

# **Zombification in Poland in particular during COVID-19 pandemic and low interest rates**

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## **Abstract**

This article addresses the issue of corporate zombification in the case of listed companies in Poland. The purpose of this paper is to analyse financially vulnerable zombie firms from the listed non-financial companies in Poland, in particular, during the COVID-19 pandemic and the period of low interest rates. Data from 2000 to 2021 from the EMIS database on the financial statements of companies registered on the Warsaw Stock Exchange and NewConnect were used. In the process of research, such methods as local linear projection regression, logistic regression combined with the scoring methods were used. The results of the research show that the economic crisis caused by the coronavirus pandemic and the period of low interest rates have increased zombie firms among the listed companies in Poland. The anatomy of zombie firms differs significantly from the anatomy of non-zombie companies. The dynamics of financial indicators of zombie companies that appeared during the recession (Global Financial Crisis, the COVID-19 pandemic) and the period of low interest rates as in the period without a recession, show the ambiguity of the financial condition of these enterprises. For the survival of zombie companies, the most important indicator is their size. The continued existence of zombie firms also depends on leverage and profitability as the main financial indicators.

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**Keywords:** corporate zombies, bankruptcy, COVID-19, local linear projection regressions, scoring approach

**JEL:** D22, D24, E43, G33

## 1. Introduction

No one foresaw that zombie companies would start spreading like this. Thirty years ago, there were only 2% of them. These were unproductive and credited non-financial enterprises formed as a result of the crisis of the early 1990s (Adalet McGowan, Andrews, Millot 2017a, 2017b). However, the very concept of a “zombie company” arose in 2008. After 10 years, the number of such firms reached 12% among non-financial companies. These include 20% of Chinese stock exchange companies, 14% of American stock exchange firms included in the S&P1500 index and in the Eurozone (Malinen 2018). Zombie companies are harmful to both society and the economy. They prevent the emergence of efficient enterprises on the market, slow down productivity, etc. Observations of scientists have shown that the emergence of another crisis (2008, the COVID-19 pandemic) is accompanied by the return of the problem of the zombie company.

After getting acquainted with the literature on zombie companies, it should be noted that researchers most often pay attention to the causes of the appearance of zombies (Peek, Rosengren 2005; Caballero, Hoshi, Kashyap 2008; Broz, Ridzak 2017), as well as their distribution and behaviour (De Veirman, Levin 2012; Asanuma 2015; De Martiis, Fidrmuc 2017). The first publications appeared in Japan, later in other countries. Unfortunately, this problem has not been studied in depth enough.

The purpose of this paper is to analyse financially vulnerable zombie firms from the listed non-financial companies in Poland, in particular, during the COVID-19 pandemic and the period of low interest rates. To achieve this goal, it is necessary to conduct the following studies: (i) identifying zombie firms from the listed non-financial companies in Poland, (ii) studying the anatomy of zombie firms and comparing them with the characteristics of non-zombie enterprises, (iii) presenting stylized facts about the life period of zombie firms, (iv) determining the characteristics for the survival of zombie companies from the listed companies in Poland. Special attention in the study is paid to the period of the coronavirus pandemic and low interest rates. As is well known, zombie firms are financially vulnerable. These firms have limited ability to service accounts payable and are on the verge of bankruptcy. Mass bankruptcy of zombie enterprises can lead to the next economic crisis.

To implement this task, data from the EMIS<sup>1</sup> (the Emerging Markets Information Services) database on the financial statements of non-financial companies registered on the Warsaw Stock Exchange and NewConnect are used. The study examines not only corporations, but also small developing enterprises from the NewConnect market.

The research hypothesis and questions formulated here are that:

H1: The economic crisis caused by the coronavirus pandemic and the period of low interest rates have increased the number of zombie firms among the listed companies in Poland.

Scientists variously determine the connection between the economic crisis caused by the coronavirus pandemic with the increase in zombie companies. Even on the eve of the pandemic, Adalet McGowan, Andrews and Millot (2017a) noted the growth of zombification after another financial crisis. Since the mid-2000s, not only have zombie companies increased, but so too have the funds spent on them. This phenomenon overwhelms the markets and has a negative impact on non-zombie firms. Also, the Swedish researcher Cella (2021) continues to assert the growth of zombie companies. However, Zoller-Rydzek and Keller (2020) state that there is no evidence of the growth of zombie companies during the coronavirus pandemic. Government support will not increase zombie firms.

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<sup>1</sup> <https://www.emis.com/about>.

H2: The anatomy of zombie firms differs significantly from the anatomy of non-zombie companies.

What is the anatomy of firms? First of all, it is important to determine the financial condition of enterprises. It is necessary to consider the characteristics of companies (such as the size of enterprises, employment, investment, debt indicator, and others) and highlight the features. Caballero, Hoshi and Kashyap (2008) noted an important feature of zombie companies, namely unproductivity and creditworthiness, unlike firms that are not zombies.

Studying the life period of zombie enterprises, the paper poses both a research question and a hypothesis:

Q1: What is the life period of zombie enterprises?

Q2: What features of the behaviour of zombie companies are observed during the recession and the period of low interest rates?

To determine the life period of a zombie company, it is necessary to consider financial indicators in the period from the emergence of zombie firms and their continued existence, using local linear projection regressions. During the Great Recession, Foster, Grim and Haltiwanger (2016) note a decrease in the intensity of the redistribution of production and costs between producers. Continuing the research in the paper, we consider the behaviour of zombie firms during the Global Financial Crisis and during the COVID-19 pandemic and the period of low interest rates.

After getting acquainted with the literature related to zombie companies, it is necessary to try to determine what helps zombie firms to prolong their existence. To this purpose, a research question is posed in the paper:

Q3: What characteristics are important for the survival of zombie companies?

Answering the research question posed, logistic regression combined with the scoring methods is applied when using explanatory variables – financial indicators that have been categorized. The econometric model was constructed using variables transformed by the Weight of Evidence approach.

Having conducted empirical research on the topic of zombification in Poland in particular during the COVID-19 pandemic and low interest rates, the following contribution to the literature can be noted. This study is conducted for the first time on Polish data.

The second section reviews the scientific research devoted to zombie companies. The next sections present the empirical approach, dealing with such matters as the methodology, database and variables while further displaying the results of the analysis carried out in four parts: (i) identifying zombie firms from the listed non-financial companies in Poland, (ii) the anatomy of zombie firms, (iii) the stylized facts about the life period of zombie firms, (iv) the characteristics for the survival of zombie companies from the listed companies in Poland. The work ends with conclusions.

## 2. Literature review

Currently, more and more discussions of the problem of zombie companies can be found in the literature. As mentioned in the introduction, for the first time the term zombie firms was associated with Japanese unproductive and accredited firms. After the crisis of the 1990s, Japanese banks gave birth to zombie firms by giving them loans (Caballero, Hoshi, Kashyap 2008). Scientists Adalet McGowan, Andrews and Millot (2017a) continue to study this problem in OECD countries and observe the growth of zombie companies after the next financial crisis.

Zombie companies are enterprises with financial difficulties that are on the verge of bankruptcy (Sekine, Kobayashi, Saita 2003; Ahearne, Shinada 2005; Peek, Rosengren 2005; Urionabarrenetxea, San-Jose, Retolaza 2016; Imai 2016; Urionabarrenetxea et al. 2017; Goto, Wilbur 2019). These enterprises are unable to invest (that is, they do not stimulate growth), unable to pay off their debt, and have high borrowing costs. The only life support is the bank.

Researchers have noticed that the weakness of the banking system helps zombie companies to exist. Credit institutions unable to cope with loan losses finance zombie companies. Low interest rates have a negative impact on the profitability of banks, which are forced to lend to zombie companies. Banks, while maintaining their existence, thereby help zombie firms' debtors avoid bankruptcy.

In the literature, there is another way to support zombie companies, namely Quantitative Easing (QE) programmes. The central bank, buying bonds, finances banks, which in turn give loans. This leads to an increase in the level of corporate debt, that is, it supports zombie companies.

In the literature recently there are two directions associated with zombie companies. The first direction is to find ways to identify zombie companies (Fukuda, Nakamura 2011; Onaran 2012; Adalet McGowan, Andrews, Millot 2017a, 2017b; Zhu et al. 2019). Researchers of the second direction are trying to indicate the factors of the existence of zombie firms and the consequences (see Hoshi 2006).

There are different definitions of zombie firms in the literature. The first contribution to the definition of zombie companies was made by Caballero, Hoshi and Kashyap (2008). The researchers use the benchmark interest payment indicator to identify firms that artificially continue to exist because of a subsidized loan. In this way, the definition of zombie firms consists of three stages:

- find a hypothetical lower bound for interest payments ( $R^*$ ), which determines the high quality of the loan,
- the result obtained ( $R^*$ ) is compared with the observed interest payments ( $R$ ),
- based on econometric assumptions, the difference between the actual interest rate ( $r$ ) and notional lower bound rate ( $r^*$ ) is determined, according to the formula:

$$\frac{R_{it} - R_{it}^*}{BS_{it-1} + BL_{it-1} + Bonds_{it-1} + CP_{it-1}} = r - r^* \quad (1)$$

where:

- $i$  – firms i.e., the unit of observation,
- $t$  – time period,
- $BS$  – short-term bank loans,
- $BL$  – long-term bank loans,
- $Bonds$  – total bonds outstanding,
- $CP$  – the amount of commercial paper outstanding.

As a result, subsidized loans are identified.

The representatives of the Bank of France Avouyi-Dovi et al. (2017) have implemented the innovative approach of Caballero, Hoshi and Kashyap (2008) to definitions of zombie companies.

Researchers Adalet McGowan, Andrews and Millot (2017a, 2017b) draw attention to the following indicators:

- the Interest Coverage Ratio (ICR)<sup>2</sup> should be less than one for three years,
- the company's age should be 10 years or more. This restriction is used to ensure that young and dynamic firms do not have the status of zombie companies. These enterprises may have negative operating profit.

Storz et al. (2017), Schivardi, Sette and Tabellini (2017), Rodano and Sette (2019) and others use in their works the definition of zombie companies presented by Adalet McGowan, Andrews and Millot (2017a).

Banerjee and Hofmann (2018), analysing listed companies, draw attention to Tobin's q indicator,<sup>3</sup> which should be less than the median indicator in their economic sector. Scientists also apply a criterion for the ICR, which should be less than one. At the same time, unlike Adalet McGowan, Andrews and Millot (2017a), they use this criterion for two years.

## 2.1. Reasons for the appearance of zombie firms and consequences

Having studied the literature (Onaran 2012; BIS 2019), we can conclude that one of the reasons for the appearance of zombie companies is the non-neutral self-cleaning function of the market economy. This is explained by the fact that zombie enterprises that do not cover their debt obligations for a long time remain in existence.

Sometimes banks refinance debt obligations of enterprises without taking into account their financial condition and such an operation may not last in favour of the borrower, i.e. while the firm can pay interest on the loan (see Caballero, Hoshi, Kashyap 2008). This contributes to both the emergence and existence of zombie companies, especially during the period of reduction of the interest rate.

The consequences of the emergence of zombie firms should be noted. Most scientists (including Adalet McGowan, Andrews, Millot 2017a) note an increase in the growth of zombie companies. As is well known, after 2008, the following measures were carried out by central banks: loose monetary policy and quantitative easing programmes. There was an opportunity for financially weak enterprises to increase their debt obligation. This helped zombie enterprises to continue to exist and create new zombie enterprises, which prevented the emergence of healthy companies. At the same time, the global economy is experiencing a decline in global productivity (BIS 2019).

Thus, conclusions can be drawn. Zombie companies cause harm and danger to society and the economy both at the national and international level. Zombie enterprises reduce labour productivity, block jobs and projects, and restrict access to new, efficient companies (Adalet McGowan, Andrews, Millot 2017a, 2017b).

## 2.2. The existence of zombie firms and their impact on the economy and economic growth

Researchers continued to study the characteristics of zombie firms. The scientist Hoshi (2006) built an econometric probit model, with the help of which he determined what qualities a firm should have

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<sup>2</sup> ICR – earnings before interest and taxes (EBIT) over interest payments.

<sup>3</sup> Tobin's q indicator – the ratio of the market value of the company's assets to their book value.

in order to turn out to be a zombie firm. It should be a company with high debt, no profitability, a small unit located on the outskirts of the city and should work in non-manufacturing industries.

Caballero, Hoshi and Kashyap (2008) proposed a regression model with the help of which they came to the conclusion that the more zombie firms in a given branch, the less the growth of investment and employment of non-zombie firms. Fukuda and Nakamura (2011) were able to find the reasons for the continued existence of zombie firms in the Japanese economy in the 1990s. They needed to sell fixed assets and reduce staff. In addition to the above, Iwaisako, Fukuoka and Kanou (2013) and Asanuma (2015) point to the help of Japanese banks that supported the firm-zombies.

Currently, it should be noted that there are still a small number of research papers devoted to the analysis of zombie companies in Europe. Urionabarrenetxea, San-Jose and Retolaza (2016) identified an extreme type of zombie, namely enterprises with negative capital. They have established their negative impact on productivity. At the same time, zombie companies make up 10% of Europe's GDP. McGowan et al. (2017) conducted research on zombie companies in OECD countries. They noted the negative effect of the existence of zombies on the economy. Urionabarrenetxea et al. (2017) presented an interesting approach to identifying zombie companies in Spain using Extreme Zombies Index. The developed index contains four directions related to zombie companies: infection, spread, signs of recovery and immediacy. On the basis of a logarithmic-linear model, the riskiest profiles among zombie companies (i.e. extreme zombie firms) are determined. In their opinion, these firms should be under the control of competent authorities. These are large firms, poorly regulated, located in areas with large business structures. Acharya et al. (2019), studying the implementation of the direct monetary operations programme of the European Central Bank since 2012, found that zombie companies incorrectly used cash loans. They put aside the funds they received without using them for employment and investment. At the same time, large creditworthy firms were subjected to losses, which affected the development of the economy.

Given the small amount of research on zombie companies, it is difficult to establish a complete theory of zombie firms. However, conclusions can be drawn, starting with the problem of the state of the Japanese banking system, which created and fed zombie companies, and continuing research in European countries, which have revealed negative trends in the economy and sustainable growth of enterprises.

### 3. Description of the database

This section of the paper presents the dataset selected to analyse the state of zombie companies, particularly during the COVID-19 pandemic. To implement the task, the EMIS dataset was used. EMIS data includes information on over 147 emerging markets. In this paper, non-financial Polish companies registered on the stock exchange from 2000 to 2021 were studied. At the same time, companies from the financial economic sector are excluded. The number of observations for the entire analysis period was 8,620. Meanwhile, the number of zombies company consisted of 1,479 (see Table 1).

The structure of the sample used in the study is shown in Figure 1. The companies were considered in terms of economic sector (construction, industry, other services) and size (large, medium, small) (see Figure 1), which however confines itself to the structure of data for the last two only, as well as the most recent two full years, i.e. before the COVID-19 pandemic (in 2019) and during the pandemic (in 2020).

Figure 1 suggests no change in the structuring of enterprises before and during the COVID-19 pandemic.

#### 4. Description of variables

To achieve the goal mentioned at the introduction of the article, based on EMIS data, it is necessary to determine the financial performance of zombie companies. The selected variables are based on the literature (see Urionabarrenetxea, San-Jose, Retolaza 2016; Urionabarrenetxea et al. 2017; Banerjee, Hofmann 2018). Table 2 presents the definitions of variables.

#### 5. Identifying zombie companies

To identify zombie companies in Poland, an adequate definition of zombie firms has to be chosen. Two definitions are used for the accuracy of the results.

##### Definition 1

According to the first definition, a zombie company is characterized by insufficient funds to cover interest on debt. At the same time, the ICR should be less than one for two consecutive years.

##### Definition 2

The second definition is based on the first definition. In addition to the characteristics described above, a zombie company has a low expected potential for future growth for listed companies, which is measured using Tobin's q indicator. This potential is measured using Tobin's q, which should be less than the median indicator in this economic sector.

These definitions are taken from the literature (Storz et al. 2017; Schivardi, Sette, Tabellini 2017; Adalet McGowan, Andrews, Millot 2018; Banerjee, Hofmann 2018). It can be concluded that these enterprises do not receive operating profit in the long term and do not have the potential in the eyes of investors to make a profit in the future. Thanks to the use of Tobin's q index, it becomes possible to correctly identify start-up firms, since they have the potential for future profits.

The two definitions of zombie companies presented above do not take into account the age of the enterprises, since this problem is insufficiently substantiated in the literature related to this topic.

Analysing Figure 2 from 2000 to 2002, there has been an increase in the share of zombie companies listed on the stock exchange in Poland, according to two definitions. This indicator began to decline until 2007 (by 6% according to the first definition of zombie firms, by 4% according to the second definition). This can be explained by Poland's economic growth. Since the global financial crisis of 2008, the share of zombie companies has been increasing (in 2009 – 14% according to the first definition of zombie firms, 9% according to the second definition; in 2014 – 22% according to the first definition of zombie firms, 13% according to the second definition; in 2017 – 26% according to the first definition of zombie firms, 15% according to the second definition) and during the COVID-19

pandemic and the period of low interest rates reached 27% by the first definition and 16% by the second definition. According to the conducted research, there is also an increase in zombie companies in the literature during the coronavirus pandemic (for example, Cella 2021). In Sweden, accounts payable in banks for zombie companies are increasing. There is a necessity, as Cella (2021) signals, to establish financial monitoring.

Based on the conducted research, there are no grounds to reject the first research hypothesis that the economic crisis caused by the coronavirus pandemic and the period of low interest rates have increased zombie firms among the listed companies in Poland (H1). During this period, both percentages of zombie firms, according to two definitions, increased.

Continuing to investigate the state of zombie firms, the persistence of zombification should be noted. Zombie companies continue to remain in this category. The following calculations are used to measure the persistence:

$$\text{Remain a zombie} = \frac{p}{n} \quad (2)$$

where:

- $p$  – the number of zombie firms in the period ( $t$ ) that also remain zombies in the period ( $t + 1$ ),
- $n$  – number of zombie companies in the period ( $t$ ).

Based on the presented formula (2), the probability of zombie persistence ranges from the lowest level in 2003 according to the first definition of zombie firms (2002 according to the second definition) to 60% (53%) in 2020 – during the pandemic.

Classification by company size best reveals which of them determine to the greatest extent the increase in the number of zombie firms (see Figure 3). Since 2000, companies that became corporate zombies in Poland have most often been small enterprises as well. In 2020, during the pandemic period and the period of low interest rates, small enterprises accounted for 36% of zombie firms according to the first definition of zombie firms (26% according to the second definition). The presented results can be found in the literature (e.g. Hoshi 2006 and others).

Considering the percentage of zombie companies in the economic sector (see Figure 4), it was found that construction and other services are characterized in 2020, during the pandemic period, by a relatively high percentage of zombie companies – 24% and 31%, respectively (21% according to the first definition of zombie firms and 18% according to the second definition). It is no coincidence that these economic sectors from the 2000s had a tendency to turn out to be corporate zombies.

The construction sector is characterized by liquidity risk. Smaller enterprises are especially vulnerable because they are financially connected with investors, contractors, and also depend on consumer demand, etc. Overdue obligations aggravate the condition of construction companies.

According to the study, the other services sector has been ahead of the construction sector in terms of its indicators since 2013 and achieved leadership in bankruptcy during the pandemic. Epidemic restrictions have had an impact on the financial condition of companies. The demand for services has been sharply limited. The hotel and catering industry companies were affected. Liquidity-related problems are characteristic of the economic sector under consideration.

Studying the literature, it should be noted that scientists more often pay attention to the growth in the number of corporate zombies, not paying attention to the share they have of economic indicators

such as assets, equity, as well as short-term and long-term debt. Figure 5 shows the share of zombie companies in total assets, equity and debt in Poland. The left panel shows the share of zombies among all enterprises, and the right panel shows the fraction of zombies in the group of small and medium-sized firms.

The analysis revealed that among all enterprises, 10–12% of assets, equity and long-term debts and 13–14% of short-term debts belong to zombie companies. At first glance, it seems that zombie enterprises are not so economically important. However, if we consider a zombie enterprise among small and medium-sized firms, then we can clearly note their negative impact on the economy. Calculations showed they accounted for 55–60% of assets, 55–60% of equity, 40% (30% according to the second definition) of long-term debt, and 55% (45% according to the second definition) of short-term debt.

Summing up the work done in identifying corporate zombies, it should be noted that in Poland the percentage of zombie companies among stock exchange enterprises from 2000 to 2021, including the period of the coronavirus pandemic and the period of low interest rates, increased unevenly. Small companies are particularly vulnerable among the construction industry and other services.

## 6. Zombie anatomy

The next subsection examines the anatomy of zombie firms and compares them with the characteristics of non-zombie enterprises. The anatomy of zombie firms consists of the following characteristics: size, structure of capital expenditures, employment, intangible investments, capital expenditures, cash reserves, interest paid, profitability, leverage, etc.

Answering the second research hypothesis about the features of the anatomy of zombie firms in comparison with non-zombie companies (H2), Table 3 is presented, which contains important characteristics regarding the anatomy of zombie firms. The use of both parametric (t-test) and non-parametric tests (Wilcoxon-Mann-Whitney test) revealed statistically significant differences between the financial ratios of zombie companies and non-zombie companies at the mean and median levels.

As previously recalled, zombie companies, firstly, are smaller than non-zombie companies. Their assets, capital and employment are on average 2–3 times less compared to non-zombie firms. The results obtained correspond to the literature presented earlier (see Banerjee, Hofmann 2018). The structure of capital expenditures (represented by the CAPEX indicator) of zombie companies are on average 1.2 percentage points lower (3.2 percentage points according to the second definition) relative to non-zombie firms. This phenomenon was also noticed by Beck, Bruno and Carletti (2021). In order to survive, zombie firms restrict business by selling assets (represented by the Assets disposal indicator), which is 0.2 percentage points higher compared to non-zombies and reducing staff measured using a variable Employment growth (on average by more than 11%; 8% according to the second definition) per year). Zombie corporations partially do not have cash flow, have a negative ICR, their Tobin's q index, responsible for further growth, is at a low level. The interest paid by zombie companies is on average 1 percentage point higher compared with non-zombie enterprises. This indicates a higher credit risk. Zombie enterprises are characterized by a high leverage ratio. At the same time, their debt grows by an average of 10% per year. It can be assumed that there is no barrier to the next zombie debts. Statistics show that the probability of the termination of the existence of zombie firms in Poland

is on average higher relative to non-zombies. The performed tests, both parametric (t-test) and non-parametric (Wilcoxon-Mann-Whitney test), reject the hypothesis that the considered features are equal. Based on the results obtained, there are no grounds to reject the second research hypothesis (H2).

Based on the previous research results, a question arises: What helps zombie firms prolong their existence?

Answering the question, it is necessary to analyse the financial indicators for zombie firms that continue to exist and zombie companies that decided to exit the market, i.e. stopped existing. In this case, financial indicators were reviewed for the year before the exit of zombie enterprises.

Data analysis shows that zombie firms that continued to exist (marked as No exit) had lower losses as a result of their activities compared to zombie companies that left the market – marked as Exit (see Table 4). In addition, they had less borrowed funds (represented by the Leverage indicator). Their interest paid on the debt was lower. It should be noted the size of the enterprises. As statistics show, in comparison with the retired zombie companies, their firms turned out to be larger. To prolong their existence, these zombie firms mostly sold their assets (represented by the Assets disposal indicator), but to a lesser extent reduced their staff (measured using a variable Employment growth). It should be noted that the surviving zombie firms turned out to be more innovative (variable Intangible investment). They invested their capital in investments in intangible capital. The above-mentioned factors helped to preserve their existence.

Having studied the anatomy of zombie firms, we became more familiar with the peculiarities of the behaviour of zombie companies in Poland and their aspirations to save their business.

## **7. Stylized facts of the zombie firms' life period**

This subsection presents stylized facts about the life period of zombie companies. Stylized facts are the characteristic features of the zombie firm life period. The life period of zombie companies is considered within 4 years from birth. The analysis is carried out using zombie firms that continue to exist. The study examines financial indicators based on the balance sheet, income statement and cash flow. Local linear projection regressions are used to determine the life period of zombie companies.

The study consists of two parts. The first part presents the methodology of the study. In the second part the results of the regression analysis are presented.

### **7.1. Research methodology**

To determine the life period of zombie companies, local linear projection regressions are used. Jordà (2005) used the local projection method for the first time, which is an alternative method with respect to vector autoregression (VAR). According to the literature, the local projection method has been used for about 17 years, especially in the study of fiscal policy (Auerbach, Gorodnichenko 2013; Jordà, Taylor 2016).

This study also uses the method presented by the scientist Jordà, Schularick and Taylor (2005). This method is more suitable for presenting the dynamics of financial indicators from a multidimensional point of view, unlike standard models. Using this method, it is possible to take into account the panel data structure as well as the presence of nonlinearity (Auerbach, Gorodnichenko 2013; Jordà,

Schularick, Taylor 2015). Having granular data, it can be difficult to evaluate an econometric model to determine the impulse responses of financial indicators. This confirms the correctness of using the above approach, especially if the shock is defined (in this study, the appearance of zombie companies in period  $t$ ).

In the study, the set of regressions represented by the formula is used to determine the local projection (see Banerjee, Hofmann 2018):

$$y_{i,s,t+h} = \alpha_{s,t+h} + \beta_h D(\text{Enterzombie})_{i,s,t} + \gamma_h D(\text{Prezombie})_{i,s,t} + \theta_h X_{i,s,t-1} + \varepsilon_{i,s,t+h} \quad (3)$$

where:

$h = \{0, 1, 2, 3, 4\}$ ;

$i$  – company;

$s$  – economic sector;

$t$  – year;

$y$  – the response variable, in this research – enterprise performance (accordingly log assets, Assets disposal, CAPEX, Intangible investment, Employment growth, Cash flow, ICR, Tobin's  $q$ , Leverage, Debt growth),

$\alpha_{s,t+h}$  – sector-time fixed effect.

$D(\text{Enterzombie})$  is equal to "1" if the company became a zombie in period  $t$ . The variable  $D(\text{Enterzombie})$  is responsible for the selection of zombie companies that were identified in period  $t$  according to the definition. This variable  $D(\text{Enterzombie})$  does not change over time, since the purpose of the study is to observe the financial condition of identified zombie firms in period  $t$  over the next 4 years.

$D(\text{Prezombie})$  is equal to "1" if the company is a zombie in  $t$  but didn't become a zombie in period  $t$ .

$X_{i,s,t-1}$  is the firm's size (logarithm of total assets) a year before the zombie companies were identified. This explanatory variable was considered in the  $t - 1$  period due to the fact that a year before obtaining zombie status, it is necessary to control the size of the enterprise. Only one variable was used as a control variable – the size of the zombie company, since it does not participate in determining the identification of zombie companies. Although scientists Frank and Goal (2009) note that the capital structure in an enterprise depends on the size, profitability and Tobin's  $q$  index.

The parameters  $\beta_h$  show the dynamics of financial indicators for 4 years from the moment of identification of zombie companies. These parameters determine the effectiveness of zombie companies relative to non-zombie firms. If  $\beta_h > 0$ , then the considered financial indicator for zombie companies is higher relative to non-zombie companies.

As a result of the evaluation of the presented model, graphs of the dynamics of financial indicators of zombie companies for 4 years were constructed, using a 95% confidence interval. The life period analysis of zombie companies is limited to 4 years to obtain more accurate results. The study was conducted on zombie enterprises that continued to exist during this period of time ( $t+1, t+2, t+3, t+4$ ), taking into account the risks of survival bias in the estimators of the projection of the dynamics of financial indicators. This bias in estimates could have occurred as a result of the zombie company's exit from the market.

The local projection approach is based on estimating the given regression in each projection period  $h$ . The given approach is more stable with respect to erroneous specification. It is worth noting

that when estimating the panel model (in this case, the Fixed Effect), it is important to take into account the problem associated with autocorrelation and heteroscedasticity of the random error. For this purpose, a robust cluster matrix of variance-covariance of a random error was used.

## 7.2. Results

In this subsection of the study, using local linear projection regressions, graphs of the dynamics of financial indicators of zombie companies within 4 years from the moment of their identification according to the definition are presented.

Based on Figure 6, an analysis of the life path of zombie enterprises is carried out, answering the research question posed (Q1).

In the first year after zombification, there is a sharp decrease in the size of enterprises (represented by the Log assets). However, in year 2, zombie companies increase their size, but it is not possible to keep it, and after the second year, the size of the company decreases and in the fourth year increases a little above zero. Throughout the life period, the size of a zombie company is smaller relative to non-zombie firms, this is confirmed by theory.

Analysing the indicator of the Assets disposal of zombie companies, there is a sharp increase in the first year of existence (zombie firms seek to gain a foothold in the market). However, starting from the age of 2, this indicator decreases and turns out to be lower in comparison with non-zombie companies. Also, zombie companies begin to increase their structure of capital expenditures (represented by the CAPEX indicator) during the first years and sharply reduce them starting from 2 years, reducing this indicator in comparison with non-zombie companies. Investments in intangible capital of zombie firms fluctuate throughout the life period: they increase in the first year, decrease strongly in the second, and increase from the third year, reaching a level slightly above zero. The staff of zombie companies (represented by the Employment growth), adapting to survive, decreases from 3 years.

The cash flow of zombie companies increases in the first year of existence, decreases sharply in the second year, and unexpectedly increases again from the third year of life. Such fluctuations may be associated with the disposal of assets of zombie companies as well as the receipt of borrowed funds. Borrowed funds (represented by the Leverage indicator) decrease to the second year, then grow again in 3 years, but do not exceed this indicator in 4 years for non-zombie firms.

At the same time, ICR of zombie companies decreases after the second year. Tobin's q index, which is responsible for further growth, does not portend success.

Given the results obtained for the financial performance of zombie companies, it seems unlikely that they will recover and change their status. Given the results obtained for the financial performance of companies within 4 years of their life from the moment they were identified as a zombie firm, it seems likely that most of them will recover and change their status. However, some enterprises will continue to exist in the status of zombies.

Continuing the research in the paper, we consider the behaviour of zombie firms during the Global Financial Crisis and during the COVID-19 pandemic and also the period of the low interest rates. This will verify the second question posted in the article (Q2): What features of the behaviour of zombie companies are observed during the recession? The interactions between the Global Financial Crisis / the COVID-19 pandemic and the binary variable  $D(Enterzombie)$  have been added to the presented equation (3).

Having made observations regarding the dynamics of financial indicators of companies that became zombie firms during the recession (Global Financial Crisis / the COVID-19 pandemic and the period of the low interest rates) in comparison with zombie firms that emerged during the period without a recession, minor changes can be noted (see Figure 7). Zombie companies that appeared during the COVID-19 pandemic and the period of low interest rates were only considered for two years due to the availability of data.

The size of zombie companies that appeared in the period without a recession is relatively smaller than during the recession. However, subsequently, the size of the zombie enterprise that appeared during the recession decreases and becomes smaller than that of profitable companies. In the first years of the recession, there is a noticeable increase in the assets disposal indicator of zombie companies. In the case of a recession related to the Global Financial Crisis, the decrease in the indicator continues and in the fourth year of the period under consideration increases and becomes higher than that of non-zombie companies. The indicator of the structure of capital expenditures during the recession decreases and only in the second year is there a slight increase. Adapting to the conditions of the recession, zombie companies increase investments in intangible capital in the first two years, the growth rate decreases in the third year and grows again in the fourth year. Tobin's q index during the recession, especially in the first year of the existence of zombie firms, decreases without promising a future, while during the pandemic there is a greater decrease in this indicator.

It should be taken into account that the 95% confidence intervals of the estimated coefficients presented in Figure 7, representing the dynamics of the financial indicators of zombie companies that appeared during the recession, as well as in the period without a recession, partially overlap. This result makes it possible to assume that the changes are not statistically significant. However, it should be noted that the 95% confidence intervals of the estimated coefficients of zombie companies that appeared during the recession are wider relative to zombie companies that appeared during the non-recession period. This indicates the presence of uncertainty in the behaviour and financial condition of zombie firms during the recession.

## **8. Zombie survival**

This subsection presents the determinants of the survival of zombie companies in Poland. The study consists of two parts. The first part presents the methodology of the study. In the second part the results of the regression analysis are presented.

### **8.1. Research methodology**

Answering the fourth research question (Q3: Which characteristics are important for the survival of zombie companies?), logistic regression combined with the scoring methods is applied. Scoring methods are not only used in issues related to credit risk, but also for modelling a dependent variable that develops from two categories. In the literature, it is not uncommon to use logistic regression in this case. This technique is also often used in practice. The following formula is used for this:

$$\ln \left( \frac{\text{pr}(\text{Zombie}_{\text{non-survival}})}{1 - \text{pr}(\text{Zombie}_{\text{non-survival}})} \right) = \beta_1 + \beta_2 X_2 + \beta_3 X_3 + \dots + \beta_k X_k \quad (4)$$

where:

- $\text{pr}(\text{Zombie}_{\text{non-survival}})$  – the probability of exit from the market of zombie companies,
- $\beta_1, \beta_2, \beta_3, \dots, \beta_k$  – unknown parameters in the econometric model,
- $X_2, X_3, \dots, X_k$  – explanatory variables – financial ratios of zombie companies.

The dependent variable has two values: 1 if the zombie enterprise did not survive, i.e. it ended its activity, and 0 if the zombie enterprise is still operating on the market. Unknown coefficients in the model are determined by the Maximum Likelihood Method (see Greene 2003).

It was conditionally established to determine the data sample of zombie firms in the ratio of 20:80, where 20% are zombie companies that have left the market and 80% are zombie firms that continue to exist (see Crone, Finlay 2012). This was due to the fact that, using EMIS data, they contain an insufficient number of zombie companies that have ended their existence (4.4% according to the first definition and 3.9% according to the second definition). Validation of the presented sample was carried out to check the representativeness. The Wilcoxon-Mann-Whitney test, Kolmogorov-Smirnov test, t-test and Population Stability Index (PSI) were used.

As the sample did not contain a relatively large number of observations, it was not divided into a train sample and a test sample. To identify the predictive power of financial indicators of zombie companies, Information Value is used, as well as the Gini coefficient<sup>4</sup> (see Anderson 2007). Additionally, the correlation matrix, VIF statistics were used.

The econometric model was constructed using variables transformed by the Weight of Evidence (WoE) method. Based on this, it was possible not to break the linear dependence with respect to the logistic function under consideration (see Anderson 2007).

$$WoE_j = \ln \left( \left( \frac{N_j}{\sum N} \right) / \left( \frac{P_j}{\sum P} \right) \right) \quad (5)$$

where:

- $N_j, P_j$  – the number of survival zombie and non-survival zombie events in category  $j$  of explanatory variables,
- $\sum N, \sum P$  – the sum of all events „0” and „1” in the entire set.

To increase discriminatory power, explanatory variables – financial indicators – were categorized using Information Value (see Anderson 2007).

$$\text{Information Value} = \sum_{j=1}^n \left[ \left( \frac{N_j}{\sum N} - \frac{P_j}{\sum P} \right) \cdot WoE_j \right] \quad (6)$$

<sup>4</sup>  $GINI = 1 - \sum_{j=1}^n ((cpY_j - cpY_{j-1})(cpX_j + cpX_{j-1}))$  where:  $cpY_j$  – cumulative percentage of survival zombie companies in the  $j$ -th category of explanatory variables,  $cpX_j$  – cumulative percentage of non-survival zombie companies in the  $j$ -th category of explanatory variables.

According to the literature, the Information Value indicator, if it takes values less than 0.1, is characterized by insufficient discriminatory power (see Anderson 2007).

The following statistics were used to verify the discriminatory power of the model (see Anderson 2007):

- 1) Gini coefficient;
- 2) Kolmogorov-Smirnov statistic (*KS*), represented by the following formula:

$$KS = \max\{\text{abs}(cpY - cpX)\} \quad (7)$$

where:

- cpY* – cumulated share of survival zombie companies in category *j* of explanatory variables,
- cpX* – cumulated share of non-survival zombie companies in category *j* of explanatory variables;

- 3) AUROC statistic according to the formula:

$$AUROC \approx (GINI + 1) / 2$$

The presented methodology will help in the study to determine the characteristics of zombie companies that continue to exist.

## 8.2. Results

Applying the presented methodology in subsection 8.1, the following results were obtained. In connection with the fact that the sample of zombie companies' data was divided in the proportion of 20:80, the representativeness of the obtained data was checked (Table 6). On the basis of applied tests such as the Wilcoxon-Mann-Whitney test, Kolmogorov-Smirnov test, and t-test for numerical explanatory variables, no grounds were obtained to reject the null hypothesis of differences between the original dataset and the prepared data in the appropriate ratio of 20:80. For the categorical variable (economic sector), the Population Stability Index ( $PSI = 0.012$ ) was obtained, which indicates the stability of the variable used further in the model.

The predictive power of financial indicators of zombie companies is presented in Table 7. Based on the Information Value statistics, it should be noted that all the explanatory variables considered are characterized by sufficient discriminatory power (the Information Value indicator is greater than 0.1). At the same time, the variables Leverage, Log assets, CAPEX, Profitability take values greater than 0.3, showing high predictive power. The selected variables are also at the appropriate level for the Gini coefficient.

The model presented in the paper (see Table 5) was evaluated according to the first definition of zombie companies due to similar results. In order to verify the problem of collinearity in the model, the matrix of correlations between explanatory variables and VIF statistics was checked (see Table 7 and Table 9). In addition, Table 4 shows the score points for each variable. The sum of score points help to identify the risk category of zombie companies and takes values from 0 to 1000. With a low number of score points, a zombie firm is most at risk.

In the first place, according to importance, is the variable that is responsible for the size of enterprises (31%). As a result of the study, it can be noted that the size of the company measured by the logarithm of assets not exceeding 7.198 receives zero score points. This indicates the probability of the termination of the existence of zombie firms. Having studied the literature, for example López-García and Puente (2006) found that the size of enterprises is important. Görg and Spaliara (2009) signals a nonlinear dependence of the size of enterprises with the probability of bankruptcy of firms. Therefore, the authors introduce sales and sales squares into the model.

The second place is taken by the leverage indicator (19%). Based on research observations, we can confidently assume that zombie firms with a lower debt index are less likely to exit the market. The highest score points were given to zombie companies for which the debt indicator was less than 45.63, zombie firms with a debt holding higher than 120.88 are at risk. Researchers confirm such financial dependencies (Boon, Redwood 2003; Görg, Spaliara 2009).

The third place is given to the profitability indicator (12%). According to the results obtained, it should be noted that if the profitability indicator of zombie companies is less than -0.155, then the score points are zero. This situation signals the end of the zombie firm's activities. Gurgul (2014) identified the reasons for the development of bankruptcy of enterprises. One of the reasons is the profitability crisis. In that case, the profit cannot cover the cost of capital.

The fourth place is occupied by the CAPEX indicator (11%). The conducted research determines the probability of zombie firms exiting the market if this indicator is higher than the value of 19.004. Buddelmeyer, Jensen and Webster (2010) also state the risk of companies with relatively high fixed capital. Such enterprises have difficulties, namely high financial costs, in adapting business to the economic situation in the country.

The economic sector is in fifth place (10%). After studying the data obtained, it is necessary to determine which economic sector is most prone to the collapse of zombie companies. It turned out to be trade. Its score points are zero. The trade sector in Poland as a rule reacts to economic changes in the country, to the needs of buyers. As a result, the number of sales is limited and production is reduced.

The sixth place is occupied by employment growth and Tobin's q index (9%). Table 4 data shows that if the employment growth index is less than -28.571, then zombie companies drop out of the market.

In addition, the following statistics measuring the discriminatory power were obtained for the model: Gini coefficient equal to 0.792, Kolmogorov-Smirnov statistic equal to 0.633 and AUROC statistic equal to 0.896. The obtained statistical values confirm the good quality of the model. The Hosmer and Lemeshow goodness-of-fit test provided no grounds to reject the null hypothesis about the correctness of the functional form in the model.

Based on the presented Figure 8 the following conclusion can be drawn that the financial indicators used in the model make it possible to largely separate zombie companies that are ending their activities from zombie firms that continue to exist. After conducting a study, it was found that zombie companies that had more than 650 score points survive. Zombie firms that have scored up to 300 score points leave the market. In the case of zombie companies having from 300 score points to 650, most will retain their existence.

As a result of the conducted research, we determined which characteristics are important for the survival of zombie companies (Q3).

## 9. Conclusion

The topic of zombification in Poland in particular during the COVID-19 pandemic and low interest rates is very important. Zombie companies are on the verge of bankruptcy. It is necessary to identify them correctly and in time, so as not to find ourselves in a situation of a series of collapses of zombie enterprises. There is a high probability that this will have an impact on healthy and profitable companies. The paper conducted research in the following areas: (i) identifying zombie firms from the listed non-financial companies in Poland, (ii) studying the anatomy of zombie firms and comparing them with the characteristics of non-zombie enterprises, (iii) presenting stylized facts about the life period of zombie firms, (iv) determining the characteristics for the survival of zombie companies from the listed companies in Poland. Data from 2000 to 2021 were used from the EMIS database on the financial statements of companies registered on the Warsaw Stock Exchange and NewConnect.

Summing up the results of the research, the following conclusions can be drawn. The percentage of companies identified as zombies listed on the stock exchange in Poland, according to two definitions, decreased in 2007 to 6% (4% by the second definition), while its dynamics increased and reached 27% during the COVID-19 pandemic (first definition) and 16% (second definition). Based on the conducted research, there are no grounds to reject the first research hypothesis that the economic crisis caused by the coronavirus pandemic and the period of the low interest rates has increased zombie firms among the listed companies in Poland (H1).

Analysing the anatomy of zombie firms, it should be noted their features. Zombie companies are small in size, their investments in intangible capital are higher on average. Zombie firms mostly sell their assets because they are financially constrained. They are characterized by a negative ICR, their Tobin's q index is at a low level. The leverage ratio of zombie enterprises is higher relative to non-zombie companies. The probability of zombie firms ceasing to exist in Poland is on average higher in comparison with healthy enterprises. Based on the results obtained, there are no grounds to reject the second research hypothesis (H2) that the anatomy of zombie firms differs significantly from the anatomy of non-zombie companies.

To study the life period of enterprises during 4 years of life from the moment of their identification as a zombie company (answering the first research question Q1 – What is the life path of zombie enterprises?), local linear projection regression was used. The results of the presented local projection suggest that most of them will recover and change their status. However, there is no clear trend towards a stable financial condition of these enterprises. It should be noted that some zombie enterprises will continue to exist in the status of zombies. The study shows the difficult life path of a zombie firm. Even after overcoming the obstacles of getting out of the zombie status, they retain the symptoms of zombification.

Continuing to consider the dynamics of financial indicators of zombie companies that appeared during the recession (Global Financial Crisis / the COVID-19 pandemic and the period of the low interest rates), as well as in the period without a recession, the ambiguity of the financial condition of these enterprises should be noted (Q2).

Using logistic regression combined with the scoring method, it was possible to determine which characteristics are important for the survival of zombie companies (Q3). As a result of the research, the most important indicator is the size of zombie enterprises, measured by the logarithm of assets. The continued existence of zombie firms also depends on the leverage and the profitability indicator

as the main financial indicators. Zombie enterprises with a lower debt index are less likely to leave the market. The CAPEX, the economic sector, employment growth and Tobin's q index are also important for zombie companies to continue their business.

Analysing corporate zombification in Poland, it can be noted that during a recession associated, for example, with the Global Financial Crisis or during the COVID-19 pandemic, the number of zombie companies increases. During the coronavirus pandemic, easy monetary policy helped zombie companies to stay on the market. In this regard, the number of weak enterprises that have emerged from the status of zombies will increase.

Having investigated the problem of zombification among listed firms in Poland in the article, it would be interesting in the future to analyse the state and behaviour of zombie enterprises among non-listed companies and make a comparison.

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## Appendix

Table 1

The sample used in the research

Number	Analysis	Periods	Number of observations
1	Identifying zombie firms from the listed companies in Poland	2000–2021	8,620 (whole dataset)
2	The anatomy of zombie firms	2000–2021	8,620 (whole dataset)
3	The stylized facts about the life period of zombie firms	2000–2021	8,620 (whole dataset)
4	The characteristics for the survival of zombie companies from the listed companies in Poland	2000–2021	1,479 (zombie companies)

Source: own work.

Table 2  
The definition of variables used in the research

Variables	Definition
Total assets	Total assets, in PLN of 2020
PPE	Plant Property Equipment, in PLN of 2020
Employees	Number of employees
CAPEX	$\frac{\text{Property, plant and equipment}}{\text{Total assets}} \cdot 100$
Intangible investment	$\frac{\text{Intangible assets}}{\text{Total assets}} \cdot 100$
Asset disposal	$\frac{\text{Disposal of property, plant, equipment and intangible assets}}{\text{Total asset}} \cdot 100$
Employment growth	$\frac{(\text{Employees}_t - \text{Employees}_{t-1})}{0.5 \cdot (\text{Employees}_t + \text{Employees}_{t-1})} \cdot 100$
Cash flow	$\frac{\text{Cash flow}}{\text{Total assets}} \cdot 100$
ICR	Earnings Before Interest and Taxes (EBIT) over interest payments
Tobin's q	The ratio of the market value of the company's assets to their book value
Interest paid	$\frac{\text{Interest payments}}{\text{Total assets}} \cdot 100$
Leverage	$\frac{\text{Current debt} + \text{Non-current debt}}{\text{Total assets}} \cdot 100$
Debt growth	$\frac{(\text{Debt}_t - \text{Debt}_{t-1})}{0.5 \cdot (\text{Debt}_t + \text{Debt}_{t-1})} \cdot 100$
Exit probability	In the case of the following event: Bankruptcies, Liquidates, Restructurization the variable takes the value "1", in other cases "0"
Profitability	Earnings Before Interest and Taxes (EBIT) over total assets
Economic sector	1 – other services 2 – manufacturing 3 – construction 4 – trade
Global Financial Crisis (GFC)	It assumes the value "1" for the period 2008–2009, in other cases it assumes the value "0"
COVID-19	It assumes the value of "1" for the duration of the COVID-19 pandemic, in other cases it assumes the value of "0"

Source: own work based on the literature review.

Table 3  
Zombie companies' anatomy

Variables	Non-zombie	Zombie	Non-zombie			Zombie		
	Mean	Mean	p25	p50	p75	p25	p50	p75
<b>Panel A: according to the first definition</b>								
Total assets	719 440.5	363 468.7***	12 339.3	59 116.5	241 111.0	4 891.9	20 757.8***	91 320.0
PPE	181 336.0	69 764.1***	781.0	8 175.0	43 979.0	91.0	1 311.0***	9 677.3
Employees	488.9	138.4***	18.0	103.0	376.0	3.0	15.0***	75.0
CAPEX	22.6	21.4**	3.7	16.5	38.3	0.5	8.5***	42.8
Intangible investment	4.5	7.5***	0.0	0.5	3.1	0.0	0.2***	4.7
Asset disposal	0.6	0.8**	0.0	0.0	0.3	0.0	0.0***	0.2
Employment growth	2.0	-11.6***	-5.8	0.7	11.1	-25.0	-3.1***	6.9
Cash flow	4.5	-9.3***	-0.7	4.6	11.6	-12.6	-1.6***	1.3
ICR	14.9	-12.4***	2.2	5.8	19.2	-27.2	-8.1***	-0.9
Tobin's q	1.2	0.6***	0.5	1.0	1.6	0.0	0.3***	0.8
Interest paid	1.7	2.8***	0.2	0.8	1.8	0.2	0.8***	2.6
Leverage	44.8	54.4***	25.3	42.0	59.2	16.6	38.4*	70.2
Debt growth	13.0	8.3***	-10.1	7.9	32.2	-20.2	5.0***	36.3
Exit probability	2.7%	4.4%***	–	–	–	–	–	–
<b>Panel B: according to the second definition</b>								
Total assets	670 182.9	517 194.9*	10 157.0	50 716.6	220 608.0	7 865.0	31 211.7***	139 112.5
PPE	170 071.1	84 861.5***	637.0	6 986.0	39 657.0	88.6	1 269.4***	9 176.0
Employees	463.2	111.6***	15.0	91.0	353.0	4.0	13.0***	56.5
CAPEX	22.8	19.6***	3.6	16.4	38.7	0.2	3.2***	40.9
Intangible investment	4.7	7.6***	0.0	0.5	3.3	0.0	0.1***	4.3
Asset disposal	0.6	0.6	0.0	0.0	0.3	0.0	0.0***	0.1
Employment growth	0.4	-8.4***	-7.2	0.0	10.7	-22.2	0.0***	11.8
Cash flow	3.3	-8.8***	-1.4	4.0	11.2	-10.6	-1.5***	0.7
ICR	12.5	-11.9***	1.3	4.8	16.5	-27.2	-6.5***	-0.3
Tobin's q	1.2	0.2***	0.5	1.0	1.6	0.0	0.1***	0.4
Interest paid	1.8	2.6***	0.2	0.8	1.9	0.1	0.8	2.6
Leverage	38.0	43.3***	25.2	42.4	60.3	13.2	31.0***	60.6
Debt growth	12.3	10.1*	-10.9	7.6	32.3	-18.1	5.6*	37.9
Exit probability	2.9%	3.9%*	–	–	–	–	–	–

Notes:

\*\*\*, \*\*, \* significance level at 1%, 5%, 10% for t-test (red colour) and Wilcoxon-Mann-Whitney test (black colour).

p25 – 25th percentile of the considered variables; p50 – 50th percentile of the considered variables; p75 – 75th percentile of the considered variables.

Source: own work.

Table 4  
Zombie companies' anatomy: no exit vs exit

Variables	Non-zombie		Zombie	
	No exit	Exit	No exit	Exit
<b>Panel A: according to the first definition</b>				
Total assets	732 359.2	249 216.2	376 193.7	87 703.7
PPE	185 430.0	32 315.2	72 182.0	17 365.5
Employees	491.9	378.1	139.1	123.4
CAPEX	22.7	20.5	21.4	26.5
Intangible investment	4.6	2.0	7.7	3.8
Asset disposal	0.6	0.9	0.8	0.7
Employment growth	2.0	2.4	-10.5	-33.1
Cash flow	4.7	-0.6	-9.2	-11.5
ICR	15.2	5.6	-12.5	-11.9
Tobin's q	1.2	1.8	0.6	0.6
Interest paid	1.6	3.3	2.7	5.5
Leverage	42.2	64.2	41.4	62.1
Debt growth	12.9	16.9	8.1	13.7
<b>Panel B: according to the second definition</b>				
Total assets	683 369.8	225 660.2	534 885.3	84 005.9
PPE	174 206.6	30 667.6	87 758.5	13 922.2
Employees	466.5	351.0	113.8	59.2
CAPEX	22.8	20.8	19.1	30.3
Intangible investment	4.8	2.3	7.8	3.8
Asset disposal	0.6	0.9	0.6	0.3
Employment growth	0.5	-2.3	-7.0	-36.7
Cash flow	3.5	-2.9	-8.9	-7.6
ICR	12.8	2.7	-11.9	-10.3
Tobin's q	1.2	1.8	0.2	0.2
Interest paid	1.7	3.8	2.5	4.3
Leverage	42.7	63.9	37.0	62.2
Debt growth	12.2	17.7	10.2	6.4

Notes: the table presents the values of variables at the mean level.

Source: own work.

Table 5  
Zombie survival (according to the first definition)

Variables	Weight	Estimate	Std. err.	Min value	Max value	Score points
Log assets	31%	-1.087	0.228***	-INF	7.198	0
				7.198	9.092	293
Leverage	19%	-0.873	0.183***	9.092	+INF	52
				-INF	45.626	199
Profitability	12%	-0.779	0.247***	45.626	120.881	121
				120.881	+INF	0
CAPEX	11%	-0.738	0.283**	-INF	-0.155	0
				-0.155	0.031	89
Economic sector	10%	-1.068	0.395**	0.031	+INF	14
				-INF	0.293	6
Employment growth	9%	-1.002	0.403**	0.293	19.004	80
				19.004	+INF	0
				Other services		55
				Manufacturing		106
Tobin's q	9%	-1.146	0.495**	Construction		95
				Trade		0
				-INF	-28.571	0
				-28.571	23.655	95
Hosmer and Lemeshow goodness-of-fit				23.655	+INF	48
				missing values		78
				-INF	0.007	53
				0.007	0.065	137
Gini coefficient				0.065	+INF	75
				missing values		0
				Chi-Square = 11.65, p-value = 0.167		
Kolmogorov-Smirnov statistic					0.632	
AUROC statistic					0.896	

Notes: \*\*\*, \*\*, \* significance level at 1%, 5%, 10%.

Source: own work.

Table 6  
Sample representativeness

Variables	Wilcoxon-Mann-Whitney test		Kolmogorov-Smirnov test		t-test		Population Stability Index (PSI)
	Statistic	p-value	Statistic	p-value	Statistic	p-value	
Log assets	374 590	0.469	0.077	0.051	-1.131	0.258	–
CAPEX	382 477	0.964	0.051	0.414	0.035	0.972	–
Profitability	371 732	0.316	0.053	0.351	-1.469	0.142	–
Employment growth	100 882	0.224	0.077	0.294	-1.224	0.222	–
Leverage	395 913	0.176	0.077	0.052	1.482	0.145	–
Tobin's q	323 324	0.618	0.072	0.111	0.125	0.901	–
Economic sector	–	–	–	–	–	–	0.012

Source: own work.

Table 7  
The predictive power of financial indicators of zombie companies

Variables	Gini coefficient	Information value
Leverage	0.500	1.055
Tobin's q	0.167	0.133
Log assets	0.354	0.929
CAPEX	0.284	0.368
Employment growth	0.203	0.176
Economic sector	0.219	0.175
Profitability	0.347	0.488

Source: own work.

Table 8  
Correlation matrix

Variables	Log assets	CAPEX	Profitability	Employment growth	Leverage	Tobin's q
Log assets	1					
CAPEX	0.08	1				
Profitability	-0.14	0.01	1			
Employment growth	0	-0.01	0.12	1		
Leverage	0.06	0.13	0.33	0.15	1	
Tobin's q	-0.01	0.09	0.11	-0.07	0	1

Source: own work.

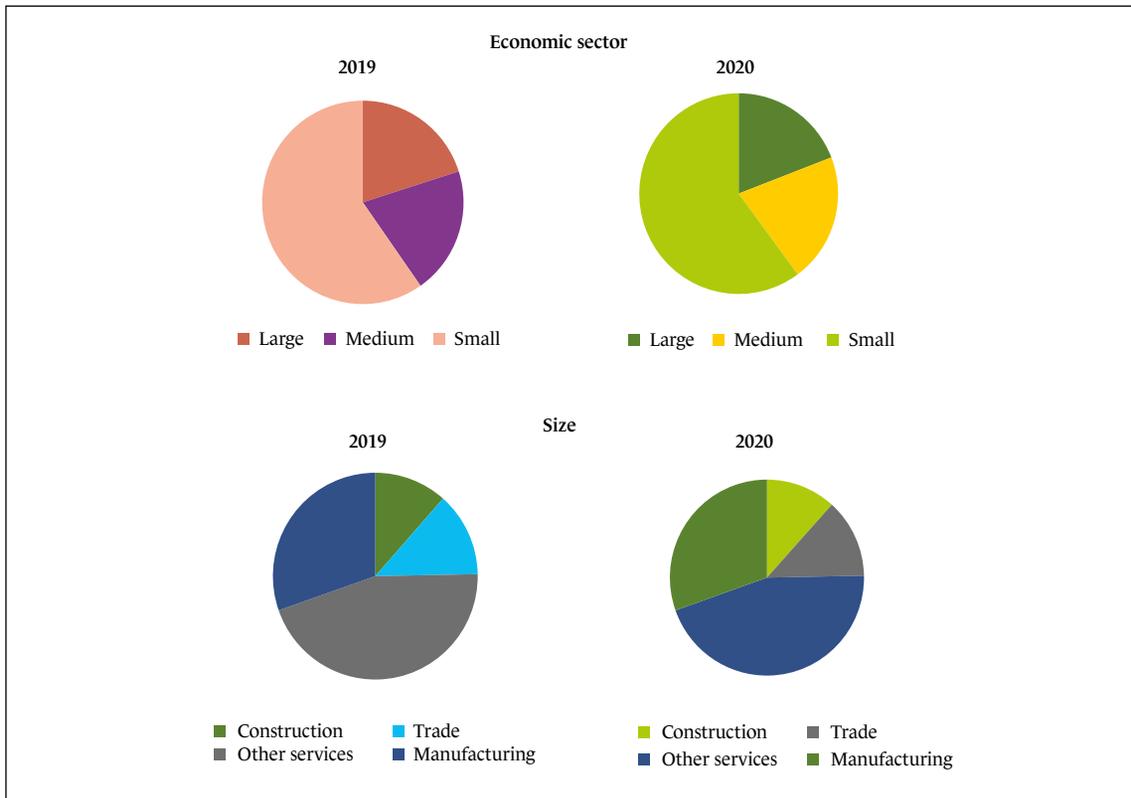
Table 9  
VIF statistics

Variables	VIF
Log assets	1.059
CAPEX	1.035
Profitability	1.183
Employment growth	1.036
Leverage	1.193
Economic sector	1.044
Tobin's q	1.034

Source: own work.

Figure 1

The structure of the dataset in 2019 (before COVID-19) and 2020 (during COVID-19)

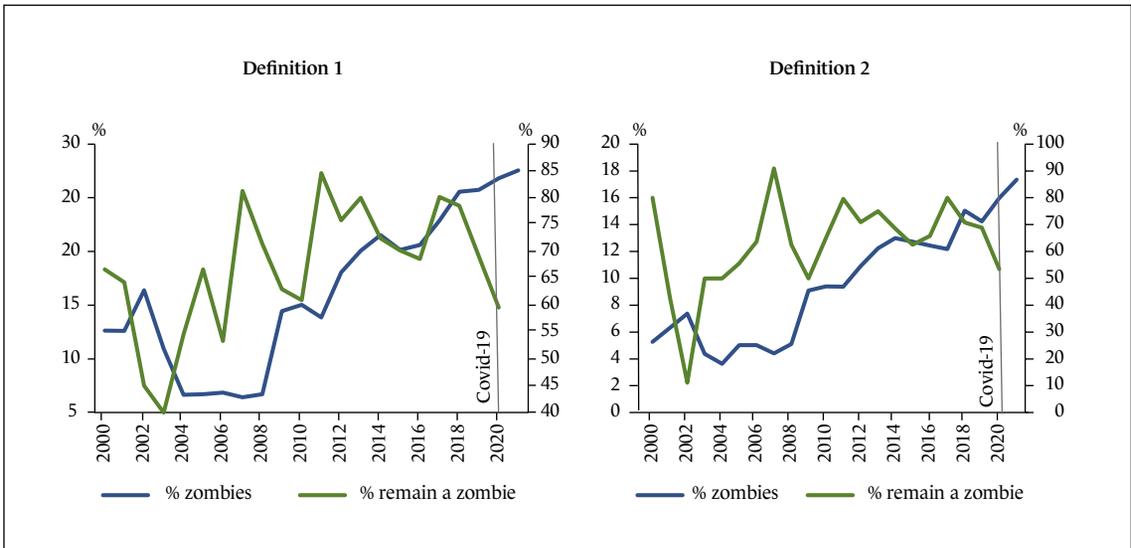


Notes:

The size of the enterprise is determined in the following order: small enterprise – turnover is less than EUR 10 million; medium enterprise – turnover is from EUR 10 million to EUR 50 million, large enterprise – turnover is more than EUR 50 million. The adopted definition of the size of the enterprise is based on the recommendation of the European Commission of 6 May 2003 (2003/361/EC).

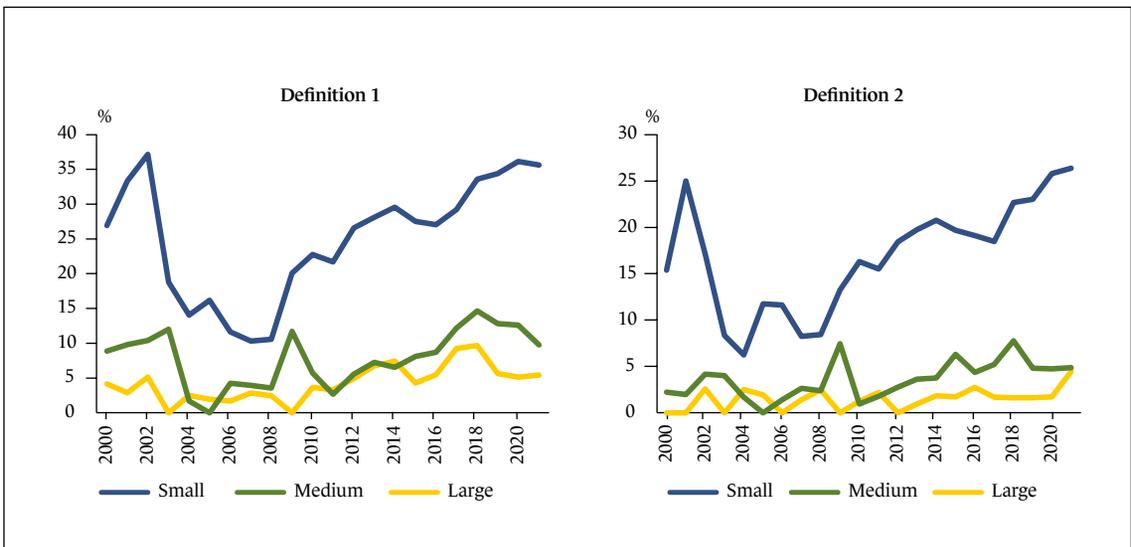
Source: own work.

Figure 2  
Percentage of corporate zombies and remaining zombies in Poland



Source: own work.

Figure 3  
Percentage of zombie firms by size in Poland

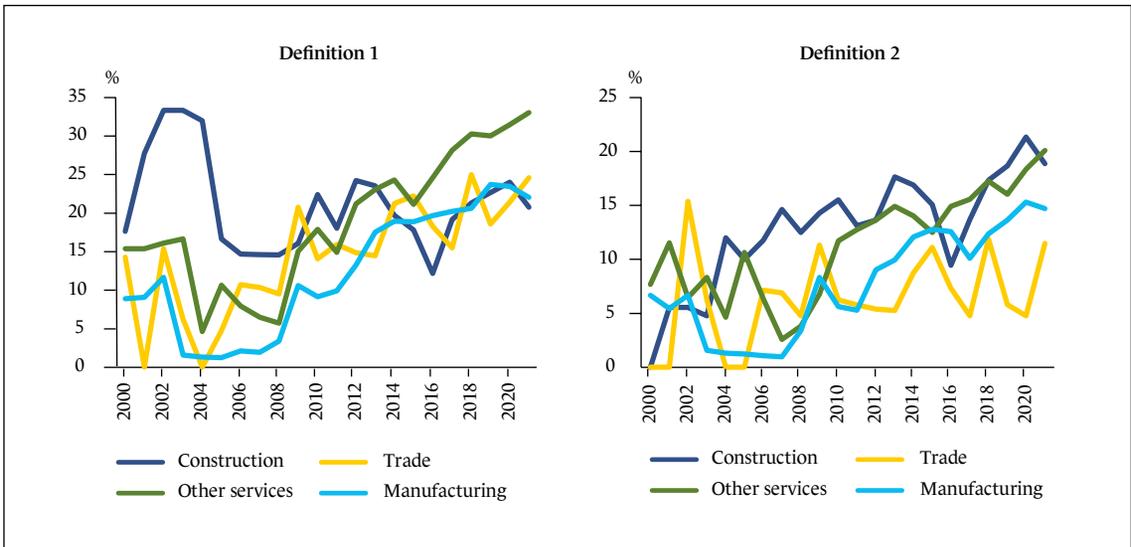


Notes:

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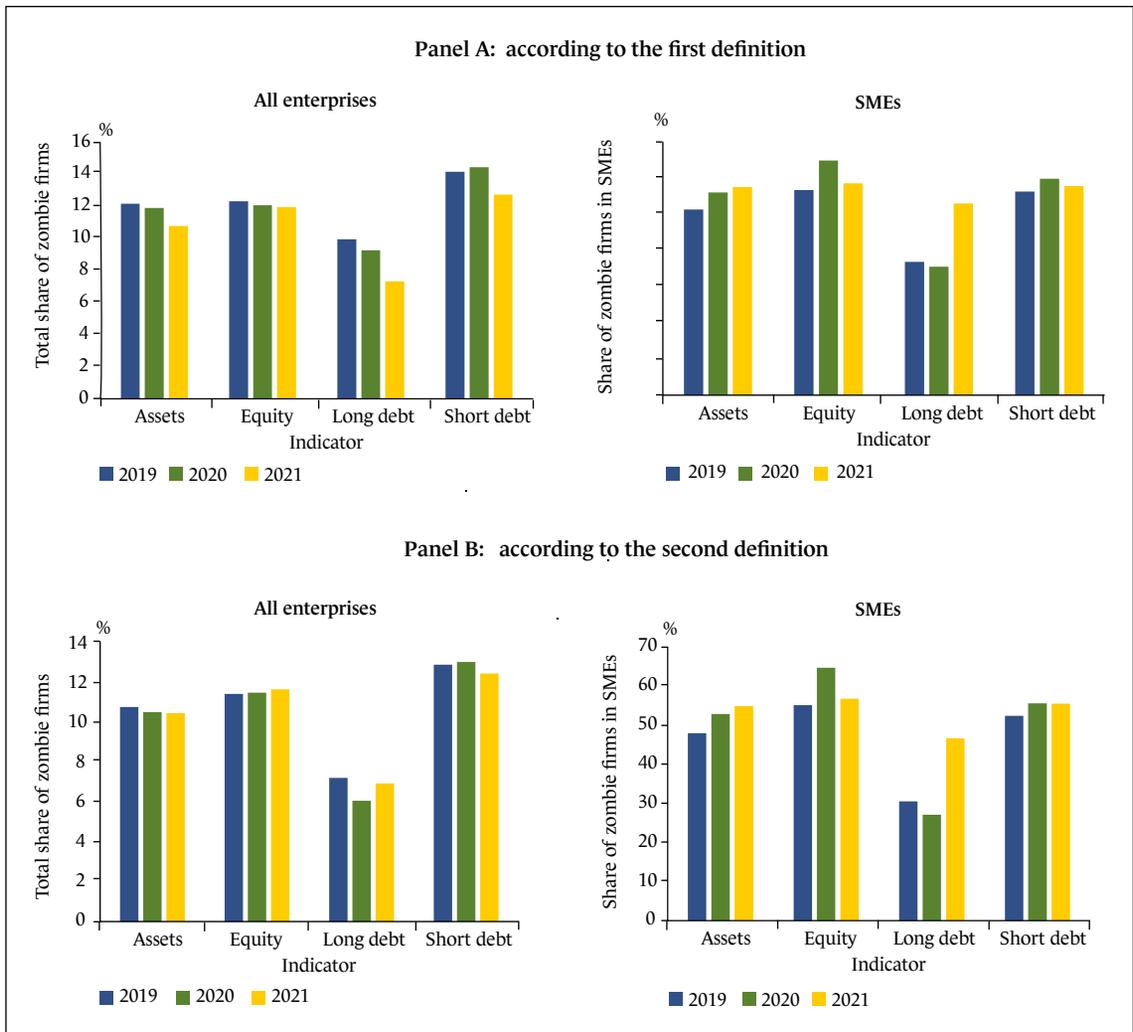
Source: own work.

Figure 4  
 Percentage of zombie firms by economic sector in Poland



Source: own work.

Figure 5  
Share of Poland's zombie firms' financial positions in all companies



Notes:  
Long debt is defined as non-current liabilities. Short debt is defined as current liabilities.

Source: own work.

Figure 6  
Life period of zombie firms (based on the first definition)

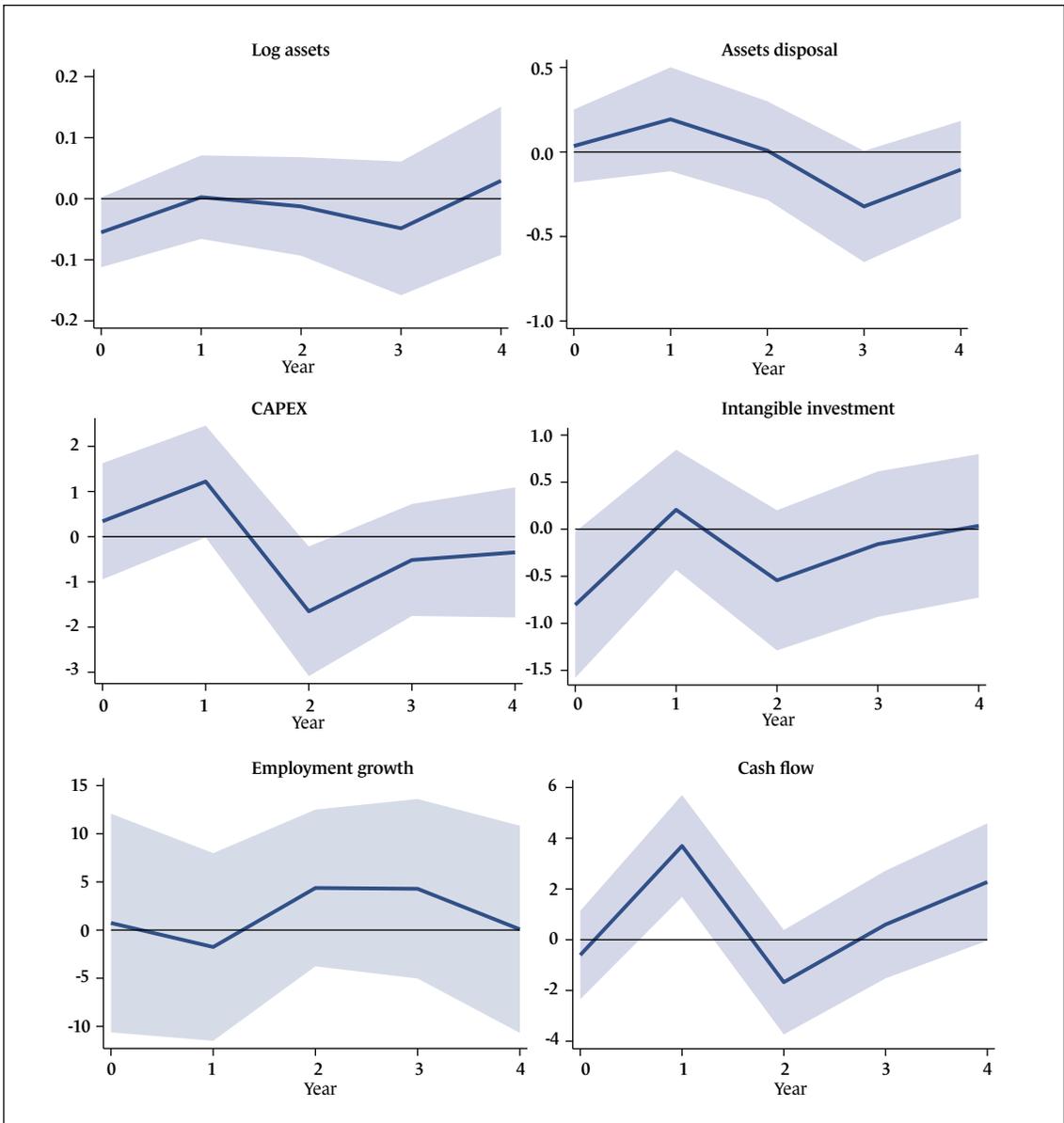
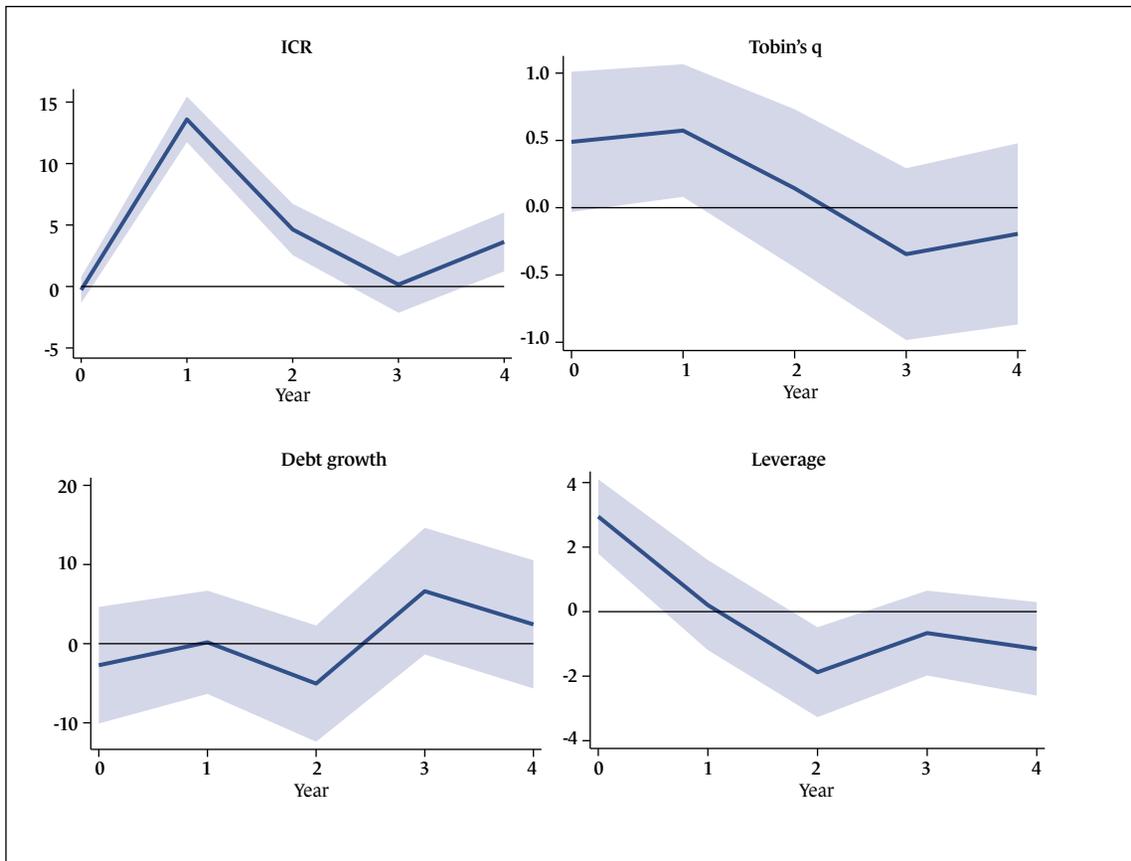


Figure 6, cont'd



## Notes:

On the Y axis on the Figure, Log assets are represented as a percentage; assets disposal, CAPEX, intangible investment, employment growth, cash flow, debt growth and leverage are represented as percentage points; Tobin's q and ICR are represented as ratios.

The grey area on the Figure represents the 95% confidence interval.

Source: own work.

Figure 7

Life period of zombie companies (based on the first definition) vs GFC / COVID-19 and the period of low interest rates

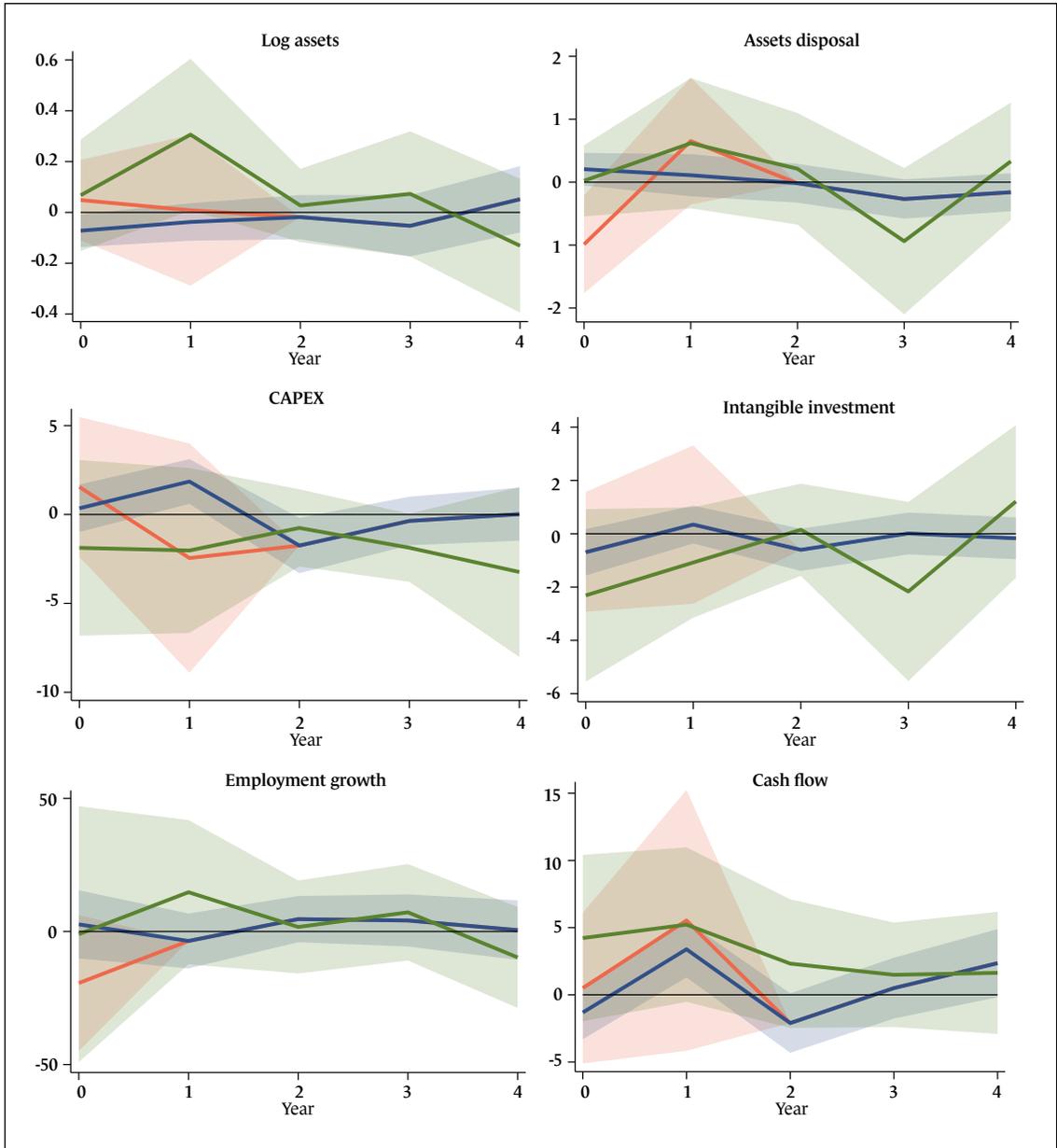
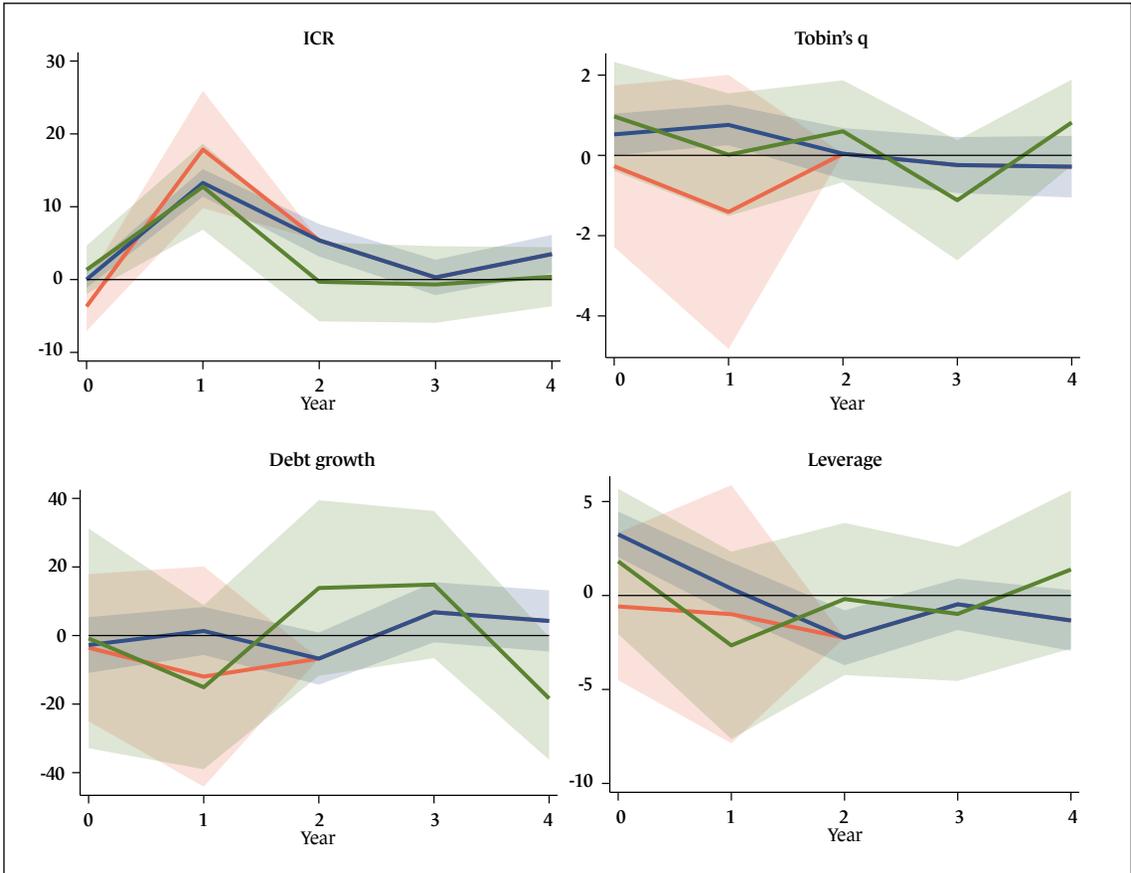


Figure 7, cont'd



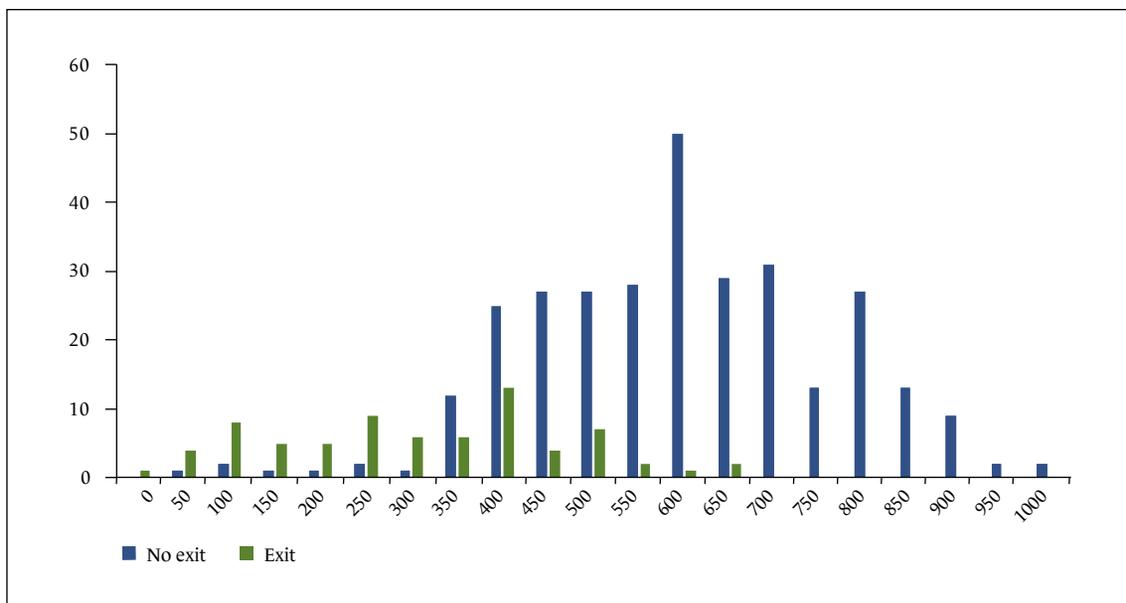
Notes:

The zombie companies' life period in the period without the GFC and COVID-19 pandemic is presented by the blue line. The zombie firms' life period during the GFC is presented by the green line. The zombie companies' life period during the COVID-19 pandemic is presented by the red line. On the Y axis, log assets are represented as a percentage; assets disposal, CAPEX, intangible investment, employment growth, cash flow, debt growth and leverage are represented as percentage points; Tobin's q and ICR are represented as ratios.

Source: own work.

Figure 8

Distribution of corporate zombies



Source: own work.

## Proces „zombifikacji” polskich spółek w warunkach pandemii COVID-19 i niskich stóp procentowych

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### Streszczenie

W artykule poruszono kwestię „zombifikacji” przedsiębiorstw będących spółkami giełdowymi w Polsce. Celem artykułu jest przeprowadzenie analizy zagrożonych finansowo firm zombie, w szczególności w okresie pandemii COVID-19 i niskich stóp procentowych. Aby zrealizować postanowiony cel, konieczne jest przeprowadzenie następujących badań: (i) identyfikacja spółek zombie spośród firm notowanych na rynku publicznym, (ii) studia porównawcze organizacji zombies na tle pozostałych spółek, (iii) charakterystyka „ścieżek życia” spółek zombie, (iv) określenie czynników wpływających na długość przeżycia opisywanych organizacji w Polsce. Szczególną uwagę w badaniu zwrócono na okres pandemii koronawirusa oraz niskich stóp procentowych. Jak wiadomo, firmy zombie są zagrożone finansowo. Mają ograniczoną zdolność do obsługi zobowiązań i stoją na skraju bankructwa. Masowe bankructwa przedsiębiorstw zombie mogą doprowadzić do kolejnego kryzysu gospodarczego.

W artykule zostały sformułowane hipotezy badawcze i pytania badawcze:

- H1. Kryzys gospodarczy wywołany pandemią koronawirusa spowodował wzrost liczby firm zombie wśród spółek giełdowych w Polsce.
- H2. Struktura firm zombie różni się od struktury innych firm.

P1. Jaka jest charakterystyka „ścieżek życia” spółek zombie?

P2. Jak zachowują się firmy zombie podczas recesji?

P3. Jakie cechy są ważne dla przetrwania firm zombie?

Badanie opisane w artykule przeprowadzono po raz pierwszy na danych polskich. Wykorzystano w nim dane z lat 2000–2021 z bazy EMIS (Emerging Markets Information Services) pochodzące ze sprawozdań finansowych spółek notowanych na Giełdzie Papierów Wartościowych w Warszawie i NewConnect. Wykorzystano takie metody, jak regresja lokalnych projekcji liniowych oraz regresja logistyczna połączona z metodami scoringowymi.

Wyniki badania pokazują, że kryzys gospodarczy wywołany pandemią koronawirusa oraz okres niskich stop procentowych spowodowały wzrost liczby firm zombie wśród spółek giełdowych w Polsce. Struktura firm zombie znacznie różni się od struktury pozostałych firm. Dynamika wskaźników finansowych firm zombie, które pojawiły się w okresie recesji (globalny kryzys finansowy, pandemia COVID-19 i okres niskich stóp procentowych), oraz tych, które powstały w okresie bez recesji, wskazuje na niejednoznaczność kondycji finansowej tych przedsiębiorstw. Najważniejszym czynnikiem przetrwania dla firm zombie jest ich wielkość. Dalsze istnienie firm zombie zależy również od ich dźwigni finansowej i rentowności.

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**Słowa kluczowe:** zombifikacja, bankructwo, COVID-19, lokalne regresje projekcji liniowej, podejście scoringowe

