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Sectoral total factor productivity and its determinants: firm-level evidence from Kazakhstan

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Abstract: This paper analyses total factor productivity (TFP) and domestic competition among firms in Kazakhstan. We show that TFP in many industries falls significantly from 2009 to 2017. At the same time, 3 to 10 of the largest firms occupy a significant market share in most industries, demonstrating the elements of oligopolistic competition. We estimate the impact of various financial indicators and variables, such as subsidies, R&D, and transportation costs on firm-level TFP. The results show that increased investments, profits, wages, subsidies and the presence of employees under 30 years of age or with higher education have a significant positive effect on TFP. In addition, the uneven distribution of subsidies among firms also contributes to the development of a monopoly in the market. Statistics show that five companies in the market receive up to 80% of subsidies in manufacturing and agriculture, which aggravates the market power of these firms.

Keywords: total factor productivity; TFP; sectoral analysis; Herfindahl-Hirschman Index; HHI; concentration ratio; Kazakhstan.

JEL codes: D24, L10.

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1 Introduction

There is a consensus among economists that total factor productivity is an important parameter in the process of economic growth. Many studies confirm that only a limited part of economic growth can be explained by the accumulation of factors of production, such as physical capital and labour. An inexplicable part of economic growth, presumably reflecting the development of production and technological processes and conditionally attributed to the number of key growth factors, is the so-called growth of total factor productivity (TFP). Improving productivity is widely recognised as the primary driver of sustained long-term growth, as noted by several researchers (Dobbs and Hamilton, 2007; Harris and Moffat, 2015; Innocenti and Zampi, 2019; Williams et al., 2016). It is also considered a highly dependable measure of the long-term competitiveness of firms, industries, or countries, as stated by Arranz et al. (2019), Castellacci (2008) and Feder (2018).

According to Giang et al. (2019) and other researchers, sustained macroeconomic growth is dependent on increased productivity at the micro-level. Therefore, it is crucial to study the factors that affect firm-level productivity, not just from a microeconomic standpoint but also from a macroeconomic policy perspective. Policymakers are interested in promoting sustainable economic development and relevant entrepreneurship and innovation-fostering policies can be designed based on this research.

In recent years, research in the field of TFP has advanced significantly, addressing not only traditional determinants, but also new aspects such as digital transformation, the impact of global supply chains and the transition to sustainability (Mindell et al., 2023; Acemoglu and Restrepo, 2019). In particular, current research shows that automation and digitalisation of production have a significant impact on the productivity and competitiveness of enterprises (Bessen, 2018). The impact of climate change and decarbonisation policies on production processes is also investigated, which is especially relevant in light of global environmental challenges (Stern et al., 2022). These factors add new dimensions to TFP analysis and require an update of methodological approaches to its assessment.

Prior research on determinants of productivity, as shown by Cieřlik et al. (2019) and Du and Temouri (2015), has demonstrated various factors that contribute to the

variability of productivity levels, with significant and persistent differences found in firm-level productivity across countries and industries. Several studies have examined the relationship between productivity and the intensity of competition, technology spillovers, and organisational structure (Galdón-Sánchez and Schmitz, 2002; Holmes and Schmitz, 2010; Los and Verspagen, 2003; Chang and Lee, 2016). Additionally, wages have also been examined in relation to productivity growth, as noted by Arranz-Aperte (2014).

The relationship between efficiency and trade has also been extensively studied, with trade shown to enhance firm productivity through learning effects, technology diffusion, and competitive pressures (Bernard and Jensen, 1999; Pavcnik, 2002). Studies in international trade theory emphasise that a firm's exporter status significantly contributes to productivity heterogeneity (Manso Machado, 2019; Nunes et al., 2020). However, the causality between trade and efficiency is bidirectional. The Melitz (2003) model shows that more productive firms are more likely to self-select into exporting due to the fixed costs of entering foreign markets. This implies that trade liberalisation does not just enhance productivity but also reallocates resources toward more efficient firms, reinforcing aggregate productivity growth (Helpman et al., 2004). Empirical evidence supports this mechanism, demonstrating that exporters tend to be larger, more capital-intensive, and more productive than non-exporting firms (Wagner, 2007; Loecker, 2013).

Some studies also examine how geographic location affects firm-level productivity differences (Ciešlik et al., 2019; Martínez-Victoria et al., 2018) or how productivity varies across different industries (Botrić et al., 2017; Dvouletý and Blažková, 2021). While the literature on TFP is extensive, empirical analysis of sectoral TFP determinants in Kazakhstan remains limited, making this study a valuable addition to research on Central Asian economies.

Using econometric methods, we analyse the impact of employee qualifications, age differences, investments in fixed assets and innovations, as well as the amount of material costs, wages, and profits on the production and productivity of firms in Kazakhstan. Profits, in particular, play a crucial role in shaping firm-level productivity, as they enable firms to invest in capital deepening, technology adoption, and process innovation. According to Schumpeterian growth theory, sustained profitability fosters R&D investment and knowledge accumulation, which are key drivers of TFP growth (Aghion and Howitt, 1992; Syverson, 2011). Additionally, the market selection hypothesis suggests that more productive firms tend to earn higher profits, reinforcing a self-reinforcing mechanism between profitability and productivity (Foster et al., 2008). Empirical studies confirm that firms with higher profit margins are more likely to engage in productivity-enhancing activities, such as automation and workforce training, which further justifies modelling TFP as a function of profits (Aghion et al., 2005; Bloom et al., 2013). We also take into account the sectoral and geographical differences in and output. In addition, we control the form of ownership of enterprises to identify the most effective types of ownership in Kazakhstan. Then, econometric models of the impact of subsidies, the use of R&D and innovation, and transportation costs on their level of productivity in Kazakhstan are also constructed.

In addition, the Herfindahl-Hirschman Index (HHI) and the concentration coefficient (CC) are analysed to assess market structure within sectors. These widely accepted indicators measure market concentration and the intensity of competition. A lower intensity of competition often results in inefficiencies, as dominant firms may exercise

market power, restricting market entry and innovation. Conversely, higher competition intensity can drive firms to optimise efficiency, invest in innovation, and improve productivity.

The paper is organised as follows. Section 2 describes the data used to review the current state of domestic production. Section 3 details the methodology. Section 4 presents the results and Section 5 concludes.

2 Data

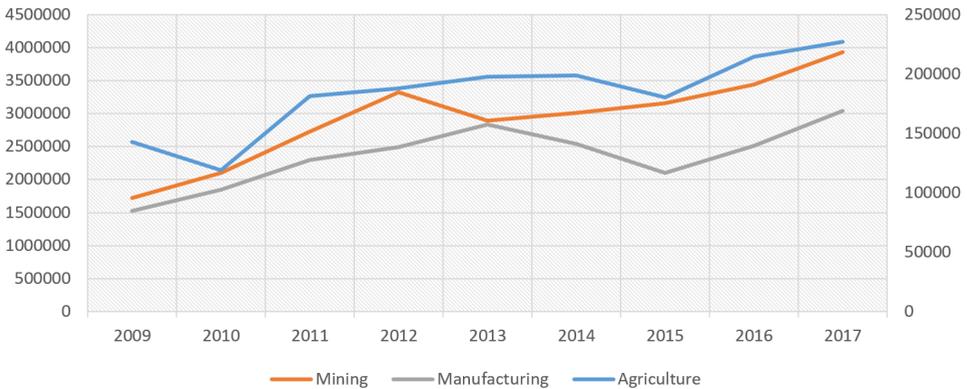
2.1 The data

The data used in this study are obtained from the 1.PF and 1.T forms, which are official statistical reporting forms collected by the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan. These datasets cover all medium and large firms, excluding educational and medical organisations, banks, public associations, and insurance companies. The 1.PF form provides detailed firm-level financial information, including revenues, expenditures, and liabilities, while the 1.T form contains employment and wage-related data. These datasets enable a comprehensive analysis of firm productivity, financial stability, and labour market dynamics across industries.

The data are collected annually from firms with more than 50 employees from 2009 to 2014 and from firms with more than 100 employees since 2015, following a change in the data collection methodology. The dataset includes 19,933 observations covering the period from 2009 to 2017 and contains information on firm location, industry classification, and various financial indicators. The two datasets were processed using STATA and merged using de-identified company numbers to ensure consistency and data integrity.

A statistical survey of firms by year shows a steady increase in the number of medium and large companies from 2009 to 2017. In the industrial context, the service sector (43.16%), manufacturing (20.23%), and agriculture (10.76%) account for a greater number of observations. The geographical composition of the data is represented by 14 regions and two cities of republican significance, Almaty and Astana. The largest concentration of firms is in Almaty (21.51%), followed by about 9.05% in Astana and 7.41% in the East Kazakhstan region. The minimum number of observations in the Zhambyl region (2.35%). In other areas, the number of firms is ranked from 3% to 7%.

Table A1 presents the structure of employment across different economic sectors. On average, firms in the agriculture sector employ approximately 239 workers, while those in the manufacturing and mining industries employ around 474 and 883 workers, respectively. The proportion of female employees is relatively low across all sectors, accounting for less than 24% of the workforce. The majority of employees fall within the 29–49 age range, followed by those aged 50 and older. Regarding educational attainment, the average number of employees with higher education per firm is 24 in agriculture, 286 in mining, and 125 in manufacturing. Additionally, firms in these sectors employ a relatively small number of workers with postgraduate education, averaging 12 in agriculture, 22 in mining, and 19 in manufacturing (Table A2).

Figure 1 Production volume in million tenge, in real terms (see online version for colours)

Notes: The auxiliary axis belongs to the agriculture sector. To obtain real values, nominal figures were converted to constant prices using a GDP deflator.

Despite the fact that there are, on average, more employees working in the extractive industry than in the manufacturing industry, the difference in production volume is small. In general, the dynamics of output in all sectors is positive, according to Figure 1.

Table A3 presents the industry decomposition, detailing the distribution of firms and observations across various sectors. It reports the number and percentage of observations, alongside the number and share of unique firms in each industry. The dataset covers a diverse range of sectors, including agriculture, manufacturing, construction, and services. Notably, the services industry accounts for the largest share, with 43.16% of total observations and 47.78% of unique firms, followed by construction and mining. In contrast, industries such as textile manufacturing and tobacco products have a relatively small representation. The total number of unique firms in the dataset is 2907, indicating a broad coverage of economic activities across multiple industries.

2.2 Indicators of domestic production by sector, in real terms

Summary statistics indicate that many enterprises carry a significant debt burden, with liabilities – including borrowed funds – exceeding production volumes in industries such as ‘production of grain and seasonal crops’, ‘production of textiles’, and ‘production of other non-metallic mineral products’. After 2014, a sharp increase in firm obligations surpassing both production volumes and revenues was observed in industries such as ‘chemical industry and oil refining’, ‘production of basic pharmaceutical products’, ‘metallurgical industry’, and ‘production of motor vehicles and other vehicles’. This trend coincides with a period of currency depreciation, declining oil prices, and a balance-of-payments deficit, which contributed to an economic downturn in Kazakhstan.

In many industries, liabilities are closely correlated with fixed assets, suggesting that firms have taken on debt primarily to finance capital investments. However, investment levels remain low across most sectors, potentially constraining long-term firm growth and productivity improvements.

Across all industries, firm revenues exceed production volumes, indicating that firms set prices above production costs, generating positive markups. Additionally, production

costs do not exceed production volumes in real terms, suggesting relative cost efficiency. Industry-level trends show that production expanded until 2014, followed by a contraction in 2015 and a gradual recovery. However, some sectors, such as ‘production of finished metal products, except machinery and equipment’, experienced a prolonged downturn beyond 2015.

3 Methodology

3.1 Assessment of the aggregate factor productivity of firms

TFP refers to the efficiency with which all inputs – labour, capital, and other resources – are utilised in production. While TFP is influenced by technological progress, innovation, and knowledge accumulation, it is not directly measured by a set of patents. Instead, patents can serve as a proxy for innovation, which may contribute to TFP growth over time. The speed of creation of new technologies depends on the level of scientific investments in research and their productivity (Manton, 2008). In TFP, ‘resources’ usually consist of labour and capital resources, whereas ‘output’ can represent an increase in business productivity and efficiency (Giannopoulos and Munro, 2019).

The empirical analysis is based on an assessment of the Cobb-Douglas production function using firm-level data:

$$Y_{it} = A_{it} K_{it}^{\alpha} L_{it}^{\beta} \quad (3.1)$$

where the lower indices i and t denote the firm and the year, respectively: Y_{it} – output, K_{it} – fixed capital (measured by fixed assets), L_{it} – labour (measured by the number of employees), and A_{it} – TFP of firms.

We evaluate the Cobb-Douglas production function and save residuals as a TFP. There are several methodologies for solving the problem of simultaneity and bias of choice when assessing capital and labour shares. The problem of simultaneity arises from the correlation between costs (capital and labour) with unobservable productivity shocks. Firms choose resources knowing the level of productivity, and this introduces an error in the estimation of parameters by the least squares method. There are many approaches to solving this problem: the instrumental variable (IV), the fixed-effects approach, control functions (Olley and Pakes, 1996; Levinsohn and Petrin, 2003), and generalised method of moments (GMMs). Factor prices are candidates for the IVs. However, the main problem of this method is finding a suitable instrument for capital. As for the fixed-effects model, which takes into account the unobservable heterogeneity between firms, it requires that the productivity shock is fixed in time, as well as the presence of strict endogeneity depending on the heterogeneity of firms (Wooldridge, 2005), which is impossible. The control function method is a semi-parametric method introduced by Olley and Pakes (1996) and Levinsohn and Petrin (2003), in which investments or intermediate material resources are introduced through a semi-parametric function to control imperceptible productivity spikes. The authors have developed a two-stage evaluation procedure to eliminate the pathologies of simultaneity and selection bias present in the least squares method. However, Wooldridge (2009) proposed a new estimation method using the GMM structure to modify the method of control

functions. His approach has a number of advantages. First, it solves the identification problem noted by Akerberg et al. (2006), who found that the assumptions of the previous approach are valid if there are some differences in the data. Otherwise, the labour variable and the nonparametric variable suffer from collinearity, since firms choose variable input at some point in time depending on their capital and productivity. Secondly, it takes into account heteroscedasticity and sequential correlation, obtaining reliable standard errors.

To ensure the robustness of our TFP estimates, we apply multiple estimation approaches, including the semi-parametric control function method of Levinsohn and Petrin (2003) and the GMMs proposed by Wooldridge (2009). The LP approach corrects for simultaneity biases by using investment decisions as proxies for productivity shocks, while the Wooldridge GMM estimator accounts for firm-level heterogeneity and provides consistent standard errors. By employing these complementary methodologies, we mitigate endogeneity issues inherent in production function estimation. The production function is presented in a logarithmic form to estimate the parameters of the model:

$$y_{it} = \alpha_0 + \alpha l_{it} - \beta k_{it} + e_{it} \quad (3.2)$$

After obtaining the regression coefficients (α and β) for capital and labour using the approach described above, we estimate the productivity at the firm level (α_{it}) by the equation:

$$\hat{\alpha}_{it} = y_{it} - \hat{\alpha} l_{it} + \hat{\beta} k_{it} \quad (3.3)$$

The cumulative TFP in the economy can be calculated as the weighted average of the TFP at the firm level for each year (De Loecker and Konings, 2006):

$$\hat{A}_t = \sum_{i=1}^n \frac{f_{it}}{\sum_i f_{it}} \hat{\alpha}_{it} \quad (3.4)$$

where f_{it} is the output, α_{it} is the productivity at the firm level, n is the total number of firms, while i is the firm index, t is the time index from 2009 to 2017. The productivity index was normalised to 1 in 2009 to facilitate the comparison of aggregate TFP dynamics across industries over time.

To validate the estimated TFP measures, we conduct several sensitivity analyses. First, we re-estimate the production function using alternative specifications, varying the input elasticities to test the stability of the results. Second, we compare our firm-level TFP estimates with those obtained using the standard ordinary least squares (OLS) regression approach. The differences highlight the extent of simultaneity bias correction achieved through our chosen methods. Finally, we contrast the aggregated sectoral TFP trends with macroeconomic indicators, such as labour productivity growth and sectoral output expansion, to assess consistency with broader economic trends.

To analyse productivity at a more granular level, we also estimate TFP at the industry level, classified by OKED categories. The methodology follows the same framework as firm-level TFP estimation but accounts for sector-specific elasticities to better capture industry-level productivity dynamics. This aggregation allows for sector-specific variations in productivity, reflecting differences in capital intensity, technological adoption, and market conditions.

By using sector-specific production function estimates, rather than applying uniform macro-sector coefficients, the analysis accounts for heterogeneity across industries. This approach ensures a more precise measurement of productivity at the industry level, facilitating comparisons between industries and identifying key productivity drivers within each sector.

3.2 Mathematical analysis of the HHI

The HHI is a generally accepted indicator of market concentration. Market concentration analysis is performed to study the current state of domestic production and the intensity of competition within industries. This analysis is necessary to assess the export potential of industries based on firm data obtained from the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan for all medium and large enterprises in Kazakhstan. The higher the competition intensity in a market, the lower the price of goods, which can enhance firms' price competitiveness when exporting, as higher competition generally leads to increased demand, all other things being equal. The HHI, which quantifies market share distribution among firms in an industry, is calculated as follows (Owen et al., 2007):

$$HHI = \sum_{i=1}^n (\text{market share}_i)^2 \quad (3.5)$$

$$\text{Market share}_i = \frac{\text{revenue}_i}{\sum_{i=1}^n \text{revenue}_i} \quad (3.6)$$

The closer a market is to a monopoly, the higher its concentration and the lower its competition intensity. For example, if an industry consists of only one firm, that firm would have a 100% market share, and the HHI would equal 1, indicating a monopoly. Conversely, if there were thousands of competing firms, each with a small market share, the HHI would approach zero, implying a highly competitive market.

3.3 Assessment of the CC in the economy

In addition to the HHI, the CC is also calculated to measure market concentration. The CC represents the sum of the percentage market shares of the largest firms in an industry. Using firm-level data (1-T and 1-PF), the largest firms (up to 10) in each industry were identified based on their production of goods and services. These figures were then matched with the total volume of industrial production in value terms by industry.

A low concentration ratio in an industry indicates high competition intensity, whereas a ratio close to 100% suggests a highly concentrated market, often characterised by monopoly or oligopoly dynamics.

$$\text{Concentration coefficient}_i = \sum_{i=1}^n \frac{\text{output}_i}{\text{total sector output}} \quad (3.7)$$

where n is the number of firms ($n = 1, 2, 3, \dots, 10$) with the maximum market share.

3.4 Assessment of the impact of various factors on the level of production and productivity of companies in Kazakhstan

After obtaining the TFP for each firm, we estimate the effect of the employment structure – the level of qualification, age differences of employees of firms, investments in fixed assets and innovations, as well as the amount of material costs of raw materials, wage, profit, and production costs influence on output and productivity of enterprises. Sectoral and geographical differences in TFP and the production of goods and services are taken into account. In addition, we control the forms of ownership of enterprises. Thanks to the available rich firm-level data, we control the issues of endogeneity by applying the methodology of fixed effects of estimating econometric models. Given that firms do not change location or industry, a fixed-effects approach is used to account for unobservable characteristics at the firm level. Then, we analyse the impact of subsidies, investments in R&D and innovation, and transportation costs on TFP in Kazakhstan.

R&D is a binary indicator for R&D activity, which is based on whether firms report plans to conduct R&D rather than actual expenditures. Despite this limitation, the dummy variable still provides valuable insights by capturing firms' intent to engage in R&D. Several papers have relied on survey-based measures of firms' R&D engagement, particularly in cases where financial data on R&D expenditures are unavailable or unreliable. For example, Hall et al. (2010) discuss various R&D proxies used in firm-level productivity studies, including survey responses indicating whether firms conduct R&D. Similarly, Crépon et al. (1998) employ a binary R&D indicator in their structural model linking innovation to productivity. Another research has shown that firms that report R&D engagement tend to exhibit higher future productivity growth, even if the immediate effect is less pronounced (Griffith et al., 2004). While not a direct measure of realised R&D spending, the indicator may still serve as a useful proxy for firms' commitment to technological progress and knowledge accumulation.

In addition to subsidies, R&D investments, and transportation costs, other macroeconomic and structural factors could also contribute to variations in TFP. One such factor is trade openness, particularly in relation to China. Over the past decade, Kazakhstan has deepened its economic ties with China, benefiting from increased trade flows, infrastructure investments under the Belt and Road Initiative, and greater integration into regional value chains. These developments may have influenced TFP by facilitating technology transfer, enhancing competition, and improving resource allocation.

Furthermore, changes in trade policy, tariff structures, or foreign direct investment (FDI) inflows could also play a role. A more open trade environment may have allowed firms to access higher-quality inputs, adopt more advanced production techniques, or face stronger competitive pressures, all of which can affect productivity. While our study primarily focuses on firm-level factors, future research could explicitly incorporate measures of trade openness – such as import penetration rates or export intensity – to better isolate these effects.

The log-linear form of the models is presented as follows:

- Model 1: Production

$$\begin{aligned}
 Output_{i,t} = & \beta_0 + \beta_1 wage\ fund_{i,t} + \beta_2 fixed\ assets_{i,t} \\
 & + \beta_3 material\ costs_{i,t} + \beta_4 under30_{i,t} + \beta_5 higher\ education_{i,t} \\
 & + year_{i,n} * \gamma + industry_{i,k} * \mu + region_{i,m} * \phi \\
 & + ownership\ type_{i,s} * \alpha + u_{i,t}
 \end{aligned} \tag{3.8}$$

- Model 2: TFP

$$\begin{aligned}
 TFP_{i,t} = & \beta_0 + \beta_1 wage\ fund_{i,t} + \beta_2 intangible\ assets_{i,t} \\
 & + \beta_3 investments_{i,t} + \beta_4 liabilities_{i,t} + \beta_5 profit_{i,t} \\
 & + \beta_6 costs_{i,t} + \beta_7 under30_{i,t} + \beta_8 higher\ education_{i,t} \\
 & + year_{i,n} * \gamma + industry_{i,k} * \mu + region_{i,m} * \phi \\
 & + ownership\ type_{i,s} * \alpha + u_{i,t}
 \end{aligned} \tag{3.9}$$

- Model 3: Subsidy

$$\begin{aligned}
 TFP_{i,t} = & \beta_0 + \beta_1 wage\ fund_{i,t} + \beta_2 intangible\ assets_{i,t} \\
 & + \beta_3 investments_{i,t} + \beta_4 liabilities_{i,t} + \beta_5 profit_{i,t} \\
 & + \beta_6 costs_{i,t} + \beta_7 under30_{i,t} + \beta_8 higher\ education_{i,t} \\
 & + \beta_9 subsidy_{i,t} + year_{i,n} * \gamma + industry_{i,k} * \mu + region_{i,m} * \phi \\
 & + ownership\ type_{i,s} * \alpha + u_{i,t}
 \end{aligned} \tag{3.10}$$

- Model 4: R&D

$$\begin{aligned}
 TFP_{i,t} = & \beta_0 + \beta_1 wage\ fund_{i,t} + \beta_2 intangible\ assets_{i,t} \\
 & + \beta_3 investments_{i,t} + \beta_4 liabilities_{i,t} + \beta_5 profit_{i,t} \\
 & + \beta_6 costs_{i,t} + \beta_7 under30_{i,t} + \beta_8 higher\ education_{i,t} \\
 & + \beta_9 R\&D_{i,t-1} + year_{i,n} * \gamma + industry_{i,k} * \mu \\
 & + region_{i,m} * \phi + ownership\ type_{i,s} * \alpha + u_{i,t}
 \end{aligned} \tag{3.11}$$

- Model 5: Transportation costs

$$\begin{aligned}
 TFP_{i,t} = & \beta_0 + \beta_1 wage\ fund_{i,t} + \beta_2 intangible\ assets_{i,t} \\
 & + \beta_3 investments_{i,t} + \beta_4 liabilities_{i,t} + \beta_5 profit_{i,t} \\
 & + \beta_6 costs_{i,t} + \beta_7 c + \beta_8 higher\ education_{i,t} \\
 & + \beta_9 transportation\ costs_i + year_{i,n} * \gamma \\
 & + industry_{i,k} * \mu + region_{i,m} * \phi + ownership\ type_{i,s} * \alpha + u_{i,t}
 \end{aligned} \tag{3.12}$$

- Model 6: General model

$$\begin{aligned}
 TFP_{i,t} = & \beta_0 + \beta_1 wage\ fund_{i,t} + \beta_2 intangible\ assets_{i,t} \\
 & + \beta_3 investments_{i,t} + \beta_4 liabilities_{i,t} + \beta_5 profit_{i,t} \\
 & + \beta_6 costs_{i,t} + \beta_7 under30_{i,t} + \beta_8 higher\ education_{i,t} \\
 & + \beta_9 subsidy_{i,t} + \beta_{10} R\&D_{i,t-1} + \beta_{11} transportation\ costs_i \\
 & + year_{i,n} * \gamma + industry_{i,k} * \mu + region_{i,m} * \phi \\
 & + ownership\ type_{i,s} * \alpha + u_{i,t}
 \end{aligned} \tag{3.13}$$

where $under30_{i,t}$ is the share of the firm's employees under 30 years; $year_{i,n}$ is a vector of years from 2009 to 2017; $sector_{i,k}$ is a vector of binary variables of sectors of the economy; $region_{i,m}$ is a vector of binary variables for each region and cities of the republican significance; $ownership\ type_{i,s}$ is a vector of binary variables for various types of firm ownership (communal property, ownership of enterprises without state and foreign participation, ownership of enterprises with state participation (without foreign participation), ownership of joint ventures with foreign participation, ownership of foreign legal entities, ownership of foreign individuals, republican property).

To examine the impact of different determinants on TFP, we estimate a series of models, with models 3, 4, and 5 serving as restricted versions of the fully specified model 6. While these models may be subject to omitted variable bias if model 6 is correctly specified, their inclusion allows us to assess the marginal contribution of key explanatory variables – such as R&D, subsidies, and transportation costs – to TFP.

By introducing variables sequentially, we can observe how individual factors influence productivity both in isolation and in combination. Additionally, this approach helps to detect potential multicollinearity and assess the stability of coefficient estimates when additional controls are included. The results demonstrate that while some explanatory variables retain their significance across different specifications, their magnitude and statistical strength may vary, underscoring the importance of accounting for multiple determinants in the final model.

To ensure clarity, we explicitly acknowledge that models 3, 4, and 5 are simplified versions of model 6 and are primarily presented to illustrate robustness and provide insights into the role of specific factors in explaining TFP.

In addition to the previously presented analysis, this study applies the econometric models, indicating their key assumptions and justifications. In particular, the function control method (Levinsohn and Petrin, 2003) suggests that firms use intermediate material resources as a proxy for the nonlinear component of productivity, which eliminates the problem of endogeneity. However, this method requires high-quality data on intermediate costs, which may limit its use in some contexts.

The GMM proposed by Wooldridge (2005) is based on the assumption that there are IVs that do not correlate with model errors, but correlate with explanatory variables. This eliminates the problems of parameter estimation bias caused by the correlation of labour and capital variables with invisible productivity shocks. In addition, the GMM method takes into account possible heteroscedasticity and autocorrelation of residuals, providing more reliable standard errors.

When evaluating models, the possibility of measurement errors in capital and labour data, as well as selection problems resulting from the dynamics of firms' exit from the market, is taken into account. Panel data is used to increase the reliability of the results, which makes it possible to control the characteristics of firms that remain unchanged over time. An additional check of the sensitivity of estimates for the selection of various IVs and functional forms is also performed.

The methodology of the study also includes consideration of potential limitations and biases that may have affected the data collection and analysis process. One such limitation is the possibility of selection bias associated with the availability of data only for medium and large enterprises, which can exclude the influence of small firms on the dynamics of overall productivity (De Loecker, 2011). In addition, the use of IVs and the

fixed effects method implies certain assumptions that may not always fully reflect the real relationships between variables (Wooldridge, 2009). Possible measurement errors in capital, labour, and productivity data may also distort the estimates of the model parameters. Finally, it is worth considering the limited study time period (2009–2017), which may not fully reflect long-term trends in productivity changes and the impact of economic policy (Ackerberg et al., 2015).

4 Results and discussion

4.1 TFP results

The section below presents the data collected and analysed in the study. The key findings of the empirical analysis are summarised in the tables and figures in Appendices A and B. Considering the massive data of the results and in order to provide a more cohesive and integrated analysis of the findings, the discussions are also included in this section. The complex relationships between various factors influencing TFP and the bulk of the data seem to make it more effective to present empirical results alongside their immediate interpretation. An attempt is made to contextualise and compare the results with prior research without repetition.

Figure 2 TFP of medium and large firms (see online version for colours)

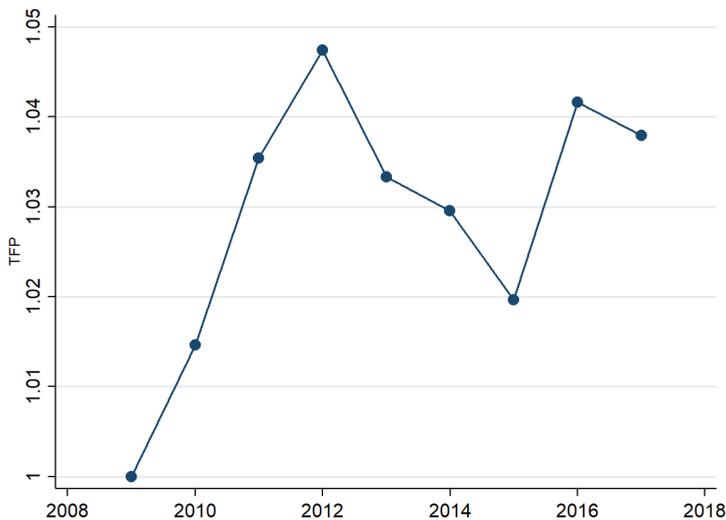


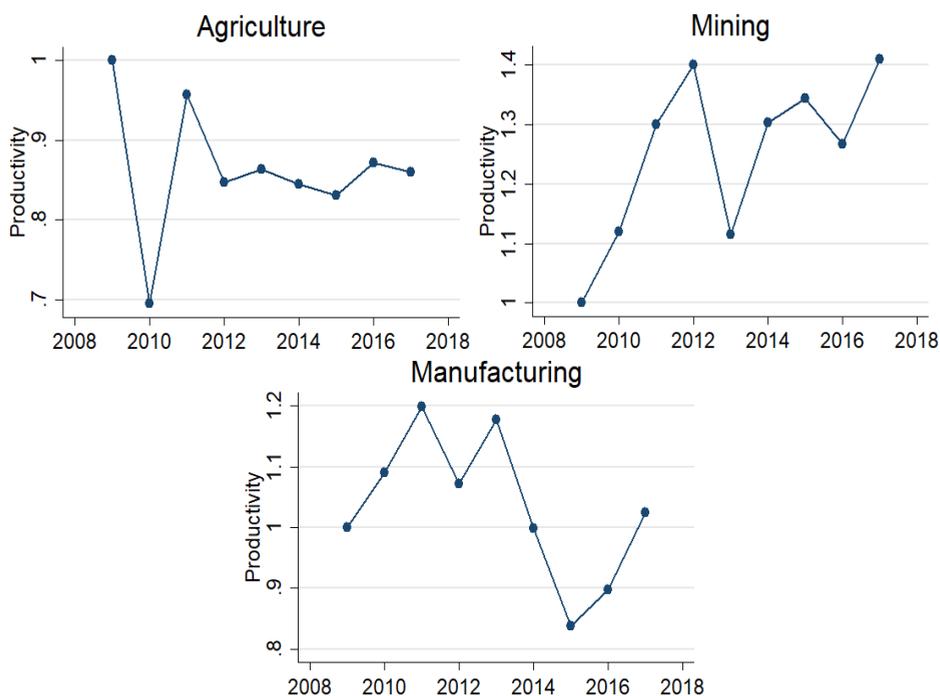
Table A5 presents the estimated shares of production factors for various sectors of the Kazakh economy of medium and large firms. The combined shares of capital and labour (0.32 and 0.68, respectively) correspond to the widespread values of these parameters in developed markets. In addition, the results show that services and agriculture are predominantly labour-intensive compared to other sectors while manufacturing and extractive industries are more capital-intensive. Services occupy a high share of the country's economy, in this regard, the entire economy is also more labour-intensive.

Figure 2 shows that TFP has been declining since 2012, reaching a minimum in 2015, except for the low values in the period after 2008. One of the reasons for this

decline in TFP growth is a fall of TFP in the manufacturing industry (Figure 3). In order to increase productivity, and consequently the level of production in agriculture, in addition to increasing the level of ‘complexity’ of goods and attracting investment, it is also necessary to focus on improving the efficiency of the workforce since agriculture is predominantly labour-intensive. This includes providing extensive training programs for employees and raising real wages to attract a more skilled workforce. Since the extractive and manufacturing industries are capital-intensive sectors, lending and investment will contribute to a more significant improvement in the productivity of these industries.

The mining industry is the leading sector of Kazakhstan’s economy and occupies a large part of the country’s export basket. However, agriculture and manufacturing are the potential key sectors of production and trade growth. The focus on increasing the ‘complexity’ of manufactured goods and the diversification of export products are valuable factors for the development of production and expansion of export potential. Based on OKED, these sectors were divided into more detailed industries for further analysis. Graphs of the productivity of industries are shown in Appendix A, as well as tables with the results of the HHI and the CC are given in Appendix B.

Figure 3 TFP of medium and large firms by sector (see online version for colours)



The productivity of grain and seasonal crops has decreased compared to 2009. This decrease is observed until 2015, following a moderate increase in productivity begins. However, the TFP surplus trend has been increasing for nine years despite the volatility in the livestock sector. Productivity growth in mixed agriculture increases until 2015 and then it significantly drops in 2016 and 2017. The HHI index and the CC indicate that firms operate in a market of perfect competition in the industry ‘crop and livestock

production, hunting and the provision of services in these areas'. This means that there is considerable competition between firms. Often a price in such markets is low and is formed on the basis of market relations. In the 'fishing and aquaculture industry', on the contrary, a high concentration of HHI shows that four large companies occupy about 26.3% of the entire market in 2019, the rest is occupied by small businesses that accept prices to a greater extent than they set them.

The analysis of the aggregate factor productivity of such industries as 'dairy production', 'production of flour milling products, starches and starch products', and 'production of bakery and flour products' within the food industry shows a decrease in productivity growth followed by a slight increase after 2016. The high competition observed in the food industry – 'food production' is characterised by a market of perfect competition according to HHI index. But, at the same time, 10 large firms produce 16.3% of all products as of 2019. And in the beverage industry, despite a large number of firms and high price competition, the share of 10 large firms occupies more than 30% of the entire market during 11 years from 2009 to 2019. The production of beverages, alcoholic and non-alcoholic, has been rapidly declining in productivity for several years, along with a 13.5% decrease in the market share of large enterprises since 2011.

'The production of basic pharmaceutical products', 'the production of textiles' and 'the production of clothing and leather products' show a significant increase in productivity, especially in the period up to 2016. These sectors are characterised by a high share of large firms in the market, which is growing every year. The share of large enterprises operating in the market of monopolistic competition ranges from 29.4% – in the manufacturing of clothing to 80.1% – in the pharmaceutical industry in 2019.

Sectors dominated by large enterprises with a market share of more than 50%: 'production of tobacco products', 'production of paper and paper products', 'production of chemical products', 'metallurgical industry', 'production of computers, electronic and optical products', 'production of electrical equipment', 'production of machinery and equipment not included in other categories', 'production of motor vehicles, trailers and semi-trailers', 'production of other vehicles', 'production of other finished products'. In almost all of these sectors, one can notice a rapid decline in the productivity of firms in 2014 and 2015, followed by a slow and slight recovery in 2016 and 2017.

High and moderate competition of medium and large enterprises with small firms is observed in the following industries: 'production of wooden and cork products, except furniture and production of straw products and materials for weaving', 'production of rubber and plastic products', 'production of finished metal products, except machinery and equipment', 'furniture production', 'production of coke and petroleum products', 'printing and reproduction of recorded materials', and 'repair and installation of machinery and equipment'.

Overall, the analysis of the TFP growth and competition in the domestic market of Kazakhstan shows that the aggregate factor productivity of many industries significantly decreases from 2009 to 2017, except for such industries as 'animal husbandry', 'mixed agriculture', 'textile production', 'production of clothing and leather products' and 'production of basic pharmaceutical products'. At the same time, in most of the industries analysed in manufacturing and agriculture, from 3 to 10 of the largest firms in the industry occupy a significant market share, demonstrating elements of oligopolistic competition in markets where prices are set by the largest firms. Thus, the lack of market competition and the monopolisation of markets are constraints to productivity growth within sectors.

The observed decline in TFP for several sectors raises important questions about industry-specific dynamics. Potential explanations include capital misallocation, where firms invest in less productive assets, declining returns to scale in mature industries, or labour market rigidities that hinder efficiency gains. Sectoral trends also suggest that structural factors – such as changes in regulatory policies, competition intensity, and technological adoption – may play a role. To explore these hypotheses, we further analyse industry-level characteristics, including capital intensity, firm's dynamics, and shifts in labour composition.

4.2 *The determinants of the production and TFP*

The first column of Table A6 shows that having more workers under 30 increases a company's output. A 10% increase in the number of young workers leads to a 1.74% increase in production.

The education level of employees also has a significant positive impact on both output and productivity. A 10% increase in the number of workers with higher education raises production by 2.7%, while TFP increases by 5.38%, all else being equal. These results confirm that employee education and qualifications play a crucial role in the production and productivity of medium and large enterprises.

The results indicate that, compared to 2009, output was 6.0% lower in 2012, 11.6% lower in 2013, 10.5% lower in 2014, and 11.1% lower in 2015 across all sectors.

Sectoral differences in production volumes are also observed. The livestock industry produces 8.9% more than the grain and seasonal crops sector. In comparison with grain production, industries such as dairy products (42.6%), flour milling and starch production (67.1%), tobacco products (44.7%), electronic and electrical equipment (37.7%), and motor vehicles (45.8%) show significantly higher output levels. However, sectors such as mixed agriculture (–6.2%), textile production (–15.8%), basic pharmaceutical products (–21.6%), and repair and installation of machinery and equipment (–6.7%) exhibit lower production levels.

Regarding productivity, the food industry (71.2%) and soft drinks production (71.8%) display the highest levels. Other sectors with relatively high TFP include animal husbandry (29.0%), dairy production (30.2%), flour milling and starch production (36.3%), and other manufacturing industries. By contrast, industries such as non-metallic mineral products (16.3%), repair and installation of machinery and equipment (16.9%), and mining (20.9%) show the lowest productivity levels.

Ownership structure also plays a role in firm performance. Communal ownership firms are the least productive, while enterprises with foreign participation or foreign ownership are significantly more efficient than state-owned firms.

Regional differences in output and efficiency are also evident. Firms in Almaty region, Almaty, and Astana are the most productive, whereas firms in Atyrau, Kyzylorda, and Karaganda regions exhibit the lowest productivity relative to those in Aktobe region.

Among firm-level factors, a 10% increase in the wage fund leads to a 2.94% rise in TFP, while a 10% increase in investments improves productivity by 0.14%. Additionally, a 10% increase in profit results in a 3.48% increase in TFP, highlighting the strong positive effect of profitability on firm efficiency. These findings suggest that wage growth enhances employee motivation and productivity, while investment and

profits – potentially reinvested into fixed assets and innovation – contribute to overall firm efficiency.

Interestingly, the presence of intangible assets slightly reduces productivity in Kazakhstan, despite theoretical expectations that such investments should enhance efficiency. This may indicate inefficiencies in how intangible assets are utilised within firms.

To address the concern regarding sector-specific differences, labour characteristics such as younger employment and higher education may have varying effects across different industries. Given data limitations and the need for robust statistical inference, we selected three industries with the highest number of observations – mining, construction, and services – to conduct sector-specific analyses. The results of these estimations are presented in Table A11. By focusing on these industries, we ensure that our findings are based on sufficiently large samples, allowing for meaningful comparisons and reducing the risk of overfitting. Sector-specific regressions offer insights into potential heterogeneities, demonstrating the extent to which these relationships differ by industry.

4.3 The impact of government subsidies, the use of R&D and transportation costs of firms on their productivity level in Kazakhstan

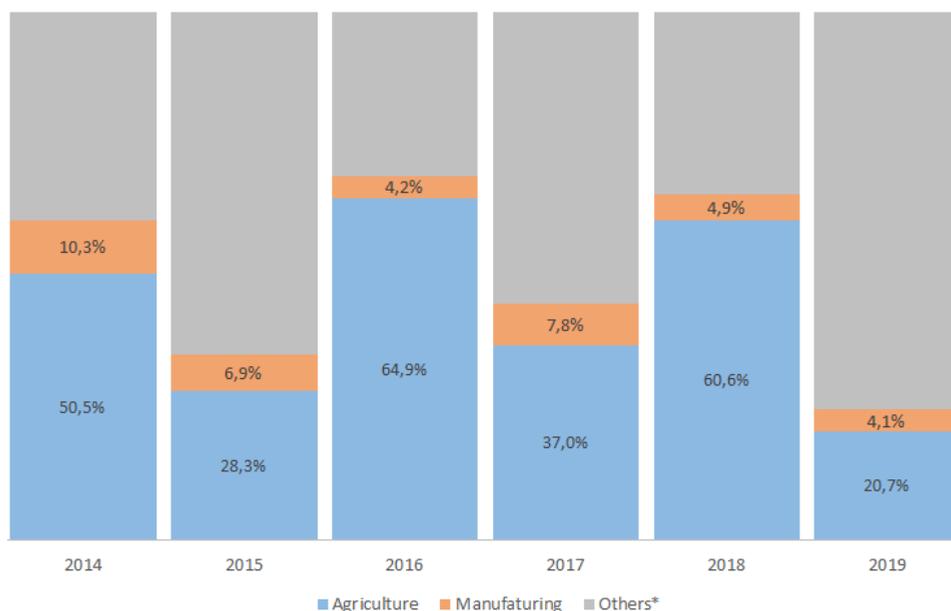
On average about 330 firms among medium and large enterprises receive subsidies annually. Agriculture receives most of the subsidies¹ from 28.3% to 64.9% between the years 2014–2019 (Figure 4). At the same time, firms operating in manufacturing receive from 4.1–10.3% of total subsidies. In 2014, subsidies received in the amount of 145 billion tenge, in 2015 – 87 billion tenge, in 2016 – 203.1 billion tenge, in 2017 almost half as much — 109.6 billion tenge, in 2018 – 190.3 billion tenge, in 2019 – 258.6 billion tenge.² Data analysis shows that the same companies receive subsidies throughout the years: 50.9% and 20.9% of firms receive the entire sample period in agriculture and manufacturing, respectively, 19.2% and 24.7% – five consecutive years, and 10.8% and 6.4% of firms receive four consecutive years in agriculture and manufacturing, respectively (Table A7). Table A8 illustrates the share of five firms in the sector receiving the largest amount of subsidies. The share of the top 5 firms in terms of output receiving the largest amount of subsidies is over 80% in both agriculture and manufacturing in 2014. Between 2015 and 2019 this share accounted for more than 40% of the total output of the sector in the manufacturing industry. In agriculture, the share of five firms receiving the largest amount of subsidies is 73.5% in 2018 and 30.9% in 2019. The main industries in agriculture and manufacturing receiving generous subsidies are: ‘cultivation of grain and leguminous crops, including seed production’, ‘poultry farming’, ‘breeding of other cattle breeds for meat production’, ‘production of meat and poultry products’, ‘flour production’, ‘production of starch and starch products’, ‘milk processing, except canning, and cheese production’, ‘sugar production’, ‘cocoa, chocolate and sugar confectionery production’, ‘pasta production’, ‘production of asphalt concrete’, ‘production of batteries and accumulators’, and ‘production of oilfield and drilling exploration equipment’. This uneven distribution of subsidies among firms contributes to the development of monopolies in the market and the decrease in the efficiency of firms. As seen in the previous sections, most industries suffer from low levels of intra-industry competition in Kazakhstan, which constrains productivity growth and is aggravated by the uneven distribution of subsidies.

Table A9 presents the evaluation results of models 3–6. The first column shows the results of model 3 when adding the Subsidy variable in logarithmic form. As can be seen from the results, the subsidy coefficient is positive and statistically significant, but economically insignificant, which can be a signal of inefficient distribution of subsidies generated by the fragility of institutions. In general, subsidies have a positive effect on the productivity of enterprises, confirming and emphasising the importance of state subsidies for enterprises.

To assess the impact of R&D on the activities of firms, the R&D of the previous period has been added, which takes the value 1 if the firm plans the research and development work next year, and 0 if not. On average, about 4.4% of firms indicated that they plan to conduct R&D. Figure 5 shows the dynamics of the share of firms in R&D by sectors: the share of mining firms increased from 20.6% in 2014 to 35.1% in 2019, and in the manufacturing industry, on the contrary, shows a decrease from 20.62% to 14.5%. The smallest share of firms that reported interest in R&D is operating in agriculture (5.3% in 2019).

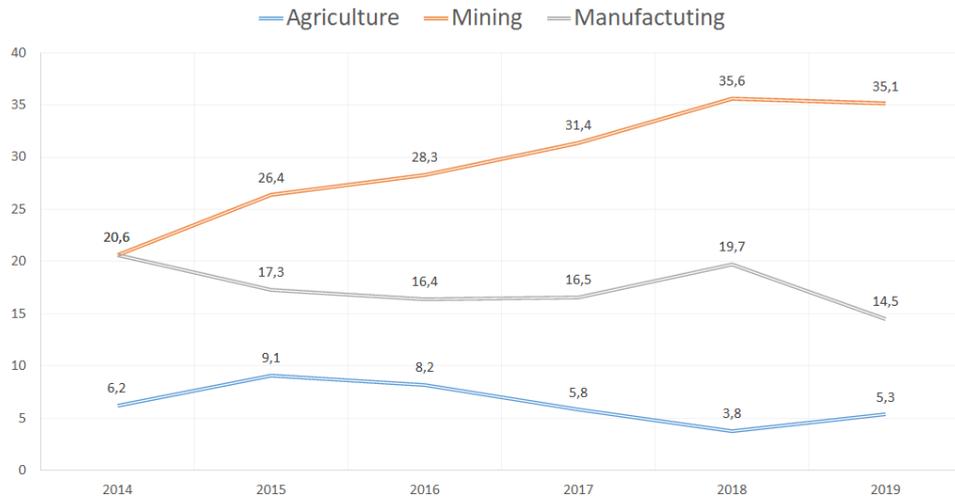
The second Table A9 column shows that when we control for the R&D variable in the equation, the resulting coefficient value is negative, which is contrary to the literature, as R&D is thought to increase the productivity of firms. A possible explanation could be that R&D requires significant investment, time for execution and obtaining positive results, so productivity gains are expected to improve over the long-term.

Figure 4 Subsidies by sector, in % (see online version for colours)



Notes: The rest include the service sector, construction, and utilities.
Subsidies in the extractive industry are insignificant.

Source: Compiled by the authors on the basis of data from the Bureau of National Statistics of the ASPR RK

Figure 5 Percentage of firms by sector planning R&D (see online version for colours)

Source: Compiled by the authors on the basis of data from the Bureau of National Statistics of the ASPR RK.

We use firms' transportation costs as an independent variable (model 5) to assess the impact of logistics and market access on productivity. The results show that transportation costs have a positive effect on TFP. According to model 5, a 10% increase in transportation costs is associated with a 0.25% increase in productivity, all else being equal.

This relationship may reflect several factors. Higher transportation costs could indicate broader market reach, as firms that distribute products over longer distances or export internationally tend to have greater productivity. Additionally, larger firms with well-developed logistics networks may experience economies of scale, allowing them to absorb fixed transportation costs more efficiently. In this context, transportation expenses do not necessarily signal inefficiency but may serve as a proxy for firm size, logistical sophistication, and market integration.

The last column of Table A9 shows that when all three variables are controlled simultaneously in one equation, the coefficients do not vary much, but the variables 'subsidies' and 'transport costs' lose their statistical significance. Table A10 analyses the impact on productivity only for firms receiving subsidies. The results indicate that transportation costs are associated with higher productivity levels among subsidized firms. Additionally, firms benefiting from subsidies tend to enhance their productivity further. Moreover, when these firms also engage in research and development, they experience a notable improvement in TFP.

5 Conclusions

According to the literature, medium and large enterprises are more prone to export than small firms, due to the ability to resist competition in the domestic and international market, a more stable financial condition, economies of scale, and high productivity.

Firms that can satisfy both domestic and foreign markets win in terms of productivity, reduced production and transportation costs.

The analysis of the TFP and domestic competition in Kazakhstan inside sectors shows that the TFP in many industries reduces significantly from 2009 to 2017, except for ‘animal husbandry’, ‘mixed agriculture’, ‘textile production’, ‘production of clothing and leather products’ and ‘production of basic pharmaceutical products’. At the same time, 3 to 10 of the largest firms in the industry occupy a significant market share in most of the analysed industries, demonstrating the elements of oligopolistic competition in the markets where prices are set by the largest firms. The lack of competition intensity and the monopolisation of markets act as constraints on productivity growth within sectors.

Assessing the impact of various financial indicators and other variables such as subsidies, R&D, and transportation costs on the productivity of firms in Kazakhstan is very important for understanding the state of firms and factors that increase the likelihood of firms to export. Econometric analysis of various factors has shown that investments, profits, wages, subsidies, the presence of employees under 30 years, or employees with a higher level of education have a significant positive effect on TFP. However, it is found that intangible assets and R&D slightly reduce the productivity of firms. The possible explanation is that R&D and intangible assets require significant investments. It takes time to pay back and increase productivity. Hence, positive dynamics of productivity improvement are expected in the long-term.

It was determined that enterprises with foreign participation, or owned by a foreign individual or legal entity, are comparatively more efficient than republican-owned firms, all other things being equal. As well as enterprises located in the big cities of Almaty and Astana, and in the Almaty region, on average, produce more and are more efficient.

The analysis of firms receiving subsidies revealed that subsidies, R&D, and transportation costs have a significant positive impact on productivity. Firms benefiting from subsidies tend to enhance their productivity, and those that also engage in research and development experience a substantial boost in TFP.

Statistical analysis of subsidies has shown that most of the subsidies implemented in agriculture constitute more than 28% of all subsidies annually. At the same time, almost the same firms receive subsidies annually, which contribute to an increase in the market power of certain firms. Statistics show that five companies in the market receive up to about 80% of subsidies in manufacturing and agriculture. Such an uneven distribution of subsidies among firms contributes to the development of a monopoly in the market and aggravates the TFP losses.

Appendices/Supplementary materials are available on request by emailing the corresponding author or can be obtained under <https://sites.google.com/view/zarina-adilkhanova/research-projects>.

Declarations

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Notes

- 1 Subsidies are defined as 'subsidies from the budget' according to data from Form 1-PF, Section 2, question 2.2.
- 2 Based on data from 1-PF, with the Bureau of National Statistics of the ASPR RK.