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Micro-firms' productivity growth in Poland before and during COVID-19: Do industry and region matter?

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ABSTRACT

Objective: This study proposes a novel empirical analysis of the total factor productivity (TFP) growth for Polish microenterprises, focusing on the effect of the global lockdown in 2020. We employed firm-level data covering enterprises with below ten employees to evaluate micro-firms' productivity performance in Polish regions and sectors in 2010-2020. There are three main goals. Firstly, we estimated the production function elasticities for two-digit NACE sectors of microenterprises. Secondly, we performed the TFP growth decomposition between regions and sectors for Polish microenterprises. Thirdly, we aimed to identify the between- and within-firm components of productivity growth in microenterprises.

Research Design & Methods: We applied control function methods to estimate the production function for two-digit NACE Rev. 2 divisions and determine individual enterprises' TFP. We based the estimations on an unbalanced panel dataset containing about 1 329 106 firms yearly. Thereafter, we employed the Olley-Pakes decomposition of TFP growth to analyse the efficiency of resource allocation measured by the between- and the within-firm component that captures the gains from firms' productivity performance.

Findings: We observed substantial heterogeneity between sectoral and regional TFP growths during the year of the COVID-19 pandemic outbreak. Productivity of microenterprises from the following sectors: construction, wholesale and retail trade, professional, scientific and technical activities was influenced considerably by the lockdown. Microenterprises from regions with the highest gross value added (GVA) shares displayed outstanding productivity during the COVID-19 pandemic concerning weighted TFP levels and TFP growths. Based on the Olley-Pakes decomposition of TFP growth, we confirmed that before 2020, the TFP growth of microenterprises in Poland was driven by within-firm gains. However, during the COVID-19 pandemic outbreak, the efficiency of resource allocation was an essential component of TFP growth.

Implications & Recommendations: Micro-firms play a significant role in the economy, but TFP analyses of microenterprises are sparse. Through this study, we showed that the pandemic outbreak significantly impacted micro-firms' performance. We identified the industries and regions of the Polish economy that are the main drivers of productivity growth and those where the economic efficiency is below the expected performance. This study might help to identify regions and sectors of the Polish economy that suffer from substantial inefficiencies and thus require policy attention.

Contribution & Value Added: As the capital-driven development model might be reaching its limits in Poland, policymakers should focus on TFP as a main growth force. This study is the first empirical analysis of the TFP growth for microenterprises in Poland. We employed firm-level data from Statistics Poland covering microenterprises to evaluate micro-firms' productivity performance in Polish regions and sectors before and during COVID-19.

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INTRODUCTION

There exists an extensive literature on the various approaches to measuring productivity (Ahmed & Bhatti, 2020). Productivity is classified into two main categories: partial factor productivity and multifactor productivity. The partial factor productivity is used to compare the productivity of each unit factor to the output production. Multifactor productivity is the ratio of total output to total inputs. It represents the total effect of all resources used in producing the total output. Furthermore, capital-, material-, or labour-based productivity and total factor productivity (TFP) are the four primary forms of productivity in the production process. The last two substantial measures – labour productivity and total factor productivity – are usually used to measure productivity as the technical efficiency of production (IMF, 2019; World Bank, 2021). Labour productivity reflects each employee's value, while increased capital employed per worker and rising TFP are the two main drivers of labour productivity development. The TFP measures how effectively inputs (such as labour and capital) are converted into outputs. Measuring TFP as the technical efficiency of production is essential from many practical points of view. The TFP growth sustains output growth in the long run as input growth, which is subject to diminishing returns, is insufficient to generate more and more output growth. Aggregated TFP and technology are distinct notions, however, both play an essential role in understanding economic growth (Basu & Fernald, 2002). Therefore, TFP growth is responsible for long-run growth, reflecting the growth potential (Krugman, 1997; Mahadevan, 2003).

Correct measurement of total factor productivity and the indication of the main determinants of enterprise productivity are necessary to correctly describe the production process and resource management. The measurement of the unobserved TFP level is mainly possible by determining the Solow residual from the production function equation. For this purpose, in the first step, we estimated the production function at the firm level and in the second, we determined enterprises' individual productivity (van Beveren, 2012). When aggregated, an enterprises' total factor productivity can indicate productivity at a selected sector, region, or economy level. There are three primary ways that aggregated TFP performance might improve. Firstly, productivity might expand due to increased business efficiency through better technology adoption, improved management capabilities, or innovation (the 'within-firm' component). Secondly, more effective businesses might gain market share within their industry, which results in allocating labour and capital to more effective businesses ('between-firm' component). Thirdly, high-productivity companies can expand into new markets, forcing less successful businesses to shut down. Unexpected shocks may influence TFP significantly and this impact can be different for different sectors or regions of the economy. Therefore, the TFP growth decomposition shows these idiosyncratic features and is particularly important for policymakers.

Several studies indicate that growth in Poland and convergence are driven mainly by factors affecting structural competitiveness, especially innovation activity, which are essential TFP components (Grela *et al.*, 2017; World Bank, 2021). Noteworthy, the Polish economy was on an upward trend before the COVID-19 outbreak. According to the International Monetary Fund's (IMF) World Economic Outlook (published in October 2019; see IMF, 2019b), the GDP growth forecast for 2020 was equal to 3.1%. However, due to the COVID-19 pandemic, we observed the decline of the Polish economy to 5.1 percentage points below expected growth. Nevertheless, this value was a moderate slowdown compared to many other countries. Since microenterprises play a significant role in the Polish economy, their productivity is a substantial driver of the total TFP in Poland.

Figure 1 presents the microenterprise sector's contribution to the Polish economy's leading economic indicators. Between 2010-2020, non-financial microenterprises constituted about 96.2% of all non-financial enterprises, employing approximately 39.6% of the persons employed. On average, they generated about 22.4% of total revenues and 17.0% of total investment outlays. Moreover, non-financial microenterprises produced 29.1% of total production and 26.7% of gross value added. In 2020, there were 2261.9 thousand non-financial enterprises in Poland, which means an increase of 31.0% compared to 2010. Most of that increase was due to the growing number of microenterprises. In 2020, there were 2194.2 thousand microenterprises, which means an increase of 32.6% compared to 2010.

In contrast, the number of small and medium-sized entities decreased from 2010 to 2020, in the case of small entities by 5.9% and medium-sized entities by 8.9%. In the analysed period, the increase in employment in microenterprises amounted to 23.2% (2020 compared to 2010), while in the entire sector of non-financial enterprises, this increase amounted to about 12.9%. Moreover, in terms of revenues (92.2% vs 59.5%), value added (67.6% vs 59.2%), and value of production (61.8% vs 55.6%), thus we can notice that microenterprises generated higher growth of these economic indicators than larger firms. However, microenterprises recorded an 18.6% decrease in the value of investment outlays, while in the entire non-financial sector, these assets increased by 43.3% (Statistics Poland, 2021).

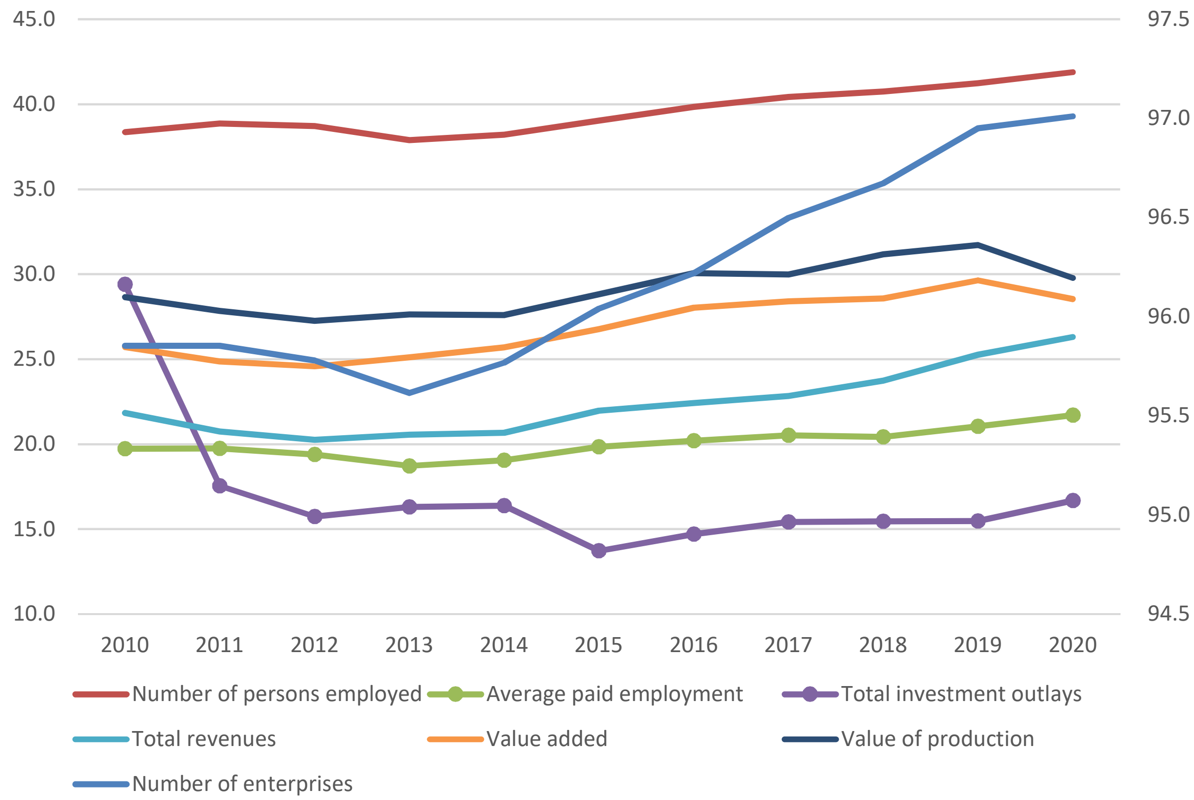


Figure 1. Relevance of micro-firms for the economy

Note: All Figures present the microenterprise sector's shares in the Polish economy's non-financial enterprise sector (in p.p.). All coloured lines are measured at the left axis. The number of enterprises is measured at the right axis.
Source: own elaboration based on Statistics Poland data 'Activity of Non-Financial Enterprises' (2010-2020).

The appropriate measure of TFP is essential also for entrepreneurs who launch new ventures and make additional investments. By introducing new technologies or working methods, these investments can boost productivity, create new jobs, and raise competition. The individual's entrepreneurism and initiative bring all the various elements of factor inputs, management processes of production and investment in innovative activities together to drive the firm's production activities. Without the entrepreneur to coordinate these elements, effectively use and deploy them, seek out novel business opportunities, and make new investments, the economic churn that propels productivity growth would likely be damped (Schumpeter & Backhaus, 1934; Kirzner, 1973). Lastly, scholars show that country-level entrepreneurship triggers TFP by increasing the effects of Kirznerian and Schumpeterian entrepreneurship (Lafuente *et al.,* 2020). Usually, companies react to crises by changing their strategies, which is more difficult for micro-firms (Kaszowska-Mojsa, 2020). The sudden spread of the COVID-19 pandemic affected small businesses, dominated by family businesses. Since they are not prepared for the prolonged state of uncertainty and tension threatening the continuity of their operations, their financial stability is endangered (Marjański & Sułkowski, 2021).

Due to the considerable importance of microenterprises in all economic categories, the impact of the COVID-19 pandemic on microenterprises' productivity spread over the whole economy. In this study, we adopted a firm-level approach using TFP measurements to discover the overall productivity factors and the underlying heterogeneity of micro-firms in Poland with an emphasis on pandemic effects. This research supplements the TFP study for small, medium, and large enterprises (SMLEs) conducted under the collaboration of Statistics Poland with the World Bank (World Bank, 2021). Our main contribution consists of several dimensions. Firstly, we used a microeconometric model for TFP estimation based on micro-firm data from the annual survey of the economic activity of microenterprises. We applied the Levinsohn-Petrin (2003) model with the Ackerberg, Caves, and Frazer (2015) correction to estimate the elasticities of the production function for two-digit NACE sectors of microenterprises. Secondly, based on individual TFP indices, we provided sectoral and regional decompositions of micro-firms' TFP growth before and during COVID-19. Thirdly, we identified the within- and between-firm effects of TFP growth.

The remainder of this article is organized as follows. Section 2 presents a literature review. Section 3 describes the data and the methodology for TFP estimation and aggregation. Section 4 presents the empirical results and discussion. Section 5 concludes the article.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Many scholars and institutions regularly perform TFP analyses of small (S), medium (M), and large (L) enterprises (Es), but the studies of microenterprises (MiEs) are very sparse. Let us recall the recent crucial studies on TFP for MiSMLEs. Using Italian SMEs data Hall, Lotti, and Mairesse (2009) prove that innovation positively impacts a firm's productivity, but especially larger and older firms seem to be less productive. Baumann and Kritikos (2016) consider the relationship between research and development outlays, innovation and productivity of MiSMEs for the German economy. Chen and Lee (2020) confirm the significant impact of firm size premium on total factor productivity growth in Europe after the Global Financial Crisis. Whereas the influence of financial constraints on total factor productivity in China was found by Wong *et al.* (2023). This effect was proved to be more serious in small-scale firms, non-state firms, and non-energy firms. Bloom *et al.* (2020) present a micro-data analysis of the impact of COVID-19 on productivity in the UK. Their results suggest that the negative within-firm effect was partially offset by the positive between-firm effect. It is also proved that the impact of COVID-19 on productivity across firms was heterogeneous, which means that more consumer-facing firms are more likely to experience productivity fall.

There are only several studies on the TFP for SMLEs in Poland (Hagemejer, 2006; Hagemejer & Kolasa, 2011; Albinowski *et al*., 2015; IMF, 2019; Górajski & Błażej, 2020; World Bank, 2017). After the economic transformation, the productivity growth of enterprises was driven by refinements in allocative efficiency and the development of highly productive firms. To the best of our knowledge, the TFP growth decomposition was never applied to firm-level data before 1997, most likely due to restricted access to such data in Poland. Albinowski *et al*. (2015) and World Bank (2017) are pioneering studies that employed the Melitz-Polanec method to decompose the productivity growth of SMLEs and investigated firm-level data in Poland from the manufacturing sector between 1997 and 2013. These studies reveal an impressively fast TFP growth in manufacturing during the given period, primarily propelled by resource reallocation from less to more productive firms. The between component accounted for three-fourths of the aggregate TFP growth. In particular, Górajski and Błażej (2020) confirm the dependence of firm-level TFP on the form of ownership, investment rate, export status, their size, and the market concentration index as well as a sector differentiation of TFP distributions for SMLEs. Moreover, Gradzewicz and Muck (2019) analysed the dynamics of SMLEs markups from the 2002-2016 period and showed that markets globalization and changes in the global value chains are the main factors behind the recent fall in markups in Poland. The most recent report referring to the productivity of Polish SMLEs in manufacturing, construction, and non-financial services between 2009-2019 was the outcome of the cooperation of the World Bank and Statistics Poland (World Bank, 2021). It is concluded that despite the extraordinary economic growth in Poland, productivity growth in the manufacturing sector has stagnated since 2012 and is much lower than in services and construction. Resource allocation efficiency (measured by the between-firm effect) has deteriorated over time in the manufacturing industry. It has been responsible for slowing down productivity growth in the sector, while between effects have improved TFP growth in construction and services.

Many regional or sectoral TFP analyses referring to the aggregated Cobb-Douglas production function under constant economies of scale in each region or sector are performed using aggregated panel data (Dańska-Borsiak & Laskowska 2012; Sulimierska, 2014; Welfe & Karp, 2017 and references therein). Świeczewska (2013) shows the analysis of the total factor productivity for the manufacturing industry sectors according to the degree of advancement of technology. Heterogeneity in elasticities of production functions in various sectors of the Polish economy was confirmed for panel aggregated data by Gosińska and Ulrichs (2020). Moreover, the KLEMS productivity accounting is used to analyse the growth decomposition for the Polish regions and sectors in Kotlewski (2021).

To the best of our knowledge, there are no studies concerning the TFP analyses of microenterprises in Poland. Therefore, we aimed to fill this research gap. However, there is a spread of literature concerning the vulnerability and resilience of microenterprises to COVID-19. Research based on the surveys, interviews or case studies of microenterprises confirms that the response to COVID-19 depends on industry, region, financial situation, state aid, and the ability to adapt to the turbulent market situation (Kochaniak *et al.*, 2023; Osińska, & Zalewski, 2023; Zając *et al.*, 2022; Michalski, 2022; Kluzek, 2022; Pyrkosz-Pacyna *et al.*, 2021; Marjański & Sułkowski, 2021; Dankiewicz *et al.*, 2021). The conclusions from the above research studies allowed us to formulate the following hypotheses:

H1: There is a significant sectoral heterogeneity of total factor productivity in the Polish microenterprises sector.

H2: There is a significant regional heterogeneity of total factor productivity in the Polish microenterprises sector.

H3: The COVID-19 pandemic had an impact on productivity in microenterprises that was heterogeneous across industries.

H4: Micro-firms from various regions could have successfully responded to overcome the COVID-19 pandemic's restrictions and limitations and could have achieved exceptionally high TFP growth in 2020.

H5: In 2020, the TFP growth was mainly induced by the between-firm effect, whereas before 2020 within-firm effect was the main driver of TFP growth for microenterprises in Poland.

RESEARCH METHODOLOGY

Data

We performed the estimations using yearly labour, physical capital, and production output data approximated by the real gross value-added for microenterprises. Data on the gross value-added, capital, and labour originate from the annual survey of the economic activity of microenterprises (EAME) of Statistics Poland, which examines the business activity of Polish enterprises with fewer than ten employees and is based on the statistical form 'SP-3- Survey on economic activity.'

Statistics Poland implemented the sample survey in the EAME using the representative method with a stratified sampling scheme.[1] The sample covers about 4% of the total population. We expanded the representative sample by weights, which are determined to replicate total employment in the population of microenterprises in Poland. Finally, our annual data cover 11 years of observations between 2010 and 2020 and make an unbalanced panel dataset containing about 1 329 106 firms yearly. The final sample covered about 68% of the total microenterprises and nearly 100% of the persons employed.

The enterprise's gross value-added Y is the difference between its global output and intermediate consumption and L is the number of employees. Physical capital K is defined as the enterprise annual fixed assets. The final measurement for variables Y and K is determined by calculating the real gross

[1] For details see Methodological report. Non-financial enterprises surveys Statistics Poland, Warsaw 2019, p. 25.

value-added and real physical capital of the enterprise at constant average prices from 2015. For this purpose, we used capital and gross value-added deflators for the two-digit NACE Rev. 2 divisions.[2]

Methodology of Production Function Estimation

We estimated the production function by applying the Levinsohn and Petrin (2003) model with Ackerberg, Caves, and Frazer (2015) correction to determine the enterprise's individual TFP. We assumed that the gross value-added Y_{it} for enterprise i from the two-digit NACE Rev. 2 division G_d in period t is determined by the Cobb-Douglas function:

$$Y_{it} = TFP_{it}K_{it}^{\beta_{k,d}}L_{it}^{\beta_{l,d}}e^{\epsilon_t}, i \in G_d \tag{1}$$

in which ϵ_t is i.i.d output shock, TFP_{it} is the unadjusted total factor productivity; L_{it}, K_{it} are the quantities of labour and capital and L_{it} is the number of employees at the end of period t. The variables Y_{it} and K_{it} are defined as real gross value-added and real physical capital levels in the microenterprise. The parameters $\beta_{k,d}$ and $\beta_{l,d}$ denote the gross value-added elasticities of capital and labour, respectively, for homogenous groups of firms G_d representing the two-digit NACE Rev. 2 division of the economy.

Hereafter, let $y_{it}, l_{it}, k_{it},$ and ω_{it} denote the logarithms of variables Y_{it}, L_{it}, K_{it} , and TFP_{it}, respectively. The firm-level production function from (1) can be estimated using control function methods, such as Olley and Pakes' (1996) model (OP model) and Levinsohn and Petrin's (2003) model (LP model), both of which can be enhanced by the correction made by Ackerberg, Caves, and Frazer (2015) (ACF). Within this framework, the productivity coefficient ω_{it} is a state variable in the company-decision problem, which involves the selection of production factors. We determined the enterprise's individual TFP by finding the output elasticities from equation (1). Control function methods use different proxy variables to approximate productivity shocks and estimate a company's probability of survival in the market. Moreover, the productivity coefficients acknowledge the Markovian structure. As a result, the OP and LP models produce consistent estimates of output elasticities that solve the endogeneity problem of explanatory variables and attrition (van Beveren, 2012). Due to data availability restrictions for each of the two-digit NACE Rev. 2 divisions, we estimated production function using the LP model with regional and time effects. Thus, we assumed that energy and materials expenditures are a proxy for unobserved TFP indices in the LP model.

Estimating the production equation within the LP model with ACF correction is a two-stage procedure. We employed the ACF correction to the control function approach since labour input may be dependent on the productivity estimated using a low-order polynomial of capital and proxy variables. In the first stage, we avoided this collinearity problem by assuming that the unobservable productivity shocks ω_{it} can be approximated using a polynomial function of capital k_{it},, labour l_{it}, and proxy variable m_{it}, represented by the energy and materials outlays:

$$\omega_{it} = h(k_{it}, l_{it}, m_{it}) \tag{2}$$

Then, the firm-level output is of the form

$$y_{it} = f(k_{it}, l_{it}, m_{it}) + \epsilon_{it} \tag{3}$$

in which $f(k_{it}, l_{it}, m_{it}) = h(k_{it}, l_{it}, m_{it}) + \beta_{k,d}k_{it} + \beta_{l,d}l_{it}$. Thus $\omega_{it} = f(k_{it}, l_{it}, m_{it}) - \beta_{k,d}k_{it} - \beta_{l,d}l_{it}$. Equation (2) can be non-parametrically estimated, approximating f by n-th degree polynomial. In the second stage, the Markovian structure of ω_{it} implies

$$\omega_{it} = g_t(\omega_{it-1}) + \xi_{it} = g_t\big(\hat{f}(k_{it-1}, l_{it-1}, m_{it-1}) - \beta_{k,d}k_{it-1} - \beta_{l,d}l_{it-1}\big) + \xi_{it} \tag{4}$$

in which ξ_{it} is productivity shock and we substitute f with the theoretical production $\hat{f}$ from the first step. Hence the production function can be written as

$$\begin{aligned} y_{it} = \omega_{it} + \beta_{k,d}k_{it} + \beta_{l,d}l_{it} + \epsilon_t = \ & g\big(\hat{f}(k_{it-1}, l_{it-1}, m_{it-1}) - \beta_{k,d}k_{it-1} - \beta_{l,d}l_{it-1}\big) + \\ & +\beta_{k,d}k_{it} + \beta_{l,d}l_{it} + \epsilon_{it} + \xi_{it} \end{aligned} \tag{5}$$

[2] Appendix A provides detailed descriptions of the endogenous and explanatory variables.

We based the estimation procedure on the idea introduced by Olley and Pakes (1996), but here both labour and capital coefficients $\beta_{l,d}, \beta_{k,d}$ are estimated. We approximate the non-linear function g by a four-degree polynomial and use the generalized method of moments (GMM) approach. Indeed, for every period t and firm i the residuals $r_{it} = \epsilon_{it} + \xi_{it}$ are orthogonal to all entries of vector $z = [k_{it}, l_{it-1}, m_{it-1}]$. Consequently, we obtained the following estimate of the company's productivity coefficient:

$$\widehat{\omega}_{it} = y_{it} - \hat{\beta}_{k,d} k_{it} - \hat{\beta}_{l,d} l_{it} \tag{6}$$

The company's unadjusted TFP is then calculated as

$$\widehat{TFP}_{it} = e^{\widehat{\omega}_{it}} \tag{7}$$

The $\widehat{TFP}_{it}$ values can be directly used to analyze the determinants affecting a company's performance or, once aggregated, indicate productivity by economic sector or region.

TFP Aggregation and TFP Growth Decomposition

TFP aggregation of firms from a given group G_t (*e.g.* NACE division or sector) in year t is performed by the weighted average

$$\widehat{\omega_{G_t}} = \sum_{i \in G_t} s_{it}\, \widehat{\omega}_{it} \tag{8}$$

with weights s_{it} based on input variables characterizing companies' sizes:

$$s_{it} = \frac{K_{it}^{\widehat{\beta_k}} L_{it}^{\widehat{\beta_l}}}{\sum_{i \in G_t} K_{it}^{\widehat{\beta_k}} L_{it}^{\widehat{\beta_l}}} \tag{9}$$

Then, the average TFP growth rate in the group G_t is determined by the formula

$$\Delta^{\%}(TFP_t) = \widehat{\omega_{G_t}} - \widehat{\omega_{G_{t-1}}} \tag{10}$$

The Olley-Pakes decompositions (Olley & Pakes, 1996, Melitz & Polanec, 2015) of log levels and TFP growth implies that

$$\widehat{\omega_{G_t}} = \overline{\omega_{G_t}} + cov(s_{it}, \widehat{\omega}_{it}) \tag{11}$$

and

$$\Delta^{\%}(TFP_t) = \Delta\overline{\omega_{G_t}} + \Delta cov(s_{it}, \widehat{\omega}_{it}) \tag{12}$$

in which $\overline{\omega_{G_t}}$ is the average TFP level in the group G_t and $cov(s_{it}, \widehat{\omega}_{it}) = \sum_{i \in G_t} (\widehat{\omega}_{it} - \overline{\omega_{G_t}})(s_{it} - \overline{s_{G_t}})$. The first component $\Delta\overline{\omega_{G_t}}$ in (12) measures the within-firm effect of TFP growth and captures an increase in individual firm productivity represented by better technology absorption, increasing managerial skills, or innovation. The second term $\Delta cov(s_{it}, \widehat{\omega}_{it})$ in (12) is called between-firm component, which measures the efficiency of resource allocation. Positive levels of between components imply that more productive firms increase their market shares.

RESULTS AND DISCUSSION

The empirical results are presented as follows. Firstly, the panel sample of microenterprises that covers 11 years from 2010 to 2020 is used to estimate a production function and calculate TFP for microenterprises in Poland. Secondly, the sectoral and regional growth decomposition of TFP is provided within three subsamples: 2011-2015, 2016-2019, and 2020. Thirdly, the influence of the COVID-19 pandemic on the microenterprises' TFP growth in 2020 is singled out. Finally, the within- and between-firm effects of growth for sectors are identified.

Estimation Results

In the first step, we performed the estimations of parameters of production functions (1) separately for homogenous groups of companies from sector G_d defined by NACE Rev. 2 division in Poland (see Table 2. in Appendix C). We employed the LP model with time and regional dummies (see Table 2 in

Appendix C) for each homogenous division G_d. The estimators' standard errors are determined using a bootstrap procedure. Figure 2 summarizes the input elasticities for all divisions.

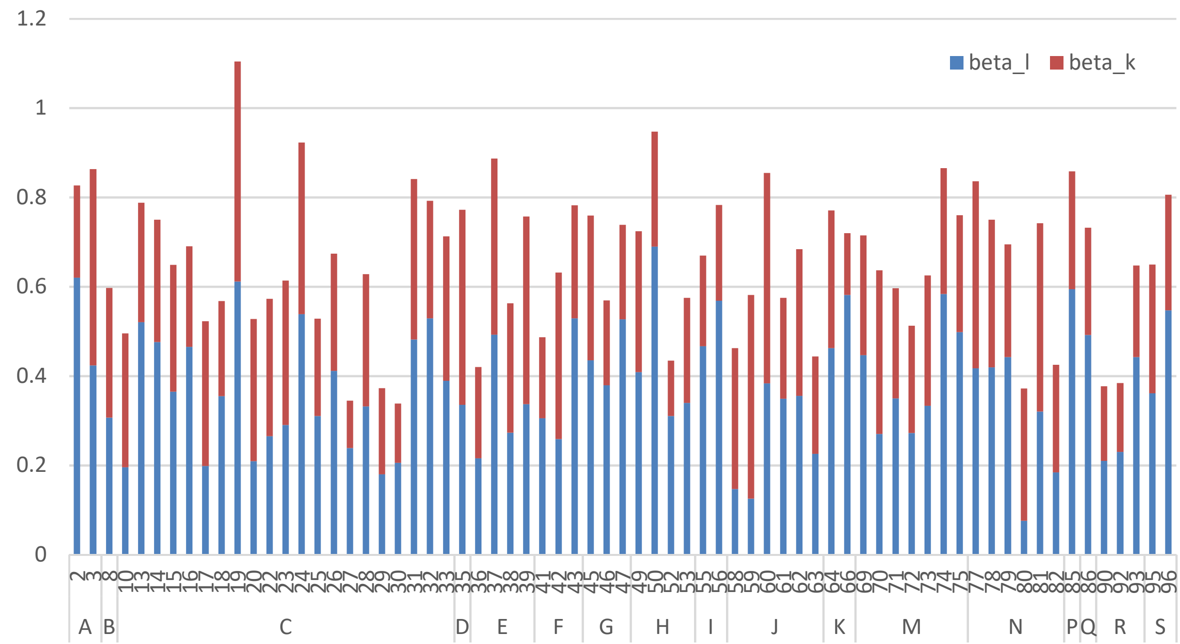


Figure 2. Production function estimation: inputs elasticities by divisions

Note: Elasticities $\beta_{k,d}$ (beta_k) and $\beta_{l,d}$ (beta_l) of the sectoral production functions (see equation (1)) by NACE divisions.

Source: own elaboration based on the LP model.

In most of the analysed regressions, Student's t-tests indicate that labour and capital have a statistically significant (see Table 3 in Appendix D) positive impact on the companies' gross value-added (all p-values < 0.01). The time and regional dummies used in explaining the transition equation (4) turn out to be significant for most cases (see the last two columns in Table 3 in Appendix D). Increasing returns to scale are only for petroleum production ($d = 19$). For all other divisions, returns to scale are decreasing. In the case of the manufacture of coke and refined petroleum products ($d = 19$), manufacture of other transport equipment ($d = 30$), water transport ($d = 50$), residential care activities ($d = 87$), and gambling and betting activities ($d = 92$) the influence of capital and labour on gross value added turn out to be insignificant, while for divisions: mining support service activities ($d = 9$), manufacture of primary pharmaceutical products and pharmaceutical preparations ($d = 21$), real estate activities ($d = 68$), social work activities without accommodation ($d = 88$), libraries, archives, museums and other cultural activities ($d = 91$), the values of estimated elasticities were negative. Due to unacceptable estimates and an insufficient number of observations, we excluded microenterprises from the divisions listed above from the estimation sample.

In the second stage of the analysis, based on the production functions estimates, we calculated the company's unadjusted TFP (see equations (6)-(7)), which is further aggregated by the weighted average and decomposed by Olley-Pakes method (as described in equations (8)-(12)). Figure 3 presents the empirical distribution of TFP for microenterprises in 2010, 2015, and 2020. The distribution was relatively symmetrical and moved towards the right in 2020. Figure 9 in Appendix B presents detailed empirical distributions for the whole sample.

Sectoral Decomposition of TFP Growth

We conducted the sectoral analysis of unadjusted TFP growth within three periods: 2011-2015, 2016-2019, and 2020 separately. The last one describes the impact of the pandemic outbreak on the productivity of microenterprises from particular sectors in Poland. The COVID-19 pandemic caused an increase in sector-specific TFP growth volatility. Therefore, we observed substantial positive impacts of COVID-19 in a number of industries as well as significant adverse effects in others.

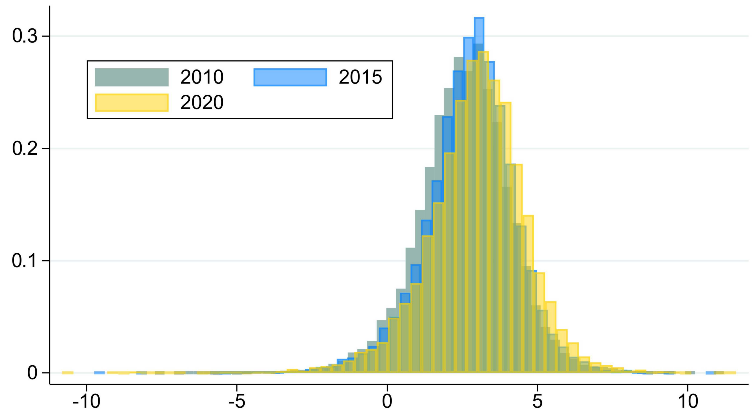


Figure 3. Empirical distribution of micro-firm TFP in cross-sectors defined by years
Note: Empirical distribution of TFP indices $\widehat{\omega}_{it} = \log \widehat{TFP}_{it}$ given by equation (6).
Source: own elaboration based on the LP model.

Figure 4 presents the changes in average annual TFP growth for 15 sectors[3] of the Polish economy that are listed in Table 1 in Appendix C.

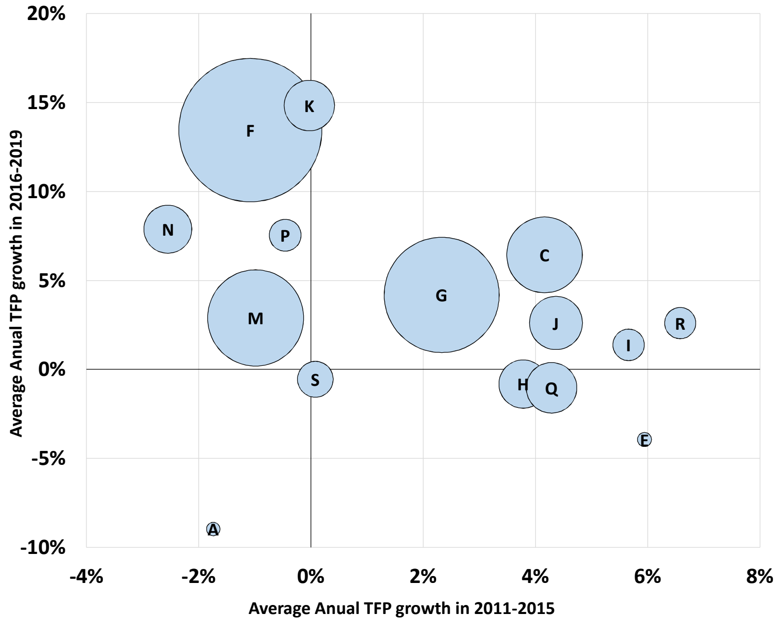
During the first analysed period, between 2011 and 2015, TFP growth leaders are (symbols and TFP growth are in brackets): arts, entertainment, and recreation (R, almost 7%), water supply; sewerage and waste management activities (E, 6%), accommodation and food service activities (I, 6%), information and communication (J, 4%), and manufacturing (C, 4%). Poor productivity performance is observed in the following sectors: administrative and support service activities (N, -3%), construction (F, -1,1%) and professional, scientific, and technical activities (M, -1%), which produce together about 47% of sector gross value added in 2015. However, these sectors' poor performance may result from the highest weighted TFP levels in 2010. On the other hand, microenterprises from the wholesale and retail trade sector (G), which accounted for almost 20% of gross value added, obtained moderate average annual growth of 2.3%. In conclusion, the average annual TFP growth of microenterprises in all sectors reached 1.4% in 2010-2015. It was presumably a result of the 2008-2009 global financial crisis, the subsequent worldwide economic recession, market volatility, and lacklustre economic growth.

In the second analysed period (2016-2019), we observed a substantial increase in average annual TFP growth (5.4% in relation to 1.4% in the previous period). Between 2016 and 2019, the excellent productivity performance can be assigned to microenterprises from two sectors: construction (F) and financial and insurance activities (K), which represented in 2019 30% and almost 4% of gross value added respectively and accounted for 13% and 15% of average annual TFP growth. The second main sector among microenterprises wholesale and retail trade (G), which generated almost 20% of gross value added in 2019, also positively contributed to overall TFP between 2016 and 2019 with 4% of average annual TFP growth. Generally, microenterprises from almost all sectors except transportation and storage (H, -0,8%) and human health and social work activities (Q, -1%) contributed positively to overall average annual TFP growth. Thus between 2016 and 2019, the average annual TFP growth in microenterprises was generally higher than in the previous period. The reasons behind that may be related to the stability of the economic situation in industry, low inflation rate, and accommodative monetary policy.

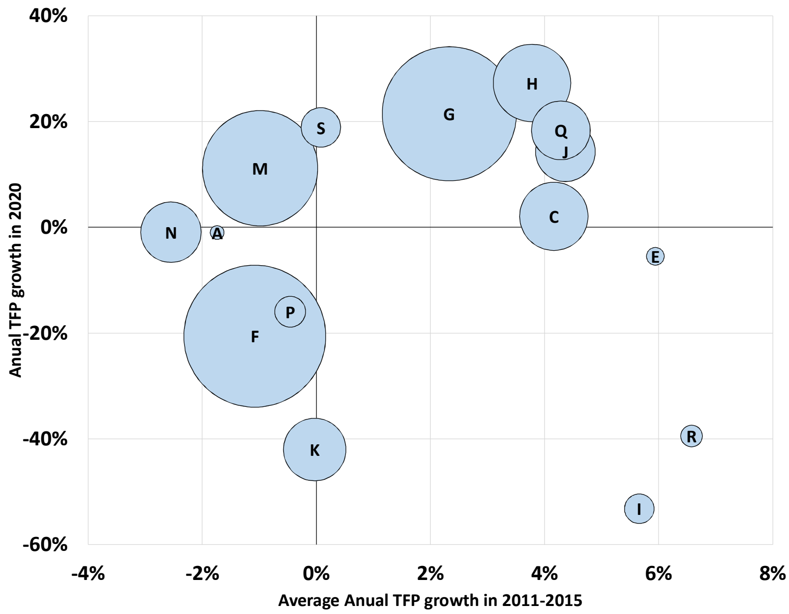
The average annual TFP growth in 2020 shows the consequences of the pandemic outbreak concerning microenterprises productivity. The following sectors: transportation and storage (H), wholesale and retail trade (G) with shares in GVA 7% and 22% in 2020 displayed outstanding average annual productivity growth of 27% and 22%, respectively. However, good performance can be also assigned to information and communication (J, 14% of average annual TFP growth) and professional, scientific, and technical activities (M, 11%), which were responsible for 5% and 15% of total gross value added in 2020. Therefore, the increased interest in online shopping and courier delivery led to the development of microenterprises

[3] Sectors B, D, L, and O are represented by the small number of microenterprises, and their GVA shares in total GVA are below 3%, thus, we omitted them in Figure 4.

associated with trade, transportation, and storage. The pandemic outbreak also positively impacted the productivity growth of microenterprises from sectors related to information, communication, professional, scientific, and technical activities and education, which is probably the consequence of the increase in demand for information technology services, telecommunication, services offering professional and specialist knowledge and online trainings during lockdown caused by COVID-19.



(a) Average annual TFP growth: 2011-2015 vs. 2016-2019



(b) Average annual TFP growth: 2011-2015 vs. 2020

Figure 4. Sectoral decomposition of TFP growths

Note: The size of the dots represents GVA shares of the sectors in the entire micro-firm gross value added in 2019 (panel (a)) and 2020 (panel (b)).

Source: own elaboration.

On the other hand, in 2020, the pandemic outbreak caused a drop in average annual TFP growth by 20% in construction (F), which is responsible for a considerable share in gross value added (24%) in 2020. Due to the global lockdown, COVID-19 has also negative influence on the TFP growth of microenterprises from sectors: accommodation and food service activities (I, -53%), financial and insurance activities (K, -42%), arts, entertainment,[4] and recreation (R, -39%). However, microenterprises from these sectors produce only less than 6% of GVA.

Let us summarise the productivity of micro-firms from the crucial sectors (in terms of GVA shares) over the analysed period. In the case of microenterprises from the construction sector, the average annual TFP growth fluctuated considerably over time. From -1.1 % between 2011 and 2015, then between 2016 and 2019 it recovered with an average of 13%, while in the last year of the sample, the COVID-19 pandemic led to a huge drop in its productivity by 20%. Between 2011 and 2020, the average annual TFP growth of companies from the wholesale and retail trade sector followed an upward trend from 2% between 2011 and 2015, then 4% in the second period to 21.5% after the COVID-19 appeared. We can explain this by the growing interest in online shopping and consumption resulting from panic. The TFP growth in the transportation and storage sector fluctuated from 4% in the first period, then it dropped to a negative value -0.8% between 2016-2019 and became a leader during the COVID-19 pandemic (27%) as the consequence of demand on online shopping and delivery services. The productivity of microenterprises from the professional, scientific, and technical activities sector developed significantly from -1% of TFP growth between 2011 and 2015 to almost 11% between 2019 and 2020.

The changes in sector GVA to overall GVA ratios between the years 2019 and 2020 are also worth considering. In sectors, which experienced negative effects of the COVID-19 pandemic (F, I, K, R) declines in GVA ratios are observed. In construction by 6% percentage points (from 30% to 24%), in accommodation and food service activities from 1.5% to 1.1%, and in arts, entertainment and recreation from 1.4% to 0.6%. Whereas in the case of leader sectors with high productivity growth, a slight increase in GVA ratios between 2019 and 2020 can be noticed, from 19% to almost 22% in wholesale and retail trade and from almost 4% to 7% in transportation and storage. The manufacturing sector calls also for particular attention because TFP in the sector has stagnated since 2012. This outcome can relate to the following issue, labour productivity growth that significantly outpaces TFP growth indicates that the expansion of the manufacturing industry comes primarily from increasing capital intensity rather than improvement in technical efficiency.

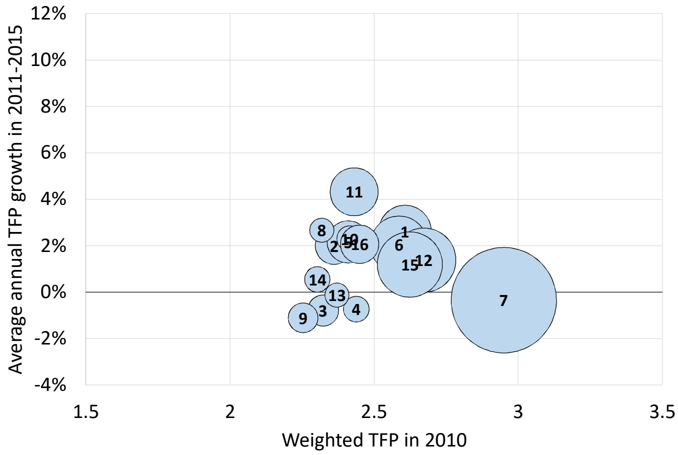
Summing up, the pandemic induced heterogeneous effects related to TFP growth. On the one hand, microenterprises from sectors: wholesale and retail trade (G), transportation and storage (H) and professional, scientific and technical activities (M), which produced in 2020 almost 50% of gross value added, were influenced positively by the lockdown caused by COVID-19. On the other hand, microenterprises representing more consumer-facing economic activities displayed negative TFP growth after the pandemic outbreak.

Regional Decomposition of TFP Growth

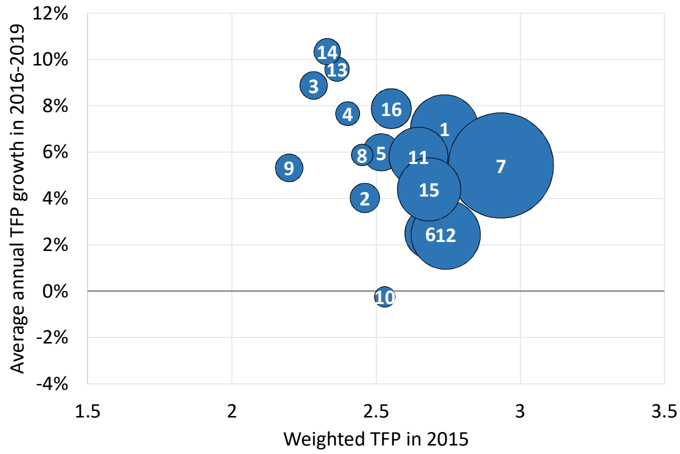
Figure 5 and Figure 6 presents the regional analysis of micro-firm average annual TFP growth. We performed this study for 16 regions and separately for three periods: 2011-2015, 2016-2019, and 2020. Table 2 in Appendix C contains an explanation of the Polish regions. The size of the dots in Figure 5 and Figure 6 represents GVA shares of microenterprises from particular Polish regions in the gross value added of all microenterprises.

Between 2011 and 2015, we observed poor productivity performance (with negative TFP growth) in microenterprises from the following regions (symbols in brackets): lubelskie (3), lubuskie (4), mazowieckie (7), podkarpackie (9), świętokrzyskie (13), while the leaders in average annual TFP growth were microenterprises from pomorskie with 4% of growth on average. During that period in most regions rather moderate TFP growth was observed from 1.2% (in wielkopolskie) to 2.7% (in opolskie). Let us analyse briefly the microenterprises from mazowieckie region (7), which produced in 2015 29% of gross value added. Although their TFP growth was negative (-0.3%) in the analysed period, they obtained the highest weighted average of TFP in 2010. We conclude that in most cases (instead of 5 exceptions) regions with a relatively low level of weighed TFP converge to highly productive regions by proving high levels of average annual TFP growth.

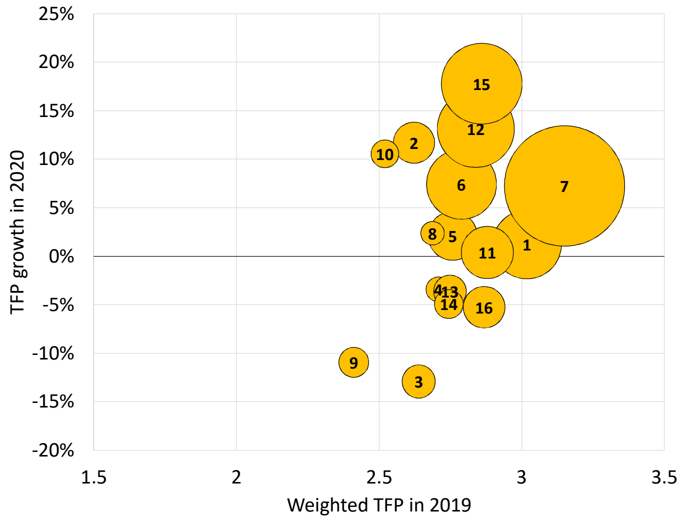
[4] The impact of COVID-19 pandemic on artist's identity and entrepreneurship is discussed in Szostak and Sułkowski (2021).



(a) Average annual TFP growth in 2011-2015 vs. weighted TFP levels in 2010 by NACE sections



(b) Average annual TFP growth in 2016-2019 vs. weighted TFP levels in 2015 by NACE sections



(c) Annual TFP growth in 2020 vs. weighted TFP levels in 2019 by NACE sections

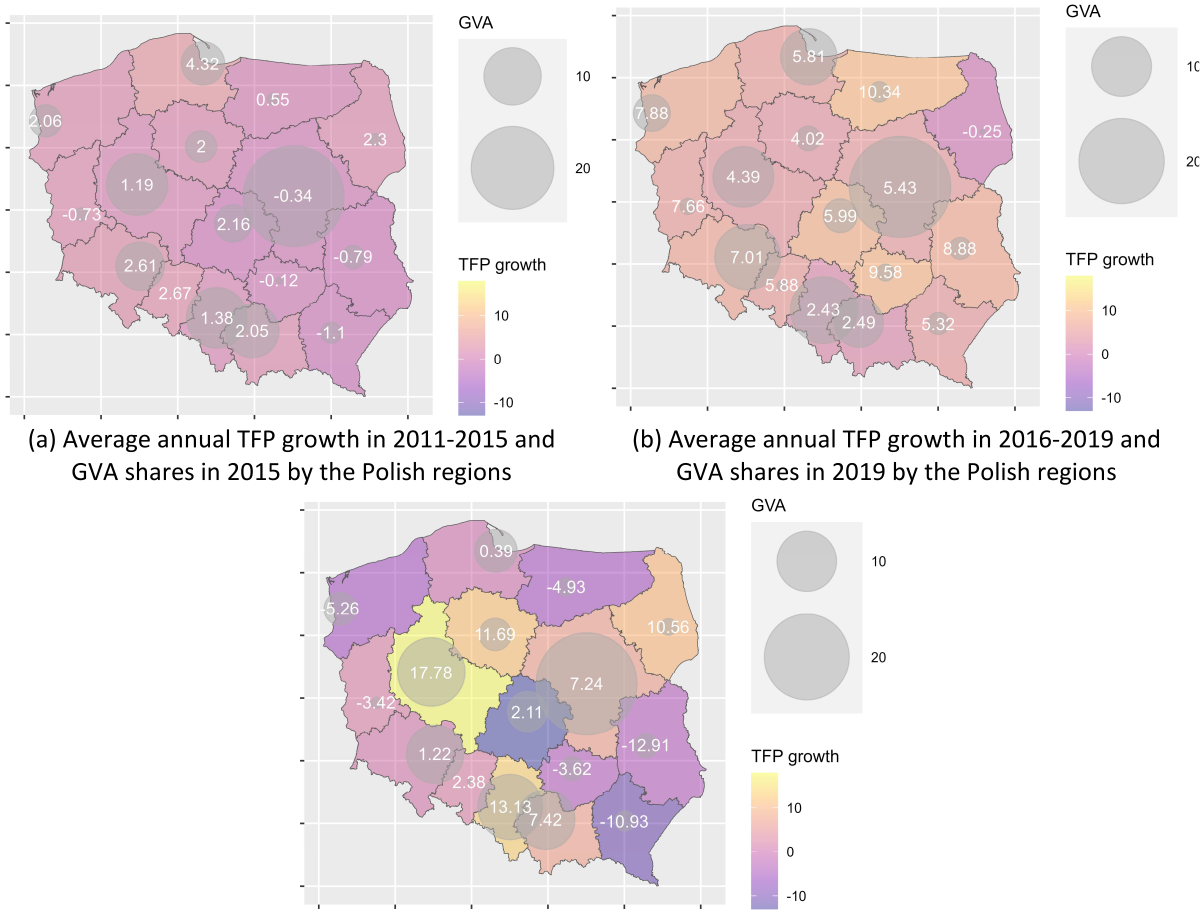
Figure 5. Regional decomposition of micro-firm TFP growths

Note: The size of the dots represents GVA shares of the sectors in the entire micro-firm gross value added in 2015 (panel (a)), 2019 (panel (b)) and 2020 (panel (c)).

Source: own elaboration.

Between 2015 and 2019, the average productivity of microenterprises in Poland increased and they displayed considerably better performance than in the previous period. Among all regions, only microenterprises from podlaskie (10) displayed on average negative TFP growth between 2015 and

2019. Microenterprises from all other regions experienced positive average TFP growth from 2% in malopolskie to 10% in warmińsko-mazurskie. In regions with highly productive microenterprises (mazowieckie – 7, śląskie – 12, dolnośląskie – 1, wielkopolskie – 15, pomorskie – 11, małopolskie – 6), which in total account for 74% of GVA, rather moderate average annual TFP growth is observed with maximum 7% in dolnośląskie. We observed the convergence from less productive to more productive regions for all regions except podlaskie (10).



(a) Average annual TFP growth in 2011-2015 and GVA shares in 2015 by the Polish regions

(b) Average annual TFP growth in 2016-2019 and GVA shares in 2019 by the Polish regions

(c) Annual TFP growth and GVA shares in 2020 by the Polish regions

Figure 6. Regional micro-firm TFP growths

Note: the numbers denote the average annual TFP growth rates, and the size of dots indicates the share of GVA (in p.p.) in a particular region in total GVA at the end of the period.
Source: own elaboration.

The results obtained for the last period present the impact of the pandemic outbreak on microenterprises' productivity. In most regions, the microenterprises proved to be productive between 2019-2020 (see Figure 6). Various factors influence the increase in average annual TFP growth in 2020, for example, the effectiveness of anti-crisis shields, the severity of COVID-19 in individual regions, and the individual ability to adapt to the lockdown by introducing remote work opportunities. The industry structure in individual regions also plays an important role, *i.e.* adapting to lockdown was easier for companies with developed IT infrastructure. At the same time, it was difficult for enterprises from tourist regions. The negative average annual TFP growth is observed in microenterprises from: lubelskie (3), lubuskie (4), warmińsko-mazurskie (14), zachodniopomorskie (16), świętokrzyskie (13), and podkarpackie (9), which jointly produced only 12% of gross value added in 2020. Although the leaders with average yearly TFP growth over 10% are only three regions: wielkopolskie 15 (18%), śląskie 12 (13%), kujawsko-pomorskie (12%), they contributed almost one-third of total gross value added. Podlaskie (10) region is kind of an outlier observation with good productivity performance (10% of growth) but one of the lowest weighed TFP levels (2.52). Microenterprises from mazowieckie (with the highest GVA share equal to 28%) positively contributed to overall average annual TFP growth (7%). To conclude, the COVID-19 pandemic outbreak had a positive effect, especially on microenterprises from regions with considerable GVA shares and rather high TFP levels. Therefore, we did not observe convergence in that period.

The Olley-Pakes Decompositions of TFP Growth

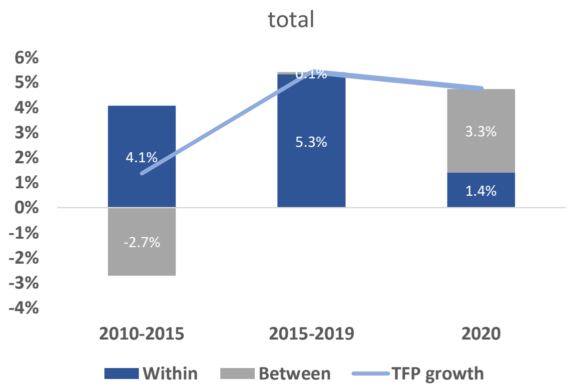
We subjected the Polish micro-firms TFP growth between 2011 and 2020 to additional analysis in order to decompose it into the within- and between-firm effects of growth (see Figure 7 and Figure 8). In this part of the study, we considered only those sectors, which was significantly influenced by the COVID-19 pandemic outbreak. Recall that the within-firm component of the TFP growth measures the gains from firms' own productivity performance. It represents a shift in the distribution of firm productivity. The between component of the TFP growth represents the productivity growth coming from the reallocation of resources across companies.

Figure 7 presents the TFP growth of those NACE sectors that exhibited positive values in 2020. In the first two analysed periods, aggregated TFP growth for all microenterprises was driven by the within-firm component, while in 2020, the between-firm component prevailed.

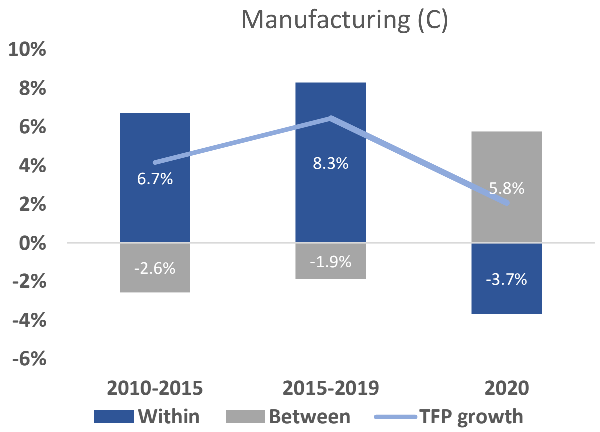
Before the pandemic outbreak, within-firm effects stimulated average TFP growth in microenterprises from the manufacturing (C) sector, but the efficiency of resource allocation was negative. In 2020, positive TFP growth was maintained by the between-firm effects, while the within-firm component caused a decline in TFP growth of microfirms from the manufacturing sector. The studies of Albinowski *et al.*, 2015 and World Bank, 2021 for small, medium and large enterprises in the manufacturing sector during 2006-2019, show that the reallocation of production factors across manufacturers within industries was negative for most years, especially in 2014 and 2019. The increase of within-firm components mainly explained TFP growth. However, during the global financial crisis, we observed the reallocation of resources into more productive firms. We confirmed the same effects for micro-firms in the manufacturing sector during the COVID-19 pandemic.

In the case of microenterprises from wholesale and retail trade (G) in 2020, the efficiency of resource allocation was also the main component of their TFP growth, while in the case of microenterprises from transportation and storage (H) the impact of within and between components was balanced. We observed the opposite situation for microenterprises from information and communication (J), for which TFP growth was mainly driven by the within-firm component.

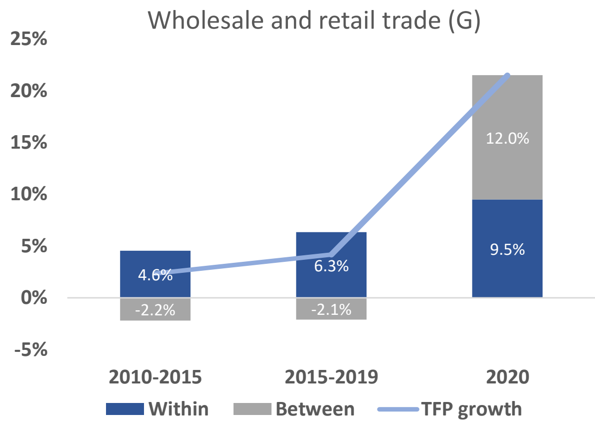
Figure 8 highlights the sectors with high negative TFP growth in 2020. In the case of microenterprises from sectors: I, R, and K, the within-firm component prevailed, while in the case of microenterprises from construction – between-firm effects, which means that in construction, the productivity degrowth of microenterprises was driven by a reallocation of resources from less to more productive firms.



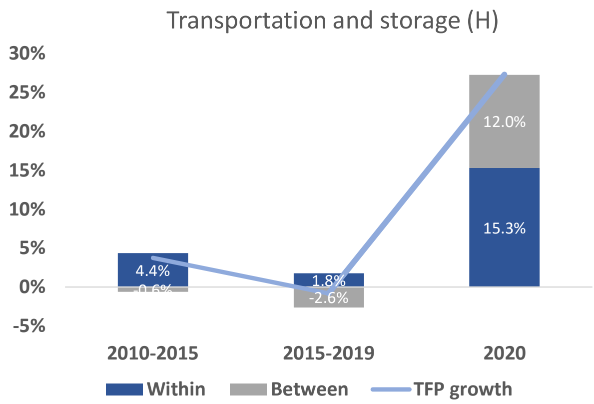
(a) Annual TFP growth for the whole sample of microenterprises in Poland by periods



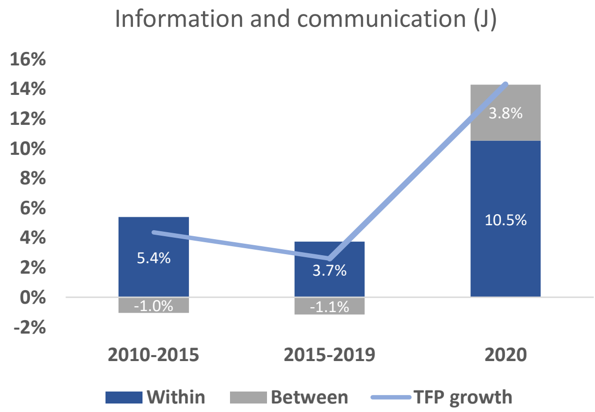
(b) Annual TFP growth in section C by periods



(c) Annual TFP growth in section G by periods



(d) Annual TFP growth in section H by periods

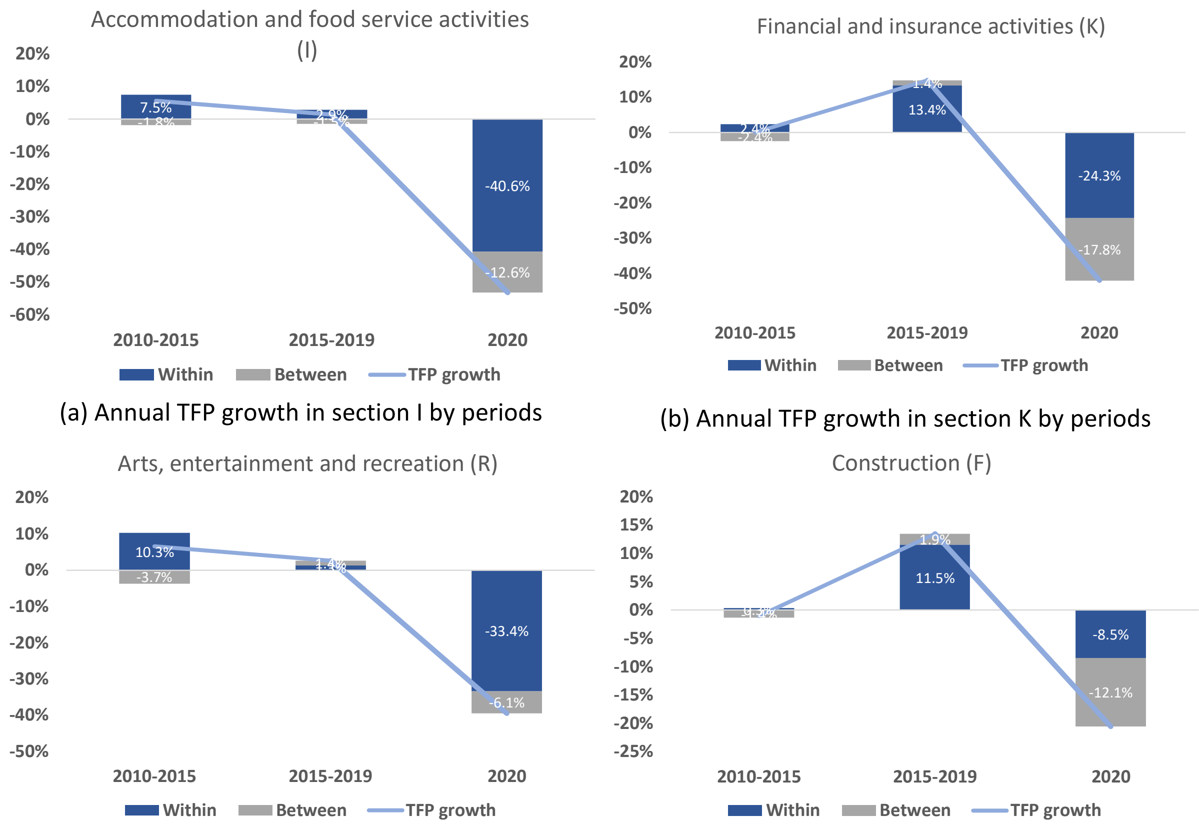


(e) Annual TFP growth in section J by periods

Figure 7. The Olley-Pakes decomposition of micro-firm TFP growth, part A

Note: the numbers denote the average annual TFP growth rates.

Source: own elaboration.



(a) Annual TFP growth in section I by periods

(b) Annual TFP growth in section K by periods

(c) Annual TFP growth in section R by periods

(d) Annual TFP growth in section F by periods

Figure 8. The Olley-Pakes decomposition of micro-firm TFP growth, part B

Note: the numbers denote the average annual TFP growth rates.

Source: own elaboration.

CONCLUSIONS

Our study aims to fill the research gap in the analysis of TFP for microenterprises in Poland. We can conclude that over the sample 2010-2020, the average TFP growth of micro firms in Poland was generally positive even during the pandemic outbreak. However, in 2020, we observed substantial heterogeneity between sectoral and regional TFP growths.

Empirical results confirmed the research hypotheses. Analysis of the sectoral and regional decomposition of TFP growth revealed considerable diversity in productivity growth rates between sectors and regions. The shock caused by the COVID-19 pandemic was transferred to the analysed sectors and regions in various ways, depending on their idiosyncratic characteristics, which determined their ability to adapt to the new situation. Productivity of microenterprises from the following sectors: construction, wholesale, and retail trade, professional, scientific and technical activities, which jointly produced about 60% of gross value added, was influenced considerably by the lockdown. The best performance can be assigned to transportation and storage, wholesale and retail trade, information and communication, professional, scientific and technical activities. The increased interest in online shopping, courier delivery and various online services might be the reason for the productivity growth of microenterprises associated with those services. On the other hand, the pandemic caused a fall in construction productivity with considerable GVA share and huge drops in sectors associated with accommodation and food service activities, financial and insurance activities, arts, entertainment and recreation, representing low production shares. The regional analysis concluded that the COVID-19 pandemic positively affected microenterprises from regions with considerable GVA shares and relatively high weighted TFP levels. Thus, we did not observe convergence in that period.

Based on the Olley-Pakes decomposition of TFP growth, we confirmed that before the outbreak of the COVID-19 pandemic, the aggregated TFP growth of microenterprises in Poland was driven by the within-firm component. In contrast, in 2020, the efficiency of resource allocation was the main component of micro-firm TFP growth. We may formulate the same conclusion for manufacturing, wholesale, and retail trade. However, in the case of transportation and storage and information and communication, the productivity degrowth after the pandemic outbreak was driven by the within-firm component.

The recent financial and sovereign debt crises prompted calls for courageous structural policies in several eurozone countries while declining growth in many developed and developing countries highlighted the need for regulatory reforms to boost productivity and growth. This analysis might help to identify regions and sectors of the Polish economy that suffer from substantial inefficiencies and thus require policy attention. The structural policy should consider the heterogeneity of productivity across sectors and regions and adjust instruments to the productivity level of particular sectors and regions. For instance, structural policy can be directed to increase investments in prosperous sectors or regions and propose support (*e.g.* enhancing digitalisation, training, and technology changes) that ensures an increase in less productive sectors or regions.

The research presents the outlook of the consequences of the COVID-19 pandemic on microenterprises in Poland. The next stage of the study assumes the finding of the determinants of TFP growth based on the micro-data panel model.

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Appendix A: Definition of firm-level variables

Based on the annual enterprise survey data and attached external variables (*e.g.* investment, capital, and gross value-added deflators), we calculated the values of the endogenous and explanatory variables according to the following formulas:

Firstly, the company's global output is defined as

$$output = rev - tax \tag{13}$$

in which:

rev - total operating revenues;

tax **-** excise tax.

The intermediate consumption ($intermConsump$) is measured by the total operating costs. The company's gross value-added (gva) is the difference between its global output ($output$) and intermediate consumption ($intermConsump$)

$$gva = output - intermConsump \tag{14}$$

The company's capital stock ($capital$) is defined as the tangible fixed assets at the end of a year. The perpetual inventory capital construction method is unreliable in this instance due to the relatively short sample period. The variables' final measurement is determined by calculating the enterprise's real gross value-added and real capital stock at constant average prices from 2015. For this purpose, we used capital- and gross-value-added deflators in the two-digit sectors.

Appendix B:

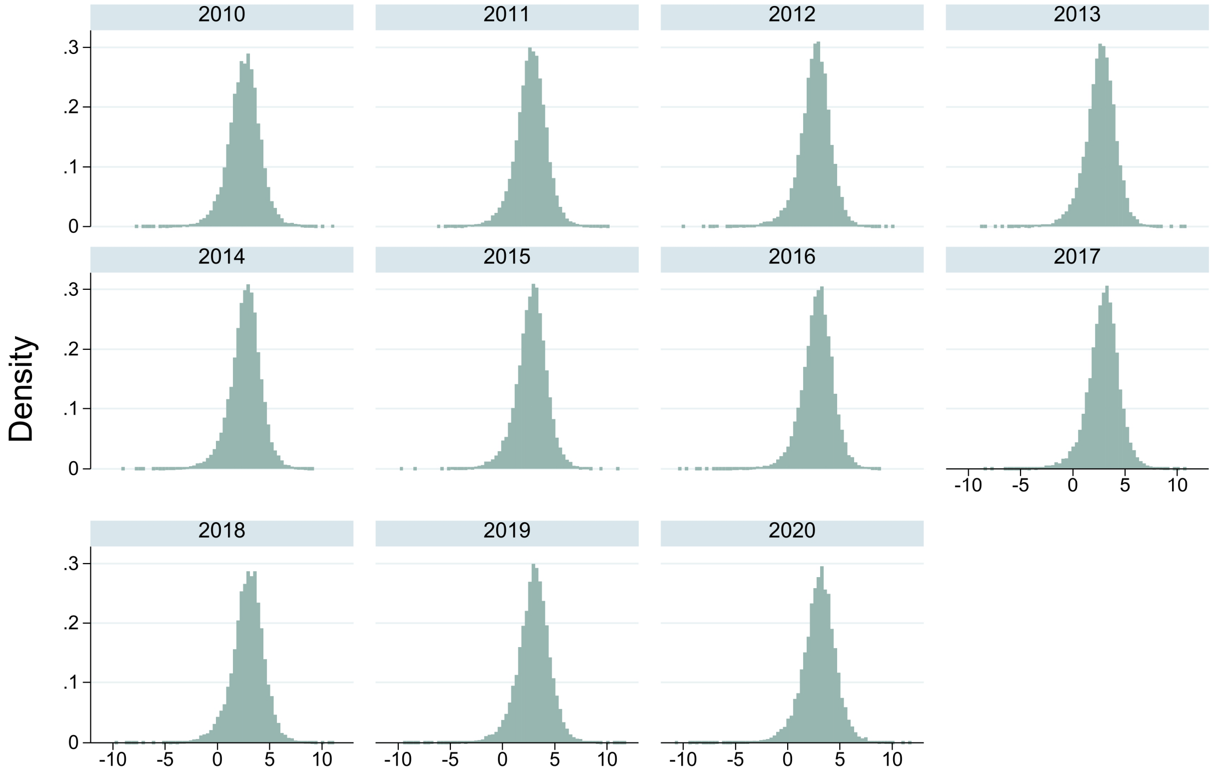

Figure 9. ***Empirical distribution of*** $\widehat{\omega}_{it} = log\,\widehat{TFP}_{it}$ ***in cross-sectors defined by years***

Source: own elaboration based on the LP model.

Appendix C:

Błąd! Nie można odnaleźć źródła odwołania. presents the sectors of industries in Poland according to NACE Rev.2 of the statistical classification of economic activities in the European Community.

Table 1. The symbols of analysed sectors in Poland

Symbol	Industry sector
A	Agriculture, forestry and fishing
B	Mining and quarrying
C	Manufacturing
D	Electricity, gas, steam and air conditioning supply
E	Water supply; sewerage, waste management and remediation activities
F	Construction
G	Wholesale and retail trade; repair of motor vehicles and motorcycles
H	Transportation and storage
I	Accommodation and food service activities
J	Information and communication
K	Financial and insurance activities,
L	Real estate activities
M	Professional, scientific and technical activities
N	Administrative and support service activities
O	Public administration and defence; compulsory social security
P	Education
Q	Human health and social work activities
R	Arts, entertainment and recreation
S	Other service activities

Source: NACE Rev.2 statistical classification of economic activities in the European Community (Eurostat, 2008).

Table 2. The symbols of regions in Poland

Symbol	Region
01	dolnośląskie
02	kujawsko-pomorskie
03	lubelskie
04	lubuskie
05	łódzkie
06	małopolskie
07	mazowieckie
08	opolskie
09	podkarpackie
10	podlaskie
11	pomorskie
12	śląskie
13	świętokrzyskie
14	warmińsko-mazurskie
15	wielkopolskie
16	zachodniopomorskie

Source: Source: NUTS 2 statistical classification in Poland (Statistics Poland).

Appendix D:

Table 3. The production function of estimation results

Section	Division	$\widehat{\beta}_{k,d}$	p. value for $H0: \beta_{k,d} = 0$	$\widehat{\beta}_{l,d}$	p. value for $H0: \beta_{l,d} = 0$	Returns to scale	Wald test for constant return to scale, p-value	Insignificant time dummies for 2010-2019	Insignificant regional dummies
A	2	0.620	0.000	0.207	0.000	0.827	0.000		4
	3	0.424	0.000	0.440	0.000	0.863	0.000	2017	1, 8
B	8	0.307	0.000	0.290	0.000	0.597	0.000		2, 5, 9, 10
C	10	0.195	0.000	0.300	0.000	0.495	0.000	2018, 2019	16
	13	0.520	0.000	0.267	0.000	0.788	0.000	2014, 2018, 2019	
	14	0.476	0.000	0.274	0.000	0.750	0.000		6
	15	0.364	0.000	0.285	0.000	0.649	0.000		12
	16	0.465	0.000	0.225	0.000	0.690	0.000		2, 3, 12
	17	0.199	0.000	0.324	0.000	0.522	0.000	2016	
	18	0.354	0.000	0.213	0.000	0.568	0.000		
	19	0.611	0.201	0.493	0.038	1.104	0.000	2010, 2017, 2018	5, 14
	20	0.209	0.000	0.319	0.000	0.528	0.000		
	22	0.265	0.000	0.307	0.000	0.572	0.000		11
	23	0.290	0.000	0.324	0.000	0.614	0.000		8, 13
	24	0.538	0.000	0.384	0.000	0.922	0.000	2013, 2015, 2016	12
	25	0.310	0.000	0.219	0.000	0.528	0.000	2011, 2016	
	26	0.411	0.000	0.263	0.000	0.674	0.000		14, 15
	27	0.239	0.000	0.106	0.001	0.345	0.000	2014	1
	28	0.332	0.000	0.296	0.000	0.628	0.000		12
	29	0.179	0.001	0.193	0.000	0.372	0.000		8, 9
	30	0.206	0.000	0.132	0.016	0.338	0.000	2015	13
	31	0.482	0.000	0.359	0.000	0.841	0.000		16
	32	0.529	0.000	0.263	0.000	0.792	0.000	2016	
	33	0.389	0.000	0.324	0.000	0.713	0.000		11, 12, 15, 16
D	35	0.335	0.000	0.437	0.000	0.772	0.000	2018	
E	36	0.216	0.015	0.204	0.166	0.420	0.000	2011, 2019	
	37	0.492	0.000	0.394	0.000	0.887	0.000		8
	38	0.273	0.000	0.290	0.000	0.563	0.000		1, 12, 16
	39	0.337	0.000	0.420	0.000	0.757	0.000		8

Section	Division	$\widehat{\beta}_{k,d}$	p. value for $H0: \beta_{k,d} = 0$	$\widehat{\beta}_{l,d}$	p. value for $H0: \beta_{l,d} = 0$	Returns to scale	Wald test for constant return to scale, p-value	Insignificant time dummies for 2010-2019	Insignificant regional dummies
F	41	0.305	0.000	0.182	0.000	0.487	0.000		
	42	0.259	0.000	0.373	0.000	0.631	0.000		10
	43	0.529	0.000	0.253	0.000	0.782	0.000		
G	45	0.435	0.000	0.324	0.000	0.759	0.000		13
	46	0.379	0.000	0.191	0.000	0.569	0.000		12
	47	0.527	0.000	0.212	0.000	0.739	0.000		
H	49	0.408	0.000	0.315	0.000	0.724	0.000		1, 5, 8, 10, 14
	50	0.690	0.000	0.258	0.142	0.947	0.000	2013, 2016	2, 5, 1, 11, 12
	52	0.310	0.000	0.124	0.000	0.434	0.000	2018	12, 15
	53	0.339	0.000	0.236	0.000	0.575	0.000		
I	55	0.466	0.000	0.203	0.000	0.669	0.000	2018	
	56	0.568	0.000	0.214	0.000	0.782	0.000		
J	58	0.147	0.000	0.315	0.000	0.462	0.000		
	59	0.125	0.000	0.456	0.000	0.582	0.000	2011, 2015	
	60	0.383	0.000	0.472	0.000	0.855	0.000	2012, 2014	
	61	0.349	0.000	0.226	0.000	0.575	0.000	2018, 2019	5
	62	0.355	0.000	0.328	0.000	0.684	0.000		
	63	0.225	0.000	0.219	0.000	0.444	0.000		
K	64	0.462	0.000	0.309	0.000	0.771	0.000		
	66	0.581	0.000	0.139	0.000	0.720	0.000		
M	69	0.446	0.000	0.269	0.000	0.715	0.000		
	70	0.270	0.000	0.366	0.000	0.636	0.000		
	71	0.350	0.000	0.247	0.000	0.596	0.000		12
	72	0.272	0.000	0.240	0.000	0.512	0.000	2018, 2019	5, 6, 13
	73	0.333	0.000	0.292	0.000	0.625	0.000		
	74	0.584	0.000	0.282	0.000	0.865	0.000		5
	75	0.498	0.000	0.262	0.000	0.760	0.000		2
N	77	0.417	0.000	0.419	0.000	0.836	0.000		12
	78	0.419	0.000	0.331	0.000	0.750	0.000	2014	14
	79	0.442	0.000	0.253	0.000	0.695	0.000		5, 6
	80	0.075	0.022	0.296	0.000	0.372	0.000		5
	81	0.320	0.000	0.421	0.000	0.742	0.000		
	82	0.184	0.000	0.241	0.000	0.425	0.000		4
P	85	0.594	0.000	0.264	0.000	0.858	0.000		
Q	86	0.492	0.000	0.240	0.000	0.732	0.000	2011	2, 4
R	90	0.210	0.000	0.167	0.000	0.377	0.000	2010	
	92	0.230	0.295	0.155	0.494	0.384	0.000	2012, 2013, 2016, 2019	5, 8, 10, 12, 15, 16
	93	0.442	0.000	0.205	0.000	0.647	0.000		8, 11
S	95	0.361	0.000	0.288	0.000	0.649	0.000	2013, 2016	4
	96	0.547	0.000	0.258	0.000	0.805	0.000		15

Source: own elaboration based on the LP model.

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Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest. The views and opinions presented in this article are those of the authors and have not been endorsed by Statistics Poland.

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