa, 2012), whether on the global level or in a single country/region/village. Due to the myriad challenges which the whole world is faced with nowadays, such as climate change, the rapid increase of the global population, the larger number of people living below the poverty line, epidemics of various diseases that affect the population of different parts of the world, etc., an increasing number of governments understand the vital importance of agriculture as a whole and the consistent availability of agricultural products for their populations in particular. For this reason, the trade of agricultural products plays an increasingly important role, not only for underdeveloped countries, but for highly economically developed and politically influential ones as well. In terms of agricultural production, the

European Union is best known for livestock products (including dairy), grains, vegetables, wine, fruits, and sugar. The most commonly exported items are grains (wheat and barley), dairy products, poultry, pork, fruit, vegetables, olive oil, and wine (ERS/USDA, 2022). Extra-EU trade in agricultural products accounted for 9% of the total extra-EU international goods trade as of 2020, while in the period from 2002 to 2020 the volume of the abovementioned trade of the EU doubled (Eurostat, 2022(b)).

The European Union is the Ukraine's largest trading partner, while at the same time Ukraine is 18th on the list of EU trading partners (European Commission, 2021). All the main subject matters of EU – Ukraine relations are touched on in the Ukraine–European Union Association Agreement and the Deep and Comprehensive Free Trade Area (DCFTA). EU – China trade relations are outlined in the Comprehensive Agreement on Investment (CAI), which grants investors from the European Union a greater degree of access to the Chinese market. As the CAI has not yet been ratified, said agreement has not yet entered into force (European Commission, n.d. (b)). Though Ukraine is a territorially relatively small country and is not seen as being particularly highly economically developed or politically influential, the research presented in this paper was dedicated to the evaluation of whether a country such as Ukraine is correlated with the most powerful ones in terms of the volume of their agricultural exports.

The dynamics of the export of Ukrainian agricultural products to the EU27 are smoother than those of the EU27 to China. Simple statistical calculations show that the agro-exports of Ukraine to the EU27 are approximately three times smaller than those of the EU27 to China. In addition, there is no similarity between the particular years in which agro-exports declined across the two analysed data sets, as agro-exports from Ukraine to the EU27 decreased in 2013, 2016

and 2020, while those from the EU27 to China did so in 2018 and 2021. By contrast, a rise in the exports of agricultural products in both data sets under analysis may be observed in 2014, 2015, 2017 and 2019. If Ukrainian agricultural exports to the EU27 do not appear as steep as those of the EU27 to China, when observing the agro-exports with their differences to the previous periods, Ukrainian exports are more changeable than those of the EU27 to China. According to the data visualisation on the scatter plot, it is possible to draw a conclusion about the presence of a low to medium positive correlation between Ukrainian agricultural product exports to the EU27 and those from the EU27 to China.

The value of the Pearson correlation coefficient of Ukrainian agricultural product exports to the EU27 and those from the EU27 to China points to the existence of strong positive correlation between the analysed data sets. With the default confidence intervals of 95%, meaning $\alpha=0.05$, the p -value corresponding to the Pearson correlation coefficient between the analysed data sets defines the abovementioned coefficient as statistically significant. Consequently, H_0 pertaining to there being no correlation between the data sets can be rejected. The Spearman correlation coefficient value of Ukrainian agricultural exports to the EU27 and those from the EU27 to China points to the existence of strong – indeed close to perfect – positive correlation between the data sets mentioned above. With the confidence limits of 95%, that is, $\alpha=0.05$, the p -value corresponding to the Spearman correlation coefficient of the agro-exports from Ukraine to the EU27 with those from the EU27 to China points to the statistical significance of the obtained results, allowing for the rejection of H_0 pertaining to there being no correlation between the analysed data sets. However, the rejection of the H_0 does not automatically mean the acceptance of the alternative. Thus, we see that neither the size of the territory occupied by

the country, nor its political system or level of influence on the international arena, can be a determining factor in making the country an important player on the international trade market in general as well as the agricultural products market in particular.

The presented research will contribute a great deal to all the spheres of scientific research connected with data analysis, political economy, international relations, international trade in general and of agricultural products in particular, etc. The research presented in the paper, as well as the results thereof, will be of interest and highly useful to those involved in all segments of international trade, public administration officials, decision and policy makers, academic society representatives, as well as beginner and experienced data analysts alike. A possible direction for further research could be in the investigation of the specific agricultural products between which correlation is the strongest; by further expanding the number of subjects involved in the agro-trade and the evaluation of the strength of correlation between them; or by modelling and forecasting the volume of agro-exports on a regional and global scale, etc.

There are some limitations of the further expansion of the research, of which the main one is the terrible events currently taking place in Ukraine. The estimated amount of the agricultural land taken from Ukraine by the aggressor country is approximately 20%. Moreover, the situation has not been resolved in any shape or form. How long will these terrible events go on for? What steps are to be made to resolve the situation to the satisfaction of all parties? How will it influence agricultural production and, therefore, the export of Ukrainian agricultural products? All such questions may either be considered limitations to the expansion of the research presented in the paper, or alternatively – notwithstanding how strange it might sound – directions for subsequent important research.

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Design of a tool to measure the behavioural aspect of conscious and sustainable consumer attitudes

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Abstract

The article focuses on consumer attitudes in the context of conscious and sustainable consumer behaviour. The authors aim to create a tool to measure the behavioural aspect of responsibility and sustainability in consumer attitudes and to examine the impact of selected factors on this rate. Empirical research was conducted on a sample of 510 households. The reliability of the new research tool was verified based on the estimation of reliability coefficients – McDonald's omega and Cronbach's alpha. The newly created tool is examined with the help of EFA. The influence of selected demographic factors was also examined, using a one-way ANOVA test to verify hypotheses. Respondents undertake awareness and sustainability actions at an average level of frequency. It can be concluded that gender and age represent significant factors in awareness and sustainability. At the same time, four key areas of sustainability and awareness were identified, namely the civic engagement dimension, consumer awareness, the circular thinking effect, and social responsibility. It is these factors that can be described as key to conscious and sustainable behaviour. Of course, the use of inquiry (with the help of a questionnaire) instead of observation as a scientific research method allows for the examination of only self-reported behaviour. This study may allow for a better understanding and measurement of attitudes in terms of conscious and sustainable consumer behaviour. Few authors focus on measuring behavioural intention, while the emphasis is often placed on the cognitive and affective components of attitudes.

Key words

behavioural component of consumer attitudes, conscious consumption, social behaviour, sustainable consumer attitudes.

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Introduction

The world is evolving and the negative impact of mankind on the environment is becoming increasingly apparent. This impact is largely marked by consumer behaviour, awareness and a willingness to act sustainably. In general, consumer attitude consists of three components, namely cognitive, affective and behavioural (Rosenberg and Hovland, 1960; Ajzen and Fishbein, 1975). Many experts examine the cognitive component, as it represents the knowledge consumers already possess. Knowledge is the basic input that determines how one will act. The affective component represents emotions that can be segmented into two generic categories, namely positive and negative (Čvirik, 2020). It should be noted that classical theories of consumer behaviour as a part of marketing perceive the consumer thought processes as a black box (Kotler and Keller, 2012), which points to the fact that even if the consumer has knowledge and positive emotions, it does not necessarily evoke a behavioural intention (activity). This is where a significant gap in scientific research can be observed.

This article aims to create a tool to measure the behavioural aspect of responsibility and sustainability in consumer attitudes and to examine the impact of selected factors on this rate.

In this article, we focus on examining the behavioural component of consumer attitude in the context of awareness and sustainability. It is important to realise that the behavioural aspect is very difficult to capture through the primary survey, as the behavioural aspect is manifested in two forms, namely action and inaction. To advance the knowledge base of this issue, we examined the behavioural component in terms of frequency of activities, which makes it possible to obtain more sensitive data. We have thus created a simple tool for measuring the frequency of the behavioural component in the

context of sustainable and conscious consumer attitudes. The tool offers the possibility of measurement in different segments, in different geographical locations and with the possibility of subsequent comparison.

Based on the primary survey, it is possible to state the average activity in the field of awareness and sustainability among Slovaks. The results also suggest the influence of age and gender on the frequency of activities, but education and the size of the city of residence do not appear to be significant factors. The results can be used to create marketing campaigns to support sustainable and conscious consumer activities.

1. Literature review

Environmental and social responsibility has an important place in consumer behaviour. The trend of ecological and responsible consumption contributes to the creation of a new lifestyle, and thus also to an emerging segment of consumers, which needs to be identified in more detail. Roche et al. (2009) define sustainable consumption as “the use of products that deliver a better quality of life while minimising the use of scarce natural resources and health-threatening toxic materials, as well as reducing emissions and pollutants throughout the product life cycle so as not to jeopardise future generations’ needs”.

Socially responsible consumption can be understood as consumer behaviour and purchasing decisions related to environmental and scarce resources, motivated not only by a desire to meet personal needs but also by an interest in the well-being of society in general (Antil, 1984; Antil and Bennett, 1979). Based on the above, a responsible consumer can be understood as a consumer who perceives the social and environmental consequences of his consumption and seeks to influence it in a positive way toward achieving global prosperity (Maciejewski

and Lesznik, 2022). In this context, several aspects influence responsible behaviour.

Abdul Wahid et al. (2011) concluded that consumers are increasingly demanding environmentally friendly products. Whereas previously it was possible to recognise the environmental aspect of the product as a competitive advantage, nowadays in the context of the circular economy we speak of necessity (often arising from the law, such as that in Slovakia on the obligation to back up PET bottles – Act 302/2019). In the literature, one may find research showing that environmental considerations, as well as social responsibility, are becoming important factors in consumers' purchasing preferences (Roberts, 1995, 1996a, 1996b; Binninger and Robert, 2008; Zakersalehi and Zakersalehi, 2012; Kita et al., 2021; Maciejewski et al., 2021). In some cases, consumers prefer environmental and social responsibility instead of price (Sua et al., 2012).

Chabowski et al. state that there is a need for a thorough examination of sustainability measures and standards, and there are various tools for measuring awareness. In the context of awareness, the authors consider three generic groups, namely environmental, social and economic (Chabowski et al., 2011). In the professional literature, one may observe several tools and concepts examining consumer awareness. Examples include Consumer Consciousness for Sustainable Consumption (Balderjahn et al., 2013), Ethically Minded Consumer Behaviour (Sudbury-Riley and Kohlbacher, 2016) and the SCB-cube model (Geifer et al., 2018), which, however, focus on cognitive and affective components of attitude.

As notable authors (e.g. Antilles and Bennett, 1979; Courtenay-Hall and Rogers, 2002; Gough, 2002; Čvirik and Ölveczká, 2020) emphasise, the model of consumer behaviour (Rosenberg-Hovland, 1960; Ajzen and Fishbein, 1975) in the context of environmental and social responsibility can also be understood in terms of cognitive,

affective and behavioural dimensions. Many authors focus on the cognitive aspect, examining consumers' knowledge base on the subject. The author of the theory of planned behaviour, Ajzen, states that the generic component is action-intent itself (Ajzen, 1991). However, it is necessary to realise that it is the behavioural component that is the actual behavioural intention, and therefore it is necessary to thoroughly examine this component. It is possible that even if the consumer has information about the correctness of a certain activity (cognitive aspect) he will not carry out his activities according to it. It is based on this logic and the gap in the study of the behavioural aspect of this issue that led to the decision to examine the behavioural aspect of awareness and sustainability in consumer attitudes.

2. Methodology

In the article, several scientific methods are used, which include scientific and philosophical methods (analysis, synthesis, scientific abstraction and the like), but also mathematical and statistical methods. In this work, methods of descriptive and inductive statistics are employed to help achieve the goal of the research.

2.1. Characteristics of the studied sample

The presented article is supported by a primary survey, which was carried out by the method of questioning, specifically in the form of a questionnaire survey. The basic population was defined as Slovak consumers over the age of 18. The age restriction was added for (1) ethical reasons and (2) also due to the fact that 18 years represents the age of adulthood, when certain knowledge, a general view of the world, as well as the ability to solve important life challenges can be expected. Empirical research was conducted in the form of a pre-prepared and agreed-upon structured online interview with each respondent. The respondents were selected

by contacting them based on their e-mail addresses. 534 respondents took part in the survey, but 24 questionnaires had to be excluded due to incomplete data. Based on the above, it can be stated that 510 respondents

formed the sample which became the basis for the research. The sample has similar parameters to the wider population but is not identical. The basic characteristics of the sample are given in Table 1.

Table 1. Sample characteristics

Factor	Value	n (frequency)	n (relative frequency in %)
Gender	female	290	56.86
	male	220	43.14
Age	18-24	118	23.14
	25-39	136	26.66
	40-59	159	31.18
	60 and over	97	19.02
Level of education	Basic education	29	5.69
	Apprenticeship	81	15.88
	High school	215	42.16
	University	185	36.27
Size of the city of residence (population)	Up to 5000	139	27.25
	5000 – 50,000	152	29.80
	50,000-200,000	95	18.63
	over 200,000	124	24.32
Σ:		510	100

Source: own calculations

As part of the data collection process, CAWI (computer-assisted web interviewing) techniques were used and appropriately supplemented with PAPI (paper-assisted personal interviewing) techniques.

2.2. Design of a model for measuring activities (the behavioural aspect) of sustainable and conscious consumer attitudes

The proposed model may be characterised as a scale tool consisting of 18 statements, to which the respondent responds on a five-point frequency scale (1 – never; 2 – almost never; 3 – from time to time, 4 – almost always; 5 – always). The aim was to examine the frequency of key activities in the context of social awareness, environmental

awareness, as well as sustainable development in terms of the behavioural component of consumer attitudes. As this is a newly created tool, it is necessary to verify its reliability. From the point of view of reliability assessment, two reliability estimation coefficients were used, namely McDonald's ω and Cronbach's α . Both coefficients have certain advantages and limitations, so the decision was made to use both for maximum objectivity. In general, a result above 0.700 is considered to be an acceptable estimate of reliability. Both coefficients show a high degree of reliability of the tool (McDonald's ω = 0.851; Cronbach's α = 0.852). From the scientific research on the creation of new measuring tools, it is appropriate to examine the impact of individual items on reliability. In

this context, it can be stated that if an element/statement is excluded and the tool has a higher rate of reliability estimation, its exclusion is deemed appropriate. The results of the “if an item is dropped” method are recorded in Table 2.

Table 2. Reliability estimation results

Items	McDonald's ω^*	Cronbach's α^{**}
1. I am involved in social assistance campaigns such as Apple Day, Daffodil Day, etc.	0.844	0.846
2. I volunteer and help other people.	0.844	0.846
3. I act in the interests of protecting the natural environment (planting trees, clearing forests, feeding forest animals, etc.).	0.835	0.840
4. I work for organisations that support sustainable development goals (organisations working in the field of environmental protection, working against social exclusion, gender equality, equality between nations, etc.).	0.846	0.848
5. I install ecological elements in my home (heat pumps, solar panels and photovoltaics, water and wastewater treatment plants, etc.).	0.835	0.840
6. I buy goods and services from companies that care about the environment.	0.835	0.839
7. I buy used clothes and other such goods.	0.846	0.847
8. I repair or have damaged appliances, furniture, etc. repaired.	0.847	0.848
9. I regularly give goods and unnecessary items to charities.	0.839	0.843
10. I save electricity and gas.	0.843	0.841
11. I save water.	0.844	0.842
12. I act in such a way that I do not pollute the environment.	0.844	0.844
13. I support a healthy lifestyle in my environment (active rest, healthy eating, reducing stimuli, etc.).	0.842	0.845
14. I sort waste and take care to recycle it.	0.843	0.843
15. I try not to waste food.	0.847	0.847
16. I try to reduce consumption by buying goods and services that are needed in advance.	0.843	0.842
17. In the elections, I vote for candidates who declare their support for disadvantaged social groups or care for the natural environment.	0.850	0.851
18. I support various types of humanitarian organisations through monetary donations (Caritas, UNICEF, etc.).	0.844	0.846

Notes: * Total McDonald's ω for the tool = 0.851 (CI 95% = <0.832 – 0.869>). ** Total Cronbach's α for the tool = 0.852 (CI 95% = <0.832 – 0.870>).

Source: own calculations

The results in Table 2 indicate that it is not necessary to exclude any of the statements, and it can be stated that the newly created tool represents a reliable whole.

3. Research results

In the next part of the article, we focus on answering research questions and hypotheses that will help to fulfil the main goal of the article.

RQ1. How can the frequency of individual items be assessed?

Respondents commented on individual statements in terms of frequency of activity, with 1 representing never, 2 – rarely, 3 – from time to time, 4 – almost always, and 5 – always. It follows from the above that the higher the value, the higher the subjective frequency of activity. The mean values and standard deviations for individual statements are recorded in Table 3.

Table 3. Mean values and standard deviations of individual statements

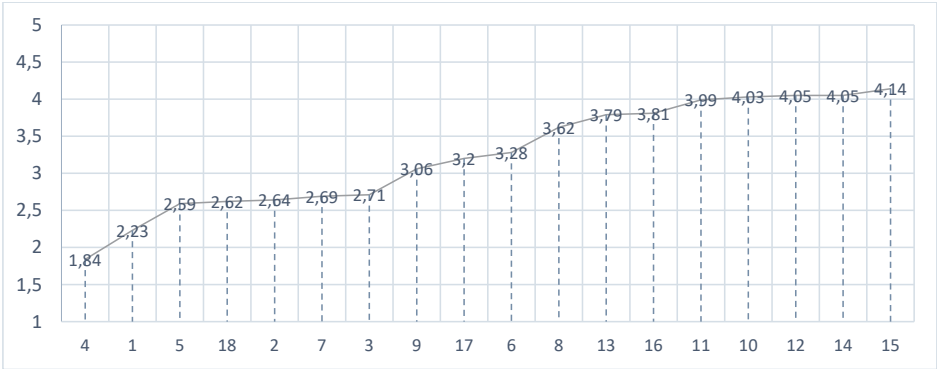
Items	CODE	Mean	St. Dev.
1. I am involved in social assistance campaigns such as Apple Day, Daffodil Day, etc.	Q.1.1	2.23	1.141
2. I volunteer and help other people.	Q.1.2	2.64	1.024
3. I act in the interests of protecting the natural environment (planting trees, clearing forests, feeding forest animals, etc.).	Q.1.3	2.71	1.098
4. I work for organisations that support sustainable development goals (organisations working in the field of environmental protection, working against social exclusion, gender equality, equality between nations, etc.).	Q.1.4	1.84	1.038
5. I install ecological elements in my home (heat pumps, solar panels and photovoltaics, water and wastewater treatment plants, etc.).	Q.1.5	2.59	1.250
6. I buy goods and services from companies that care about the environment.	Q.1.6	3.28	1.045
7. I buy used clothes and other such goods.	Q.1.7	2.69	1.092
8. I repair or have damaged appliances, furniture, etc. repaired.	Q.1.8	3.62	0.977
9. I regularly give goods and unnecessary items to charities.	Q.1.9	3.06	1.165
10. I save electricity and gas.	Q.1.10	4.03	0.944
11. I save water.	Q.1.11	3.99	0.969
12. I act in such a way that I do not pollute the environment.	Q.1.12	4.05	0.783
13. I support a healthy lifestyle in my environment (active rest, healthy eating, reducing stimuli, etc.).	Q.1.13	3.79	0.999
14. I sort waste and take care to recycle it.	Q.1.14	4.05	0.976
15. I try not to waste food.	Q.1.15	4.14	0.912
16. I try to reduce consumption by buying goods and services that are needed in advance.	Q.1.16	3.81	0.972
17. In the elections, I vote for candidates who declare their support for disadvantaged social groups or care for the natural environment.	Q.1.17	3.20	1.091
18. I support various types of humanitarian organisations through monetary donations (Caritas, UNICEF, etc.).	Q.1.18	2.62	1.188

Source: own calculations

Table 3 shows that the lowest frequency of activities occurs in terms of working for organisations supporting sustainable development goals (mean 1.84; st. dev. 1.038) and the highest-frequency activity is the effort

not to waste food (mean 4.14; st. dev. 0.976). On closer examination, individual activities were ranked based on their average frequency (Figure 1).

Figure 1. Average frequency (ascending) of individual activities



Note: the x-axis represents the coded description of each statement; the y-axis represents the average score.

Source: own processing

- RQ2:** How can the frequency of conscious and sustainable attitudes be characterised based on the created tool?
The average value represents 58.34 points (St. dev. = 10 points). The mode and median are at the level of 59 points. The minimum measured value was at the level of 28 points and the maximum measured value was at the level of 85 points. Overall, this level can be perceived as average.
- RQ3:** How can the influence of selected factors on the frequency of the behavioural component be characterised in the context of sustainable and conscious attitudes?
- H1:** There is a relationship between gender and the frequency of the behavioural component in the context of sustainable and conscious attitudes.

- H2:** There is a relationship between age and the frequency of the behavioural component in the context of sustainable and conscious attitudes.
- H3:** There is a relationship between education and the frequency of the behavioural component in the context of sustainable and conscious attitudes.
- H4:** There is a relationship between the size of the city of residence and the frequency of the behavioural component in the context of sustainable and conscious attitudes.
- During the examination of the selected factors (gender, age, education and size of the city of residence), the focus was on basic demographic factors. The average frequency values are recorded in Table 4.

Table 4. Average values for the examined segments

Factor		Mean score
Gender	female	59.63
	male	56.63
Age	18-24	55.75
	25-39	56.98
	40-59	59.11
	60 and over	62.12
Level of education	Basic education	54.79
	Apprenticeship	57.52
	High school	58.43
	University	59.15
The size of the city of residence (population)	Up to 5000	58.00
	5000 – 50,000	58.80
	50,000 – 200,000	59.23
	over 200,000	57.46

Source: own processing

Table 4 shows some differences, but these data can only be considered informative. To determine the influence of the factor, hypotheses were formulated and subsequently verified using a one-way ANOVA test. The

ANOVA test was chosen for its robustness, and due to the nature and properties of the data. The key results of the one-way ANOVA test are given in Table 5.

Table 5. Key outputs of the one-way ANOVA test

Factor	Hypothesis	P-value	alfa	df
Gender	H1	0.0008	0.05	509
Age	H2	1.08E-05	0.05	509
Level of education	H3	0.1439	0.05	509
The size of the city of residence	H4	0.5329	0.05	509

Source: own calculations

Based on Table 5, it can be stated that gender and age have a significant impact on the frequency of the behavioural component in the context of sustainable and conscious attitude, measured with the help of the newly

created tool. In the case of education and the size of the city of residence, no significant impact has been demonstrated. Based on the findings, hypotheses H1 and H2 are accepted and hypotheses H3 and H4 are rejected.

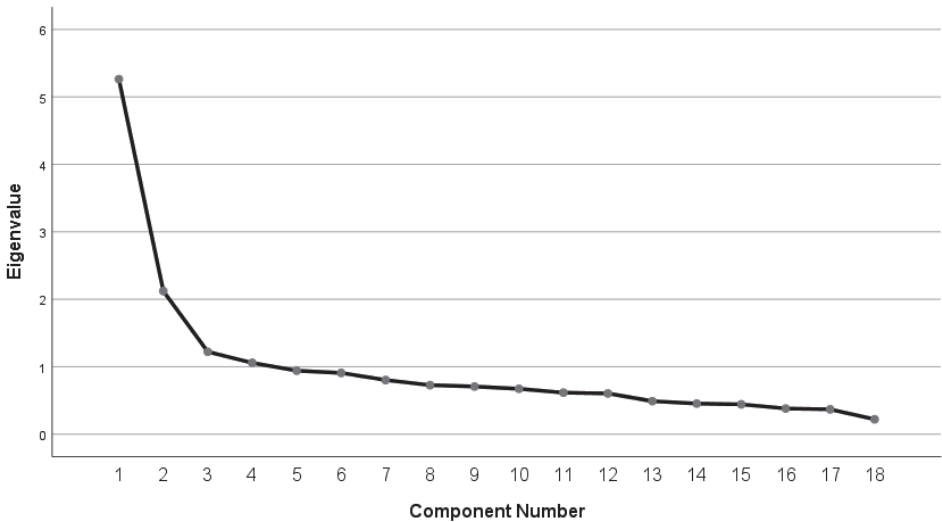
RQ4: How can the dimensionality of a research instrument be evaluated?

To examine the dimensionality of the presented research tool, exploratory factor analysis (EFA), which will also help in examining the validity of the tool, was used. First of all, it was necessary to verify whether it is possible to use EFA. The assumptions of using EFA were verified based on the Kaiser-Meyer-Olkin Measure of Sampling Adequacy and Bartlett's Test of Sphericity. In the Kaiser-Meyer-Olkin Measure of Sampling Adequacy, as a rule, the minimum value is above 0.500 and the recommended value is above 0.700. The value obtained was at the level of 0.844, which is more than satisfactory. Bartlett's Test of Sphericity tests the hypothesis of zero correlation within the variables. The result of Bartlett's Test of Sphericity at the

alpha level (0.05) indicates the appropriateness of using EFA (Approx. Chi-Square = 2788.012; df = 153; Sig. = <0.001). Based on the Kaiser-Meyer-Olkin Measure of Sampling Adequacy and Bartlett's Test of Sphericity, it can be concluded that the tool is suitable for EFA use.

If it has been proven that the use of EFA is appropriate, the next step is to determine the methodological procedure. In the article, the Extraction Method – Principal Component Analysis was used, and as a final solution the Rotation Method – Oblimin (delta = 0) with Kaiser Normalisation was used (due to the nature of the data and the examination of several possibilities, a connection between the latent factors was found). The number of factors that will represent the number of groups (latent variables) was examined within the framework of graphic visualisation with the help of a scree plot (Figure 2).

Figure 2. Scree plot



Source: own processing

Figure 2 has the number of possible components (groups of factors) on the x-axis and eigenvalues on the y-axis. Since the Kaiser Normalisation rule was used, the Eigenvalues should be greater than 1. Chart 1 indicates

that the instrument hides four latent variables. When examining the affiliation of statements to dimensions as well as their character, cumulative explained variance, the pattern matrix was used (Table 6).

Table 6. Pattern matrix

Question / statement	Component			
	Component 1	Component 2	Component 3	Component 4
Q.1.1		0.742		
Q.1.2		0.744		
Q.1.3		0.671		
Q.1.4		0.664		
Q.1.5		0.571		
Q.1.6				0.488
Q.1.7			0.545	
Q.1.8			0.733	
Q.1.9		0.530		
Q.1.10	0.651			
Q.1.11	0.696			
Q.1.12	0.623			
Q.1.13	0.444			
Q.1.14	0.561			
Q.1.15	0.769			
Q.1.16	0.620			
Q.1.17				0.703
Q.1.18		0.527		
Explained variance (in %)	29.2	11.8	6.8	5.9

Notes: Extraction Method: Principal Component Analysis. Rotation Method: Oblimin with Kaiser Normalisation.

Source: own processing

Based on Table 6, it can be concluded that the tool shows four dimensions. The first dimension explains roughly 29.2% of the total variance and contains seven statements (namely statements 10, 11, 12, 13, 14, 15, 16). The second dimension explains roughly 11.9% of the variance and contains seven statements (namely statements 1, 2, 3, 4, 5, 9, 18). The third and fourth components cover two statements each, with the third dimension explaining roughly 6.8% of the variance and the fourth roughly 5.9% of the variance. The cumulatively presented dimensions explain roughly 54% of the

variance. There is a weak positive correlation between the dimensions. This correlation clearly points to the correct choice of oblimin type rotation (varimax would distort the information).
Considering the nature of the statements (based on semiotics), dimension 1 can be characterised as the ‘civic engagement dimension’, dimension 2 as ‘consumer awareness’, dimension 3 as the ‘circular thinking effect’ and dimension 4 as ‘social responsibility’. It is these factors that can be described as the key to conscious and sustainable behaviour.

4. Discussion

In this paper, the measurement of the behavioural component (the frequency thereof) was addressed in the context of conscious and sustainable consumer attitudes. The results indicate the average level (frequency) of the behavioural component of consumer attitudes. However, it can be stated that some activities are more frequent and others are less so, which leaves a space for marketing activities to increase this frequency. In general, consumers are aware of the issue of pollution and environmental degradation, and the frequency of these activities is relatively high. Activities related to the sustainability of consumer activities are less frequent. The reason for this may be intense marketing communication promoting the need for environmental and social awareness and lower promotion of sustainability as a factor associated with awareness.

The results indicate a significant effect of age and gender on the behavioural component. In general, women are more aware of sustainability and behave in a more sustainable manner. Older consumers also display a higher frequency of sustainability and awareness-raising activities, perhaps due to the fact that they have more time to create beneficial activities. It may also be a sense of guilt, as it is the older generations who have lived longer in disharmony with higher principles than ecological and social awareness. The level of (formal) education was not a significant factor, which only confirms that the cognitive component does not necessarily manifest in the behavioural one. The size of the place (city) of residence also does not appear to be a significant factor influencing the frequency of activities of conscious and sustainable consumer attitudes.

When examining the dimensionality tool, four dimensions were identified, namely (1) the 'civic engagement dimension', (2) the 'consumption awareness dimension', (3) the 'circular thinking dimension', and (4) the

'social responsibility dimension'. These dimensions are perceived as key within consumer attitudes in the context of conscious and responsible behaviour. In the future, it would be appropriate to investigate the dimensionality of the tool in other countries for the purposes of comparison across countries and regions. These results would help identify countries with a high frequency of sustainable and conscious behaviour, which could serve as a model for other countries (with a lower frequency). The results are important, not only for the marketing activities of companies, but also for government institutions dealing with the issue.

Conclusions

The article aimed to create a tool to measure the behavioural aspect of responsibility and sustainability in consumer behaviour and to examine the impact of selected factors on this rate. This objective can be considered fulfilled.

A tool for measuring the behavioural aspect has been created, and will significantly contribute to the knowledge basis of the issue. At the same time, the tool was put into practice in Slovakia. The results of empirical research in that nation indicate the average frequency of activities related to sustainability and awareness in consumer attitudes. Factors that affect this rate, namely age and gender, have also been determined. In general, it can be argued that women are more frequently active in this context than men, and older consumers are more active than young people.

With the help of EFA, the authors concluded that the proposed multidimensional measurement tool contains four dimensions. The dimensions are in accordance with the theoretical level, which served as the basis for the creation of the tool and statements.

The results can be used in marketing communications, creating marketing campaigns to promote environmental and social

awareness as well as sustainability, all focused on behavioural intent. The results can help raise awareness and sustainability levels in shaping the concept. Both frequent activities in this trend and relatively weak points (activities with a low frequency of activity) are indicated. The contribution of the article lies in the creation and testing of a model of consumer awareness and sustainability theory in the context of the behavioural component. Although the behavioural component is often overlooked in the scientific sphere, it can be noted that the behavioural component is the result of consumer attitudes.

The work also contains certain limitations. It should be noted that the primary survey was conducted using a questionnaire, which may have caused a certain amount of distortion. To partially eliminate possible distortions, mathematical-statistical methods, which indicate a high level of data reliability, were used; the results can be generalised with the help of inductive statistics. Of course, the use of inquiry (with the help of a questionnaire) instead of observation as a scientific research method allows one to examine only "self-reported behaviour". In the future, it would be advisable to supplement the results with field observation.

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Exploring the Determinants of Private Sector Credit in Pakistan: A Sectoral Analysis

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Abstract

This study empirically explores the existence of any cross-sector differences in bank lending behaviour in Pakistan. A wider set of both demand- and supply-side variables are included, and the ARDL model is employed to estimate the results. The empirical findings confirm that significant cross-sector differences regarding the impact of different variables on private sector credit exist in the short run. Moreover, in the long run, the impact of various factors on credit to the private sector are the same across sectors. While domestic deposits positively influence credit, non-performing loans have a negative effect on credit. Interest rate has no significant effect on credit in either the short or long term. Lastly, government borrowing from commercial banks crowds out the private sector. The findings point towards a weaker transmission of monetary policy through the credit channel and support the idea that the availability of funds is more important for private sector credit penetration in a country such as Pakistan with limited resources, whereby effective policy measures are needed to stimulate savings in the economy.

Key words

Private sector credit, Crowding out, Money supply, Credit penetration.

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Introduction

Private sector credit is one of the key factors promoting high and sustainable economic growth in any economy. It helps to accumulate capital and increases the long-term productive capacity of the economy. The availability of long-term credit at an affordable cost helps financially constrained firms

to fund their investment projects (Noth, 2011; Behr et al., 2013). Countries with a higher percentage of private sector credit as GDP were able to achieve higher income per capita, whereas countries with low private sector credit penetration are left behind. The existing literature (Osman, 2014; Marshal et al.,

2015; Olowofeso et al., 2015; Samargandi and Kutun, 2016) confirms the crucial role of bank credit in boosting economic growth, especially in emerging markets.

Private sector credit is also important from the policy perspective due to its close and direct association with business cycles as well as policy rate. Therefore, it is considered the most powerful channel of the monetary policy transmission mechanism. As a reliable indicator, it also helps smoothen the business cycle fluctuations through the prudent adjustment of the policy rate by the central bank. The credit channel works via the following two linkages: (i) monetary policy-induced changes impact the supply of bank loans (the bank lending channel); (ii) they also affect the net worth, cash flow and liquid assets of the borrowing firms (the balance sheet channel), which, in turn, affects their level of activity (Bernanke and Gertler, 1995). Therefore, in the presence of the credit channel, the impact of changes to monetary policy on the cost of borrowing is magnified, as this channel reinforces the traditional money channel (Ignacio, 2014).

Despite its importance being endorsed by the theoretical and empirical literature, the credit-to-GDP ratio is low in many developing and emerging economies. In the case of Pakistan, the level of credit penetration is much lower than the regional economies. Furthermore, the penetration of private sector credit also deteriorated over time in Pakistan compared to regional and emerging economies. During the 1980s and 1990s, Pakistan's position was somewhat better; however, its ranking among its peers began to decline from 2000 onwards. For instance, during the period of 2011-2020, private sector credit as a percentage of GDP in Pakistan fell to 16.9%, compared to an increase to 51.3% in India, 41.5% in Sri Lanka and 44.4% in Bangladesh (**Table 1**). Private sector credit in Pakistan is not only low but also concentrated in a relatively small number of sectors.

Bearing in mind its vital role in defining the growth trajectory of the economy, it is imperative to identify the key determinants impacting credit to the private sector. Given the level of development of the financial markets and the structure of the economy, many demand-side as well as supply-side factors influence private sector credit. Furthermore, the significance of these factors may also vary across different sectors of the economy depending on the nature of their production and forward and backward linkages. Therefore, research exploring sector-wise determinants is essential to enhancing our understanding of the dynamics of private sector credit. The literature analysing this aspect is scant, however, especially in the case of emerging economies.

Most of the available studies on Pakistan consider the demand-side factors impacting private sector credit (Qayyum, 2002; Khawaja, 2007; Awan, 2009; Afzal and Mirza, 2010; Ali et al., 2011; Hassan and Qayyum, 2013; Bellalah et al., 2013; Zaheer et al., 2017). Only two studies (Imran and Nishat, 2012; Ahmed, 2016) take account of supply-side determinants as well. However, none of them consider sector-wise determinants of bank credit in the case of Pakistan. It is an established fact that the associations on one level of analysis may not necessarily reflect the similar strength on another level. Thus, the use of aggregate data may yield regression coefficients exhibiting considerable bias above their values at individual level (Hansan, 1971). Therefore, this study is an attempt to fill this gap. The contribution of this study is twofold: (i) to enrich the analyses by including a wider set of both demand- and supply-side determinants; (ii) to empirically identify whether any sectoral differences in bank lending behaviour exist. Biannual panel data for Pakistan from 2011 to 2021 is used in the analysis. The reason for the choice of this time span is the availability of biannual data for certain variables of interest. Nine sectors with a major share

in the credit market for which data is available are included.

The rest of the study is organised as follows: section 2 presents a review of the existing literature; trends of certain key variables are shown in section 3; data and methodology are discussed in section 4; section 5 presents the estimation and discussion of results; while section 6 concludes the study.

1. Literature

The existing literature available on bank lending behaviour may be classified into three broad categories (Tomak, 2013). The first category examines a bank's lending behaviour during a period of crisis (Gupta, 2012; Ho et al., 2012; Swamy and Sreejesh, 2012; Cull, 2012; Allen et al., 2013; Kapan and Minoiu, 2013). The second category evaluates the impact of banking ownership on the lending behaviour of banks (La Porta et al., 2002; Micco and Panizza, 2006; Poncet et al., 2010). Lastly, the third category investigates the overall drivers of bank lending (Olokoyo, 2011; Olusanya et al., 2012; Imran and Nishat, 2012; Djiogap and Ngomsi, 2012; Bellalah et al., 2013; Hassan and Qayyum, 2013; Rabab'ah, 2015; Aftab et al., 2016; Ahmed, 2016; Zaheer et al., 2017; Kasingu et al., 2020). The focus of most of the studies remains on either evidence from the cross-country level or on analysing the maturities of bank loans from the perspective of the borrower. Some of the studies explore determinants at bank level influencing long-term loans to businesses (Djiogap and Ngomsi, 2012).

a) Cross-country studies

Olokoyo (2011) evaluated the determinants of lending behaviour of commercial banks in the Nigerian economy. Variables included in the analysis are advances, deposits, banks' investment portfolios, the lending rate, the cash reserve requirements ratio and the liquidity ratio. The author found a robust relationship

between bank advances and the remainder of the variables included in the analysis.

Djiogap and Ngomsi (2012) attempted to investigate the factors affecting long-term loans from banks. Their study used a sample comprising 35 banks from six African economies, and the main finding of their study was that long-term loans made by banks to businesses depend on the size of the bank, long-term liabilities, capitalisation and the rate of GDP growth. The authors pinned down the significance of supply-side factors in making long-term loans to businesses. The study finds differences in bank lending at cross-country level, suggesting that bank size, capitalisation, sources of funding and the NPL ratio are important in determining the degree of aversion to long-term lending in a recessionary environment.

Backé and Zumer (2005) investigated the dynamics of private sector credit in selected European Union countries. Their analysis included a larger set of both supply- and demand-side factors influencing private sector credit, namely bank reforms, macroeconomic stabilisation, financial sector liberalisation, inflation, interest rates, privatisation and the restructuring of the banking sector. The study suggests that public sector credit does not have the impact of crowding out private sector credit. It is also argued that the level of financial depth will promote the growth of credit as these economies grow.

Eller et al. (2010) attempted to study the factors affecting private sector credit in 11 economies in Central, Eastern and South-Eastern Europe. Their results show that a long-run relationship exists between credit and economic activity. Furthermore, they confirm the presence of significant correlation between credit growth and supply factors in the short term, with varying degrees across the sub-periods.

Chernykh and Theodossiou (2011) inspected the factors affecting the ability of banks to extend loans in the Russian economy. Their findings emphasise the

importance of supply-side factors for banks' decisions to extend long-term loans to businesses. These factors include the size of the bank, capitalisation, and the availability of long-term liabilities.

Tomak (2013) explored the effect of bank size, inflation, GDP and the interest rate on overall lending in Turkey. The author analysed bank-level data from three public banks and 15 private banks for the purposes of estimation. The empirical results suggest that total liabilities, bank size, inflation rate and NPL ratio are important determinants of loans extended to business. Furthermore, the ownership structure of a bank also matters, as private bank loans perform better compared to state-owned banks.

Assefa (2014) examined the impact of domestic deposits, interest rate on advances, foreign liabilities, reserve requirements, inflation and money supply on bank lending in Ethiopia. The results suggest the significant impact of interest rates, foreign liabilities, domestic deposits, inflation and money supply on private sector credit in the long run. However, domestic deposits and economic growth do not influence private sector credit in the short run. Moreover, reserve requirements do not affect credit offered by commercial banks to the private sector in either the short or the long run.

Rabab'ah (2015) attempted to explore the factors affecting bank lending in the case of Jordan, analysing 10 Jordanian commercial banks during the period of 2005-2013. Further, the study used a larger set of variables, including the ratio of credit facilities to total assets, the NPL ratio, the deposit ratio, the liquidity ratio, the legal reserve ratio, the capital ratio, the lending rate, the deposit rate, asset size, economic growth and inflation. The findings suggest a significant negative impact of NPLs, liquidity and window rate on credit, and find a positive and significant impact in the case of bank size and economic growth.

Kasingu et al. (2020) estimated the impact of various demand- and supply-side factors on bank lending in Papua New Guinea. The authors argued that bank deposits, real GDP, net foreign assets and the exchange rate significantly and positively affect private sector credit in both the short and long run. However, lending rates were found to have no significant impact on credit to the private sector.

b) Pakistan

Imran and Nishat (2012) examined the determinants of bank credit in the case of Pakistan. The findings suggest that domestic deposits, economic growth, exchange rate, banks' foreign liabilities and overall monetary conditions are important determinants of private sector credit in the country in the long run, whereas inflation and the money market rate have no impact on private sector credit.

Qayyum and Hassan (2013) assessed the influence of interest rates, future expectations pertaining to economic condition, external demand and inflation on demand for loans in Pakistan. The results highlight the significance of interest rates, inflation, and economic activity as determinants of demand for bank loans. On the other hand, future expectations pertaining to economic condition and external demand have hardly any impact on demand for credit in Pakistan.

Bellalah et al. (2011) investigated the relationship between private sector credit and selected determinants, including GDP, money supply, public sector credit, and gross domestic savings in Pakistan. The authors concluded that higher government borrowing crowds out the private sector in the country.

Aftab et al. (2016) studied the impact of interest rates on credit in Pakistan. The authors found a significant negative impact of interest rates, and conversely a positive impact of inflation, on credit in both the short and long run.

Ahmed (2016) estimated the impact of demand- and supply-side factors on private sector credit in Pakistan. He found that, on the demand side, economic activity positively impacts credit, while inflation has a negative effect. On the supply front, bank lending capacity improves credit, whereas government borrowing crowds out private sector credit.

Zaheer et al. (2017) evaluated the impact of different variables on private credit in Pakistan. The results suggest that government borrowing crowds out private sector credit. Furthermore, the lending capacity of banks and industrial production have a significant positive impact on the private sector. However, CPI was found to have no influence on private sector credit.

2. Trends of certain key variables

Private sector credit is considered to be a major determinant of economic growth, especially in the case of developing countries such as Pakistan. However, the level of credit penetration in the Pakistani economy is much lower within the region, as well as when compared to other emerging economies. During the period of 2011-2020, private sector credit as a percentage of GDP in Pakistan was 16.9%, compared to 51.3% in India, 44.4% in Bangladesh and 41.5% in Sri Lanka. It was even much lower than the average (72.2%) of emerging market economies (EMEs).

Table 1. Regional Comparison of Key Macroeconomic Indicators

Period	Savings (% of GDP)					PSC (% of GDP)					Per Capita Income (USD)				
	Pak	Ind	Ban	Sri	EMEs	Pak	Ind	Ban	Sri	EMEs	Pak	Ind	Ban	Sri	EMEs
1981-1990	17.8	17.2	21.9	24.9	25.4	25.3	24.4	12.1	20.0	42.3	355	313	248	375	1,601
1991-2000	18.0	25.4	23.8	23.1	25.7	23.8	24.3	18.4	21.5	63.0	467	376	355	713	3,267
2001-2010	18.4	33.4	34.0	22.9	26.8	24.1	40.6	30.5	30.7	53.7	780	811	544	1,499	4,770
2011-2020	14.5	32.5	37.1	28.2	26.9	16.9	51.3	44.4	41.5	72.2	1,297	1,724	1,358	3,738	9,001

Source: World Bank

Although private credit levels in Pakistan were relatively higher in South Asia in the 1980s and remained stable until 2010, they declined sharply during the 2010s. On the other hand, other countries in the region were able to increase their credit levels substantially. Many factors, both domestic and global, contributed to the decline of private sector credit in Pakistan, including the uncertainty triggered by the global financial crisis, the condition of law and order in the country and the implementation of the Basel Accords, etc. In addition, the savings rate in Pakistan fell to 14.5% during 2011-2020, down from 18.4% in 2001-2010. This decline came despite the

rise in per capita income in Pakistan, albeit at a slower pace compared to its regional counterparts. The declining trend in national savings is a serious challenge to the sustainable growth and prosperity of the country. Therefore, there is a dire need to initiate policy measures on the part of government and SBP to address this crucial issue. However, the achievement of this goal would be a challenging task due to the multi-causal relationship between national income, the savings rate, and credit to the private sector.

Another problem in addition to low credit penetration in Pakistan is that a large share of credit is short-term in nature, i.e. working

capital loans rather than longer-term investment loans. Some policy measures are required to incentivise the private sector to invest in long-term projects, which is essential to enhancing the productive capacity of the economy.

Table 2. Sectoral Contribution – Loans by Type of Finance

Variables	Textile	Sugar	Rice	Fertiliser	Cement	Refined Petroleum	Electric Power	Construction	Wholesale & Retail Trade
Total loans	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Working Capital	66.5	62.7	95.9	62.7	37.4	79.8	43.5	12.3	77.2
Fixed Investment	33.2	37.2	4.1	37.3	61.8	20.2	56.3	18.6	22.0
Construction Financing	0.3	0.1	0.1	–	0.8	–	0.2	69.1	0.8

Source: State Bank of Pakistan

Table 3 presents sector-wise summary statistics of certain key variables. These statistics show considerable cross-sector differences in credit growth, LSM growth, NPL ratio and weighted average lending rate (WALR).

Table 3. Summary Statistics Mean (Standard Deviation)

Variables	Textile	Sugar	Rice	Fertiliser	Cement	Refined Petroleum	Electric Power	Construction	Wholesale & Retail Trade
Credit Growth	8.4 [7.4]	13.0 [13.1]	13.0 [16.8]	7.1 [19.5]	13.5 [31.2]	15.4 [19.5]	8.3 [12.2]	10.9 [20.3]	8.7 [9.3]
LSM Growth	1.5 [3.6]	5.5 [16.5]	5.5 [16.5]	4.6 [8.9]	6.5 [9.4]	4.8 [14.8]	5.7 [13.0]	6.7 [8.2]	3.7 [6.4]
NPLs Ratio	22.2 [6.3]	10.5 [6.5]	9.6 [1.8]	6.7 [1.9]	13 [10.1]	9.6 [1.8]	4.4 [1.0]	9.6 [1.8]	9.6 [1.8]
WALR	7.7 [1.7]	9.4 [1.9]	9.4 [1.9]	9.4 [2.0]	9.1 [1.8]	9.1 [2.3]	9.9 [2.2]	10.0 [2.0]	9.9 [2.0]

Source: State Bank of Pakistan, and authors’ calculation

3. Data/Methodology

The study explores factors affecting credit to the private sector in the economy of Pakistan. A panel comprising nine sectors is included in the analysis for which data is available, namely textiles, sugar, rice, fertiliser, cement, refined petroleum, electric power, construction, and wholesale & retail trade. Disaggregated data from June 2011 to June 2021 is used on a biannual frequency.

The reason for the choice of these time periods and frequency was the unavailability of sectoral data for some variables on monthly basis. The data was obtained from the State Bank of Pakistan. The existing literature on determinants of PSC indicates that both bank-level variables (for example, size, ownership structure, capitalisation and access to funds) and some of the major market-based variables (for example, inflation, interest rate, and GDP) affect PSC as

per the dynamics of the respective economy. According to the literature and economic theory, economic activity, the inflation rate, monetary conditions, domestic deposits, and exchange rate positively affect credit, whereas the interest rate, non-performing loans, and government borrowing from commercial banks shrink private credit. Therefore, the following variables are included in the analysis: private credit (PC),

domestic deposits (DD), exchange rate (ER), LSM Index (Y), weighted average lending rate (R), non-performing loans ratio (NPL), relative price, i.e. the ratio of sector-specific CPI to general CPI (RP), money supply (M2), and government borrowings from commercial banks (GB).

The model used in the study is presented as follows:

$$PC_t = \alpha_0 + \alpha_1 Y_t + \alpha_2 RP_t + \alpha_3 M_t + \alpha_4 DD_t + \alpha_5 YR_t + \alpha_6 NR_t + \alpha_7 GB_t + \alpha_8 ER_t + \varepsilon_t \quad (1)$$

All the variables are taken in log-growth form, except WALR and NPL. To determine the long-run association among variables, this study applies the Autoregressive Distributed Lag (ARDL) approach developed by Pesaran (1997). This technique has several advantages over other conventional methods of co-integration such as that of Johansen and Juselius (1990). One of the major advantages of this approach is that it offers a view of both the short-run and

long-run relationships between variables. Furthermore, it is capable of tackling the problem of endogeneity (Pesaran and Shin, 1999). It is equally useful with a small sample size. In addition, it can be applied irrespective of the order of integration of variables, i.e. whether they are I (0) or I (1) (Pesaran and Pesaran, 1997).

Equation (1) can be written in ARDL form as follows:

$$\begin{aligned} \Delta PC_t = & \alpha_0 + \alpha_1 Y_{t-1} + \alpha_2 RP_{t-1} + \alpha_3 M_{t-1} + \alpha_4 DD_{t-1} + \alpha_5 YR_{t-1} + \\ & \alpha_6 NR_{t-1} + \alpha_7 GB_{t-1} + \alpha_8 ER_{t-1} + \sum_{i=1}^n \beta_k \Delta PC_t + \sum_{i=1}^n \gamma_k \Delta Y_t + \\ & \sum_{i=1}^n \delta_k \Delta RP_{t-i} + \sum_{i=1}^n \sigma_k \Delta M_{t-i} + \sum_{i=1}^n \rho_k \Delta DD_{t-i} + \sum_{i=1}^n \tau_k \Delta NR_{t-i} + \\ & \sum_{i=1}^n \tau_k \Delta R_{t-i} + \sum_{i=1}^n \omega_k \Delta GB_{t-i} + \sum_{i=1}^n \varphi_k \Delta ER_{t-i} + \mu_t \end{aligned} \quad (2)$$

4. Discussion of empirical results

a) Combined results

The estimated combined results of all sectors are given in Table 4. The results show that in the long run, LSM, inflation, government borrowing from commercial banks, exchange rate depreciation, and non-performing loans all have a negative and statistically significant impact on private sector credit. The negative impact of LSM/GDP on private sector credit is contrary to the results of earlier studies on Pakistan (Imran and Nishat, 2012; Qayyum and Hassan, 2013; Ahmed, 2016; Zaheer et al., 2017). However, it is possible that the growth of LSM may reduce the

borrowing needs of businesses due to an improvement in their liquidity position in the long run. The signs of coefficients with inflation, government borrowing from commercial banks and non-performing loans are consistent with economic theory.

Studies on Pakistan show mixed results regarding the impact of inflation on private sector credit. For instance, Qayyum and Hassan (2013) and Ahmed (2016) show a negative association between inflation and private sector credit, while Imran and Nishat (2012), Zaheer et al. (2017) and Aftab et al. (2016) indicate the positive effect of inflation on private sector credit. Bellalah et al. (2013), Ahmed (2016) and Zaheer et

al. (2017) show that government borrowing from commercial banks crowds out the private sector. However, the negative impact of exchange rate depreciation on private sector credit is contradictory to the results obtained by Imran and Nishat (2012). As movements in the exchange rate may impact different sectors differently and through different channels, there is a likelihood of a negative impact on aggregate. Domestic deposits are positively associated with private sector credit, which is in accordance with the theory and studies on Pakistan

(Imran and Nishat, 2012; Aftab et al., 2016). The impact of the weighted average lending rate is not significant in statistical terms, which supports the findings of Imran and Nishat (2012). However, Qayyum and Hassan (2013) and Aftab et al. (2016) find a negative impact of interest rates on credit in Pakistan.

In the short run, the negative coefficient of the equation confirms that co-integration exists among variables in long run. However, no variable has any influence on credit in the short run.

Table 4. Results of ARDL Model Biannual Data from 2011 to 2021

Long-run Relationship (Combined)		Short-run Relationship (Combined)	
Variables	Coefficient	Variables	Coefficient
Y	-0.2**	COINTEQ01	-0.5***
Inf	-0.4***	D(Y2)	0.03
DD	1.7***	D(Y3)	-0.2
GB	-0.1**	D(Y5)	-0.1
ER	-0.4***	D(Y6)	-0.1
R	0.5	D(Y7)	0.3
NR	-0.6***	D(R)	1.6
-	-	D(NR)	0.2
-	-	C	2.0

Note: *** and ** indicate a 1% and 5% level of significance, respectively.

Source: own elaboration

Domestic deposits positively influence private sector credit, showing that the availability of funds is more important for private sector credit penetration. In fact, this is true in the case of countries with limited resources such as Pakistan where the government also competes with the private sector on the credit market, negatively affecting private sector credit. In Table 4, the negative sign associated with government borrowing from commercial banks confirms the crowding-out effect due to government borrowing. Likewise, non-performing loans are negatively associated

with private sector credit, which supports the argument that the presence of the government in the credit market provides a risk-free lending opportunity to banks, instead of lending to the private sector with an associated high risk of default. Further, the weighted average lending rate has no significant impact on private sector credit in Pakistan. These findings support the idea that the availability of funds is more important than the cost thereof. Moreover, the findings also indicate a weaker transmission of monetary policy through the credit channel.

b) Sector-wise short-run results

The sector-wise short-run estimates are presented in **Table 5**. The results show that significant cross-sector differences regarding the impact of different variables on PSC exist in the short run. The results also differ from the combined short-run results given in **Table 4**. The negative and statistically significant coefficients of the co-integration equation for most sectors (with the exception of the fertiliser and power sectors) show that part of any short-term deviation from the long-run equilibrium is corrected each period, though the speed of adjustment varies across the sectors.

Economic activity, for which LSM can be perceived as a proxy, has a significant positive impact on credit to the sugar, petroleum, and wholesale & retail trade sectors. On the other hand, it negatively influences credit to the textile, rice, and construction sectors. The former group, especially the sugar sector, requires working capital loans to fulfil its financial needs during the production phase. The petroleum sector also requires funds to increase production in response to increased demand. The negative impact in the case of the latter group could be due to an improvement in their liquidity position. In the case of the cement sector, LSM has no significant impact on credit in statistical terms.

In terms of inflation, it has a negative impact on credit to the sugar and construction sectors, while positively affecting credit to the textile and wholesale & retail trade sectors. Notably, the impact on construction and textiles is larger in magnitude. It has no significant impact on other sectors. In the case of the former group, the higher profitability of the sectors, especially the sugar

sector, may reduce the borrowing needs. On the other hand, higher input costs could be a reason for the positive effect of inflation on credit, such as in the case of the textile industry.

Domestic deposits significantly influence credit to the sugar and construction sectors. The impact is significant in both sectors, with a positive association with the former and a negative one in the case of the latter, which is somewhat counterintuitive. The weighted average lending rates have no significant impact on credit. Non-performing loans have only a positive relationship with credit to the textile and sugar industries. In the case of other sectors, no significant influence was found.

Government borrowing crowds out credit to most sectors including the textile, sugar, rice, refined petroleum, construction, and wholesale & retail trade sectors. However, it has positive impact on the sugar and cement sectors. The differences across sectors could be due to links between government spending and these sectors. For example, subsidies to the agriculture sector and spending on infrastructure have a close association with the cement sector.

Finally, exchange rate depreciation has a positive effect on credit to the majority of sectors such as textiles, cement, refined petroleum, and wholesale & retail trade in the short run. Contrary to the aggregated results, the exchange rate has a positive impact on credit to the sectors producing export-oriented goods or competing with imported goods to expand their supply to meet increased demand in the short run. It negatively affects credit to the rice and construction sectors, as profitability increases due to exchange rate depreciation.

Table 5. Results of ARDL Model Biannual Data from 2011 to 2021
(Sector-wise Short-run Relationship)

Variables	Textile	Sugar	Rice	Fertiliser	Cement	Refined Petroleum	Electric Power	Construction	Wholesale & Retail Trade
COINTEQ01	-1.0**	-1.3***	-1.1***	-0.1	-0.5***	-0.4***	0.1	-0.1***	-0.4***
D(Y)	-1.1***	0.03**	-0.3***	1.0**	-0.2	0.2**	0.1***	-0.4***	0.3***
D(Inf)	2.2***	-0.4***	-0.1	0.4*	0.1	-2.4	-0.1***	-2.0**	0.1*
D(DD)	-0.3	3.0**	1.2	-0.4	0.7	0.4	-1.6	-3.2**	-0.6
D(GB)	-0.1***	0.2***	-0.3***	0.2	0.5***	-0.6*	-0.8***	-0.2***	-0.1***
D(ER)	0.7***	0.1	-0.7**	-0.5	2.5***	0.9**	-0.8***	-0.2*	0.7***
D(R)	-0.2	5.7	8.3	4.4	-1.6	-0.2	0.1	-3.4	1.2
D(NR)	0.2**	0.5***	2.4	-8.5	-2.1	2.9	3.7	3.1	-0.4
C	8.2	4.3	2.9	-1.3	0.6	1.8	0.5	1.5	-0.2

Note: ***, ** and * indicate a 1%, 5% and 10% level of significance, respectively.

Source: own elaboration

Conclusion

This study attempts to empirically identify the existence of any cross-sector differences in bank credit behaviour. To enrich the analyses, a wider set of both demand- and supply-side variables are included. Panel data for nine sectors with a major share in the credit market for which data is available are included in the analysis. Biannual data from 2011 to 2021 is used in the analysis.

The estimated results show that significant cross-sector differences regarding the impacts of different variables on private credit exist in the short run. Therefore, any policy designed to impact private sector credit will have different outcomes for different sectors of the economy.

The results show that domestic deposits have a significant positive effect on private credit in the long run. This support the idea that the availability of funds is more important for private sector credit penetration in a country such as Pakistan with limited resources. The presence of government on the credit market as a potential borrower

has negative implications for private sector credit. The negative sign associated with government borrowing from commercial banks conforms the existence of the crowding-out effect due to government borrowing. Similarly, non-performing loans have a negative impact on private sector credit, which shows that the presence of government on the credit market provides a risk-free lending opportunity to banks rather than lending to the private sector when there is a high risk of default. Lending rates have no significant effect on private sector credit in Pakistan. This also indicates weaker transmission of monetary policy through the credit channel, which is a matter of concern from the perspective of the central bank.

Therefore, based on the findings of this study, our recommendations are as follows. As the availability of funds is important for credit penetration, certain policy measures are needed to stimulate the saving rate in the economy. Since the interest rate has no significant impact on private sector credit, interest rate spread may be narrowed down by increasing the rate on deposits and linking it to certain benchmarks, such as the

yields on government securities. Further, the spread of Islamic banking is higher than conventional banking because of the lower level of sensitivity of depositors and borrowers. This discourages the exploration of the already limited investment opportunities for Islamic banks. Therefore, the creation of a more competitive environment between the two types of banking system is required.

Lastly, due to the crowding-out effect and smaller fiscal multiplier of government spending in the case of Pakistan (Raashid et al., 2020), one may suggest that the government use other fiscal options available (such as increasing revenues through taxes or reducing expenditure). Therefore, financing the fiscal deficit by borrowing from commercial banks is a double-edged sword, which does not contribute to economic growth. In fact, it constrains long-term growth by crowding out the private sector.

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Monitoring the integration of environmentally friendly technologies in business structures in the context of climate security

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Abstract

Introduction to the topic under investigation. The risks of climate change have brought about the consolidation of business structures with the aim of reducing greenhouse gas emissions. In such conditions, ensuring the transition to a low-carbon economy requires the application of a comprehensive approach to monitoring goals for the integration of environmentally friendly technologies in business structures. In particular, it involves defining environmentally friendly hierarchical and causal relationships between goals in business structures in the context of climate security. Purpose. The purpose of the study is to develop a methodological approach to monitoring the integration of environmentally friendly technologies in business structures in the context of climate security, based on the analysis of building a model for monitoring the business structure activities of enterprises, systematising the goals of business structures and the sources of information. Methodology. In order to develop a methodological approach to monitoring the integration of environmentally friendly technologies in business structures in the context of climate security, it is necessary to determine the environmentally friendly hierarchical and cause-and-effect relationships between goals in business structures. The development of a system for monitoring the marketing environment is based on the goals of hierarchy and causality. This approach will be the basis for the formation of a monitoring system for the introduction of environmentally friendly technologies at enterprises (according to the types of economic activity). Main results. The study has revealed that the types of goals are interrelated ac-

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cording to similar environmentally friendly characteristics in the context of climate security, and together they form an integral system. Another important aspect of the relationship between the goals is that the set of goals for the integration of environmentally friendly technologies is the source code for the intersection of sets; that is, the goals of management entities in the business structure management system are formed after the goals for certain types of business structure activities are formed. The study has considered the goals of monitoring business structure activities, sources of information, monitoring methods and information obtained as the output of the monitoring system of integrating environmentally friendly technologies through the prism of topological and metric spaces, which makes it possible to have a certain morphological projection of input data to the output. A model for monitoring business structure activity for the integration of environmentally friendly technologies through the prism of topological and metric spaces was proposed. In the context of the study, the topological space is considered a continuum and a system of subsets. The theoretical contribution. The innovative scientific added value of the study is the improvement of the methodological approach to forming a system for monitoring the activities of business structures in the conditions of integrating environmentally friendly technologies. This approach is based on modelling through the prism of metric and topological spaces. The methodological approach makes it possible to achieve a high level of information content and timely monitoring for the integration of environmentally friendly technologies into business structures in the context of climate security. Practical implications. The practical value of the proposed model lies in the possibility of using it to strengthen climate change resilience in business and the transition to a low-carbon economy. The practical implications of the study are to develop the resilience of business structures in the implementation of low-carbon economy transition strategies and plans by integrating environmentally friendly technologies, in particular, the diversification of energy supply channels, recycling renewable resources, testing and implementing innovative solutions for the prevention of climate change, and so on.

Key words

climate change, low-carbon economy, eco-innovations, environmentally friendly technologies, climate security, clean energy, environmental management, marketing environment, business structure.

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Introduction

Climate change requires the introduction of solutions for the reduction of greenhouse gas emissions by developing a low-carbon economy and strengthening the monitoring of environmentally friendly technologies in business structures. The climate security of enterprises is ensured due to the transition to the production of green goods, the circular use of resources, etc.

Accordingly, the European strategic goals for the transition to a low-carbon economy includes the following green benchmarks: the development of carbon markets; circular cities; the energy efficiency of buildings; renewable energy; increasing the climate resilience of the agriculture and forestry sector, etc. Since 2019, in the countries of the European Union, the National Energy and Climate Plans (NECPs) have been in force with the goal of increasing the resilience of European climate security. These were proposed by means of an action plan for the EU countries for the period 2021–2030 aimed at the reduction of greenhouse gas emissions. Such plans aim to coordinate the goals of all government departments and plan for activities that promote the attraction and implementation of public and private investments (The national energy and climate plans, 2018).

A challenge commonly faced by business structures is planning for the transition to a low-carbon economy. With this in mind, the development of a monitoring system for integrating environmentally friendly technologies in business structures is an issue of the utmost urgency.

1. Literature review

Forming a system for monitoring the environmentally friendly technologies of enterprises is based on the goals of said monitoring. A summary of the references (Curry, 2019; Sumets et al., 2021; Tun et al., 2016; Zadorozhnyi and Muravskyi, 2021;

Koetter and Kochanowski, 2012; Kucher et al., 2021; Dyvak et al., 2018; Maj and Kubiciel-Lodzińska, 2020; Popova et al., 2021; Borysiak and Brych, 2022; Goomas et al., 2011; Mihi-Ramirez et al., 2019; Pryimak et al., 2020; Draghici et al., 2014) provides grounds to claim that, in general, the purpose of monitoring the activity around business structures is to identify the state of the implementation of the established goals of business structures, to find the relevance of the established goals of the business structures, and to identify the need for regulatory decisions. The implementation of these goals usually takes place in an algorithmised form.

The prevention and mitigation of, and adaptation to, climate change requires enterprises to strengthen their environmental, climate and energy management (Darmorost et al., 2019; Brych et al., 2023; Borysiak et al., 2022). The implementation of eco-innovation is positioned as a target for organisations to be more sustainable in order to reduce negative externalities in the developed countries (García-Granero et al., 2018; David Ferreira Lopes Santos et al., 2019).

The business structure goals are the initial primary data on the basis of which a system for monitoring the business structure activities is formed. In the scientific literature on management issues, including issues of information management (Bueno and Gallego, 2017; Altındağ and Öngel, 2021; Voitseshyn et al., 2020; Martyniuk et al., 2020; Borysiak et al., 2022, Saifi et al., 2016; Pryimak et al., 2020; Kucher et al., 2021; Brych et al., 2022; Popova et al., 2019; Zamecnik and Rajnoha, 2015; Kniaz et al., 2021; Shkvaryliuk et al., 2021), a significant number of authors lay out the approaches to classifying and systematising the goals of enterprises according to the types of activity.

Barriga Medina et al. (2022) used a structural equation model to analyse the positive effect of eco-innovation on the financial

and environmental performance of business structures. On the other hand, a proactive environmental strategy does not directly affect firm performance, but technological eco-innovation reduces the environmental impact (Ryszko, 2016).

Accordingly, the urgent goal of energy enterprises is to develop climate management through diversification of renewable resources (Borysiak et al., 2022). Madaleno et al. (2020) investigate whether eco-innovations positively affect turnover and employment.

Critical analysis of the authors' approaches has shown the need to improve a universal classification of business structure goals based on the integration of environmentally friendly technologies and the resilience of climate security. Given this, when classifying the business structure goals, it is vital to take only those classification features and types of goals that are universal to all business structures into account.

The purpose of the study is to develop a methodological approach to monitoring the integration of environmentally friendly technologies in business structures in the context of climate security, based on the analysis of building a model for monitoring the business structure activities of enterprises, systematising the goals of business structures and the sources of information.

2. Methodology

The research hypothesis is that ensuring the transition to a low-carbon economy requires the application of a comprehensive approach to monitoring goals for the integration of environmentally friendly technologies in business structures. In particular, it involves defining environmentally friendly hierarchical and causal relationships between goals in business structures. The hierarchy and causality goals underlie the development of a system for monitoring the marketing environment. This approach will be the basis for forming a monitoring system for the introduction of environmentally friendly technologies at enterprises (according to the types of economic activity).

The research was conducted according to the following classification of business structures goals: by scale; by the level of coverage; by the respective goals of divisions of business entities; by the level of management; by management subjects; and by type of activity. In this classification, the types of goals are interrelated according to similar environmentally friendly characteristics, and together they form an integral system. In a formalised form, the relationship between business structure goals by scale and level is written as follows:

$$\left. \begin{aligned} \bigcup_{i=1}^3 C_{b_i} \supset \bigcup_{j=1}^n C_{k_j} \supset \bigcup_{t=1}^r C_{m_t} &\Leftrightarrow \bigcup_{\alpha=1}^{\gamma} C_{\alpha}; \\ C_s \Rightarrow C_t \Rightarrow C_o &\subset \bigcup_{i=1}^3 C_{b_i}; \\ C_{k_1} \cup \dots \cup C_{k_n} &\subset \bigcup_{j=1}^n C_{k_j}; \\ C_{m_1} \cup \dots \cup C_{m_n} &\subset \bigcup_{t=1}^r C_{m_t}, \end{aligned} \right\} \quad (1)$$

where C_s – strategic goals of business structures; C_t – tactical goals of business structures; C_o – operational goals of business structures; $Ck_1 \dots Ck_n$ – goals of the

components (business entities) from which business structures are formed; $Cm_1 \dots Cm_n$ – goals of business structure component divisions.

The business structure goals of integrating environmentally friendly technologies form a boolean $\bigcup_{a=1}^j C_a$.

Strategic goals of integrating environmentally friendly technologies are the starting point for tactical goals, and the tactical goals determine the operational ones. The set of strategic, tactical and operational objectives $\bigcup_{i=1}^3 C_i$, is the basis for a set of objectives of the business structure component $\bigcup_{j=1}^n C_{k_j}$

and the set of objectives of the units of the business structure component $\bigcup_{i=1}^j C_{n_i}$.

The nature of the relationships between the sets of business structure goals of integrating environmentally friendly technologies by management level is captured in the formula $\bigcup_{\beta=1}^2 C_{\beta}$, management entities – $\bigcup_{\gamma=1}^3 C_{\gamma}$ and types of activities – $\bigcap_{\phi=1}^{\phi} C_{\phi}$. A special feature of the relationships between the sets of these goals is the occurrence of an intersection of sets, namely $\bigcap_{\phi=1}^{\phi} C_{\phi}$:

$$\left. \begin{aligned} C_k \cup C_p &\Leftrightarrow \bigcup_{\beta=1}^2 C_{\beta}; C_v \Rightarrow C_c \Rightarrow C_n \Leftrightarrow \bigcup_{\gamma=1}^3 C_{\gamma}; \\ C_q \cup C_f \cup C_i &\Leftrightarrow \bigcup_{\delta=1}^3 C_{\delta}. \\ \bigcap_{\phi=1}^{\phi} C_{\phi} &\Leftrightarrow \bigcup_{\beta=1}^2 C_{\beta} \cap \bigcup_{\gamma=1}^3 C_{\gamma}; \\ \bigcup_{\beta=1}^2 C_{\beta} \cap \bigcup_{\gamma=1}^3 C_{\gamma} &= \left\{ \varepsilon \mid \varepsilon \in \bigcup_{\beta=1}^2 C_{\beta} \wedge \varepsilon \in \bigcup_{\gamma=1}^3 C_{\gamma} \right\}, \end{aligned} \right\} \quad (2)$$

where C_k – the goals of the management subsystem; C_p – the goals of the managed business structure management subsystem; C_v – the goals of top-level management entities; C_c – the goals of mid-level management entities; C_n – the goals of grassroots management entities; C_q – the objectives of the business structure operating activities; C_f – the objectives of the business structure financial activities; C_i – the goals of business structure investment activity; and ε – the goals of management entities in the business structure management system.

As seen above, it is precisely for management entities that the business structure management system intersects the goals of integrating environmentally friendly technologies for management subsystems and management levels.

Another important aspect of the relationship between the goals is that the set of goals for the integration of environmentally friendly technologies $\bigcup_{\delta=1}^3 C_{\delta}$ is the source code for the intersection of sets $\bigcap_{\phi=1}^{\phi} C_{\phi}$, that is, the goals of management entities in the business structure management system are formed after the goals for certain types of business structure activities are formed:

$$\bigcup_{\delta=1}^3 C_{\delta} \Rightarrow \bigcap_{\phi=1}^{\phi} C_{\phi}. \quad (3)$$

It should also be emphasised that sets $\bigcup_{\alpha=1}^{\gamma} C_{\alpha}$ and $\bigcup_{\delta=1}^3 C_{\delta}$ are not identical:

$$\bigcup_{\alpha=1}^{\gamma} C_{\alpha} \setminus \bigcup_{\delta=1}^3 C_{\delta} \Leftrightarrow \bigcup_{\eta=1}^l C_{\eta}; \bigcup_{\eta=1}^l C_{\eta} \Rightarrow \bigcup_{\delta=1}^3 C_{\delta}. \quad (4)$$

where $\bigcup_{\eta=1}^l C_{\eta}$ – business structure goals defined by the business structure mission and vision.

The set $\bigcup_{\eta=1}^l C_{\eta}$ transforms into the set $\bigcup_{\delta=1}^3 C_{\delta}$ and, as a result, subordinates the sets $\bigcup_{\alpha=1}^{\gamma} C_{\alpha}$, $\bigcup_{\beta=1}^2 C_{\beta}$ and $\bigcup_{\chi=1}^3 C_{\chi}$ to itself.

As a result, the logic of relationships between the business structure goals of integrating environmentally friendly technologies is as follows:

$$\left. \begin{aligned} \bigcup_{\alpha=1}^{\gamma} C_{\alpha} &\equiv \bigcup_{\delta=1}^3 C_{\delta} \cup \bigcup_{\eta=1}^l C_{\eta}; \\ \bigcup_{\eta=1}^l C_{\eta} &\Rightarrow \bigcup_{\delta=1}^3 C_{\delta} \Rightarrow \left[\bigcup_{\beta=1}^2 C_{\beta} \wedge \bigcup_{\chi=1}^3 C_{\chi} \right]. \end{aligned} \right\} \quad (5)$$

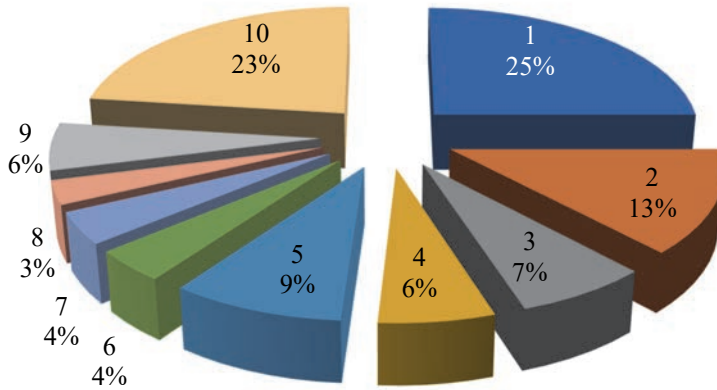
3. Research results

An important stage in forming and using a system for monitoring the business structure activity of integrating environmentally friendly technologies is the choice of information sources and monitoring methods. Despite the variety of information sources obtained by business structure management entities, first of all, it is the alternative sources that are of practical value. This is because objective information is usually considered to have a documentary basis or is confirmed by several sources. Given this, it is important to consider alternative information sources when creating a system for monitoring the business structure activities of integrating environmentally friendly technologies, especially in the context of automation and algorithmisation.

The first step to this task is to build a classification of sources of receiving information pertaining to the management of integrating environmentally friendly processes: by content (sources of direct information,

sources of indirect information); by source (internal and external sources of receiving information); or by nature (sources of planning, regulatory and forecast information, sources of actual information). Among the wide variety of approaches to constructing a classification of information sources necessary to form a system for monitoring the business system activities of integrating environmentally friendly processes, only those classification features and types of information sources that may have practical significance should be distinguished.

Figure 1 shows the results of the expert survey, which showed that the most frequently used monitoring methods are the comparison method (25%), the index method (13%), the expert assessment method (9%) and the observation method (7%). In total, these methods are used by 54% of respondents. The content analysis method (6%), the systematisation method (6%), the induction (4%) and deduction methods (4%), and the generalisation method (3%) are also used, albeit not as frequently.

Figure 1. Results of the expert survey on the frequency of monitoring methods used

Note: 1 – comparison method; 2 – index method; 3 – observation method; 4 – content analysis method; 5 – expert evaluation method; 6 – induction method; 7 – deduction method; 8 – generalisation method; 9 – systematisation method; 10 – other methods.

Source: own elaboration

A systematised set of information sources and monitoring methods is a prerequisite for the practical application of the monitoring system of integrating environmentally friendly technologies. Despite this, it should be recognised that the monitoring object determines the requirements for the monitoring system. One of these is automation, and as a result, the algorithmisation of monitoring. This is due to the breadth of the list of parameters that characterise the monitoring

object and the large number of factors that affect these values. Given this, it is advisable to consider the goals of monitoring the business structure activity, information sources, monitoring methods and information obtained as the output of the monitoring system of integrating environmentally friendly technologies through the prism of topological and metric spaces, which makes it possible to have a certain morphological projection of input data into the output:

$$\left. \begin{aligned} \bigcup_{\alpha=1}^{\gamma} C_{\alpha} \supset \bigcup_{\kappa=1}^{\lambda} D_{\kappa} &\equiv \Lambda_{1\dots n}; \bigcup_{\kappa=1}^{\lambda} D_{\kappa} \supset \kappa_1 \dots \kappa_n; \\ \Lambda_{1\dots n} &\equiv \left\{ \bigcup_{\alpha=1}^{\gamma} C_{\alpha} \mid \bigcup_{\alpha=1}^{\gamma} C_{\alpha} \bigcup_{\kappa=1}^{\lambda} D_{\kappa} \cap \left\{ \bigcup_{\mu=1}^{\nu} M_{\mu} \supset \mu_1 \dots \mu_n \right\} \in \bigcup_{\alpha=1}^{\gamma} C_{\alpha} \right\} \\ I_n^1 &\Leftrightarrow r; I_n \wedge I_n^1 \equiv I_n^0 \in X \mid d(I_n^1, I_n^0) < I_n^1, \end{aligned} \right\} \quad (6)$$

where $\bigcup_{\kappa=1}^{\lambda} D_{\kappa}$ – multiple sources of information ($\kappa_1 \dots \kappa_n$) in the system of monitoring the activities of the business structure (integrating environmentally friendly technologies); $\Lambda_{1\dots n}$ – topology $\bigcup_{\alpha=1}^{\gamma} C_{\alpha}$ on $\bigcup_{\kappa=1}^{\lambda} D_{\kappa}$; r – ball radius; d – the distance between the elements of the set.

In the context of the study, the topological space (Figure 2) is considered a continuum and a system of subsets.

In turn, metric space is considered a pair of a certain set and a distance defined for any pair of elements of this set; that is,

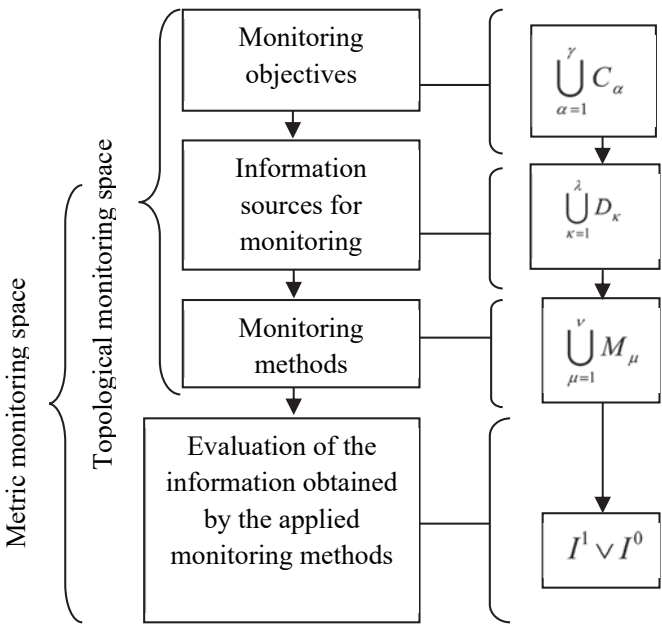
indicators and possible values by which they may be acquired.

4. Discussion

In order to strengthen the resilience of climate security, companies in the European Union are introducing low-carbon actions through the development of the mandatory carbon market and the voluntary carbon market (Report on international voluntary and compulsory carbon markets with special emphasis to mechanisms applied in case of carbon farming and potential opportunities for Ukrainian developers, 2022). Taking into

account the fact that one of the principles of forming a system for monitoring the activities of business structures in the conditions of low-carbon transition is to focus on meeting the information needs of business structure managers for the integration of environmentally friendly technologies, the key task in the creation of a monitoring system is to choose information sources and monitoring methods. Performing this task is important for all types of monitoring systems, but in the context of increasing competition and increasing the level of informatisation in business, the information needs of management entities are rapidly changing.

Figure 1. Model for monitoring business structure activity for the integration of environmentally friendly technologies through the prism of topological and metric spaces



Source: own elaboration

As a result, the requirements for objectivity in choosing information sources and monitoring methods are growing. This requires modelling the monitoring of the business structure activities through the prism of topological and metric spaces, which

makes it possible to permanently update the compliance of the monitoring components with the information needs of management entities. The goals of integrating environmentally friendly technologies of business structures

are complementary to the objectives of regional, national or international initiatives towards energy efficiency, renewable energy, or the modernisation of energy supply systems based on the transition to the low-carbon economy at the local and regional levels. With this in mind, verifying the relevance of the business structure and establishing the needs of regulatory decisions, as well as modelling the totality of goals of the business structure to low-carbon transition is one of the most important prerequisites for the formation of a system for monitoring the environmentally friendly technologies of business structures. Integrating the monitoring objectives with the objectives of the business structure requires the coordination of these objectives with the objectives of the components of the business structure, the objectives of the divisions of these components, the objectives of management entities, as well as the objectives of the activities of the business structure.

The research hypothesis is that ensuring the transition to a low-carbon economy requires the application of a comprehensive approach to monitoring goals for the integration of environmentally friendly technologies in business structures. In particular, it involves defining environmentally friendly hierarchical and causal relationships between goals in business structures. The development of a system for monitoring the marketing environment is based on the goals of hierarchy and causality. This approach will be the basis for the formation of a monitoring system for the introduction of environmentally friendly technologies at enterprises (according to the types of economic activity).

As a result of the study, it is proven that the essence of coordinating objectives for the integration of environmentally friendly technologies is to avoid contradictions. Implementing this task within enterprises (according to the types of economic activities) indicates the need to formalise

objectives of all types and levels, determine the sequence of forming objectives and specify the cause-and-effect relationships between them.

Forming business structure monitoring activities for the integration of environmentally friendly technologies through the prism of topological and metric spaces, in particular in terms of formalising monitoring goals, sources of management information and monitoring methods, is important given the qualitative monitoring parameters of business structure activities in the context of the transition to a low-carbon economy. The practical value of the proposed model lies in the possibility of using it to strengthen climate change resilience in business and the transition to a low-carbon economy.

Topological and metric spaces make it possible to transform the conditions for high-quality monitoring at the input into the monitoring system to the results of applying this system. As a consequence, topological and metric spaces, by means of their information and analytical nature, are a morphological structure in which all the components are connected by causal relationships, in particular through factors affecting each of the levels of decomposition.

Conclusions

In order to build a system for monitoring the marketing environment in the context of climate security, it is proposed that the study take the goals of hierarchy and causality. This approach will be the basis for the formation of a monitoring system for the introduction of environmentally friendly technologies at enterprises (according to the types of economic activity).

The contribution of this paper to the science lies in improving the methodological approach to monitoring the environmentally friendly activities of business structures in the context of climate security. This approach is based on modelling through the

prism of metric and topological spaces and involves the use of tools for the set theory. The methodological approach makes it possible to achieve a high level of information content and timely monitoring for the integration of environmentally friendly processes into business structures. Additionally, a model for monitoring the business structure activity for the integration of environmentally friendly technologies through the prism of topological and metric spaces was proposed. In the context of the study, the topological space is considered a continuum and a system of subsets.

The practical value of the proposed model lies in the possibility of using it to strengthen climate change resilience in business and the transition to a low-carbon economy. The practical implications of the study and the directions of future research are to build resilience in business structures to implement low-carbon economy transition strategies and plans through integrating environmentally friendly technologies, in particular, diversifying energy supply channels, recycling renewable resources, testing and implementing innovative solutions for the prevention of climate change, and so on.

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The green energy transition in Germany: a bibliometric study

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Abstract

The global energy landscape is undergoing a significant shift toward green energy solutions, with Germany leading the way in the transition to renewable energy through its Energiewende initiative. This topic is of great importance as it offers valuable insights for other countries in the European Union and worldwide seeking sustainable and environmentally friendly alternatives for their energy sectors.

This paper aims to provide a comprehensive assessment of Germany's green energy transition, focusing on the technological advancements, strategic management, and country economics that drive this transformation.

Utilising a bibliometric study research method, the paper analyses data from scientific publications in the Scopus database and employs VOSviewer and Bibliometrix software to develop bibliometric maps of keyword co-occurrences.

The analysis reveals the main changes in Germany's green energy transition, uncovering the meaning and important structures of keywords, suggesting new directions for research, and pointing out strategies based on the technological transition toward renewable energy sources and green job creation.

By integrating sustainable development and technological changes, this study contributes to the understanding of green energy transition strategies and their impact on adjacent domains, offering valuable insights for business and society.

Furthermore, the assessment of Germany's green energy transition serves as a valuable example for governments and policymakers in other countries, helping them to learn from Germany's experience and implement similar strategies in their energy sectors. The full paper will discuss the limitations of the paper and potential directions for future research.

Key words

bibliometric analysis, energy sector transformation, VOSviewer.

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Introduction

The energy sector is the foundation of all economies and impacts all other sectors (Yang, 2022; Zema and Sulich, 2022). Even though Germany is one of the largest carbon emitters in the European Union, it is the leader in redirecting the process of electricity generation towards renewable energy (Schumacher and Sands, 2006). There are multiple reports and scientific papers describing this contradiction (Feder, 2022; Ringel, 2018); however, little has been explained about the technological change supported by strategic management (Sulich and Grudziński, 2019; Švarova and Vrchota, 2013). This transition, called *Energiewende* in German (Feder, 2022), has enabled Germany to transition from fossil fuels to clean and nuclear energy, and then implement more renewable energy resources in its energy mix (Grzesiak and Sulich, 2022; Li, 2021). Collectively, scientific journals have published an extensive range of contributions to the green energy transition (Moskalenko et al., 2022), including management research (Shpak et al., 2021) and technical-based research (Maruf, 2021) describing the German *Energiewende*.

The cost of energy generation is a key factor that plays into the health of German industry and the economy (Rubin et al., 2007; Yang, 2022). The transition to net zero emissions by 2045 requires significant investment and a clear understanding of the options available for generating electricity, as well as an energy mix that provides grid stability (Shen et al., 2021). This change is also brought about by the strategic approach in the energy industry in Germany (Gajdzik et al., 2021; Gruber, 2021; Sulich and Grudziński, 2019) and a new understanding of energy security matters. As a result, renewable energy currently accounts for 32.1% of the energy generated in Germany, with wind accounting for the majority of this, or 20.3% of the total (Yang, 2022). Germany still exhibits a large reliance on fossil fuels, which contribute 55.4%

of its energy generation, with coal comprising the major share (28.1%) of its energy mix (Grzesiak and Sulich, 2022). Those data are not only visible in the publications in scientific journals, but are also part of the larger transition pattern in the German energy sector. In addition to the publications, elements of this pattern are accessible for bibliometric analysis, and the resulting networks are open to visual analysis in the form of bibliometric maps. The assessment of Germany's energy sector transition and the identification of changes in this sector of the economy are critical due to the country's reliance on depleting resources in other countries (Wettengel, 2023). The direct implications of the green energy transition in Germany are green jobs and changes in the German labour market. In Germany, the renewable energy sector creates more jobs per unit of energy than the fossil fuel-based sector (Kammen and Engel, 2009). The characteristics of the German energy sector may be an interesting example for other countries, especially European countries.

The aim of this paper is to explore secondary data gathered in the Scopus scientific database reflecting the green transition in Germany. Therefore, this paper reviews and presents the outcomes of a bibliometric analysis of scientific literature to generate a network visualisation of keyword maps (van Eck et al., 2010) and tables. The search for green energy transition in Germany was based on specified and calibrated queries with syntaxes and keyword variants employed in the exploration of scientific publications. This complex approach, which combines descriptive and analytical methods, necessitates a series of techniques in order to provide an objective assessment of Germany's green energy transition. The research method used is bibliometric analysis, which is a variation of the systematic literature review (SLR) method (Boyack et al., 2017; Zema and Sulich, 2022), with an exploration of scientific publications indexed

in the Scopus database research queries. Using Scopus and VOSviewer and Bibliometrix software, co-occurrence networks were generated to identify associations between frequently occurring keywords in scientific articles. This method provides a unique assessment of the changes observed in Germany, in terms of both the hidden and explicit aspects (Boyack et al., 2017). Understanding the process of business development and strategy transformation in the energy sector is a particularly difficult task (Jørgensen, 2005). The goal of this paper is not only to discover its underlying structure, but also to determine Germany's contribution to the emerging pattern of energy sector transformation. This paper is not purely a bibliometric analysis, because it combines three types of analytical software which are based on the quantitative approach with the qualitative interpretation of the results obtained (Gajdzik et al., 2021; Johnson-Cramer et al., 2022; Sulich and Sołoducho-Pelc, 2022).

This paper is organised as follows. After this brief introduction, the Methodology section explains the research procedure in detail along with its limitations. The detailed methodological explanation is accompanied by the presentation of the calculations and results obtained. Based on the proposed SLR variation method, the data are analysed and presented. Subsequently, in the Discussion and Conclusions subchapter, the theoretical and practical managerial implications of this study, which may be important to policymakers, businesses, researchers, and the public at large, are presented. In the last section, the limitations of the study and the possible future avenues of new research are also addressed.

1. Methodology

The method adopted in this research is the SLR variation method with queries (Bran et al., 2021; Lamers et al., 2021). In this paper, scientific literature from the Scopus database was used. The subjects of the research were scientific publications collected in

the abovementioned database. The starting point of this timespan was determined by the earliest publication indexed in the Scopus scientific database; therefore, the research covered the period of 1969–2022. The Scopus database is a bibliographic database with an organised digital collection of references to published scientific literature, including journal articles, conference proceedings, patents, books etc. (Elsevier, 2023; Zema and Sulich, 2022). In general, scientific databases contain highly detailed subject descriptions in the form of keywords, classification terms, or abstracts. Bibliographic metadata is information associated with a bibliographic record, which can be explored using visualisation tools. Scopus was chosen due to its popularity and reputation among researchers (Singh et al., 2021; Zema and Sulich, 2022).

Bibliometric keyword co-occurrence analysis has become a popular tool in management research, including business and social studies. Formal techniques for evaluating literature serve to identify influential works and track the evolution of the field (Johnson-Cramer et al., 2022). Scientometric techniques of citation analysis are based on the premise that research papers cite publications that they consider relevant. Co-occurring keywords are presented in the network as nodes in the bibliometric map. Co-occurrence analysis of keywords also highlights publications, represented as edges in the bibliometric map, indicating that they have been cited. Therefore, results presented graphically as networks uncover patterns of influence, diffusion and conceptual development of the analysed results of queries (Johnson-Cramer et al., 2022).

The SLR variation method is supported by the research queries exploring the Scopus database. The SLR has its own procedure, which is not presented in detail in this paper. In this study, the SLR method is used as a tool for the identification of knowledge gaps and future directions of research. The

SLR variation method used in this paper is based on the research queries which are used to explore the Scopus database. The results are presented in the form of bibliometric maps with the use of the VOSviewer programme (version 1.6.18). Bibliometric analysis is used in this research to produce a network visualisation of keywords for the queries (Zema and Sulich, 2022). This kind of analysis identifies and highlights

clusters of keywords that have emerged in various relationships shaping the subject of Germany’s green transition in the scientific literature as a whole. In this variation of the SLR method, the five original queries were formulated and developed as presented in Table 1. There are differences in the formulated queries, although the queries have a syntax that corresponds with the database in which they are used.

Table 1. Syntaxes used in queries for the exploration of the Scopus scientific database

No.	Query Syntax	No. of Results 1 Dec. 2022
1	TITLE-ABS-KEY („energy sector” AND „transition” OR „transformation”) AND (LIMIT-TO (LANGUAGE, „English”))	2,159
2	(TITLE-ABS-KEY („energy sector”) AND TITLE-ABS-KEY („transition” OR „transformation” AND „green”)) AND (LIMIT-TO (LANGUAGE, „English”))	258
3	(TITLE-ABS-KEY („energy sector”) AND TITLE-ABS-KEY („transition” OR „transformation” AND „green”)) AND (LIMIT-TO (LANGUAGE, „English”)) AND (LIMIT-TO (SUBJAREA, „ENER”))	145
4	((TITLE-ABS-KEY („energy sector”) AND TITLE-ABS-KEY („transition” OR „transformation”)) AND („green”) AND (LIMIT-TO (SUBJAREA, „ENER”)) AND (LIMIT-TO (AFFILCOUNTRY, „Germany”)) AND (LIMIT-TO (LANGUAGE, „English”))	73
5	(TITLE-ABS-KEY („energy sector”) AND TITLE-ABS-KEY („transition” OR „transformation” AND „green”)) AND (LIMIT-TO (LANGUAGE, „English”)) AND (LIMIT-TO (SUBJAREA, „ENER”)) AND (LIMIT-TO (AFFILCOUNTRY, „Germany”))	11

Source: own elaboration based on Scopus data

Data were collected using queries in the Scopus database. This resulted in a global dataset and facilitated the retrieval of articles based on the previously discussed search constraints (the results of the first query in Table 1) that were further segregated into smaller datasets. The query syntaxes presented in Table 1 provide a view of the research assumptions and criteria. The area of the research was set as “energy sector” by means of the direct keyword. This specified keyword searched in the TITLE-ABS-KEY fields in Scopus produced over 16,000 results. Due to the vast collection of results, the queries were calibrated and developed in Boolean style. The queries presented in

Table 1 were used to study the Scopus database on 1 December 2022, with different numerical results depending on the exact syntax of each formulated query. The only constant limitation among all queries was the language of publication, when elements of other syntaxes were added. English was the most common language among the indexed publications, and was chosen accordingly. Additional keywords searched within query 1 were “transition” and “transformation”, then the keyword “green” was added in query 2. In the following queries further limitations were applied, such as subject area (SUBJAREA) and affiliation country (AFFILCOUNTRY). These were

selected from the refined results sidebar on the Scopus website and the results were limited to those criteria. Queries 4 and 5 differ not only in terms of the number of results obtained but also the order of each query syntax, which was the reason behind the disproportion inherent in the results. Each time, a set of files was downloaded for the Scopus database in .csv format containing the results of queries 1 through 5 from the studied time intervals, and all publication fields were marked during export. The following fields were chosen for export from Scopus: citation information, bibliographic information, abstract, keywords, funding details, and other information (Johnson-Cramer et al., 2022; Zema and Sulich, 2022). As bibliometric software recognises only exactly matching strings of characters, a manual normalisation process is required to maintain accuracy, especially in the spelling of researched keywords. Due to generally employed bibliometric software not distinguishing between small and capital letters in the names of countries, organisations, etc., the VOSviewer programme converts the capital letters of abbreviations to lowercase. Therefore, this original form proposed by the software was maintained in the text of this study so as not to cause confusion. The distinguished keywords are consistent with the obtained bibliometric maps. This should allow readers to more readily understand which network nodes are being discussed.

The exported data were analysed in VOSviewer, and the resulting bibliometric maps display the results. The choice of the number of co-occurrences of keywords determines the graphical presentation and clarity of the bibliometric map (Waltman et al., 2013). Therefore, a minimum of five co-occurrences of keywords was established for each bibliometric map, unless another number of co-occurrences was specified for a specific map. Co-occurrence keywords serve as nodes on the bibliometric map (van Eck and Waltman, 2010). The size of the

nodes, the links between the nodes, and the colour-coded clusters are three of the most important characteristics represented by network maps. Between the nodes are edges indicating the relationships between co-occurrences of keywords. Therefore, lines represent the strongest co-occurrence links between keywords. The distance between two nodes approximates the co-occurrence relationship between two keywords. The stronger the relationship between two nodes, the closer they are to each other. The bibliometric map groups items (keywords) into clusters. This means that nodes within the downloaded dataset are clustered using an algorithm programmed and applied by VOSviewer. A cluster is a subnetwork consisting of bibliometric map items. By default, VOSviewer employs a clustering algorithm to assign co-occurring keywords to clusters, which consist of nodes that are closely related. Items of greater significance are displayed more prominently on a map than those of lesser significance (Dzwigol et al., 2023; Sulich and Sołoduch-Pelc, 2022). Each network node is assigned to precisely one cluster. A resolution parameter establishes the number of clusters; the greater the value of this parameter, the greater the number of clusters. In the visualisation, VOSviewer uses colours to indicate which cluster a node belongs to. In each of the presented maps, all co-occurring keywords are coloured according to their membership in the clusters (Gajdzik et al., 2021; Sołoduch-Pelc and Sulich, 2022). The keyword co-occurrence analysis and the resulting maps provide insights into the intellectual structure of a field (Kwilinski et al., 2022). The recognition of certain patterns is possible when VOSviewer is used, because the software creates a list based on text mining of the title, abstract, and keywords in the articles within the dataset. The maps created make it possible to visualise the intellectual structure of the investigated domain. The iterative analysis was conducted using

bibliometric maps and the results of the co-occurrence analysis to identify similarities, patterns, and differences. Individual observations were merged in weekly conferences to reach a consensus among those with expertise on the research topic.

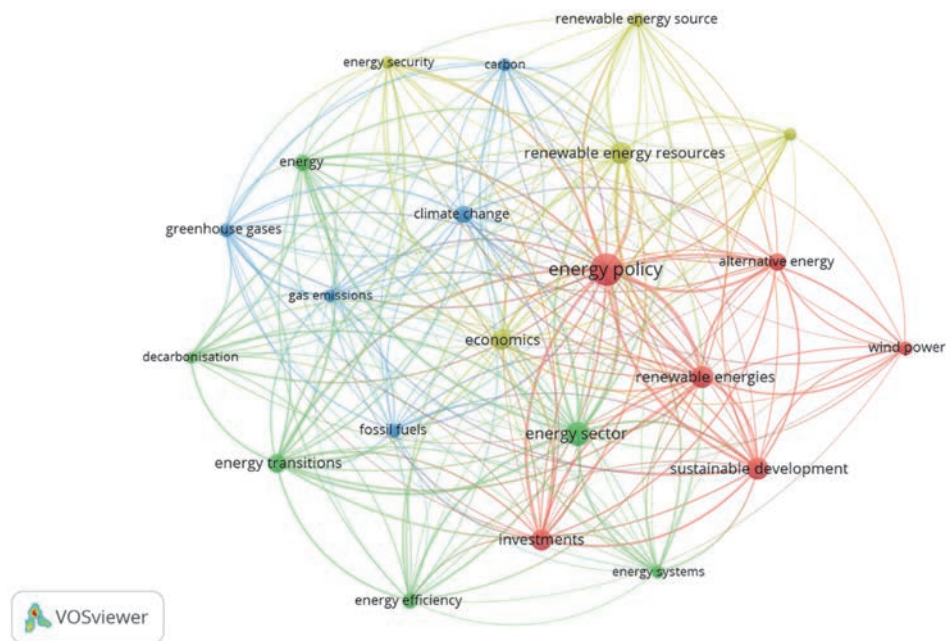
The results of the third query were the subject of further analysis undertaken in Bibliometrix (version 4.1.2) in the R environment (version 4.2.1) according to the methodology proposed in the scientific literature (Aria and Cuccurullo, 2017; Martín-Cervantes and Martínez, 2022). In order to provide a comprehensive view of the green energy transition in Germany, selected analytical options were chosen from the Bibliometrix software sidebar (Aria et al., 2021; Cuccurullo et al., 2016). This methodology is optimal for visual representations of the most relevant authors (in terms of scientific production with the presentation of their h-index), the most relevant university centres based on scientific production (with the most relevant affiliations indicated), the evolution of scientific production focused on the green energy transition in Germany (proposed based on the keywords plus analysis), and a conceptual map that outlines four types of themes in the research subject (Ciavolino et al., 2022; Zema et al., 2023). The data were imported to the Bibliometrix software in the form of a BibTeX file. The results of the *ad hoc* bibliometric analyses are

presented in the results section. To maintain order in the article, VOSviewer bibliometric maps with descriptions are presented first, followed by the results of Bibliometrix analyses. The interpretation of these results forms the basis for the next section.

2. Research results

This section contains a bibliometric analysis of the green energy transition in Germany, based on queries 3-5 and the use of VOSviewer software, in which the bibliometric map depicted in Figure 1 was generated based on the 145 scientific publications distinguished by query 3, as shown in Table 1. The full counting method was chosen for the analysis of co-occurrences between indexed keywords. The minimum number of co-occurrences for a keyword was 10, and in total 23 of 1121 keywords met the threshold. The four clusters automatically identified by the VOSviewer software were coloured and presented in Figure 1 as a bibliometric map which illustrates the co-occurrence of keywords associated with the green transition in the German energy sector. Only “European Union” was deselected in the final VOSviewer dialogue box containing the suggested keywords (Zema and Sulich, 2022). At this aggregate level, associational themes or clusters of keywords that frequently occur together can be identified.

Figure 1. Bibliometric map of keyword co-occurrence results from Scopus based on original query 3



Source: own elaboration, generated in VOSviewer (version 1.6.18)

In Figure 1 the keywords “green energy transition” and “germany” do not appear, although these keywords were included in the query 3 syntax. The lines between the central nodes “energy policy” and “renewable energies” are thicker than the others, indicating that there are more co-occurrences of these keywords. The lines between keywords and their proximity indicate the frequency with which articles in the dataset use both keywords together. The keywords selected and utilised by the VOSviewer programme are listed in Table 2 and separated by semicolons. Regardless of the original writing style, the keywords in Table 2 are written in small letters, as per the unification procedure in the VOSviewer software. Automated bibliometric software created colour-coded clusters in Table 2, as shown

in Figure 1. The number of keywords identified by the VOSviewer and represented as nodes in Figure 1 determines the order of clusters presented in Table 2. Clusters 1 and 2 consisted of six items, while clusters 3 and 4 consisted of items.

The presented clusters represent the different groups of keywords. In the red cluster, those keywords are related to the strategies or policies in the energy sector in Germany, while in the green cluster, environmental aspects are underlined (Zielińska, 2019). The relationship between fossil fuels and their environmental impact is presented in the blue cluster; in the yellow cluster, automatically distinguished co-occurring keywords present the economic and social effects of Germany’s green transition, which may provide energy security (Wettengel, 2023).

Table 2. Clusters of index keyword co-occurrences in Figure 1 for Scopus Query 3

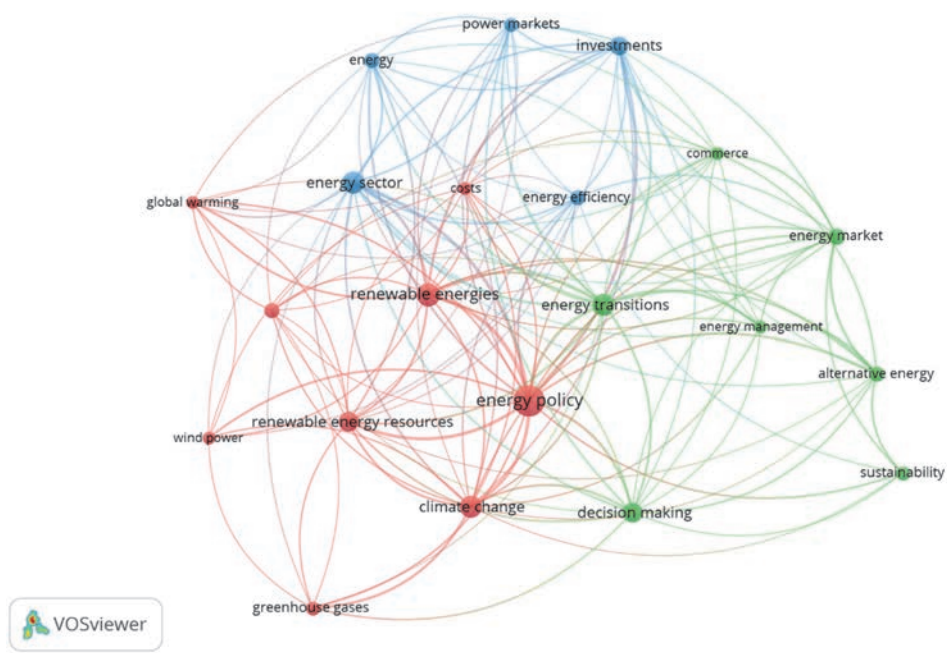
Cluster	Colour	Keywords
1	Red	alternative energy, energy policy, investments, renewable energies, sustainable development, wind power
2	Green	decarbonisation, energy, energy efficiency, energy sector, energy systems, energy transitions
3	Blue	carbon, climate change, fossil fuels, gas emissions, greenhouse gases
4	Yellow	economics and social effects, economics, energy security, renewable energy source, renewable energy resources

Source: own elaboration

Based on the 73 scientific publications defined by query 4, as presented in Table 1, VOSviewer generated the bibliometric map shown in Figure 2. The analysis of indexed keywords co-occurrences using the full counting method was selected. The minimum number of co-occurrences for a keyword was five, and of the total 593 keywords,

22 met the requirement. The three automatically identified clusters were coloured by the VOSviewer software and presented in Figure 2 as a bibliometric map. In the final dialogue box of the VOSviewer programme, only “germany” was deselected from the list of suggested keywords.

Figure 2. Bibliometric map of keyword co-occurrence results from Scopus based on original query 4



Source: own elaboration, generated in VOSviewer (version 1.6.18)

There are three clusters automatically distinguished by VOSviewer (Table 3). The subnetwork subjects and keywords in red revolve around the energy policy, which is the biggest node in this cluster. This group of the most frequently co-occurring keywords is part of the researches dedicated to the climate changes counteracting and

achieving sustainable development. The green cluster represents a more managerial approach; therefore, there are bigger “energy transitions” and “decision making” nodes in Figure 2. The smallest (blue) subnetwork is related purely to the economic dimension of the green energy transition in Germany (Ante et al., 2021).

Table 3. Clusters of index keyword co-occurrences in Figure 2 for Scopus Query 4

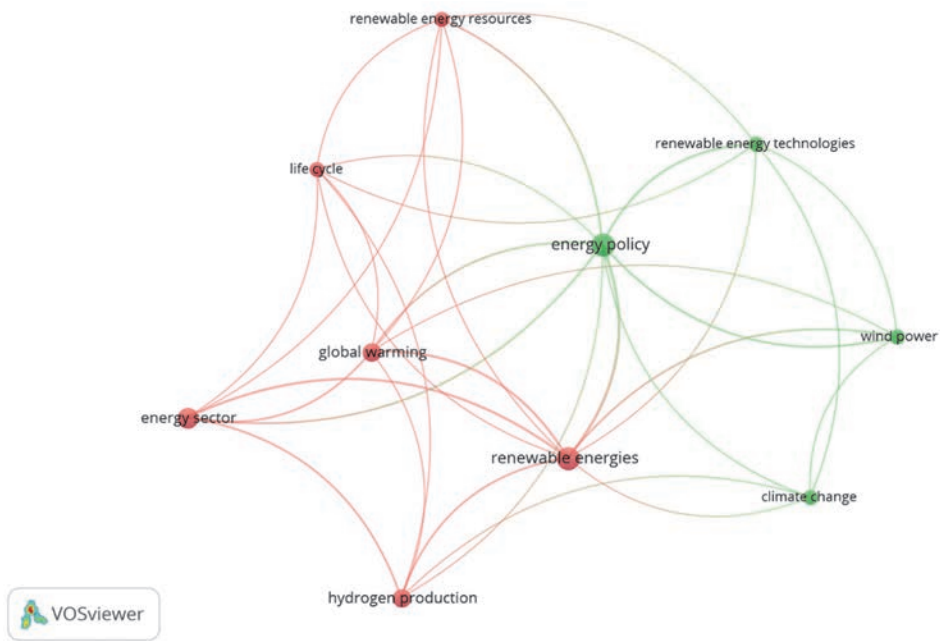
Cluster	Colour	Keywords
1	Red	climate change, costs, energy policy, global warming, greenhouse gases, renewable energies, renewable energy resources, sustainable development, wind power
2	Green	alternative energy, commerce, decision making, energy management, energy market, energy transitions, sustainability
3	Blue	energy, energy efficiency, energy sector, investments, power markets

Source: own elaboration

The bibliometric map generated by VOSviewer is based on the 11 scientific publications distinguished by query 5, as shown in Table 1. The full counting method was chosen for the analysis of co-occurrences between indexed keywords. The minimum number of co-occurrences for a keyword was two, and

10 out of a total of 127 keywords met the requirement. The two clusters automatically identified by the VOSviewer software were coloured and presented in Figure 3 as a bibliometric map. None of the suggested keywords were deselected in the final dialogue box of the VOSviewer programme.

Figure 3. Bibliometric map of keyword co-occurrence results from Scopus based on original query 5



Source: own elaboration, generated in VOSviewer (version 1.6.18)

There are two clusters presented in Figure 3 and Table 4. The red subnetwork is related to renewable energies, the biggest node in this cluster after the “energy sector”. The green cluster revolves around energy policy and wind power. The difference between them is visible in the deep analysis of the 11 literary publications (Table 1). The

publications related to the green cluster assume a gradual transformation towards clean technologies, whereas the red subnetwork places more emphasis on direct change. Therefore, “hydrogen production” and “wind power” are the main different technologies.

Table 4. Clusters of index keyword co-occurrences in Figure 2 for Scopus Query 5

Cluster	Colour	Keywords
1	Red	energy sector, global warming, hydrogen production, life cycle, renewable energies, renewable energy resources
2	Green	climate change, energy policy, renewable energy technologies, wind power

Source: own elaboration

The bibliometric maps and their description subnetworks presented in this section are the result of narrowing the dataset of analysed publications. The results obtained indicate that there are different

approaches to the green energy transition (*Energiewende*) in Germany. The differences reflect the scientific and professional discussion of the aims of the *Energiewende*, to which the analysed works contributed.

To complement the results achieved in VOSviewer, the analysis was also undertaken by means of Bibliometrix software in the R environment. The most relevant authors, in terms of scientific production expressed by NP (the number of published papers related to the green transition in Germany) and their h-indexes, were identified in Table 5.

The results presented in Table 5 also distinguish less well-known indexes (Duan, 2023; Hofbauer and Limanskis, 2022; Pawliczek and Zimmermannova, 2018), the number of citations (times cited, TC) and the first paper on the topic published by each author (PY_start, year of first publication by a given author).

Table 5. Most relevant authors of publications related to the green energy transition in Germany

Surname and Initial	h_index	g_index	m_index	TC	NP	PY_start
Brodny J	2	2	0.5	99	2	2020
Cui Q	2	2	0.4	26	2	2019
Kiełkowska U	2	2	0.667	5	2	2021
Lema R	2	2	0.286	48	2	2017
Markandya A	2	2	0.25	107	2	2016
Pietrzak MB	2	2	0.667	5	2	2021
Skrzatek M	2	2	0.667	5	2	2021
Tutak M	2	2	0.5	99	2	2020
Wu Y	2	2	1	18	2	2022
Žuk P	2	2	0.667	10	2	2021

TC = Times Cited, NP = Number of Papers, PY_start = year of first publication by a given author

Source: own elaboration in Bibliometrix (version 4.1.2)

Table 5 presents the 10 most prominent scientists in alphabetical order with very similar indicators of their scientific production related to the green energy transition in Germany. The most influential of the scientists can be identified if their citations related only to the two papers are compared. In this case, it is not surprising that researchers working in Germany or Poland (J. Brodny and M. Tutak) are the leaders in this classification. The h-index presented in Table 4 has nothing in common with the authors' personal h-indexes (verified on 16 June 2023); for example, A. Markandya's personal h-index is 38 (with 220 documents indexed in Scopus), J. Brodny's personal h-index value is 29 (123 Scopus documents), and M. Tutak's personal h-index is

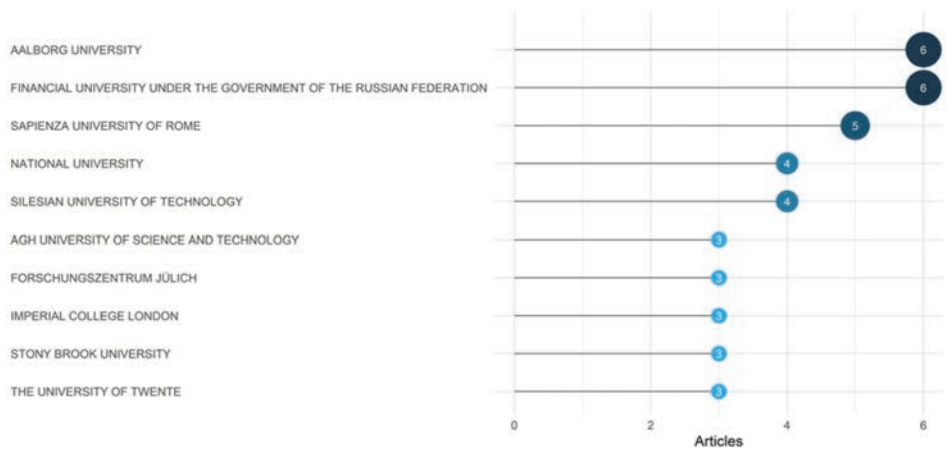
24 (91 Scopus documents). In contrast, the m-index, which is related to the h-index, is a rate-based measure which is calculated by dividing a researcher's h-index by the number of years that have passed since their first published paper. This index aims to quantify a researcher's impact and productivity, taking into account the length of their active career. Thus, it provides a measure of the 'rate' of their valuable contributions to their field.

Proposed by Leo Egghe in 2006 as an improvement over the h-index, the g-index is calculated based on the distribution of citations of the papers published by a given researcher. The g-index is the maximum reachable value of the h-index if a fixed number of citations can be distributed freely over

a fixed number of papers. In effect, A scholar has a g-index of g, if g represents the highest rank for which the combined number of citations received by the top g papers is at least equal g^2 citations (Table 4). This measure attempts to give more weight to more frequently cited articles.

The most relevant university centres based on scientific production (with the most relevant affiliations indicated) are presented in Figure 4. Together with the affiliations, the number of publications focused on the green energy transition in Germany indexed in Scopus is presented.

Figure 4. The Top 10 university centres by number of publications relating to the green energy transition in Germany



Source: own elaboration, generated in Bibliometrix (version 4.1.2)

The top 10 universities based on the number of papers published at each institution which are relevant to the green energy transition in Germany are listed in Figure 4. Based on the respective scientific output at each institution, the leading university is Aalborg University (Poulsen and Lema, 2017) in Denmark (which neighbours Germany) with six articles, the same number of publications as those published under the auspices of the Financial University under the Government of the Russian Federation. At two universities located in Poland (also a neighbouring country of Germany), the Silesian University of Technology (Brodny and Tutak, 2020) and AGH University of Science and Technology (Dyczko et al., 2021; Kowalska et al., 2022; Kudelko et al., 2013), four and three articles respectively were published on the topic.

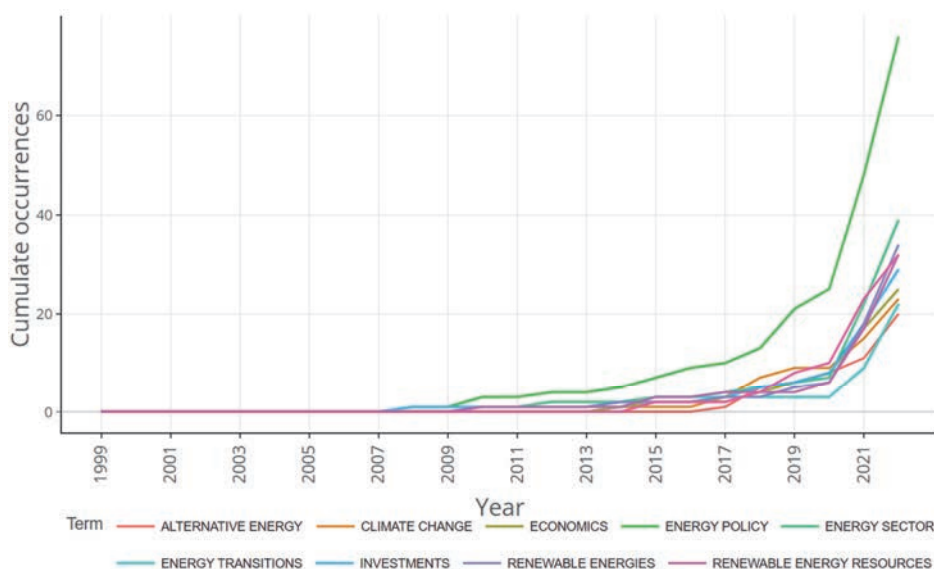
The National University of Ukraine also published four articles. Other universities high on the list as shown in Figure 4 include Sapienza University of Rome, Italy, and the University of Twente in the Netherlands (Heldeweg et al., 2015), which published five and four articles respectively. There are nine European universities among the list of 10 which are affiliated with the highest number of articles on the subject of green energy transition in Germany. This proves the significant influence of the German economy and the solutions introduced in the region in practice (Brodny et al., 2021; Żuk et al., 2021).

The evolution of the scientific production focused on the green energy transition in Germany was also analysed by means of Bibliometrix software based on keywords plus collection (Ciavolino et al., 2022; Zema

et al., 2023). The list of keywords plus in the timeline as cumulate occurrences is presented in Figure 5. The evolution of the research began in 1999, when “renewable energy resources” appeared as the first and predominant keyword related to the subject. Within the following years the collection of keywords expanded to include the nine terms

listed in Figure 5. The most commonly used term is “energy policy” marked in green, when the other keywords appear less often in the context of the green energy transition in Germany (Röpke, 2013); however, they are strongly related to the topics of “energy transitions” and “investments” (Sulich and Sołoducho-Pelc, 2021).

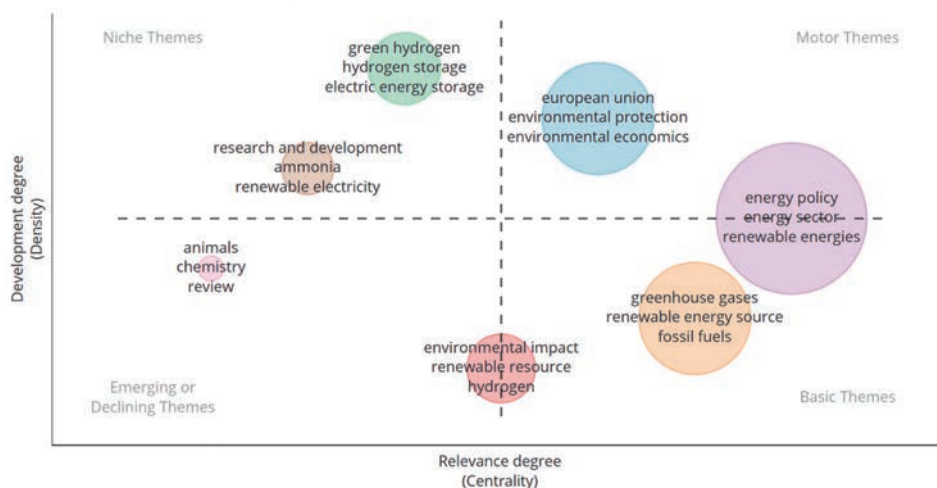
Figure 5. The evolution of keywords in publications on the green energy transition in Germany



Source: own elaboration, generated in Bibliometrix (version 4.1.2)

The results presented in Figure 5 correspond with the results of the analysis undertaken in VOSviewer as presented in Figure 1. The keywords “renewable energies” and “renewable energy resources” are very similar to each other. The further analysis of the

keywords plus automatically distinguished in Bibliometrix software (Zema et al., 2023) provided a conceptual map that outlines four distinct themes pertaining to the research subject, as shown in Figure 6.

Figure 6. Thematic map of publications

Source: own elaboration, generated in Bibliometrix (version 4.1.2)

The upper right-hand quadrant of the thematic map, represented in blue and labelled 'motor themes', highlights the core and mature themes in the field of green energy transition in Germany. These themes have received substantial attention in the research context and are associated with keywords such as "european union", "environmental protection", and "environmental economics". The significance of these themes is reflected in the prevalence and high citation counts thereof, representing well-established areas of research (Zema et al., 2023). These subjects could be linked to policies, regulations, and economic incentives implemented by the European Union to promote renewable energy sources and mitigate the environmental impact (Herberg et al., 2020; Rubin et al., 2007).

In the top left corner of Figure 6 are the 'niche themes' symbolising emerging areas that, while not yet thoroughly explored or highly cited, hold promise for future research. This research gap is illustrated by the green cluster, revolving around "green hydrogen", "hydrogen storage", and "electric energy storage", and the brown cluster, encompassing "research and development", "ammonia", and "renewable electricity".

These clusters may suggest developing trends or areas of interest in the field that are beginning to gain traction (Ciavolino et al., 2022). The 'niche themes' represented by the green and brown clusters point towards a potential shift in focus towards green hydrogen (Chai et al., 2021), energy storage technologies (Hoffart et al., 2021), and innovative research in the areas of renewable electricity and ammonia. These could represent the emerging technologies and strategies that are likely to become more important in the future, especially in the German context where there has been a strong emphasis on clean energy technologies (Rogge and Johnstone, 2017; Röpke, 2013).

In the third quarter of the thematic map in Figure 6, 'emerging' or 'declining' themes are represented, displaying a dynamic landscape. The small pink cluster, which contains "animals", "chemistry", and "review", represents themes that are either gaining momentum or diminishing. The red cluster, which intersects with the fourth quarter and encompasses "environmental impact", "renewable resource", and "hydrogen", signifies a bridge between emerging themes and basic, established ones. Furthermore, the overlap of the red cluster with 'basic themes', including

“environmental impact”, “renewable resource”, and “hydrogen”, may suggest that these topics, while established, are undergoing renewed investigation or transforming due to advancements or changes in the field (Kuchta et al., 2017; Kwilinski et al., 2023).

In the fourth quadrant of Figure 6 are ‘basic themes’, representing foundational themes that have consistently been the focus of research. While they may not be as frequently cited as motor themes, they are essential to a deeper understanding of the topic of the green energy transition in Germany. This quarter is not only characterised by its intersections with the others, but also by an independent light orange cluster that contains the keywords “greenhouse gases”, “renewable energy source”, and “fossil fuels”. This indicates a solid base of research focusing on these fundamental aspects of environmental study (Borodina et al., 2022; Heldeweg et al., 2015). The continued focus on these areas shows their importance in the energy debate and that they remain central to the transition towards a green energy future in Germany. Overall, this thematic map provides an overview of the research landscape in the field of the green energy transition in Germany. The different clusters of themes (Figure 6) highlight the areas of core, emerging, and future importance, presenting an evolving snapshot of this field of study.

3. Discussion

Germany has a significant influence on the energy policies of neighbouring countries (Mortensen, 2022; Naumenkova et al., 2022). Changes in the strategies used in the energy sector are frequently described in scientific publications indexed by Scopus by researchers who collaborate with businesses (Mathur et al., 2019; Yushchenko and Patel, 2016). This kind of close cooperation between academia and the business environment towards achieving sustainability

in the energy sector has already had an effect in Germany. As a result, scientific works frequently reflect pro-environmental changes in Germany’s energy sector strategies. The topic of the green energy transition in European countries has saturated the research community in recent years, although the number of scientific publications is still increasing. Both theoretical and empirical research provide a vast number and variety of patterns and models for other countries to follow in their own green energy transitions.

The goal of this paper was to evaluate the “green energy transition” in Germany by providing a meaningful representation of how scholars and their Scopus-indexed publications pertaining to the green transition have structured the concept. In this paper, it is assumed that scientists, as the authors of the explored publications indexed in Scopus, influence business strategies and cooperate with business. Therefore, their works reflect the changes in Germany’s energy sector, and there is close collaboration between academia and the business community to ensure the sustainability of the sector (Sulich and Sołoducho-Pelc, 2022). Due to the descriptive nature of those studies, bibliometric analyses of the green energy transition in Germany are a rare subject in the literature. Given the interpretative nature of this area of study, it constitutes theoretical sampling rather than statistical sampling, supported by the graphical representations of bibliometric maps. This sampling strategy captured the nested nature of multiplicity in the field, and the articles analysed are meaningfully representative, although by no means exhaustive.

The choice of the Scopus database has inherent limitations, most notably the fact that some of the newer journals are not indexed in these systems. The Scopus database requires a standard academic subscription, which can be a source of limitation for those who would like to replicate this study.

Following on from this issue of accessibility is the structure of the data that can be exported from databases.

It is important to acknowledge the three main limitations of bibliometric analysis. First, by focusing on keyword analysis and keyword co-occurrence patterns, the methodology is inherently retrospective and predisposed to highlight patterns concentrated around the most important keywords. Another limitation is that only the frequency and popularity of the keywords in scientific publications are presented, without either a positive or negative context. Furthermore, the longer the publication is in print, the more opportunity it has to circulate and influence other publications. While acknowledging this as the second limitation, there is a strong suggestion that bibliometric analysis can offer a corrective effect to the recency bias that tends to benefit older publications. The third limitation is the scope of the paper introduced by the query syntaxes used. One way to overcome this problem is by exploring interdisciplinary areas that highlight the connections with the green energy transition in Germany. This is a limitation of the SLR method related directly to the formulation of queries. Regarding the queries, the limitation in the query syntax and the results generated by the VOSviewer software.

This review set out to raise more questions related to the strategies used in the energy sector (Sołoducho-Pelc, 2016). The maps generated in this study are meant to generate curiosity as much as to offer a definitive reading of the literature.

Conclusions

The main conclusion of this paper is that the changes in the German energy sector towards more green and sustainable strategies are reflected in scientific literature. The scientific contribution of this paper is the presentation of the existing research in

published scientific papers on the subject of the green transition in Germany and a proposition for the classification of the pattern of this economic change. The bibliometric study based on the SLR variation method with queries is an initial step in the exploration of the research problem developed by means of Bibliometrix software analysis. This study identifies, explores and covers multiple research gaps. The proposed order of queries, bibliometric maps, and the clusters thereof address the taxonomic research gap in the present study. The second knowledge gap relates to the study, while the methodological research gap is addressed by combining the two adopted methods. The final research gap addressed in this study is based on limited literature reviews and publications devoted to the transformation of the German energy sector. The methodological contribution of this paper is based on a comparison of the descriptive and SLR literature review methods employed in the current study. This research procedure opens the way for the replication of bibliometric research, strengthening the development of management science (Graczyk, 2021; Kozar and Sulich, 2023). A further scientific contribution is the detailed description of procedures that assure the reproducibility of the paper by other authors.

The practical contributions of this paper may interest researchers, managers, and policymakers interested in changes in the energy sector in Germany. The direct implication for policymakers is the visible creation of two directions for green strategy: slower, more gradual change, or faster and more direct change. This choice is a specific direction of the development of green strategies in the German energy sector and involves both organisational and technological solutions.

The originality of this paper is based on the usage of combined methods of analysis of bibliometric maps and the description

thereof. The visualisations present the relationships between patterns of green transition formulation. Bibliometric maps, together with the results of Bibliometrix analysis, prove the trends in science and inform other authors about the general progress or research gaps in the explored interdisciplinary field. The novelty value of this research lies in the presentation of the existing research gaps and the identification of the main directions of ongoing research on the green energy transition in Germany. One potential avenue for further research would be additional analysis using other kinds of bibliometric software combined with secondary statistical data analysis. Another possible form of analysis could be focused on other countries or groups of countries, and present the influence of the German green transition on the local energy sector.

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Education and socially responsible management as an effective communication tool in local self-government

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Abstract

Education, training and knowledge have always been a basic prerequisite for social and economic development. Society - economic crises, shocks in the global economy, environmental problems constantly create greater pressure on public budgets. The limited range of available resources of the public sector, the increasing financial requirements of individual sectors such as health care, social affairs, the environment, internal and external security and, on the other hand, the insufficient ability of institutions and departments to objectively formulate their financial needs require a rational and, above all, qualified approach in meeting financial needs and distribution of limited resources. In the crisis conditions of uncertainty, risk, economic imbalance, education, permanent education, practical experience and the resulting knowledge play a major role in the management of not only a private but also a public sector. In addition to being an effective tool, they are also an important external communication tool. The aim of the scientific state is to point out the importance and influence of education and knowledge in managing and achieving economic, social and social effects.

The research sample consisted of a basic set of 2922 municipalities, which represents 99.83% of the total number of municipalities in the Slovak Republic. This file was divided into 10 size categories, in which 4 categories of achieved education of local government representatives were determined. Correlational regression analysis was used to analyze the influence of the achieved education of local government management and the economic results of the municipality. In the

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analysis of dependency in local self-government, the qualification structures of management, the size of the self-government were taken into account as independent variables, and individual performance parameters as dependent variables, namely the economic result per inhabitant as a key parameter. Chi-square test, Fisher's test, Spearman's coefficient were also used in the work.

The research results refuted the published knowledge presented in foreign as well as domestic studies, which confirm the positive impact of education on economies. This relationship was not confirmed in the 2922 examined municipalities of the Slovak Republic.

The output of the scientific report was to summarize the mutual influences of the pillars of social responsibility, where qualification prerequisites and required competences could contribute or influence the efficiency and responsible management of self-government. Many countries are faced with solving the question of what can and cannot be financed from public budgets and how to effectively use available public resources within individual levels and departments of the public sector.

Key words

education, local government, social responsibility, communication tool, Slovak Republic.

Introduction

Many countries are faced with solving the question of what can and cannot be financed from public budgets and how to effectively use available public resources within individual levels and departments of the public sector. Even in the case of local self-government, the financial needs incomparably exceed the total amount of funds that can be allocated annually from the municipal budget to ensure the performance of the transferred and original competences entrusted to them in accordance with the law. In order to ensure the qualitative development of local self-government and the environment in which its residents live, work and do business, it is necessary to create a financing system that supports the objective redistribution

and use of public funds. When deciding on their amount and method of allocation, it is necessary to take into account support for the fulfilment of individual and socio-economic goals, local government budget possibilities, social responsibility, principles of economic rationality based on relevant education, practical experience and knowledge of local government leaders.

1. Literature review

The positive effects of education and qualifications on human resources were discussed by many authors such as Mihályi G. (2019), who analyzed the relationships between knowledge, competences and self-government management, Romer

P.M. (1989) in his work "Economic growth and human development", Odit, M. P., Dookhan, K., & Fauzel, S. (2010) in his work "The impact of education on economic growth: the case of Mauritius", or Ndiyo, N. A. (2007) "A dynamic analysis of education and economic growth in Nigeria". Other authors who investigated the positive effects of education and knowledge in relation to the achievement of economic effects were Lee C. G. (2010), Krueger, A., & Lindahl, M. (2001), Knowles, S., Lorgelly, P. K., & Owen, P.D. (2002), Keller, K.R.I. (2006), Kalaitzidakis, P., Mamuneas, T.P., Savvides, A., & Stengos, T. (2001) or Johnson, R.W. (1996). Temple J. (1999) investigated the positive impact of human capital on economic growth. The specific area of the impact of education on selected underdeveloped as well as developed regions was dealt with by the authors Siddiqui A. (2006), who examined the impact of education and the return on investment in education at the macroeconomic level in South Asia. ZENG J. (1997) also carried out similarly focused research, when he focused on the mutual effect of human and physical capital in relation to overall economic growth. Regional aspects of the influence of education, dual education (Papcunová, V. et al., 2022) and economic growth were also investigated by Ramos, R., Surinach, J., Artís, M. (2009) using the example of Catalonia and the mentioned authors Odit, M. P., Dookhan, K., & Fauzel, S. (2010), who investigated these relationships using the example of Mairícia.

1.1. Education, knowledge and human resources in local government

Authors who perceive education, knowledge and competence as the primary tool for solving regional problems of economic and social backwardness were Musila, J.W., & Belassi, W. (2004) with an analysis of the impact of education and its expenditure on economic growth in Uganda, as

well as Ndiyo, N.A. (2007) which focused on the dynamic analysis of education and economic growth in Nigeria, Gyimah-Brempong, K., Paddison, O., & Mitiku, W. (2006) examining the effects of higher education on economic growth in Africa. The effects of education on economic development in developed countries and regions were investigated by Kavanagh, C- Doyle, E. (2006) in the context of Ireland, Keller, K. R. I. (2006) the impact of education in the Asian area, or Knowles, S., Lorgelly, P. K., & Owen, P. D. (2002) in the developed countries of America, Europe and Asia. During the COVID-19 crisis, many countries experienced a large-scale drop in GDP, when the productivity of goods and services decreased, which was associated with a subsequent increase in unemployment. Within the issue of education and human capital, several authors focus their attention on examining financial aid for the educated as one of the pillars of educational policy. Given its scope, they seek to quantify the effects of policies designed to promote education and seek to understand the way in which they interact with private funding of education. (see e.g. Abbott et al. 2019). Several studies confirm that increasing the educational level of the population has a positive effect on GDP. (Marquez-Ramos & Mourelle, 2019, Lucas, 2015). The level of economic growth of a country varies depending on the development of its human capital, and thus also on the level of education achieved. Education has long been considered an important determinant of economic well-being. The theoretical literature on economic growth emphasizes at least three mechanisms through which education can affect economic growth. First, education can increase the human capital embodied in the labor force, which increases labor productivity and thus transitory growth toward a higher equilibrium level of output. Second, education can increase the innovation capacity

of the economy and new knowledge about new technologies, products and processes promotes growth (as in endogenous growth theories, see e.g. Lucas (1988), Romer (1990), Aghion and Howitt (1998)). Third, education can facilitate the dissemination and transfer of knowledge needed to understand, process new information and successfully implement new technologies developed by others, which in turn will stimulate economic growth (eg Nelson and Phelps, 1966; Benhabib and Spiegel, 1994). Empirical evidence on the impact of education on economic growth has long been highly controversial. Research over the last decade shows that ignoring differences in educational quality significantly distorts the picture of how educational and economic outcomes are related (Hanushek et al., 2007). In the framework of human capital research, several studies have also been carried out in recent years examining the role of investment in education, human capital as a channel through which specific human capital in the corporate sphere drives endogenous growth. The mentioned connections were tested e.g. as part of a survey conducted between 2002 and 2010 on a population sample in 63 countries (Ehrlich, et al., 2017). Other conducted studies focus on the response of income and the risk of poverty to increased investments in human capital in relation to demographic factors. The results suggest that investing in people is more cost-effective than investing in physical capital as a means of achieving stated income or poverty goals (Collin & Weil, 2020). The empirical research carried out thus partially confirms one of the hypotheses of the human capital theory, regarding the mutual link between higher education and income growth. (more in Heckman, James J., John Eric Humphries, A Gregory Veramendi, 2018). Responsible management includes the competencies and knowledge of management, which monitors, creates and

influences financial indicators and thus the fiscal health of the municipality. It is necessary to adapt knowledge, education and competences to the factor of time or to the time period - historical, current, developing, i.e. future (Ramsey, 2013). The environment of the public sector is influenced by factors that are absent in the private sector, namely civil control, public opinion, public interest and others. It is decision-making with the participation of the public in the so-called local self-governments. public choice connects two markets, the political and economic market, i.e. public and private (Potůček et al., 2005).

1.2. Education and social responsibility in local government

The local government, which works on its own social responsibility, tries to improve its own reputation and image towards all citizens as a whole, to improve its own ability to attract and retain educated employees, to maintain the motivation and commitment of its employees, to improve its own relations with companies, other public administration organizations, the media, suppliers, citizens/customers and the company in which it operates. Greater efficiency, accountability and transparency is just as important as in the private sector (Jadudová & Repa, 2011). Public administration bodies influence three pillars with their activities - economic, social and environmental. Systematic application of the concept of social responsibility in local government strengthens its image, acts as an important means of communication, increases transparency and contributes to residents' interest in the management of public affairs. The advantage of applying the concept is also strengthening the responsibility of public administration bodies towards their residents (Pavlík & Bělčík, 2010). Socially and environmentally responsible organizations are often considered prestigious (Glavas and

Godwin 2013; Jones et al. 2014) and as such, external stakeholders distinguish them from non-socially and environmentally irresponsible companies (Brammer et al., 2014). In this context, self-government, which is perceived as different, provides employees with a sense of their own uniqueness, because working for a prestigious, different organization whose values are similar to their own promotes feelings of pride (Kim et al., 2010), increases employees' self-confidence (Brammer et al., 2014) and their self-esteem (Jones et al., 2014). The economic benefits in interaction with employees are primarily based on increased employee loyalty, which is linked to the possibility of attracting and retaining not only high-quality, but also top-notch employees, and the fact that employees whose needs are met within the organization are more likely to perceive their employer as a suitable place for self-realization (Kara et al., 2013). The competitive advantage itself as an economic benefit from the application of social responsibility can take the form of the social capital of the organization and the good reputation that the organization will acquire, the improvement of the good name in the local community, but also the mitigation of legal measures, e.g. direct financial savings associated with ecological (Zelený, 2010) and social practices.

2. Methodology

The main goal of the scientific state is, based on the analysis of theoretical approaches and socially responsible behaviour, primary research and secondary research, to identify the effects of education and on the results of local self-government management, as an element of

the economic and social pillar of socially responsible behaviour, as well as the real impact of education on selected indicators of economic performance self-government - an element of the economic pillar of social responsibility. The output of the scientific state is to summarize the mutual influences of the pillars of social competence, where qualification prerequisites and required competences would contribute or they affected the efficiency and responsible management of self-government. The results of the analysis of the scientific state must be subjected to a deeper confrontation of the results, as it is not entirely clear whether the achieved formal education or practical experience are the ones that bring economic benefits to the local government. However, we assume that from the point of view of management itself, if he has a higher education, he also has less practical experience equal to the number of years of study. With a higher education, however, a higher inclination towards social responsibility can be assumed, which represents an effort to constantly improve, to acquire new knowledge that can be applied in better management. The subject of the research of the scientific state is the education (theoretical as well as the practical component) of the statute holder and its influence on the basic economic indicator, namely the result of the economy per inhabitant. The subject was also the investigation of the influence of education, as an element of the social pillar of social responsibility, on another, economic pillar of social responsibility - efficient and responsible management. The research sample consisted of an almost basic set of 2922 (after statistical cleaning of the values). The structure of the investigated subjects was as follows.

Table 1. Size structure of the village in the basic set

Size group	number of municipalities
-199	388
200 - 499	741
500 - 999	768
1000 - 1999	580
2000 - 4999	290
5000 - 9999	65
10000 - 19999	36
20000 - 49999	43
50000 - 99999	9
100000 +	2

Source: own elaboration

From the point of view of the representation of individual levels of education, the most numerous groups of mayors and mayors were with secondary education (mainly in the smallest municipalities) and university education II. degree in municipalities in the size group up to 2000 to 99999 inhabitants.

Table 2. Educational structure of mayors by size of municipalities

Size group	indicator	primary/ secondary	I. degree of higher education	II. degree of higher education	III. degree of higher education	together
– 199	count	286	15	80	7	388
	% in the group	73,7	3,9	20,6	1,8	100
200 – 499	count	501	14	217	9	741
	% in the group	67,6	1,9	29,3	1,2	100
500 – 999	count	428	19	302	19	768
	% in the group	55,7	2,5	39,3	2,5	100
1000 – 1999	count	237	14	289	40	580
	% in the group	40,9	2,4	49,8	6,9	100
2000 – 4999	count	96	9	163	22	290
	% in the group	33	3,1	56	7,6	99,7
5000 – 9999	count	16	1	42	6	68
	% in the group	24,6	1,5	64,6	9,2	100
10000 – 19999	count	5	0	23	8	36
	% in the group	13,9	0	63,9	22,2	100
20000 – 49999	count	9	0	24	10	43
	% in the group	20,9	0	55,8	23,3	100
50000 – 99999	count	3	0	5	1	9
	% in the group	33,3	0	55,6	11,1	100
100000+	count	2	0	0	0	2
	% in the group	100	0	0	0	100

Source: own elaboration

We used correlation and regression analysis to analyze the influence of the achieved level of education and the economic result of the municipality. Since the analysis will be applied to the entire basic set, we assume that the results will be sufficiently valid. Correlation analysis is applied in this case to assess the intensity (tightness) of free (statistical) dependence between performance

indicators - the result of management and education. We used regression functions to evaluate the intensity between these variables (correlation analysis was used to reveal mutual relationships between the mentioned parameters). The basis for determining this dependence in local governments was the Chi-square test (c2-test) on independence. If the conditions for using the Chi-square

test are not met, we will use Fisher's test (also referred to as Fisher's exact test in the PASW program) to test the dependence of two variables. The investigated dependence between the variables (e.g. the achieved education of local government management and local government management) takes on values from 0 (no relationship) to 1 (perfect relationship). When interpreting the contingency coefficient in our research, we used the scale introduced by Cohen (1988) for the correlation coefficient. A correlation of less than 0.1 is trivial; 0.1–0.3 small; 0.3–0.5 is medium and above 0.5 is large. Using the Spearman coefficient method, we determined the degree of dependence between

the selected indicators and qualification. We defined Spearman's correlation coefficient as a sample correlation coefficient calculated from pairs. Using the ordinal regression method, we defined the factors that have the strongest influence on the performance of local self-government. It is assumed that the trend $f(t)$ depends (linearly or non-linearly) on the unknown parameters $\beta_0, \beta_1, \dots, \beta_k$ and the known functions $\varphi_0(t), \varphi_1(t), \dots, \varphi_k(t)$, which no longer contain any unknown parameters, i.e. $j. f(t) = g(\beta_0, \beta_1, \dots, \beta_k; \varphi_0(t), \varphi_1(t), \dots, \varphi_k(t))$. We present the relations for regression and correlation analysis in the following form: for y dependent on x , the relation applies:

$$a = \frac{\sum (x - \bar{x})(y - \bar{y})}{\sum (x - \bar{x})^2} \quad (1)$$

Construction method of scientific observation for y dependent on x constant b is in the form:

$$b = \bar{y} - a\bar{x} \quad (2)$$

For x dependent on y , the relation applies:

$$a = \frac{\sum (y - \bar{y})(x - \bar{x})}{\sum (y - \bar{y})^2}, \quad b = \bar{x} - a\bar{y} \quad (3)$$

Construction method of scientific observation for x dependent on y .

In the analysis of dependency in local self-government, the qualification structures of management, the size of the self-government were taken into account as independent variables, and as dependent variables individual performance parameters, namely the economic result per inhabitant as a key parameter. Based on domestic and foreign research, we assumed that education will have a positive effect on the positive result of the economy calculated per capita. The obtained results are presented in the results and discussion section.

3. Research results and discussion

The performed analysis was based on the basic set, thus providing a sufficiently relevant view of the investigated contexts. The following text of the scientific statement presents the summary results from partial regional analysis according to individual indicators. In the introductory part, we analysed the confirmation of the assumption that with the increasing size of the group of municipalities, the achieved level of education of the elected chief representative also increased. This assumption was only partially confirmed. In selected NUTS 3, a moderately strong direct linear dependence

was proven. Such regions included NUTS 3 Trnava, Trenčín, Žilina, Banská Bystrica and Prešov. This assumption was not confirmed in Bratislava, Nitra and Košice.

Table 3. Spearman's coefficient of educational attainment and village size

NUTS 3 Bratislava	Correlation Coefficient	1,000	0,109
	Sig. (2-tailed)		0,309
	N	90	89
NUTS 3 Trnava	Correlation Coefficient	1,000	,361**
	Sig. (2-tailed)		0,000
	N	276	276
NUTS 3 Trenčín	Correlation Coefficient	1,000	,335**
	Sig. (2-tailed)		0,000
	N	251	251
NUTS 3 Nitra	Correlation Coefficient	1,000	,244**
	Sig. (2-tailed)		0,000
	N	354	353
NUTS 3 Žilina	Correlation Coefficient	1,000	,366**
	Sig. (2-tailed)		0,000
	N	315	315
NUTS 3 B. Bystrica	Correlation Coefficient	1,000	,323**
	Sig. (2-tailed)		0,000
	N	515	514
NUTS 3 Prešov	Correlation Coefficient	1,000	,304**
	Sig. (2-tailed)		0,000
	N	665	663
NUTS 3 Košice	Correlation Coefficient	1,000	,237**
	Sig. (2-tailed)		0,000
	N	461	461

Source: own elaboration

The results of the correlation analysis were different in the case of examining this influence according to individual size groups in individual regions. The greatest impact of education and management was proven in the case of municipalities with a size from 10,000

to 19,999 in NUTS 3 Nitra, i.e. 0.962. The strongest relationship presenting an indirect linear dependence was achieved in municipalities from 10,000 to 19,999 inhabitants in NUTS 3 Bratislava (- 0.951) and from 5,000 to 9,999 in NUTS 3 Trenčín - 0.940.

Table 4. Analysis of the dependence of economic results according to the size of income and NUTS regions

NUTS 3 / size group	do 199	200 – 499	500 – 999	1000 – 1999	2000 – 4999	5000 – 9999	10000 – 19999	20000 – 49999
NUTS 3 Banská Bystrica	-0,057	0,061	0,002	-0,103	-0,029	-0,092	0,260	-0,580
NUTS 3 Bratislava			0,067	-0,135	0,238	-0,012	-0,951	-0,459
NUTS 3 Košice	-0,109	0,124	-0,083	0,052	0,089	-0,137		0,137
NUTS 3 Nitra	0,403	-0,018	-0,099	-0,079	0,132	-0,704	0,962	-0,923
NUTS 3 Prešov	-0,035	0,072	-0,029	-0,092	-0,217	-0,291	0,570	0,681
NUTS 3 Trenčín	-0,067	0,051	0,053	0,315	-0,120	-0,940	0,280	0,581
NUTS 3 Trnava		-0,127	0,183	0,172	-0,125	0,559	-0,089	-0,791
NUTS 3 Žilina	-0,099	0,005	0,095	-0,027	0,176	-0,020		-0,114

Source: own elaboration

The results are in contrast to the primary assumption of a positive correlation between education and economics. In this case, with a higher level of education, worse results in management were achieved. On the contrary, direct linear dependencies

prevailed in the largest municipalities (from 20000 to 49999) in NUTS 3 Prešov and Trenčín (0.581). With increasing education, the positive value of the economic result per inhabitant increased.

Table 5. Economic result per capita by level of education and NUTS regions

Economic result per inhabitant	NUTS 3 B. Bystrica	NUTS 3 Bratislava	NUTS 3 Košice	NUTS 3 Nitra	NUTS 3 Prešov	NUTS 3 Trenčín	NUTS 3 Trnava	NUTS 3 Žilina
Primary/secondary	46,8	54,1	25,2	39,2	53,5	32,0	24,0	67,9
I. degree of higher education	-5,2	18,9	30,0	47,8	19,4	-5,0	31,8	45,7
II. degree of higher education	26,6	27,6	24,8	23,6	15,4	44,3	48,4	58,7
III. degree of higher education	21,1	63,8	63,2	32,0	41,6	109,4	25,8	33,0

Source: own elaboration

The previous table shows the average values of economic results per inhabitant according to individual NUTS 3. The average values vary considerably. On the basis

of the analysis carried out, it is not possible to clearly prove the general positive influence of education on the overall management of local governments.

Conclusions

Public sector organizations do not apply the principles of social responsibility consciously and purposefully, but they still behave responsibly. All public sector organizations manage funds from public budgets and performance is subject to public control. Decision-making on management takes place by public election. For this reason, public sector organizations are obliged to behave economically, socially and environmentally responsibly towards all interested parties. In recent years, socially responsible behaviour has become an increasingly discussed topic, an important communication tool, and the number of organizations applying the principles of socially responsible behaviour is growing. These activities must correspond with the performance of the local self-government. The scientific study focused on the investigation of the relationship between education, as a basic element and factor affecting the tendency to act responsibly in local self-government and the achieved economic result in local self-government. As part of the research, the management results of all municipalities in the Slovak Republic were analysed. Although many foreign and domestic studies unequivocally confirm the positive influence of education and management, in the case of economic growth from a macroeconomic point of view, in our case this relationship was not confirmed in all cases. From the point of view of social responsibility, emphasizing education is key, but in this case, the synergy of formally acquired knowledge and practical experience must be used. By combining the above variables, each representative of the local self-government acquires a knowledge base that enables responsible and effective management with the provision of sustainable growth.

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