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Cross-cutting topic
Measuring outsourcing of services

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I. Introduction

The objective of this paper is to present the experience of the Statistics Poland in measuring the outsourcing of services as well as establishing the relationship between the outsourcing of services and the productivity of enterprises in Poland. Longstanding observations of the services sector based on data collected within the surveys of official statistics in Poland suggest that the contribution of this sector to the national economy has been continuously growing.

Reasons for the outstanding development of the services sector have been discussed on the international forum for decades. Growing demand for services raised by business entities, often referred to as the outsourcing of services phenomenon, might be one of the reasons. What motivates the enterprises to take a decision to outsource services? One of the most frequent reasons is the desire to improve the efficiency of their operation, which from an economic perspective means increasing the productivity of one's own factors of production (measured i.e. by the total factor productivity (TFP)). The use of resources offered by other entities by entrusting them with some tasks and allocating its own resources in the areas where the given entity has a competitive edge gives such an opportunity.

Within the paper the following information are presented: literature on the subject, in particular this concerning definitions of outsourcing, analysis of data reflecting the services outsourcing and the productivity of enterprises, procedures applied in order to establish the relationship between the services outsourcing and efficiency of enterprises as well as the results achieved.

II. Literature on the subject

The concept of outsourcing

There are many definitions of outsourcing in the literature, evolving with the development of the phenomenon and its application in business practice. Regardless of the approach, each definition traces the origin of the term "outsourcing" to the English language, where "out" means "outside" and "resources" means "resources."

One of the most frequently cited definitions is that of Greaver (1999). According to this definition, outsourcing involves the transfer of an organization's recurring internal tasks to external service providers, in accordance with the provisions of an agreement (contract), as well as the related personnel, machinery, equipment, facilities, technology, and other resources, along with the decision-making authority regarding their use. According to P. Bendor-Samuel (2005), outsourcing also involves an organization entrusting the execution of a specific process (process ownership) to a service provider, specifying in detail the results the client intends to achieve, but without instructions on how to perform individual tasks, leaving the initiative in this regard to the contractor. Trocki (2001), in turn, defines outsourcing as "an undertaking consisting in separating functions performed by the parent enterprise from its organizational structure and transferring them to other economic entities."

The first considerations on the concept of outsourcing can be found in the research work of Coase (1937). While examining the functioning of enterprises, he analyzed the benefits and costs of using the available production capacity of a given enterprise compared to purchasing this capacity from other enterprises. His considerations focus on the transaction costs incurred by enterprises within their operations and the role of the price mechanism in decision-making. He draws on, among other things, economic theory, according to which the allocation of production factors among various types of activities is directly dependent on their price levels.

Coase assumes that when undertaking production, firms aim to generate the lowest possible transaction costs. Consequently, they strive to expand a given activity using their own resources until the costs of carrying it out within the firm equal the costs of concluding a transaction for the same activity on the open market or the costs of carrying it out in another firm. Therefore, firms use the price mechanism when deciding whether to conduct a given activity, or parts of it, in-house or to outsource it.

At the same time, Coase notes that utilizing the production capabilities of other companies is associated with certain drawbacks and costs. When entering into long-term contracts for the supply of specific goods or services, the contracting authority is unable to precisely specify the subject of the contract at the time of signing. Therefore, it is usually described in general terms, specifying the limits within which the subject of the contract can be further specified. However, there always remains the risk of not being able to obtain a good or service that fully meets the company's needs. This situation applies more to the outsourcing of services than to the outsourcing of goods, due to the fact that in the case of goods, companies are able to define key features in advance, and details are less important.

Porter (1985) developed the value chain concept, which is based on the analysis of the effectiveness of activities undertaken within an organization. Porter's model allows for the identification of stages in the value-added process and the identification of strengths and weaknesses within an enterprise. This allows to identify areas of activity that support and contribute to the creation of a competitive advantage for the entire organization. The entities should focus their activities on areas in which they have a competitive advantage, while other activities should be outsourced to entities that will gain a competitive advantage in them. Porter also demonstrates how collaboration with external entities can influence the value chain and simultaneously sees such an approach as an opportunity to increase the efficiency of enterprises. He also considers the use of the value chain concept in designing the organizational structures of economic entities.

A more advanced approach to outsourcing is presented by Quinn and Himler (1994), who introduced the concept of strategic outsourcing to the literature. They focus on core competencies that should be considered when making outsourcing decisions. They present two new strategic approaches to outsourcing that, when used together, allow managers to leverage the company's skills and resources significantly beyond the level possible with other strategies. These approaches are as follows:
- focusing on the company's own resources related to core competencies, where the company can achieve a defined advantage and deliver unique product quality to customers;
- strategically outsourcing other activities, including those traditionally considered integral to the company, for which the company has no significant strategic need or specific capabilities.

By applying the above approaches, companies could significantly increase their resources by:
- developing a few carefully selected core competencies in which the company can gain a comparative advantage,
- focusing investments and all innovation activities on these competencies,
- outsourcing other activities in which the company cannot or does not need to have an advantage;

According to Quinn and Himler, the benefits of successfully combining these two strategies are significant. Managers can increase company efficiency by maximizing the return on internal resources by focusing investment and energy on what the company does best. Well-developed competencies pose significant barriers to current and future competitors seeking to gain a competitive advantage in activities that remain within the company's focus. The development of core competencies, on the other hand, is possible through outsourcing other activities. By outsourcing these activities, the company can leverage the investments, innovations, and specialized skills of other businesses that would be prohibitively expensive or even

impossible to replicate internally. In a rapidly changing market and technology, this combined strategy reduces risk, shortens business cycles, lowers investment, and creates a better response to consumer needs.

Strategic outsourcing is also a central theme in Greaver's (1999) study. A key element of this discussion is identifying the reasons and benefits that encourage companies to outsource. However, he emphasizes that research conducted in this area may yield slightly different results each time, which should not be surprising given the differences in the populations studied. One of the conclusions drawn from the study is that the specific reasons for outsourcing and their significance depend largely on the functions performed within a given organizational structure. The goals of outsourcing for management (responsible for the management strategy) will differ from those indicated by financial or information technology management. Therefore, a key aspect of implementing outsourcing is understanding the reasons and benefits of this resource management strategy.

Greaver (1999), reviewing issues related to strategic outsourcing, details the reasons and benefits that encourage companies to utilize this management strategy. One of the reasons for outsourcing, as cited by Greaver, is increased productivity, which is a manifestation of operational development. Increasing operational efficiency and effectiveness, or improving economic performance, as reasons for using outsourcing also appear in Trocki's (2001) reflections. Reviewing the history of outsourcing, he indicates that the need to increase productivity and focus on core competencies were the primary motivations for seeking new organizational solutions, including the use of goods and services offered by external companies.

The phenomenon of outsourcing was already common knowledge during the development of craft production, when artisans were dependent on raw material suppliers and other craftspeople. They operated within a complex system of cooperative relationships, and their key competencies were linked to their personal qualifications, skills, and talent, not to the resources at their disposal. This changed as a result of the Industrial Revolution, which resulted in the possession and management of modern, efficient production resources becoming a source of competitive advantage (Krzyżanowski, 1985). At the turn of the 19th and 20th centuries, large enterprises controlled by capital owners dominated. This enabled the internal development of these companies and their vertical integration. During this period, outsourcing saw a marked decline. It was not until the 1960s that difficulties encountered in rationalizing the operations of these organizations forced a search for new solutions. One of these solutions was the pursuit of downsizing organizations while maintaining their existing strength and economic position. This period saw the flourishing of capital structures of economic activity in their various forms, e.g. corporations and holding companies.

At the same time, some tasks were transferred to independent market partners: suppliers, subcontractors, and service providers. These activities were reflected in the theoretical and practical development of the "make or buy" concept, popular in the 1960s and 1970s. This concept addresses the fundamental operational issues of every organization: whether to make, perform (make), or buy, or outsource (buy), as well as whether to undertake the activity independently or in partnership with other organizations (Perechuda, 2000). However, an incorrect decision in this regard can result in higher production and operating costs for businesses, inefficient resource utilization, and a loss of operational effectiveness (Tayles & Drury, 2001). Economic development, partly due to technological progress, and the resulting competition forced increased operational efficiency. Businesses sought to limit organizational control to core activities that provided them with a competitive advantage. This enabled the development of the market for cooperative services and the flourishing of outsourcing in its modern form.

Ross Perot's Electronic Data Systems is considered a pioneer of modern outsourcing. In 1963, it was the first company to offer Frito-Lay services involving the provision of IT and data processing tasks for a fee. This pioneering solution involved outsourcing an entire data processing department to a large enterprise

(Hirschheim, Heinzl, & Dibbern, 2002). This service was referred to as equipment management. It soon became clear that almost every function within a company's organizational structure could be replaced by services offered by external, specialized companies.

The concept of outsourcing was introduced in the 1980s by General Motors to describe a system for external parts procurement. One of the key reasons for the rapid growth of outsourcing in the 1990s is considered to be the widespread adoption of the concept of management in the United States, focused on increasing shareholder value, which forced efficiency gains (Matejun, 2015).

Initially, outsourcing was considered a modification of the previously mentioned "make or buy" concept, which aimed to reduce business operating costs. However, over time, the approach to this organizational solution has evolved. Outsourcing was used as a way to reduce the risk of technological change, and later as a concept enabling focus on core activities. Currently, outsourcing is primarily considered a method for strategically shaping the structure of business operations.

Measuring the services outsourcing and enterprises' productivity

The literature on the subject provides knowledge on the solutions used so far to measure the phenomena of services outsourcing as well as its relationship with the productivity of enterprises. The variables reflecting the phenomenon of services outsourcing or the productivity of enterprises, as well as methods for estimating the total factor productivity (TFP) and quantifying the relations between the analysed variables were selected based on information contained in the studies devoted to the discussed topic.

In the vast majority of research works, the binary variables were used in order to reflect the outsourcing of services[1]. These variables indicate the fact if the given enterprise outsources the services to satisfy the demand for services, or not. In a study by Girma and Görg (2004), the intensity of outsourcing services, measured as the ratio of the value of external services to the cost of remuneration, was adopted as the outsourcing of services. On the other hand, in a study by Schmidt-Ehmcke (2010), outsourcing of services was measured as the costs of external contract work, whereas Gradzewicz and Mućk (2019) in their considerations concerning the impact of globalization on the monopolistic marks-up of Polish enterprises, use the share of the value of external services in intermediate consumption.

Total factor productivity (TFP) was most often selected as the variable reflecting the productivity of enterprises (Pavcnik (2000), Smarzynska-Javorcik (2002), Girma and Görg (2004), Farinas and Martin-Marcos (2008), Schmidt-Ehmcke (2010), Mohlmann and Groot (2013), Kinkel et al. (2016), Gradzewicz and Mućk (2019)). Sometimes a simpler measure was used, i.e. labor productivity measured by gross value added per employee (Girma and Görg (2004), Görg and Hanley (2005), Mohlmann and Groot (2013)).

Taking into account the results of already completed works, the availability of data and the need for the most precise representation of the analyzed concepts, it was assumed that in the research two measures will be used as a proxy for the outsourcing of services:
① share of services purchased from third parties (external services) in total operating costs and
② ratio of services purchased from third parties (external services) to the renumeration costs;

Moreover, the productivity of enterprises should be represented by the total factor productivity (TFP).

The procedures for identifying the impact of outsourcing services or other economic phenomena on the TFP were usually carried out in two stages. In the first stage, the labor productivity or the TFP was estimated at

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[1] Olsen (2006), Farines i Martin-Marcos (2008), Schmidt-Ehmcke (2010), Mohlmann i Groot (2013).

the level of unit data in order to use the obtained results as a dependent variable in the second stage to determine the analyzed relationships. For example, Pavcnik (2000) first estimates the Cobb-Douglas production function using the method developed by Olley and Pakes, and then analyzes the impact of a country's trade policy on changes in the TFP, using the difference in differences (DID). Instead, to quantify the effects of trade liberalization on the TFP a linear regression model is applied. In turn, Girma and Görg (2004) estimated the TFP based on the Cobb-Douglas production function using the Generalized Least Squares (GLS) method. In order to establish the relationship between the intensity of outsourcing services and the TFP or labor productivity, they used the Ordinary Least Squares (OLS) method. A similar approach can be found in the study of Görg and Hanley (2005), who analyzed the relationship between the intensity of international outsourcing and labor productivity. They used the regression models based on the least squares method, as well as the method of instrumental variables. In turn, Mohlmann and Groot (2013), in the first stage, measured the TFP at the enterprise level based on the Cobb-Douglas production function using the method developed by Levinsohn and Petrin. In the second stage of the analyses, they used linear regression models, in particular panel data models with fixed effects (FE).

In the literature, the various forms of the production function are indicated, as well as the methods which enable estimation of the parameters of these functions, and thus also the TFP. The starting point for the analyzes is the classic least squares method (OLS). The use of this method depends on the assumption that the amount of capital input k_{it} or the labour input l_{it} are independent of other explanatory variables in a model, including the unobservable productivity that is part of the error term ε_{it}. Meanwhile, when determining the amount of inputs, enterprises take into account the productivity of production factors observed by them, which is not identified by econometricians but included in the error effect. Proposals for solving the problem of endogeneity comprised the use of:

- the panel data models with fixed effects (Hoch (1955, 1962), Mundlak (1961, 1963), Mundlak and Hoch (1965)),
- the first order derivative of the demand function in relation to the prices of intermediate consumption or producer prices of finished goods (Klein (1953), Solow (1957), Nerlove (1963), Griliches (1971), Hall (1988)),
- the introduction of instrumental variables (Griliches and Mairesse, 1998).
- the use of control functions – in particular the methods developed by Olley and Pakes (1966), Blundell and Bond (1999), Levisohn and Petrin (2003), Wooldridge (2009) or Ackerberg, Caves and Frazer (2015), which are employed in the contemporary literature.

Olley and Pakes (1996) or Levinsohn and Petrin (2004) presented the semi-parametric methods for estimating the parameters of the production function. In these methods the error term of the Cobb-Douglas production function is into the proper error term and (unobserved by the econometrician) the total factor productivity (TFP). The procedure takes place in two stages. In the first step, using the classical method of least squares, the parameter for labor inputs are identified, while the aim of the second step is to obtain the parameter for capital inputs, using the unconditional demand function for variables taken as a proxy for the total factor productivity.

The approaches developed by Olley and Pakes, or Levinsohn and Petrin, differ mainly in the variable used as a proxy for the TFP. Olley and Pakes apply investments, while Levinsohn and Petrin use intermediate consumption. The main motivation for using intermediate consumption instead of investments was the fact that most enterprises usually do not record capital expenditure on fixed assets in the reporting year. When the logarithmic form of the production function is used, it makes it impossible to estimate the TFP for these enterprises. Meanwhile, the intermediate consumption is an inherent element of production and zero values for this variable occur sporadically. It potentially makes it possible to obtain the TFP estimates for a larger part of the company population. In their approach, Levinsohn and Petrin assume, inter alia, that enterprises

are able to adapt certain production factors to changes in their productivity flexibly and cost-free. This assumption, however, was subject to criticism, as in fact labor inputs are not independent of the variables applied as a proxy for the total factor productivity.

Therefore, Ackerberg, Caves, and Frazer (2015) propose an alternative approach to the TFP estimation, which is based on the method developed by Levinsohn and Petrin. The starting point is the Cobb-Douglas production function, in which the production is reflected by the gross value added. However, in order to control the unobservable productivity, a conditional rather than an unconditional (as in the case of Olley and Pakes, or Levinsohn and Petrin's methods) function of demand for variables being a proxy for the total factor productivity is used. The estimation procedure is conducetd in two-stages. In the first stage, no coefficients for the independent variables are estimated, but the non-transmitted error ε_{it} is eliminated. This step uses the least squares method. The coefficients for the input variables are estimated in the second stage using the method of generalized moments. The Generalized Moment Method (GMM) was also applied to estimate the production function by Wooldridge (2009). He proposed to solve the problems identified in the Levinsohn and Petrin or Olley and Pakes procedure by replacing the two-step production function estimation procedure with a single-step procedure.

The method developed by Ackerberg, Caves and Frazer was applied e.g. by De Loecker and Warzynski (2012) to estimate the TFP when they tried to determine the size of the marks-up. In this case, however, the translogarithmic production function was adopted as a starting point. A similar procedure of the estimation of the production function was also used by Gradzewicz and Mućk (2019) in a study devoted to the analyzes of marks-up in the Polish economy. And this solution has been applied in the presented research.

III.   Data sources on outsourcing in the Statistics Poland

In the sources of the Statistics Poland there is many different data on outsourcing of services. The overall information on the value of services purchased from the third parties are recorded on annual basis within the survey *Annual business survey of enterprises*. Information are collected from all companies with the number of persons employed 10 and more running the business activities classified according to the NACE sections: A, B, C *Manufacturing*, D, E, F *Construction*, G *Wholesale and retail trade; repair of motor vehicle and motorcycles*, H *Transportation and storage*, I *Accommodation and food service activities*, J *Information and communication* (excluding division 59), K *Financial and insurance activities*, L *Real estate activities*, M *Professional, scientific and technical activities*, N *Administrative and support service activities*. Within the questionnaire of survey there are collected data from the financial statements: profit and loss account as well as data from the balance sheet.

Moreover, there is also survey directly dedicated to services outsourcing – *Demand for services*. Within the questions there is collected (both quantitate as well qualitative) information on: value of services purchased form the third parties by services category, direction of service purchases (domestic/foreign), barriers to purchase of services and enterprises plans in the scope of external service ac-quiring. The survey is conducted every 5 years. The surveyed population covers all national economy entities with the number of persons employed 50 and more which carry out activities classified, according to NACE Rev. 2.0, to sections: C *Manufacturing*, F *Construction*, G *Wholesale and retail trade; repair of motor vehicle and motorcycles*, H *Transportation and storage*, I *Accommodation and food service activities*, J *Information and communication* (excluding division 59), K *Financial and insurance activities*, L *Real estate activities*, M *Professional, scientific and technical activities*, N *Administrative and support service activities*.

IV. Outsourcing of services in Poland

Regarding data available in statistics the following (mentioned above) variables were identified as the best alternative for proxy of services outsourcing:

① *The share of services purchased from third parties (external services) in total operating costs;*

② *The ratio of services purchased from third parties (external services) to the renumeration costs ;*

Both of them concerns the outsourcing of services, however, each of them reflects different aspects of this phenomena. There is a discussion which of them should be used as a best proxy for the services outsourcing. It is particularly essential when analysis on the relation between the services outsourcing and the productivity of enterprises is taken into account. The share of services purchased from third parties in total operating costs ① can be applied as the variable presenting the size of services outsourcing while the ratio of services purchased from third parties to the renumeration costs ② is deemed to be a measure for intensity of services outsourcing and more precisely follow the definition of outsourcing.

① The share of services purchased from third parties in total operating costs

In 2023 the share of services purchased from third parties as total in operating costs amounted to 20,7% while in 2010 it was 16,7% (on average). Simultaneously, in 2023 in the half of surveyed population the external services constituted less than 13,7% of total operating costs (in 2010 – 10,6%).
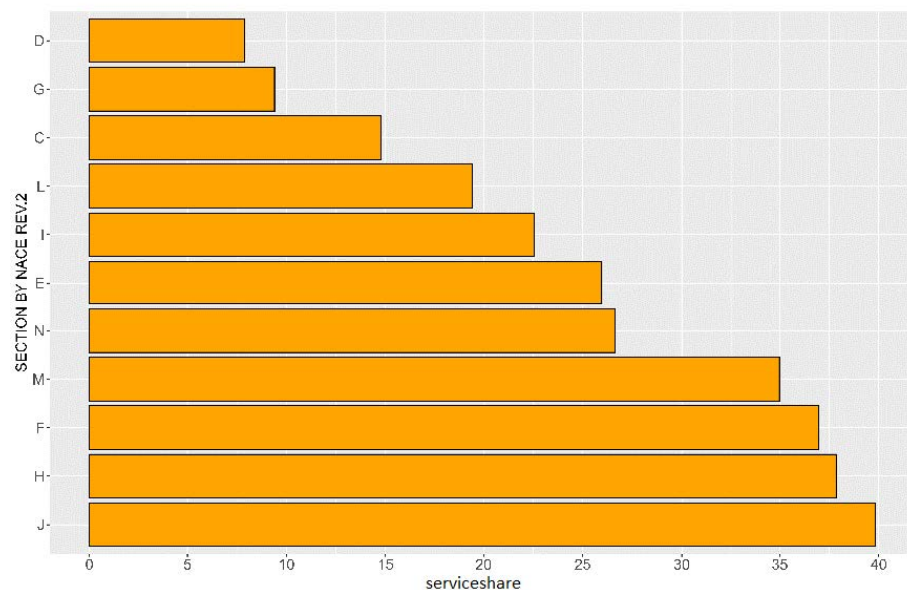
In terms of the share of external services the enterprises are highly heterogenous. In 2023 the coefficient of variation (CV) amounted to 95,1%. The Pearson's skewness coefficients calculated for the share of external services in operating costs were positive, indicating a right-sided asymmetry. It is proven by the positional measure of asymmetry based on quartiles, which also was positive and the value at the level of 0,34 indicates weak right-sided asymmetry.

Figure 1 Histogram for the share of external services in operating costs in % in 2023
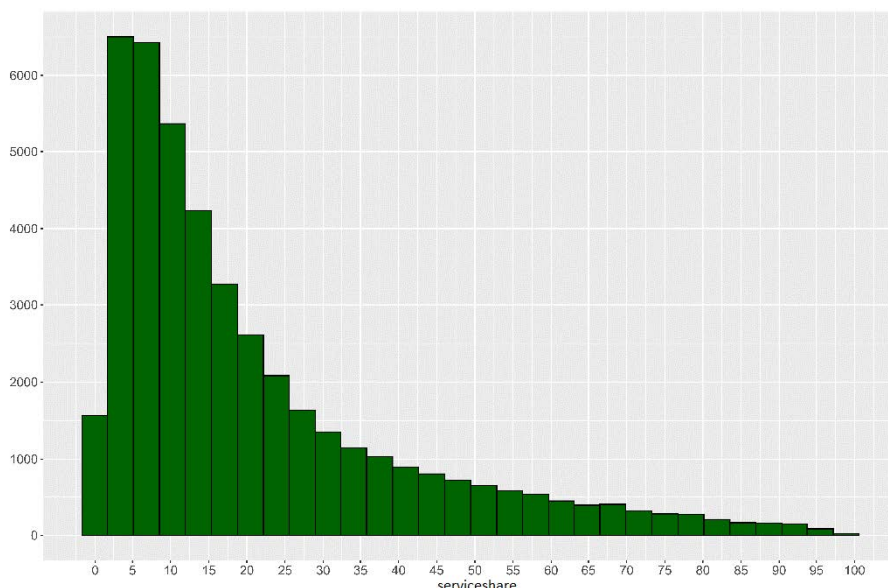
In 2023 the highest share was recorded in Section J *Information and communication* (39,8%), followed by Section H *Transport and warehousing* (37,8%) and Section F *Construction* (36,9%). The lowest values of measure are observed in Section D – 7,9% and Section G (9,4%).

Figure 2 The share of external services in operating costs by NACE sections in % in 2023

The bigger business (regarding the number of persons employed) the smaller share of external services in the operating costs. In the enterprises with the number of persons employed from 10 to 49 people the services purchased from third parties constituted 21,7% of operating costs in 2023, in units with the number of persons employed from 50 to 249 people – 19,2% and in those the biggest – 18,5%.

Figure 3 The share of external services in operating costs by size classes in % in 2023
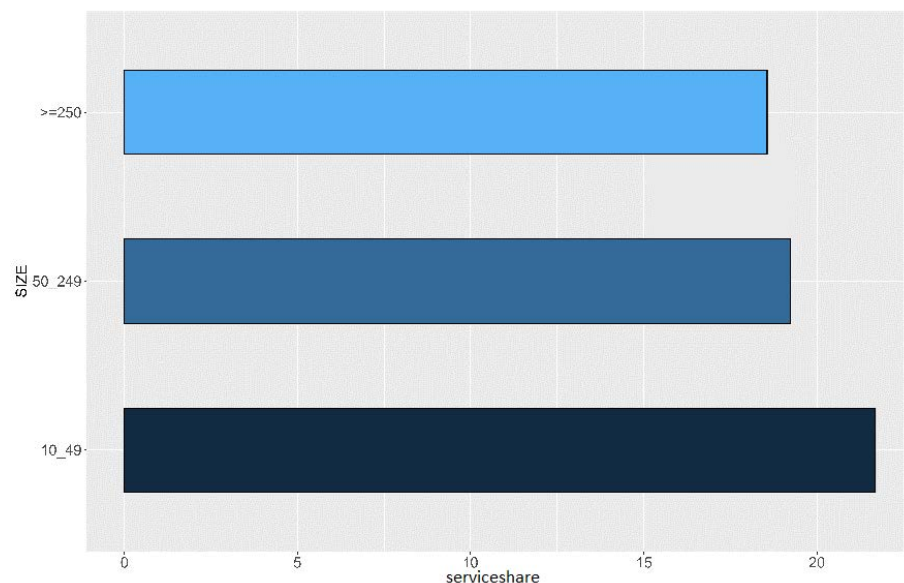
② The ratio of services purchased from third parties to the renumeration costs

In 2023 the value of external services was on average about 1.6 times higher than the renumeration costs (in 2010 – 1.4 times). However, when looking into the median value it turns out that in the half of population the that ratio was accounted for 0.69 or less (in 2010 – 6.5).

Such difference between mean and median indicates the asymmetry in population. It is followed by the Pearson's skewness coefficients as well as the positional measure of asymmetry based on quartiles. All these measures presents a right-sided asymmetry. Moreover, the ratio of external services to the renumeration costs is characterized by significant heterogeneity. In 2023 the standard deviation was above 2 times higher than mean.

Figure 4 Histogram for the ratio of external services to renumeration costs in 2023
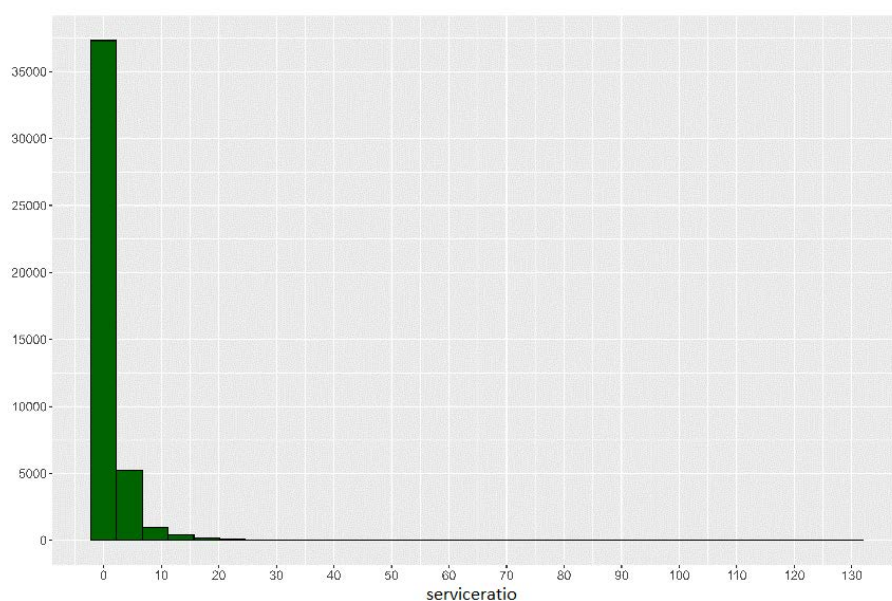
In 2023 the highest ratio of external service to the renumeration costs was recorded in Section F *Construction* and in Section H *Transport and warehousing*. It was accounted for suitably 3.8 and 3.6. Simultaneously, in the NACE sections: D *Electricity, gas, steam, and air conditioning supply*, C *Manufacturing* and I *Accommodation and food service activities* enterprises the costs related to purchase of external services were lower than the renumeration costs (ratio below 1.0).

Figure 5 The ratio of external services to renumeration costs by NACE sections in 2023
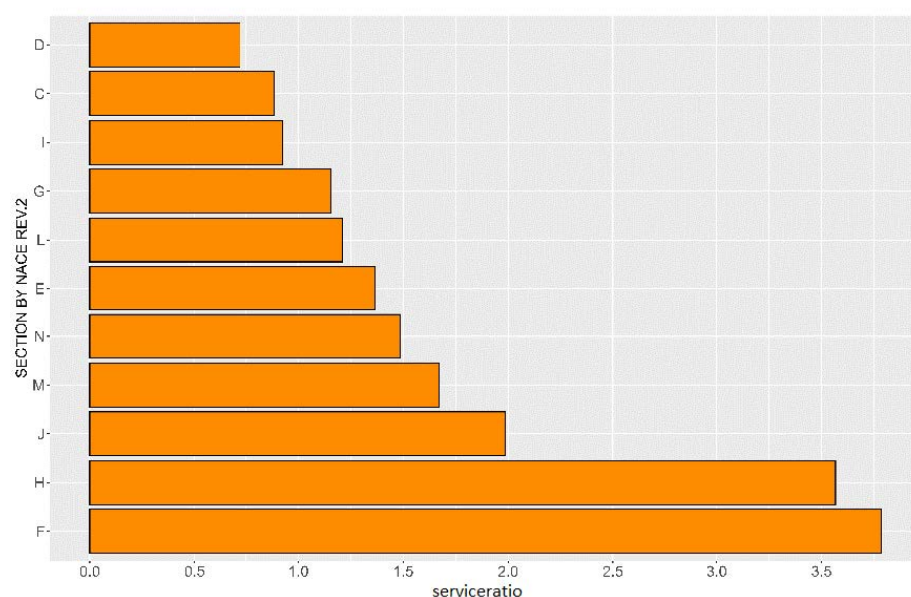
As far as the size class of enterprises is concerned in the businesses with the number of persons employed from 10 to 49 persons the costs of services purchased from third parties were 1.8 times higher than renumeration costs. In the population of enterprises with the number of persons employed from 50 to 249 that ratio amounted to 1.2 times while in the case of the biggest enterprises – about 1.1 times.

Figure 6 The ratio of external services to renumeration costs by size classes in 2023
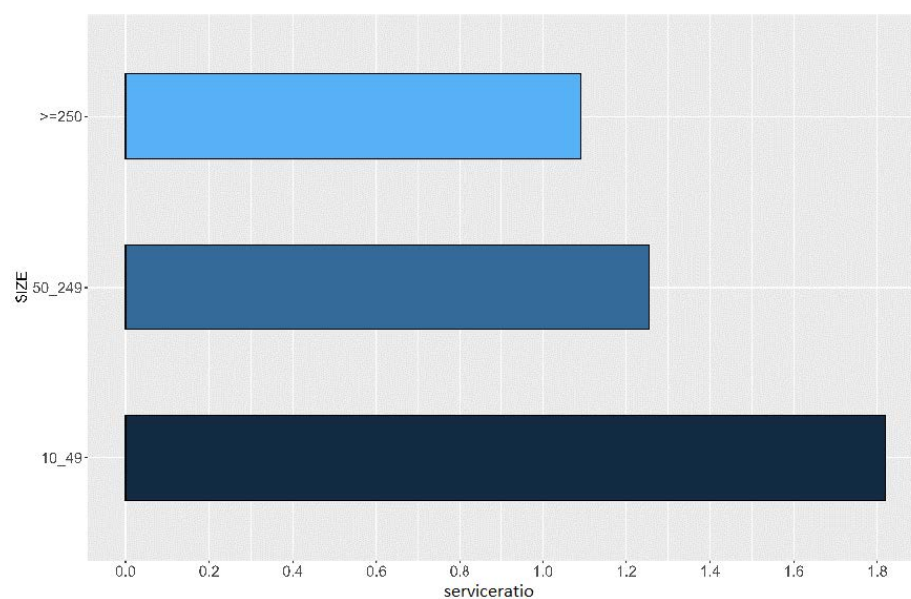
Outsourcing of services by services category

More detailed data on outsourcing of services[2] shows that in 2020 the transport and storage services are those which constituted the biggest share in total value of services purchased from other business (23,3%), followed by other services (not specified on questionnaire) with the share of almost 19%. The advertising, market research and public opinion polling services constituted 6,5%, computer services – 6,2% while rental and leasing services – 5,8%.

Figure 7 The structure of external services by services categories in % in 2020
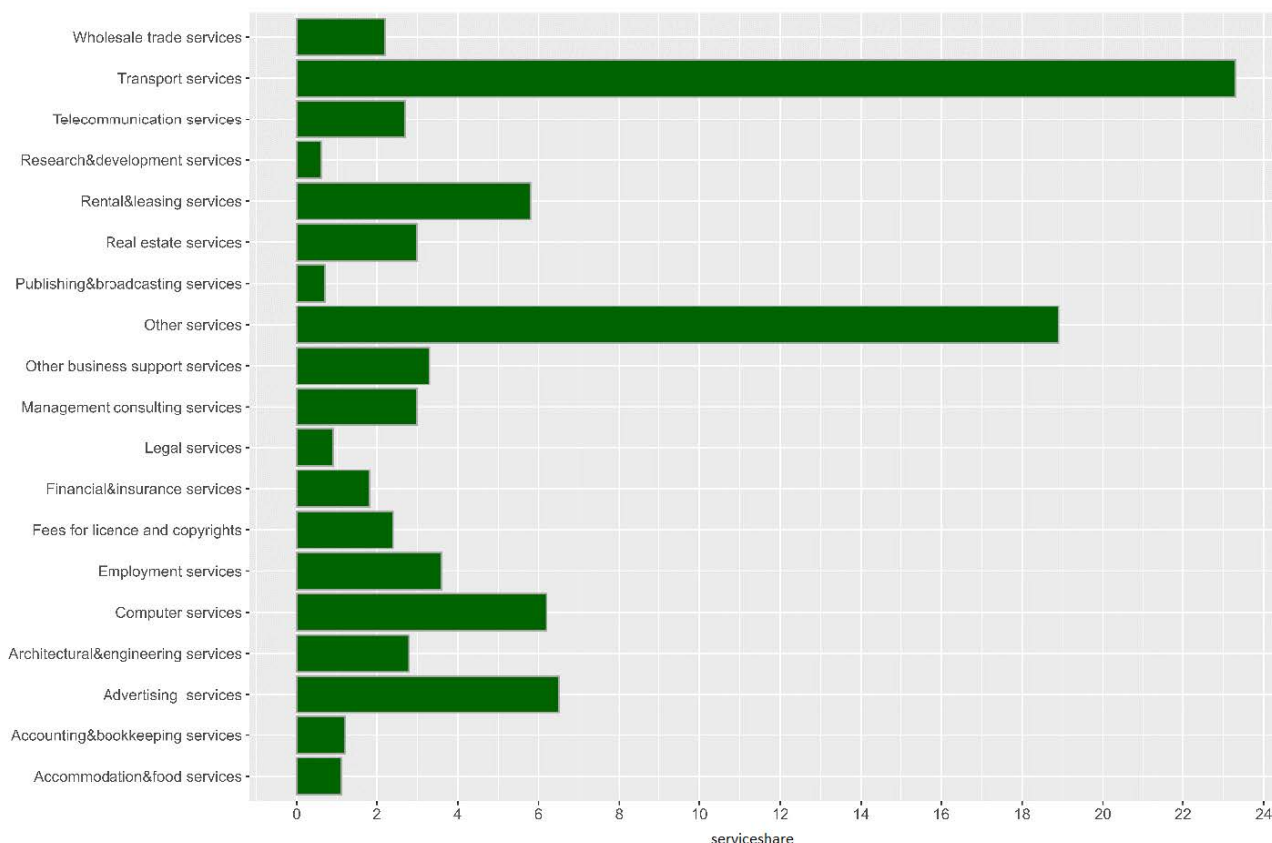
However, the structure of services purchased from the third enterprises differentiates depending on the business activity and the size of enterprises.

In companies with the number of persons employed from 10 to 49 persons the biggest share in external services is assigned to *other services related to business support services* (about 25%), followed by *transport and storage services* (almost 12%) and *accommodation and food services* (almost 8%). In the bigger companies *transport and storage services* played the dominant role (above 24% of external services in those with the number of persons employed from 50 to 249 persons and almost 22% in those with the number of persons employed above 250 persons). The further positions belong to *other services related to business support services* and *advertising services.*

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[2] Based on the results of *Demand for services* survey

Figure 8 The structure of external services by size classes in % in 2020
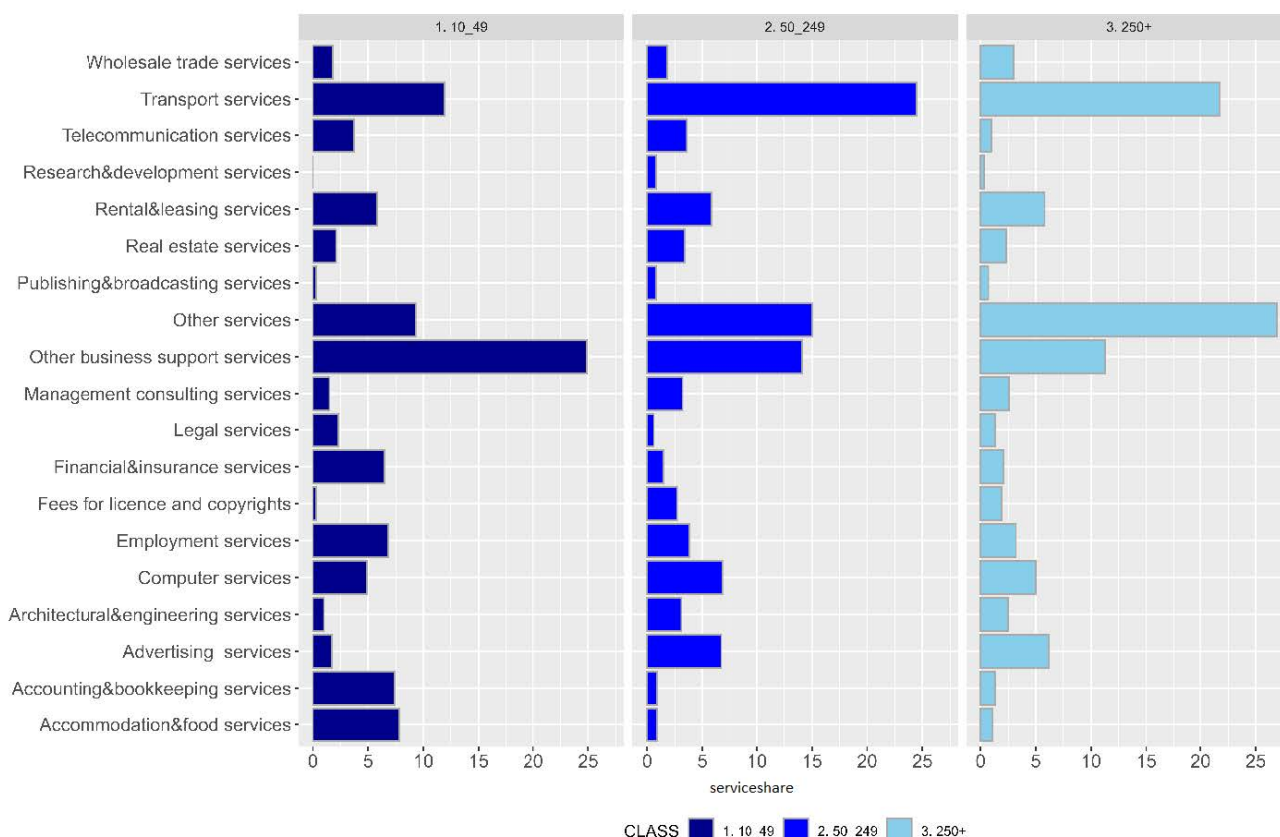
Regarding the type of business activities and the category of services purchased by companies from third parties three different types of outsourcing can be identified. The first one is the outsourcing of core activity services. In many cases enterprises purchase their core business services instead of producing them inside company. In 2020 *Transport and storage services* constitute the biggest share of services purchased from third business in Section H *Transporting and storage* (66,6%). *Computer services* and *telecommunication services* played dominant role in the enterprises in Section J *Information and communication* (suitably 30,8% and 25,1% of its external services) while *advertising services* 23,5% in Section M *Professional, scientific and technical activities*. In Section N *Administrative and support service activities* almost 31% of external service *other services related to business support services* constituted. Moreover, *other services* (not specified under other services categories in questionnaire) had significant share in external services of Section F *Construction* (about 60%) as the construction services are not specified separately in the questionnaire of survey.

The outsourcing of services which support the core activity is the second type of outsourcing. For example, in 2020, in Section F *Construction* the *architectural and engineering services* constituted almost 9% of services purchased from the third companies. In Section G *Wholesale and retail trade; repair of motor vehicles and motorcycles - advertising, market research and public opinion pooling services* amounted to almost 15% of external services. In Section I *Accommodation and food service activities* share of *other business support services* (i.e cleaning services, *security and investigation services, tourist services)* accounted for over, 24% and *advertising services* over 10% of external services. Moreover, in Section L *Real estate activities other services* (not specified under other categories − *construction services?*) constituted about 39% of external services and *other business support services* constituted almost 31% of external services. This category comprises wide range of support services, such as: *cleaning, security and investigation services.*

And, finally, there is the third category of services – services supporting running business activities, such as computer and telecommunication services, accounting, book-keeping and auditing services, legal services.

As a result the question arises… By what are companies driven when take a decision to outsource some services instead of producing them insight their own activity? One of the reasons mentioned by experts the increase in the productivity of companies is.

V.   Services outsourcing vs. productivity of enterprises in Poland

The relationship between the outsourcing of services and the productivity of enterprises in Poland is the subject matter of the methodological works conducted by the Statistics Poland. The main purpose of this works is to establish the relationship between the outsourcing of services and the productivity of enterprises in Poland (measured by the total factor productivity (TFP)).

The research work has been carried out in two stages. The first stage has been devoted to estimate the total factor productivity (TFP) at the enterprise level. The aim of the second stage was to establish the relationships between the obtained TFP estimates and the size as well as intensity of outsourcing.

For the needs of methodological works the size of outsourcing is measured by the share of external services in operating costs while the intensity of outsourcing - by the ratio of external services to the renumeration costs. Few variables were considered in order to reflect the productivity of enterprises. i.e.: value added per persons employed or per worked hours. However, the total factor productivity (TFP) was selected as the best variable reflecting the operational efficiency of enterprises.

As part of the work, no separate study was conducted, which would collect data directly from enterprises. On the other hand, a unique set of unit data[3], which is available in the official statistics institutions, was used. Data is collected as part of the *Annual survey of business activity of enterprise* (survey symbol according to PBSSP[4] - 1.61.05) and the *Demand for services* survey (survey symbol according to PBSSP - 1.49.10). In addition, the aggregated data obtained in the following surveys of official statistics were used in the conducted analyzes:

- *The structure of consumption of materials, energy, and external services, as well as the material stocks* (symbol of survey by PBSSP 1.44.15),
- *The survey of producer price for services* (symbol of survey by PBSSP 1.64.16),
- *The survey of prices for consumer goods and services* (symbol of survey by PBSSP 1.64.07).

The subjective scope of the methodological work covered legal units with the number of persons being employed 10 and more which run activities classified according to the *Polish Classification of Activities/ Statistical Classification of Economic Activities in the European Community* (PKD/NACE) to:

- Sekcji C *Manufacturing;*
- Sekcji D *Electricity, gas, steam, and air conditioning supply;*
- Sekcji E *Water supply; sewerage, waste management and remediation activities;*
- Section F *Construction;*
- Section G *Wholesale and retail trade; repair of motor vehicles and motorcycles;*
- Section H *Transporation and storage;*

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[3] The access to individual data was possible due to the fact that the undertaken research works was conducted within the methodological works of the *Polish Official Statistics*.

[4] PBSSP – Program of Statistical Surveys of Official Statistics introduced on the yearly basis by the regulation of Council of Ministries.

- Section I *Accommodation and food service activities;*
- Section J *Information and communication;*
- Section L *Real estate activities;*
- Section M *Professional, scientific and technical activities;*
- Section N *Administrative and support service activities;*

Other services sections covered by the *PKD*/NACE, including Section K *Financial and insurance activities*, were not comprised by the scope of analyzes due to the not-fully market type of activity or the limited data accessibility.

In the first stage, a data panel was used, developed on the basis of information collected for the years 2010-2023 (with 638 846 records for 95 130 units) as part of the *Annual survey of economic activity of enterprises* on the SP form *Annual survey of the enterprise*[5].

In the second stage panel covered the units from the first stage for which the TFP could be estimated. Moreover, a necessary condition was the availability of data on key independent variables. As a result, two sets of econometric models (each for one of the key independent variable) were estimated. The first one used the share of external services in the operating costs as explanatory variable. It based on panel with 638 826 observations for 95 128 units. The second one - the ratio of external services to renumeration costs and the panel covered 638 806 observations for 95 118 units.

The I[st] stage of procedure

In the first stage the total factor productivity (TFP) was estimated at the enterprise level. Taking into account the most commonly used forms of the production function and the methods of their estimation, the TFP was first estimated on the basis of the Cobb-Douglas production function, using the method developed by Levinsohn and Petrin, and then based on the translogarithmic production function, using the method developed by Ackerberg, Caves and Frazer (2015). However, finally, in the second stage the TFP values estimated on the basis of the translogarithmic form of the production function were used, as it allowed for a better fit of the model to the data. The advantage of the translogarithmic production function over the Cobb-Douglas production function is indicated both by the values of the Student's t-statistics obtained for the squares of the independent variables and for the variable reflecting interactions between variables, as well as by the results of Wald's test which verifies the significance of these variables in model. At the same time, this method made it possible to estimate the TFP at the enterprise level for all surveyed activities within one econometric model. This approach makes it easier to compare the results of the TFP estimates between different sectors of economic activity.

Table 1 Results of Cobb-Douglas production function estimation using LP method as well as translog production function using LP ACF method[6]

Specification		(1)	(2)
		LP	LPACF
		CD	TRANSLOG
Variable		lnva	lnva
lnh	lnH	0.78995***	0.81352***
		(0.00358)	(0.00001)
lnsrtrw	lnK	0.09763***	-.07199***
		(0.00297)	(0.00004)
var_1_1	$(lnH)^2$		0.04577***

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[5] The draft of questionnaire available at: https://form.stat.gov.pl/formularze/2025/passive/SP.pdf .
[6] LP - Levinshon&Petrin method, LP ACF - Levinshon&Petrin with Ackerberg, Cavesa i Frazer correction method.

			(0.00008)
var_1_2	lnH*lnK		-0.00746***
			(9.67e-06)
var_2_2	$(lnK)^2$		0.01306***
			(0.00020)
No of observations		638 846	638 846
No of groups		95 130	95 130

*Standard error in brackets *** p<0.01, ** p<0.05, * p<0.1*

Table 2 Elasticity coefficients estimated under LP ACF method

Variable	Elasticity coefficient
lnlprac	1.148
lnsrtrw	0.113

The elasticity coefficients estimated for the independent explanatory variables used in the translog production function indicate that gross value added is more elastic with respect to hours worked than with respect to the value of fixed assets. A 1% increase in the number of employees results in an average increase in value added of 1.148%, while a 1% increase in the value of fixed assets implies a 0.113% increase in value added.

Such a low elasticity of production with respect to capital, i.e., the variable used in this model—the value of fixed assets - is a fairly common phenomenon reported in the literature. In the case of the analysed panel of 646 846 records, a negative elasticity of production with respect to the value of fixed assets was recorded in 24 326 records (i.e., 3.8% of the total number of records in the panel), while a negative elasticity of production with respect to the number of hours worked did not occur in any record.

Finally, the second stage of the research utilizes the results of TFP estimates obtained through a procedure performed for the translogarithmic production function using the LP ACF method. It should also be noted that, although the percentage of firms with negative production elasticities with respect to capital may depend on the definition of this production factor used, this definition does not affect the values of total factor productivity (TFP) estimated within the production function model (Baily et al. (1992)).

Total factor productivity (TFP)

The population was diverse regarding estimated values of lnTFP. In 2023 the standard deviation represented 16.5% of the arithmetic mean of this variable.

Among the activities covered by the research, the most diverse were enterprises classified according to the NACE under Section D *Electricity, gas, steam, hot water, and air conditioning supply* for which the standard deviation represented 24.3% of the arithmetic mean, followed by entities classified under Section N *Administrative and support service activities* with a variance coefficient (CV) of 20.0%, and Section I *Hotels and restaurants* with CV of 19.3%. The least heterogeneous turned out to be enterprises operating in the field of water supply and sewage and waste management (according to NACE Section E), or in the field of real estate services (according to PKD Section L) with CV of 12.5% and 13.1%, respectively.

Pearson's skewness coefficients for lnTFP were positive for most activities, indicating right-sided asymmetry. However, the values of the positional skewness measure based on quartiles fluctuated around zero, indicating a lack of asymmetry, which was confirmed by the graphical presentation of the variable's distribution in the form of a histogram.

Figure 9 Histogram for log of total factor productivity (lnTFP) in 2023
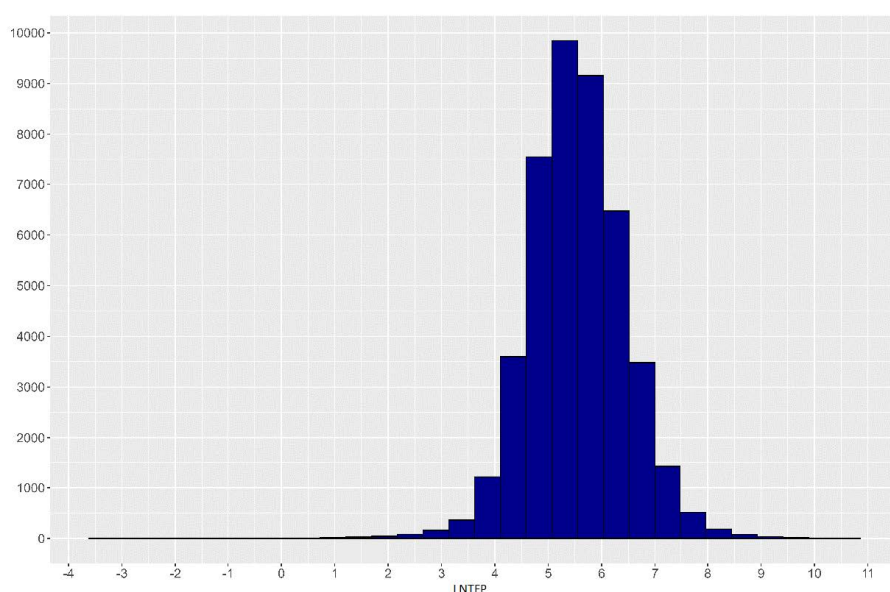
In 2023 the highest average lnTFP values were recorded in Section L *Activities related to the real estate market* – 6.3 and in Section J *Information and communication* – 5.9. The lowest values were obtained in sections I *Hotels and restaurants* – 4.8 and in Section N *Administrative and support service activities* and Section G – 5.3.

Figure 10 The average measures for lnTFP by the NACE sections in 2023
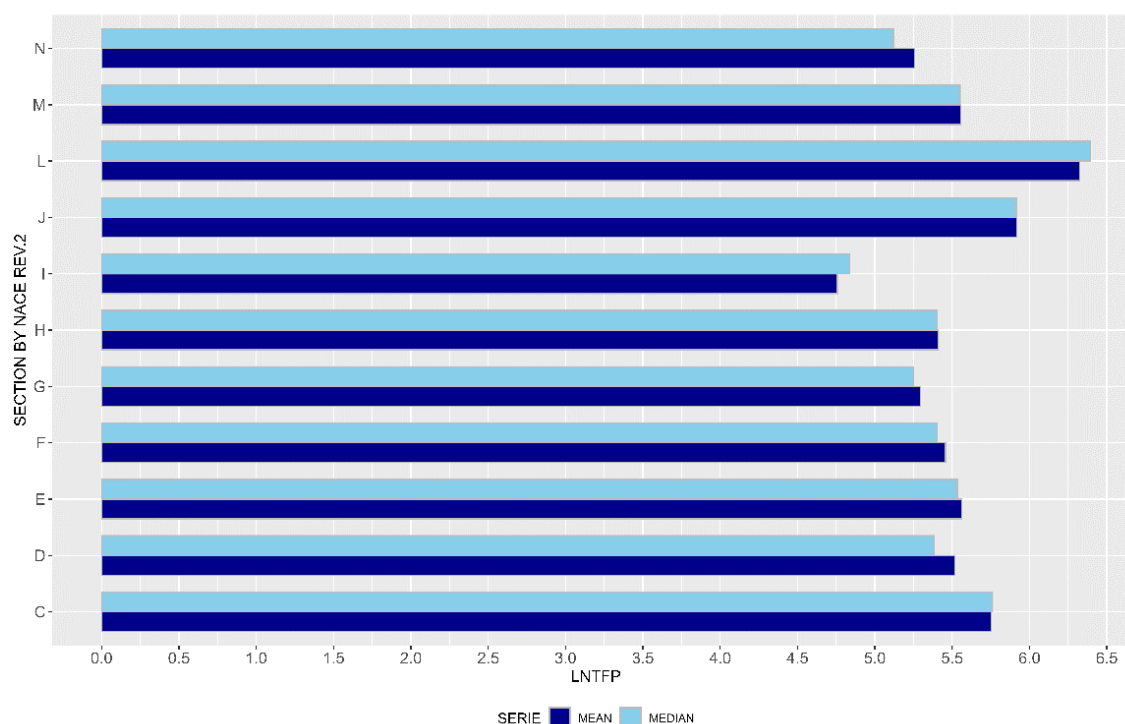
When looking into data with the breakdown by size classes it turns out that the companies with the number of persons employed 250 and more are those the most productive. In 2023 the mean as well as median value of lnTFP for that sub-population accounted for 6.4. In the companies with the number of persons

employed from 50 to 249 the lnTFP was on average 5.8 (both for mean as well median), while in the companies with the number of persons employed from 10 to 49 – 5.3.

Figure 11 The average measures for lnTFP by size classes in 2023

The IInd stage of procedure

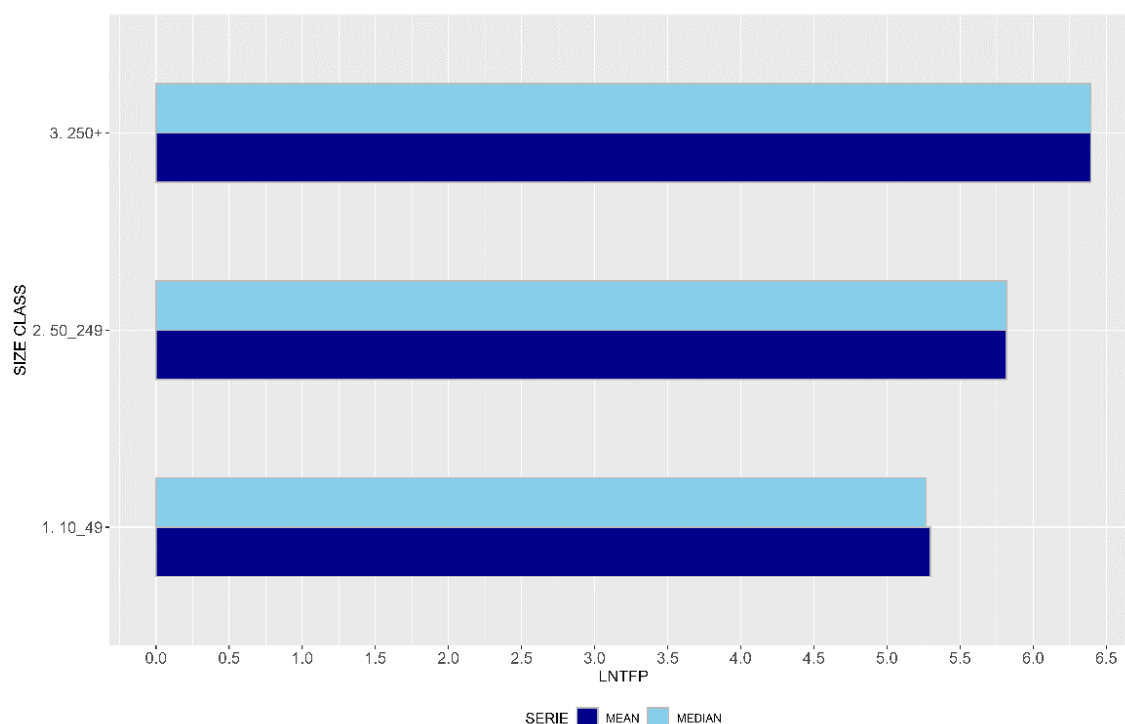In the second stage of work, an attempt was made to determine the relationship between outsourcing of services measured as:

① the share of external services in operating costs (size of outsourcing) and

② the ratio of external services to the renumeration costs (intensity of outsourcing)

and the lnTFP.

For this purpose, panel data models with fixed effects (FE) and generalized additive models (GAM) were used. In addition to the variables reflecting various aspects of services outsourcing (specified above), the models also include control independent variables such as: the share of renumeration costs in operating costs, the share of export revenues in the total sales revenues, or binary variables reflecting the size class of enterprises measured by the number of employed persons, or the fact of conducting the specific types of economic activity at the level of NACE sections.

Two sets of econometric models were estimated. The first one used as a key independent variable the share of external services in operating costs ①, while the second one the ratio of external services to the renumeration costs ②.

The procedure for each set of models was the same. Firstly, the OLS (ordinary least square) model with the key variable was processed. The second step was to estimate two panel data models with fixed effects (FE) (the first one with the key variable in a linear form and the second one with key variable in both linear and

quadratic form). Finally, for the purpose of establishing non-linear relations, a semi-parametric panel data model was used, i.e. a generalized additive model (GAM). In this model the key independent variable is introduced in a non-parametric form. In the GAM model, the coefficients for the control independent variables are estimated, as well as the fitted net values of the lnTFP[7] which are the part of the lnTFP value that was not explained by the parametric part of the model. This procedure uses a non-parametric estimator based on the spline function. On the basis of the fitted net values of the TFP obtained at the enterprise level, plots of the fitted quadratic function and the local spline polynomial function were created, which enabled presentation of the results graphically.

Moreover, in order to determine the relationship between the services outsourcing and the TFP regarding the size of the enterprise, the same procedure was planned to be carried out for the sub-populations of this panel broken down by the size classes of enterprises.

① **The share of external services in operating costs (serviceshare) vs. total factor productivity (TFP)**

Table 3 Estimation results for OLS, FE and GAM models for panel as total

lnTFP	(1)	(2)	(3)	(4)
	OLS	FE	FE	GAM
	lntfp	lntfp	lntfp	lntfp
serviceshare	0,00195***	-0,00056***	-0,00581***	
	(0,00007)	(0,0001)	(0,00023)	
serviceshare2			0,00007***	
			(2.92e-06)	
renumshare	-0,01303***	-0,00458***	-0,00425***	-0,00911***
	(0,00007)	(0,00011)	(0,00011)	(0,00013)
exportshare	0,00476***	0,00188***	0,0019***	0,00061***
	(0,00004)	(0,00005)	(0,00005)	(0,00004)
kl50_249	0,44332***	0,13596***	0,13586***	0,03446***
	(0,00229)	(0,0028)	(0,0028)	(0,00302)
kl250	1,07064***	0,34471***	0,34346***	0,08411***
	(0,00410)	(0,00583)	(0,00583)	(0,00671)
d	0,73733***	-0,10164***	-0,10273***	-0,19996***
	(0,01051)	(0,03142)	(0,0314)	(0,03566)
e	0,30453***	-0,04192**	-0,03783*	-0,120608***
	(0,00621)	(0,02046)	(0,02045)	(0,02334)
f	0,09795***	0,05944***	0,06129***	0,04836***
	(0,00396)	(0,01032)	(0,01031)	(0,01148)
g	-0,1029***	-0,09349***	-0,09408***	-0,04941***
	(0,00289)	(0,00709)	(0,00709)	(0,00798)
h	-0,26659***	-0,11842***	-0,11696***	-0,13028***
	(0,00465)	(0,0144)	(0,01439)	(0,01622)
i	-0,24964***	-0,14587***	-0,14353***	-0,15431***
	(0,00718)	(0,02193)	(0,02192)	(0,02477)
j	0,5905***	-0,01791	-0,01787	0,03405**
	(0,00589)	(0,01547)	(0,01546)	(0,01702)
l	0,85669***	0,34913***	0,3516***	0,20428***

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[7] Natural logarithm of the TFP.

	(0,00543)	(0,01436)	(0,01435)	(0,01623)
m	0,3998***	-0,08868***	-0,08958***	-0,04769***
	(0,0053)	(0,01283)	(0,01282)	(0,01439)
n	0,1125***	-0,0205	-0,02086	-0,03145**
	(0,00628)	(0,01363)	(0,01362)	(0,01516)
Constans	5,14071***	5,25957***	5,29853***	
	(0,003)	(0,00597)	0,00616	
No of observations	638 826	638 826	638 826	524 776
No of groups		95 128	95 128	
R²	23.34			
R² within		0.0152	0.0164	0.0144
R² between		0.1548	0.1440	
R² overall		0.1754	0.1620	

*Standard error in brackets *** p<0.01, ** p<0.05, * p<0.1*

The values of the coefficients of determination R^2 for models (2) and (3) indicate a similar fit of both models. The F-test significance results justify the rejection of the null hypothesis at any significance level, according to which none of the explanatory variables has a significant impact on the explained variable. The values of the Student's t-statistic for the explanatory variables included in both models indicate that at the 5% significance level, the vast majority of explanatory variables have a statistically significant impact on the explained variable. No statistically significant differences from the reference industry *Manufacturing* (according to NACE Section C) were noted in the case of binary variables defining the type of business activity, e.g., Section J *Information and communication*, or Section N *Administrative and support service activities*. The values of the coefficients estimated for the control explanatory variables are consistent with expectations, indicating that the model performs correctly.

Regarding the purpose of the methodological works the most important results are the estimates obtained for explanatory variable which reflects the scale of the outsourcing phenomenon in the enterprise (*serviceshare*). Model (2) shows that an 1 p.p. increase in the share of outsourced services in operating costs is associated with an average 0.06% decrease in TFP.

At the same time, the coefficients estimated for the *serviceshare* and *serviceshare2* variables in model (3) provide a basis for the conclusion that as the share of outsourced services in operating costs increases, TFP decreases until a certain minimum is reached, and above that minimum, it increases. Introducing the square of the *serviceshare* variable into model (3) did not significantly improve model fit, although the statistical significance of the parameter for the square of this variable may indicate a nonlinear relationship between lnTFP and *serviceshare.*

Therefore, in order to more precisely characterize the shape of this nonlinear relationship, the results of the GAM model (4) estimation were used, including in particular the fitted net values of the lnTFP variable, which were estimated at the level of individual records in the panel, taking into account the existence of a nonlinear relationship between lnTFP and *serviceshare*. Based on these data, graphs of the nonparametrically fitted locally smoothed polynomial function and the fitted quadratic function were developed.

Figure 12 Relationship curves between fitted lnTFP from GAM model (4) and *serviceshare*
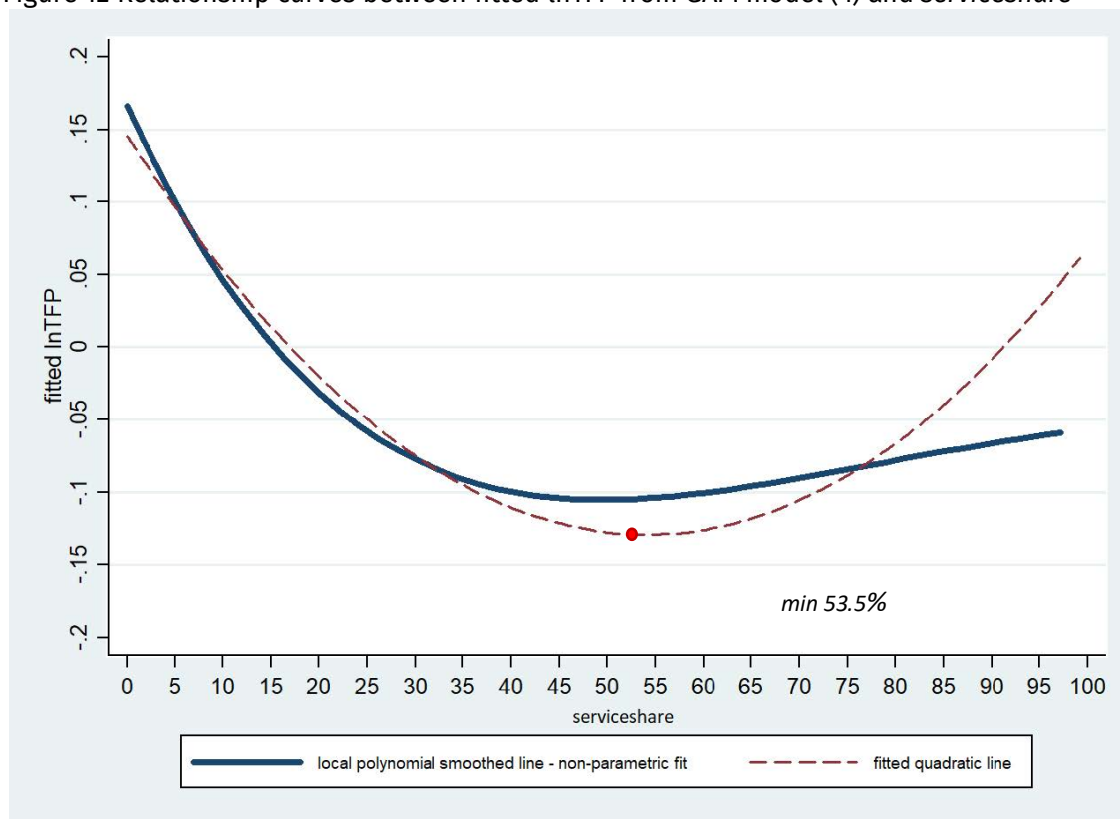
Based on the estimation results obtained in models (2) and (3) and the graphical presentation of the obtained, it should be concluded that although the linear model suggests a negative correlation between the share of external services in operating costs and TFP, it may in fact take the form of a quadratic function. As the share of outsourced services in enterprises' operating costs increases (*serviceshare*), TFP decreases to the minimum obtained for the share of outsourced services at approximately 53%. Above this value, however, an increase in TFP should be expected. The positive correlation applies to only 8.2% of the records in model (4).

At the same time, the shape of the locally smoothed polynomial function curve indicates that the strength of the relationship between lnTFP and *serviceshare* varies depending on the range of values of this explanatory variable. Together with an increase in the share of external services in operating costs up to around 33%, TFP declines sharply. In the range of share from around 33% to around 53%, TFP declines more gently, and then TFP begins to grow, but at a slower rate than in the case of the decline.

The results of the estimation of panel data models with fixed effects (FE) as well as the GAM model carried out for the sub-populations broken down by the size classes measured by the number of persons employed indicate that the relation between the share of external services in operating costs and TFP varies depending on the size class.

Table 4 Estimation results for FE models based on the sub-populations by size classes

Specification	FE model (5)			FE model (6)		
	Entities with the no of persons employed:			Entities with the no of persons employed:		
	from 10 to 49 persons	from 50 to 249 persons	250 persons and more	from 10 to 49 persons	from 50 to 249 persons	250 persons and more
	lntfp	lntfp	lntfp	lntfp	lntfp	lntfp
serviceshare	-0.00109***	0.00045**	-0.00021	-0.00754***	-0.00415***	0.00073
	(0.00012)	(0.00019)	(0.0004)	(0.0003)	(0.00042)	(0.00084)
serviceshare2				0.00009***	0.00007***	-0.00002
				(0)	(0.00001)	(0.00001)
renumshare	-0.00628***	-0.00085***	0.00086**	-0.00588***	-0.00056***	0.00079**
	(0.00015)	(0.00021)	(0.00042)	(0.00015)	(0.00021)	(0.00042)
exportshare	0.00152***	0.00212***	0.00159***	0.00152***	0.00213***	0.00158***
	(0.00007)	(0.00008)	(0.00016)	(0.00007)	(0.00008)	(0.00016)
d	-0.13205***	-0.00505	0.06688	-0.13334***	-0.00526	0.06887
	(0.04206)	(0.05214)	(0.13134)	(0.04203)	(0.05211)	(0.13135)
e	-0.04	0.03144	-0.14939	-0.03618	0.03373	-0.14941
	(0.02668)	(0.03528)	(0.10637)	(0.02666)	(0.03526)	(0.10637)
f	0.08462***	0.01353	-0.07596	0.08579***	0.01539	-0.0762
	(0.01277)	(0.02013)	(0.04984)	(0.01275)	(0.02012)	(0.04984)
g	-0.0653***	-0.13136***	-0.08771***	-0.06636***	-0.13179***	-0.08791***
	(0.00897)	(0.01361)	(0.03145)	(0.00896)	(0.0136)	(0.03145)
h	-0.09683***	-0.08233***	-0.26918***	-0.0956***	-0.0826***	-0.26975***
	(0.01772)	(0.03018)	(0.07566)	(0.01771)	(0.03017)	(0.07566)
i	-0.13544***	-0.08011*	-0.27271**	-0.1341***	-0.07845*	-0.27275**
	(0.02678)	(0.04496)	(0.11976)	(0.02676)	(0.04494)	(0.11976)
j	0.03264*	-0.09882***	-0.22897***	0.03138	-0.09975***	-0.22967***
	(0.01967)	(0.03032)	(0.058)	(0.01965)	(0.03031)	(0.05801)
l	0.36136***	0.21381***	0.15189*	0.3629***	0.21556***	0.14988*
	(0.01737)	(0.03159)	(0.08857)	(0.01735)	(0.03158)	(0.08859)
m	-0.0544***	-0.14628***	-0.29946***	-0.05639***	-0.14845***	-0.29936***
	(0.0166)	(0.02406)	(0.04958)	(0.01659)	(0.02405)	(0.04958)
n	-0.0328*	0.02149	-0.12685***	-0.03385*	0.02215	-0.12638***
	(0.018)	(0.02569)	(0.04352)	(0.01799)	(0.02568)	(0.04352)
Constans	5.15394***	5.44769***	6.09445***	5.20366***	5.47943***	6.08862***
	(0.00791)	(0.0103)	(0.02172)	(0.00818)	(0.01062)	(0.02218)
No of observations	406 618	186 910	45 298	406 618	186 910	45 298
No of groups	77 189	28 910	6 071	77 189	28 910	6 071
R^2 within	0.0092	0.0056	0.0043	0.0109	0.0065	0.0043
R^2 between	0.0524	0.0333	0.0225	0.0442	0.0292	0.0240
R^2 overall	0.0644	0.0309	0.0212	0.0520	0.0256	0.0228

*Standard error in brackets *** p<0.01, ** p<0.05, * p<0.1*

The values of the coefficients of determination R^2 for the above models indicate a similar model fit. The F-test significance results allow us to reject the null hypothesis, at any significance level, that none of the explanatory variables has a significant impact on the explained variable.

The estimation results of model (5), which assumes a linear relationship between lnTFP and the share of external services in operating costs, indicate that the key explanatory variable is not statistically significant for the model for the population of entities with the number of persons employed 250 and more (at the 5% significance level).

The introduction of the square of the *serviceshare* variable into model (6) allows us to conclude that in the case of entities with the number of persons employed from 10 to 249, the relationship between lnTFP and *serviceshare* has the form of a quadratic function, whereas in the population of entities with the number of persons employed 250 and more, the square of the key variable is statistically insignificant. This is confirmed by the results of the GAM model (7).

The coefficients estimated for the majority of control variables are consistent with expectations. Only in case of enterprises entities with the number of persons employed 250 and more the estimated for the share of renumeration costs in the operating costs (*renumshare*) estimates are contradictory to the theory of economy. In that case the correlation between the share of renumeration costs and TFP is positive.

Similarly to models estimated for whole panel of enterprises, the differences in the coefficient of determination R^2 obtained for models (5) and (6) are insignificant. Therefore, when interpreting the results, the graphical presentation of relationship between the fitted lnTFP obtained within model (7) and the key explanatory variable *serviceshare* was used. For individual sub-populations of the panel, according to size class, graphs of the locally smoothed polynomial function and the fitted quadratic function were developed.

Table 5 Estimation results for GAM models based on the sub-populations by size classes

	Model GAM (7)		
	Entities with the no of persons employed:		
Specification	from 10 to 49 persons	from 50 to 249 persons	250 persons and more
	lntfp	lntfp	lntfp
renumshare	-0,01071***	-0,00609***	-0,00242***
	(0,00017)	(0,00022)	(0,00046)
exportshare	0,00053***	0,00059***	0,00031**
	(0,00006)	(0,00007)	(0,00014)
d	-0,25686***	-0,13084**	0,13509
	(0,04904)	(0,05545)	(0,13939)
e	-0,14033***	-0,08907**	0,29708**
	(0,03064)	(0,0386)	(0,12088)
f	0,04498***	0,0623***	0,04762
	(0,01462)	(0,02058)	(0,05213)
g	-0,05022***	-0,03695***	0,06338*
	(0,0102)	(0,01423)	(0,03466)
h	-0,13527***	-0,11382***	-0,3134***
	(0,02013)	(0,03162)	(0,07335)
i	-0,15004***	-0,18910***	0,01195
	(0,03044)	(0,04853)	(0,14115)
j	0,04878**	0,01433	0,13009**
	(0,02184)	(0,03038)	(0,06361)
l	0,20671***	0,22192***	0,26403***
	(0,02002)	(0,03198)	(0,09107)
m	-0,04214**	-0,04167*	0,17458***

	(0,01864)	(0,02516)	(0,05265)
n	-0,04536**	0,00166	-0,02227
	(0,02023)	(0,02563)	(0,04633)
No of observations	319 713	163 828	41 256
R^2	0.018	0.009	0.004

*Standard error in brackets *** p<0.01, ** p<0.05, * p<0.1*

Figure 13 Relationship curves between fitted lnTFP from GAM model (4) and *serviceshare* for entities with the no of persons employed from 10 to 49
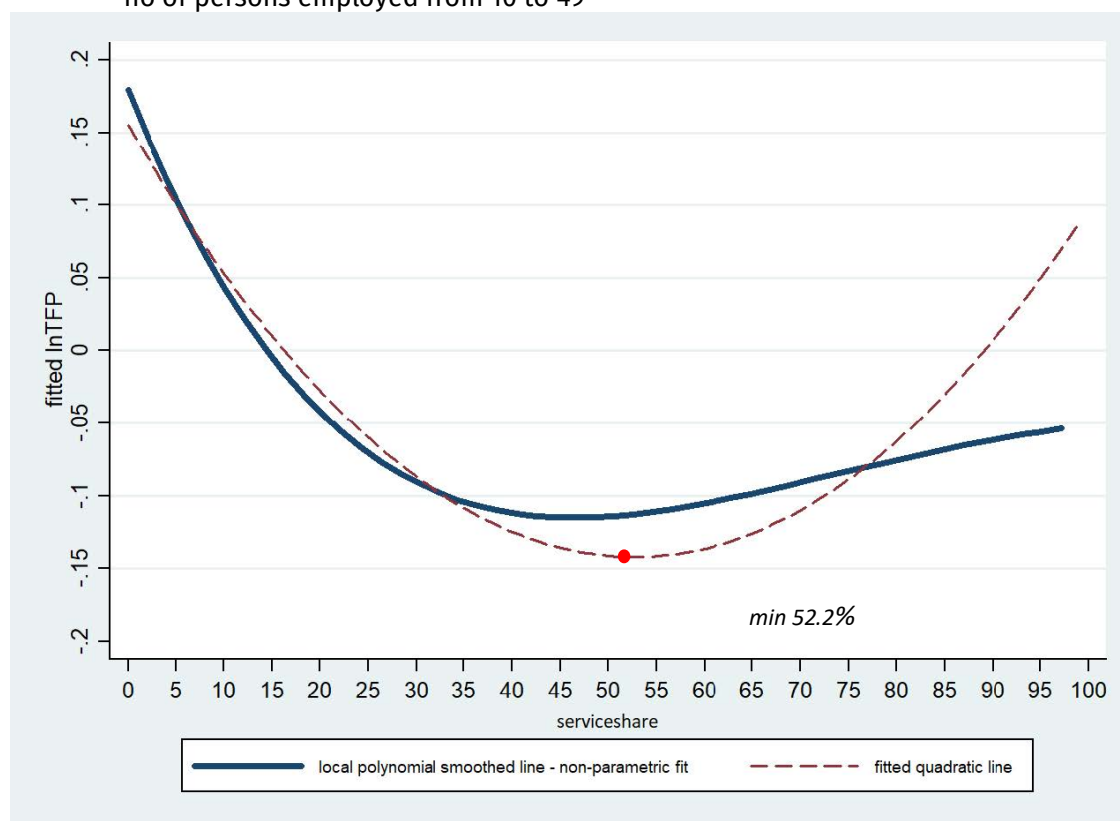
For the population of enterprises with number of persons employed from 10 to 49 TFP initially declines as the share of external services in operating costs increases, reaching a minimum at 52%. Then TFP increases with increasing service share. However, this positive correlation applies to only 9.2% of the observations in the studied sub-population.

Simultaneously, the local polynomial spline curve indicates a sharp decline in TFP in the range of external services share from 0% to approximately 32%, then TFP declines more slowly up to approx. the 52.2% level of share. Therefore, a negative correlation applies to almost 47% of records in the sub-panel of entities with 10 to 49 employees, and in over 52% of records this correlation oscillates around zero.
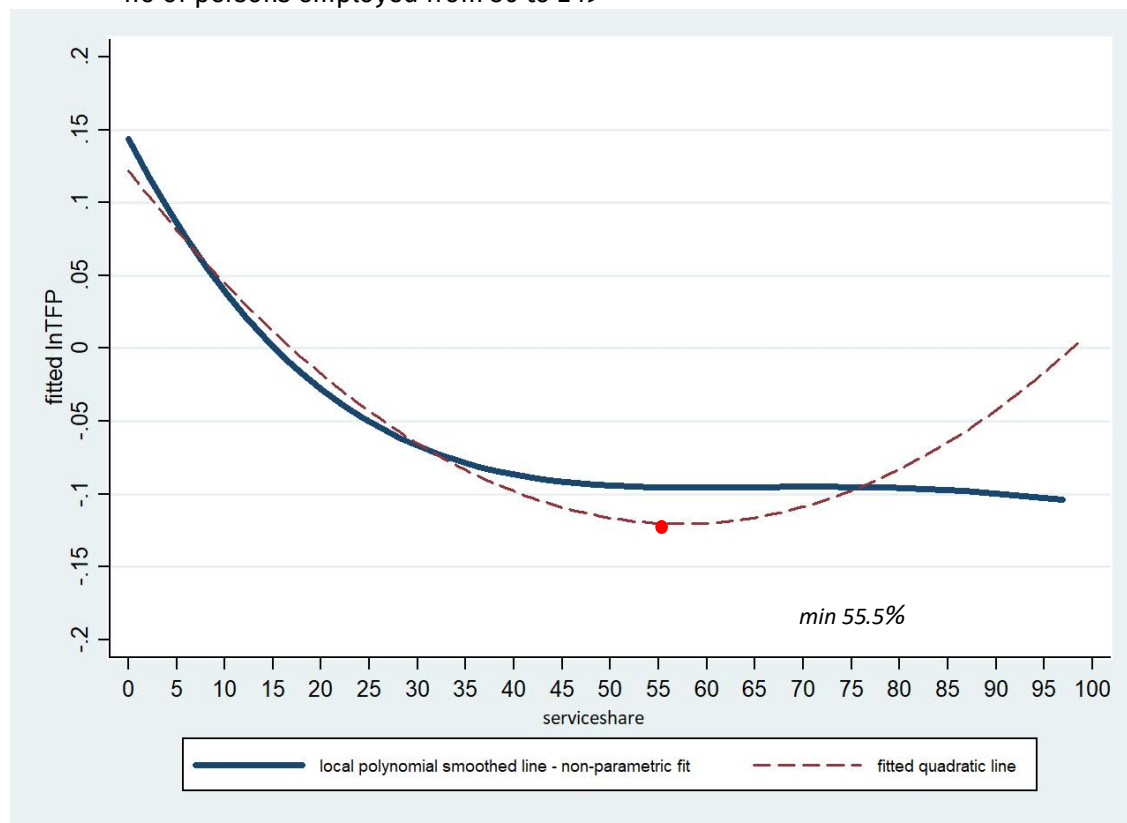
Figure 14 Relationship curves between fitted lnTFP from GAM model (4) and *serviceshare* for entities with the no of persons employed from 50 to 249

For enterprises with the number of persons employed for 50 to 249, it can be concluded that, according to the fitted quadratic function, TFP decreases with increasing share of outsourced services in operating costs up to 55.5%, while it increases above this value. Therefore, TFP growth concerns 7.3% of the observations in that sub-population.

According to the locally smoothed polynomial function, TFP declines sharply with increasing share of outsourced services in operating costs until it reaches approximately 33%, after which the decline is gradual. In the 55%-75% range, TFP remains constant, and above this level, it begins to decline gently again. In the service-to-work range from 0% to approximately 12%, the correlation is strongly negative and affects approximately 54% of the records in this sub-population. In the rest of the field, TFP fluctuates around the same level (over 45% of records).

Figure 15 Relationship curves between fitted lnTFP from GAM model (4) and *serviceshare* for entities with the no of persons employed 250 and more
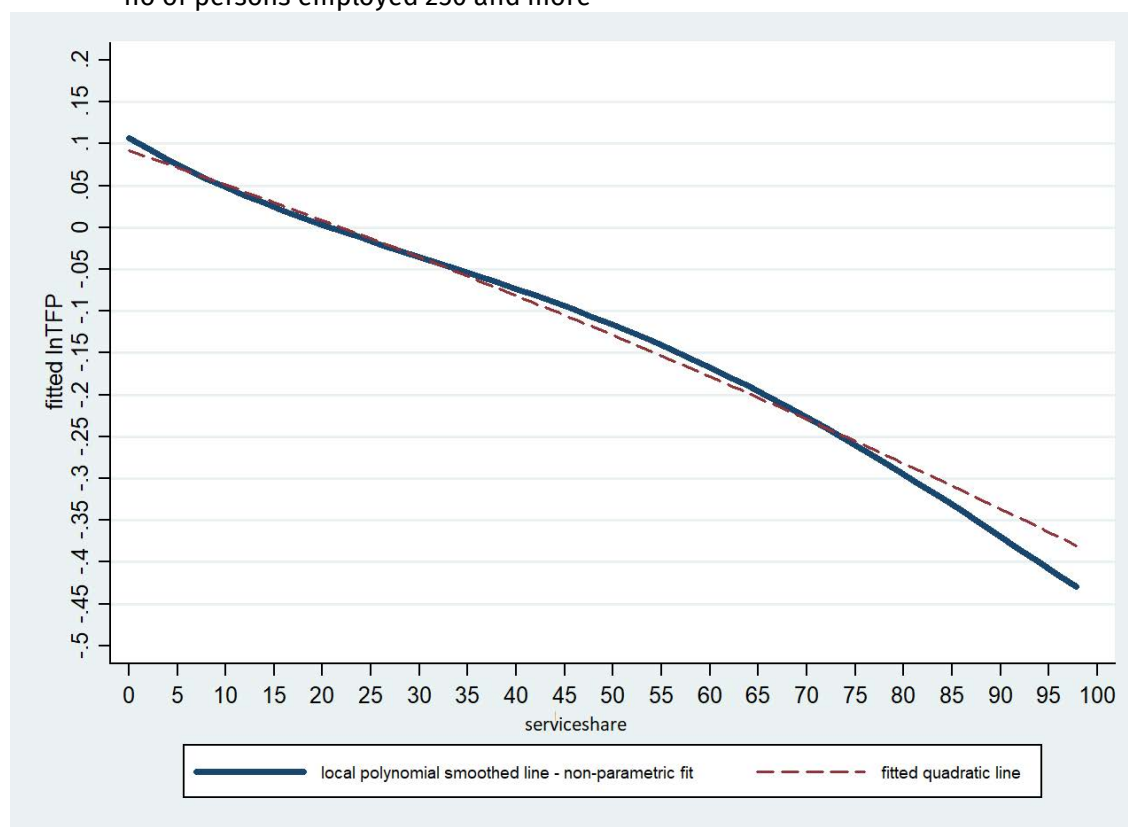
For enterprises with the number of persons employed 250 and more, both the fitted quadratic function and the locally smoothed polynomial function indicate that TFP declines across the entire range as the share of outsourced services in operating costs increases.

② **The ratio of external services to the renumeration costs (serviceratio) vs. total factor productivity (TFP)**

Table 6 Estimation results for OLS, FE and GAM models for panel as total

lnTFP	(1)	(2)	(3)	(4)
	OLS	FE	FE	GAM
	lntfp	lntfp	lntfp	lntfp
serviceratio	0.02166***	0.01412***	0.01926***	
	(0.00027)	(0.00033)	(0.00044)	
serviceratio2			-0.00005***	
			(0)	
renumshare	-0.01191***	-0.00328***	-0.00293***	-0.00697***
	(0.00007)	(0.00011)	(0.00011)	(0.00013)
exportshare	0.00471***	0.00187***	0.00187***	0.0006***
	(0.00004)	(0.00005)	(0.00005)	(0.00004)
kl50_249	0.44766***	0.14078***	0.14201***	0.03791***
	(0.00228)	(0.0028)	(0.0028)	(0.00302)
kl250	1.07603***	0.35255***	0.35435***	0.09058***
	(0.00408)	(0.00582)	(0.00582)	(0.00672)

d	0.72809***	-0.11015***	-0.11093***	-0.20149***
	(0.01046)	(0.03136)	(0.03135)	(0.03569)
e	0.30676***	-0.04758**	-0.04626**	-0.12084***
	(0.00612)	(0.02043)	(0.02042)	(0.02336)
f	0.08438***	0.05614***	0.0563***	0.05144***
	(0.00376)	(0.0103)	(0.0103)	(0.01149)
g	-0.10412***	-0.09161***	-0.09107***	-0.04776***
	(0.00283)	(0.00708)	(0.00708)	(0.00798)
h	-0.28924***	-0.12193***	-0.12248***	-0.13054***
	(0.0045)	(0.01437)	(0.01437)	(0.01624)
i	-0.24289***	-0.14843***	-0.14862***	-0.15187***
	(0.00712)	(0.02189)	(0.02189)	(0.02479)
j	0.59467***	-0.0196	-0.01977	0.03482**
	(0.00562)	(0.01544)	(0.01544)	(0.01703)
l	0.85779***	0.34358***	0.34336***	0.20354***
	(0.00539)	(0.01434)	(0.01433)	(0.01624)
m	0.39825***	-0.09405***	-0.09499***	-0.04902***
	(0.005)	(0.0128)	(0.0128)	(0.0144)
n	0.08765***	-0.02326*	-0.02402*	-0.03039**
	(0.00615)	(0.0136)	(0.0136)	(0.01517)
Constans	5.11983***	5.19673***	5.18115***	
	(0.00279)	(0.00544)	(0.00551)	
No of observations	638 806	638 806	638 806	524 771
No of groups		95 118	95 118	
R^2	24.04			
R^2 within		0.0185	0.0191	0.0126
R^2 between		0.1511	0.0909	
R^2 overall		0.1876	0.1721`	

*Standard error in brackets *** p<0.01, ** p<0.05, * p<0.1*

The values of the coefficients of determination R^2 for models (2) and (3) indicate a similar fit of both models. The F-test significance results at the level justify the rejection of the null hypothesis at any significance level, according to which none of the explanatory variables has a significant impact on the explained variable. The values of the Student's t-statistic for the explanatory variables included in both models indicate that at the 5% significance level, the vast majority of explanatory variables have a statistically significant impact on the explained variable. No statistically significant differences from the reference industry Industrial processing (according to NACE Section C) were noted in the case of binary variables defining the type of business activity, e.g., Section J *Information and communication*. The values of the coefficients estimated for the control explanatory variables are consistent with expectations, indicating that the model performs correctly.

The estimation results also indicate that, compared to enterprises conducting business activities classified in Section C *Manufacturing*, companies classified in Section F *Construction* and Section L *Real estate activities* are characterized by higher productivity (taking into account the significance level of 5%).

When regarding the estimates obtained for key explanatory variables reflecting the intensity of the outsourcing in the enterprise it can be concluded that an 1 p.p increase in the ratio of external services to renumeration costs is correlated with an average 1.4% increase in TFP (model (2)). At the same time, the

coefficients estimated for the *serviceratio* and *serviceratio2* variables in model (3) provide a basis for the conclusion that together with the increase in ratio of external services to renumeration costs, the TFP goes up until a certain maximum is reached, and above that maximum, it decreases.

Introducing the square of the *r_uslobwynkoszt* variable into model (3) did not significantly improve model fit, although the statistical significance of the parameter for the square of this variable may indicate a nonlinear relationship between lnTFP and *r_uslobwynkoszt*. Therefore, to more precisely characterize the shape of this nonlinear relationship, the results of the GAM model (4) estimation were used, including in particular the fitted net values of the lnTFP variable, which were estimated at the level of individual records in the panel, taking into account the existence of a nonlinear relationship between lnTFP and *serviceratio*. Based on these data, graphs of the non-parametrically fitted locally smoothed polynomial function and the fitted quadratic function were developed.

Figure 16 Relationship curves between fitted lnTFP from GAM model (4) and *serviceratio*
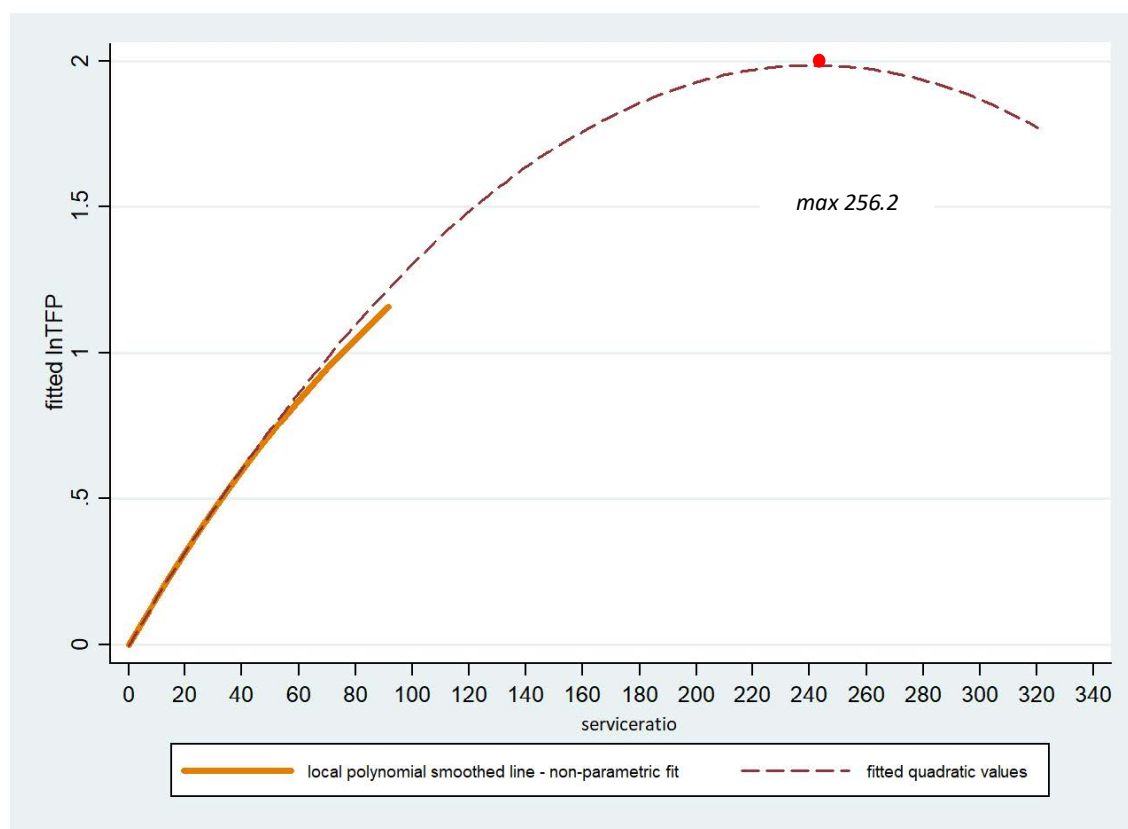
Regarding the estimation results obtained in models (2), (3) and (4) as well as the graphs prepared based on the results of GAM model (locally smoothed polynomial function as well as fitted quadratic function), it should be concluded that the correlation between the ratio of the external services to renumeration costs takes the form of a quadratic function. Together with the increase in the ratio (*serviceratio*), TFP goes up to the maximum value of relation at level of 256.2. As the value of *serviceratio* exceeded the maximum only in case of 4 records it can be stated that in the analysed panel the correlation is positive. However, that correlations differentiate when looking into sub-panels with the breakdown by the size classes.

Table 7 Estimation results for FE models based on the sub-populations by size classes

Specification	FE model (5) Entities with the no of persons employed:			FE model (6) Entities with the no of persons employed:		
	from 10 to 49 persons	from 50 to 249 persons	250 persons and more	from 10 to 49 persons	from 50 to 249 persons	250 persons and more
	lntfp	lntfp	lntfp	lntfp	lntfp	lntfp
serviceratio	0,01304***	0,0101***	0,01117***	0,01856***	0,01197***	0,00916**
	(0,00039)	(0,00083)	(0,00227)	(0,00052)	(0,00122)	(0,00363)
serviceratio2				-0,00005***	-0,00003**	0,00007
				(0)	(0,00001)	(0,00009)
renumshare	-0,00477***	-0,00039*	0,0015***	-0,00436***	-0,00029	0,00143***
	(0,00015)	(0,0002)	(0,0004)	(0,00015)	(0,00021)	(0,00041)
exportshare	0,0015***	0,00211***	0,00158***	0,0015***	0,00211***	0,00158***
	(0,00007)	(0,00008)	(0,00016)	(0,00007)	(0,00008)	(0,00016)
d	-0,14458***	-0,00442	0,07152	-0,14669***	-0,00449	0,07103
	(0,04199)	(0,05211)	(0,13127)	(0,04197)	(0,05211)	(0,13127)
e	-0,04774*	0,03274	-0,14961	-0,04592*	0,0325	-0,14967
	(0,02663)	(0,03526)	(0,10634)	(0,02662)	(0,03526)	(0,10634)
f	0,08205***	0,01663	-0,07456	0,08216***	0,01689	-0,07473
	(0,01274)	(0,02012)	(0,04983)	(0,01274)	(0,02012)	(0,04983)
g	-0,06289***	-0,13114***	-0,0862***	-0,06212***	-0,13095***	-0,08635***
	(0,00895)	(0,0136)	(0,03143)	(0,00895)	(0,0136)	(0,03143)
h	-0,09733***	-0,09284***	-0,26715***	-0,09783***	-0,09165***	-0,26752***
	(0,01769)	(0,03018)	(0,07564)	(0,01768)	(0,03019)	(0,07564)
i	-0,13883***	-0,07911*	-0,27392**	-0,13907***	-0,07932*	-0,27381**
	(0,02673)	(0,04493)	(0,11972)	(0,02672)	(0,04493)	(0,11972)
j	0,03106	-0,09933***	-0,22718***	0,03115	-0,0998***	-0,22741***
	(0,01963)	(0,0303)	(0,05798)	(0,01963)	(0,0303)	(0,05798)
l	0,35445***	0,21291***	0,15644*	0,35436***	0,21272***	0,15589*
	(0,01734)	(0,03158)	(0,08855)	(0,01734)	(0,03158)	(0,08855)
m	-0,05882***	-0,14727***	-0,29887***	-0,05944***	-0,14779***	-0,299***
	(0,01657)	(0,02404)	(0,04957)	(0,01657)	(0,02404)	(0,04957)
n	-0,03623**	0,02794	-0,12847***	-0,03648**	0	-0,12832***
	(0,01797)	(0,02568)	(0,04349)	(0,01796)	(0,02568)	(0,04349)
Constans	5,0793***	5,43166***	6,05998***	5,06166***	5,42722***	6,06403***
	(0,00729)	(0,00922)	(0,01917)	(0,00737)	(0,00946)	(0,02)
No of observations	406 599	186 909	45 298	406 599	186 909	45 298
No of groups	77 179	28 910	6 071	77 179	28 910	6 071
R^2 within	0.0123	0.0065	0.0049	0.0131	0.0065	0.0049
R^2 between	0.0663	0.0428	0.0236	0.0371	0.0432	0.0236
R^2 overall	0.0847	0.0379	0.0228	0.0738	0.0383	0.0226

*Standard error in brackets *** p<0.01, ** p<0.05, * p<0.1*

The values of the coefficients of determination R^2 for the above models indicate a similar model fit. The F-test significance results allow us to reject the null hypothesis, at any significance level, that none of the

explanatory variables has a significant impact on the explained variable. The estimation results of model (6), which assumes a linear relationship between lnTFP and the ratio of external services to renumeration costs, indicate that the key explanatory variable is statistically significant for the model for all sub-population of size classes.

The introduction of the square of the *serviceratio* variable into model (6) allows us to conclude that in the case of entities with the number of persons employed from 10 to 249, the relationship between lnTFP and *serviceratio* has the form of a quadratic function, whereas in the population of entities with the number of persons employed 250 and more, the square of the key variable is statistically insignificant.

The coefficients estimated for the control variable are consistent with expectations in case of companies with the number of persons employed from 10 to 249. In the population of entities with the number of persons employed 250 and more, an increase in the share of renumaration costs is positively correlated with TFP what is against the theory of economy.

Similarly to models estimated for total panel of enterprises, the differences in the coefficient of determination R^2 obtained for models (5) and (6) are insignificant. Therefore, when interpreting the results, in particular to determine the ranges of values of the ratio of external services to renumeration costs (*serviceratio*) for which TFP increases, a graphical presentation of the relationship between the fitted lnTFP obtained within model (7) and the key explanatory variable *serviceratio* was used. For individual sub-populations of the panel, according to size class, graphs of the locally smoothed polynomial function and the fitted quadratic function were developed.

Table 8 Estimation results for GAM models based on the sub-populations by size classes

Specification	Model GAM (7)		
	Entities with the no of persons employed:		
	from 10 to 49 persons	from 50 to 249 persons	250 persons and more
	lntfp	lntfp	lntfp
renumshare	-0,00848***	-0,00465***	-0,00115**
	(0,00017)	(0,00023)	(0,00047)
exportshare	0,00053***	0,00075***	0,00068***
	(0,00006)	(0,00007)	(0,00014)
d	-0,26846***	-0,09556*	0,00867
	(0,04908)	(0,05541)	(0,13802)
e	-0,13978***	-0,08611**	0,1919
	(0,03067)	(0,03857)	(0,11973)
f	0,04799***	0,06422***	0,01447
	(0,01463)	(0,02058)	(0,05164)
g	-0,04764***	-0,06003***	0,02429
	(0,01021)	(0,01423)	(0,03433)
h	-0,13435***	-0,09976***	-0,22905***
	(0,02014)	(0,0316)	(0,07264)
i	-0,1469***	-0,18136***	-0,07502
	(0,03046)	(0,0485)	(0,1398)
j	0,05041**	-0,00848	0,01726
	(0,02186)	(0,03035)	(0,063)
l	0,20637***	0,19589***	0,1283

	(0,02003)	(0,03196)	(0,09019)
m	–0,04361**	–0,07471***	–0,01271
	(0,01865)	(0,02514)	(0,05214)
n	–0,04328**	0,00429	–0,03928
	(0,02025)	(0,02561)	(0,04588)
No of observations	319 709	163 810	41 252
R²	0.016	0.006	0.001

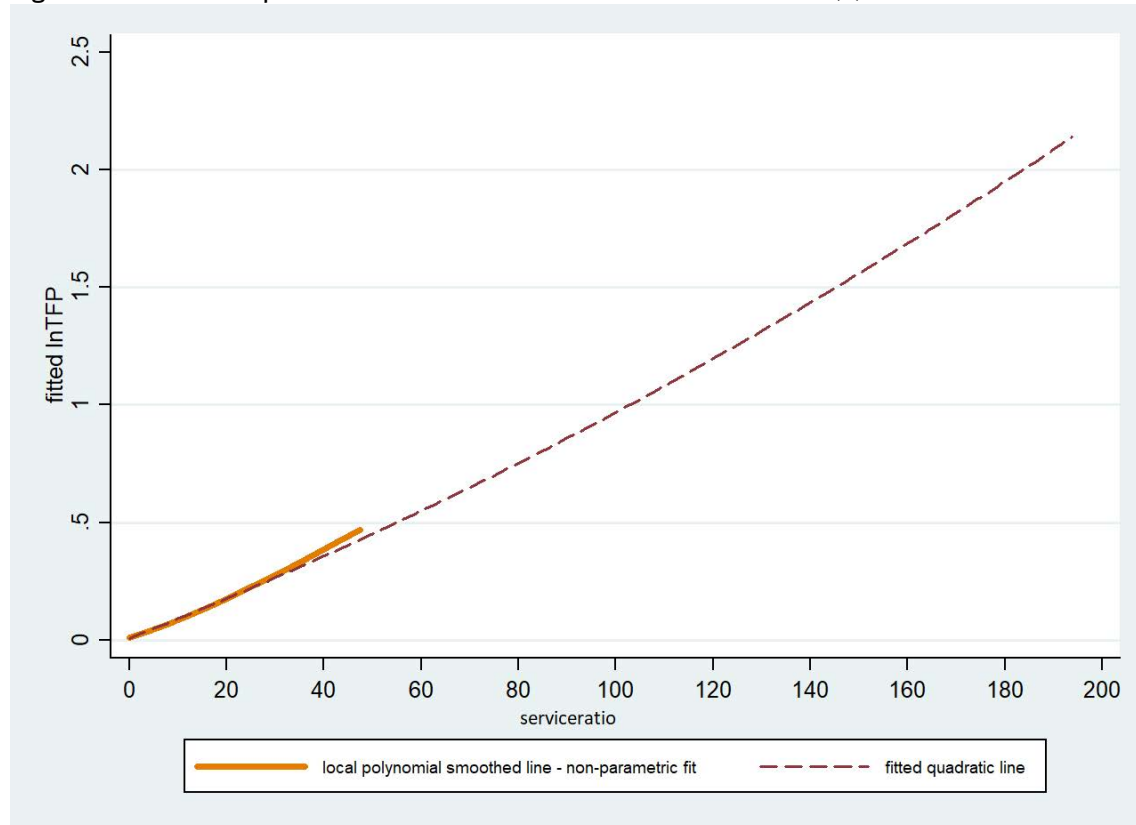*Standard error in brackets *** p<0.01, ** p<0.05, * p<0.1*

Figure 17 Relationship curves between fitted lnTFP from GAM model (4) and *serviceratio* for companies 10_49
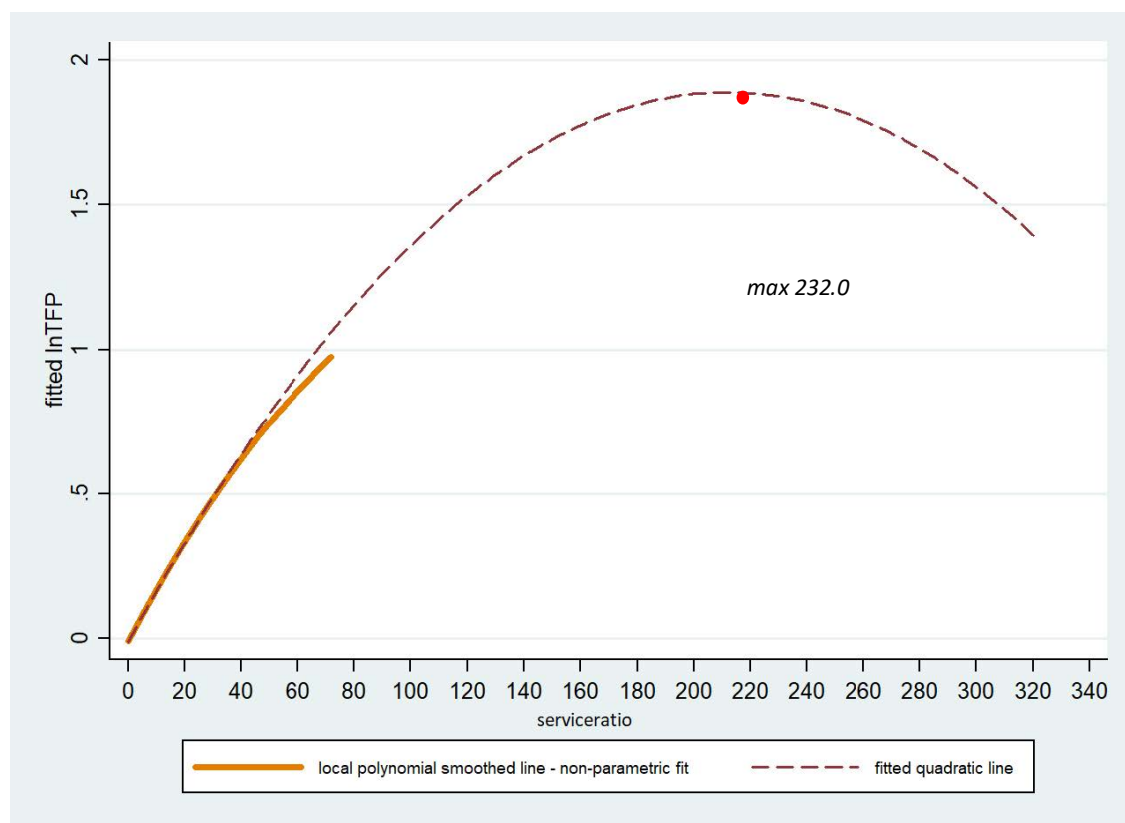
For the population of enterprises with number of persons employed from 10 to 49, the TFP rises together with the increase in the ratio of the external services to renumeration costs until it reaches the level of 232. After exceeding that maximum the TFP starts to fall. However, in the analysed sub-population such situation concerns only 7 records.

The local polynomial spline curve indicates a sharp increase in TFP following the parabola for quadratic fitted values in the range of ratio between 0-approx. 70.

Figure 18 Relationship curves between fitted lnTFP from GAM model (4) and *serviceratio* for companies 50_249

In the population of enterprises with number of persons employed from 50 to 249, the TFP goes up in the entire domain of function. Both lines for the fitted quadratic values as well as the fitted locally spline polynomial function are coherent to each other and indicate the positive correlation.

Figure 19 Relationship curves between fitted lnTFP from GAM model (4) and *serviceratio* for companies 250+
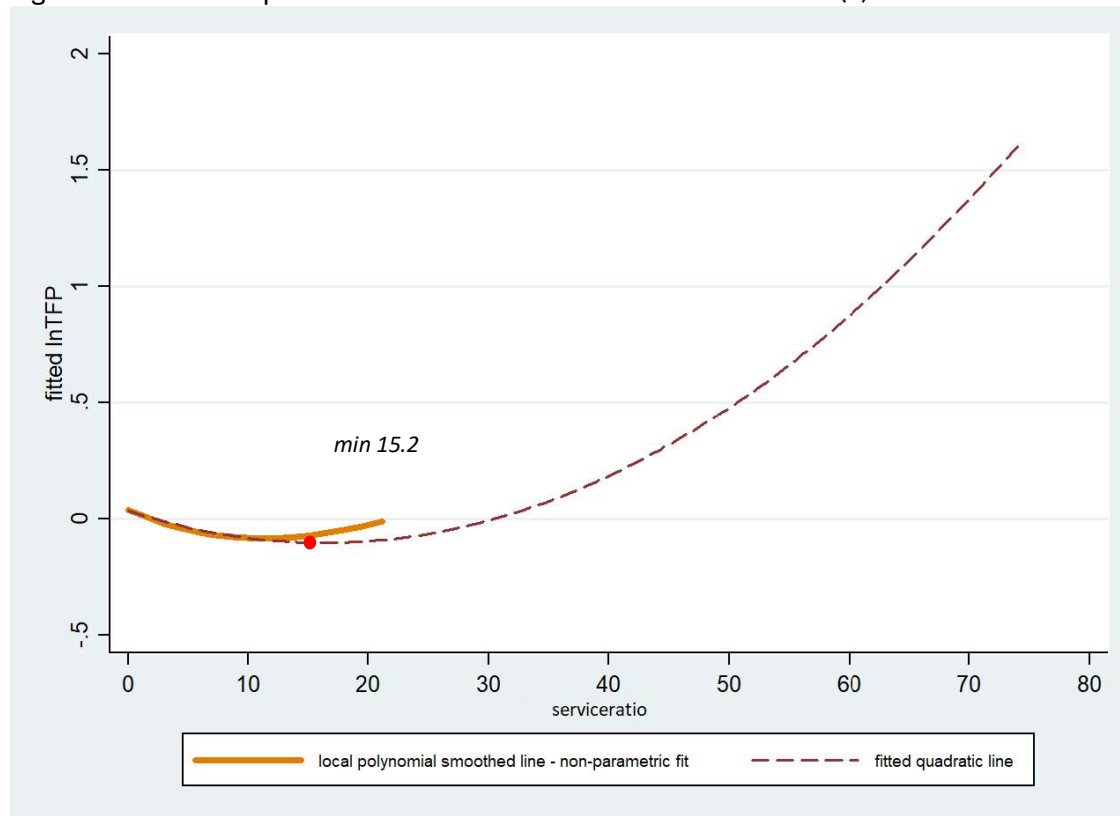
According to the quadratic function in the case of the biggest enterprises (with the number of persons employed 250 ad more) the TFP slightly decreases till the ratio of external service to renumerartion costs reaches the level of 15.2. Then it starts to increase. The negative correlation takes place in case of 142 records (0,3%).

Conclusions

1. The correlation between the services outsourcing and the productivity of enterprises is differentiated and depends on the approach to the variable reflecting the phenomenon as well as the size of enterprises measured by the number of persons employed[8].

2. Generally, together with the increase in the share of services purchased from third companies in the operating costs of enterprises its TFP decreases, however, the negative correlation doesn't take a linear form. Based on the results of (FE and GAM) models estimated for the enterprises in Poland it is concluded that the TFP decreases sharply when the share of outsourced services in operating costs rises up to the level of about 33%. Then it decreases slower up to reaching minimum at the level of 53.5% share. After exceeding that value the TFP starts slow increasing, but the positive correlation concerns only approx. 8% of records in panel as total.

   Simultaneously, if the ratio of the purchased service to the renumeration costs of enterprise goes up the increase in the TFP is recorded (on average 1 p.p increase corresponds to 1.4% rise in the TFP). The

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[8] As well as the type of business activity

estimates of FE and GAM model shows also that the TFP rises until the ratio of the purchased service to the renumeration costs reaches the value approx. 256. However, regarding that the maximum was exceeded only in 4 records it can be concluded that the correlation is positive.

3. When looking into the sub-population of enterprises with the number of persons employed from 10 to 49 the findings are similar to those obtained for total panel (mainly due to the fact that the this group of companies constitutes almost 64% of total number of entities in panel). The share of external services in the operating costs is negatively correlated with the TFP (only 9.2% presents positive correlation). The TFP decreases sharply when the share of outsourced services in operating costs rises up to the level of about 32% and reaches its minimum at the level of 52.2% share. Then the TFP starts slow increasing, but the positive correlation concerns only approx. 8% of records in panel as total.

    In the same time, together with the rise in the ratio of the purchased service to the renumeration costs the TFP goes up (on average 1 pp increase corresponds to 1.3% rise in the TFP). Regarding the estimates of FE and GAM models it is founded that the TFP increases until the ratio gets the value of approx. 232. In the analysed panel the maximum was exceeded only in 7 records.

4. In the the sub-population of enterprises with the number of persons employed from 50 to 249 it was observed very slight positive correlation between the share of external services in operating costs and the TFP (on average 1 p.p increase corresponds to 0,04% rise in the TFP). However, the estimates for FE as well as GAM model show that this correlation is rather non-parametric. The TFP decreases dynamically up to the share of external services at the level of 32%. The minimum of TFP is reached when the share of external services is about 55.5%. After exceeding that value TFP is stable.

    When taking into account the ratio of external service to the renumeration costs it turn out that there is a positive correlation with the TFP in the entire domain of function. The increase of that ratio by 1 pp is related with the rise of TFP by about 1%. The same findings results from FE and GAM models.

5. In case of enterprises with the number of persons employed 250 and more establishing the correlation between the share of external services in the operating costs and the TFP using parametric methods is challengeable. Both forms of FE models (with linear as well as quadratic form of key variable) turn out to be statistically insignificant. Moreover, estimates for one of the control variable – the share of renumeration costs in the operating costs – are contradictory to the theory of economy. However, based on the GAM model estimates as well as the graphical interpretation it is concluded that together with the rise in the share of external services the TFP drops in the entire domain of function.

    When regarding the ratio of the external services to the renumeration costs it is positively related with the TFP - 1 pp increase corresponds to 1.1% rise in the TFP (on average). However, the estimates for GAM model show that the when the ratio of external services to renumeration costs is 15.2 or less the TFP slightly decreases (it concerns 142 records in sub-panel) and after exceeding that minimum the TFP goes up.

6. Based on the results obtained for both variable representing different aspects of services outsourcing it is concluded that the rise in the purchase of services is not enough in order to boost the productivity of enterprise. It has to be related with the simultaneous resigning from producing services inside the company reflected as the drop in i.e. the renumeration costs.

VI.   Challenges for the future

Undoubtedly, measuring various aspects of services outsourcing as well as establishing the relationship between services outsourcing and enterprise productivity constitute significant challenges for statistics. The activities undertaken as part of the methodological work referred to in this paper are one of the first attempts to solve the presented research topic.

For future it is planned:

1) Searching for further variables that could provide a proxy for services outsourcing (including the necessary data sources);
2) Establishing the relations between the services outsourcing and TFP regarding the type of business activities (at the NACE section level);
3) Establishing the relations between the services outsourcing and TFP regarding the category of outsourced services;