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Improvements in the Area of Logistics Processes Improving Company Productivity

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Abstract:

Purpose: *The aim of this article is to present a validation of the author's method of productivity research with a particular focus on logistics processes.*
Design/Methodology/Approach: *The article presents the results of a productivity case studies with a special focus on logistics processes for 3 Polish enterprises. An analysis of the literature was made to present the research gap. A productivity survey method consisting of several steps is presented. Including proposals for the structure of indicators used to measure the level of productivity in an enterprise by the logistics processes implemented. The article includes a compilation of 4 case studies in a group of medium and large manufacturing enterprises in which, based on the productivity analysis of logistics processes, a weak logistics process was identified and improvements were implemented. The research desk analysis aims to show the impact of the application of the approach of the presented productivity survey method on the indicators of the productivity level in enterprises.*
Findings: *The case studies demonstrate the application of the described method and confirm the validity of conducting productivity studies taking into account partial productivity indicators by logistics processes.*
Practical implications: *Verification of the presented method shows that productivity analysis including logistics processes and their improvements bring positive results to enterprises.*
Originality Value: *The presented method was verified excluding micro and small enterprises due to its complexity and the requirements of detailed analysis in a team. The development of a method for studying the productivity of an enterprise in terms of the logistics processes implemented.*

Keywords: *Production, manufactures, logistics processes managing, productivity growth.*

JEL codes: *D24, L60.*

Paper type: *General review, research article.*

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1. Introduction

Productivity growth is seen in the modern world as one of the most important sources of economic growth, social progress and improvement of society's standard of living. This attitude has made productivity growth a national goal pursued on a massive scale in all enterprises in many countries, regardless of the type of products produced or services provided (Piętowska-Laska, 2012; Rawat *et al.,* 2018).

Productivity is important for enterprises because it allows to assess the state of development of the enterprise, paying attention to the resources used in the production process. Through productivity analysis, it is possible to assess the impact of the consumption of individual input resources. Productivity is sought to be increased, as are other economic categories: performance, efficiency and profitability.

Many productivity indicators are mentioned in the literature (Kosieradzka, 2012; Michlowicz, 2012; Myronenko, 2019), but the impact of logistics and its elements on productivity is dealt with perfunctorily. Logistics is one of the elements in a manufacturing enterprise that affects productivity. So far, it has been pointed out as one of the aspects through which productivity can be influenced. This is due to the fact that the logistics system of an enterprise requires the involvement of capital related to infrastructure and is related to the inventory maintained in enterprises (Bendkowski and Matusek, 2013; Croxton *et al.,* 2001).

Productivity metrics dedicated to logistics processes can be found in the literature. However, there is a lack of a productivity measure that will comprehensively assess the logistics of an enterprise in terms of productivity analysis.

Therefore, an attempt was made to develop a method for studying the productivity of an enterprise in terms of the logistics processes implemented.

2. Literature Review

The literature presents productivity as a complex issue, analyzed on many levels. Both at the micro-scale in enterprises and globally for the national economy. Productivity growth is equated with increased prosperity in the economy (Piętowska-Laska, 2019). Klaus Schwab (2016) writes that productivity is measured as labor productivity or an indicator of total productivity, slows down in the decade preceding the survey. This was noted despite a sharp acceleration in technological advances and investment in innovation (Productivity Brief, 2015).

Productivity is a relationship between the goods and services produced in a certain period, and the resources consumed to produce them in that period (A Guide to Productivity Measurement, 2011).

Contemporary determination of productivity is manifested in the dual approach to the term productivity, namely (Pietowska-Laska, 2019):

- economic and social, i.e., focusing the way of thinking on a constant search for ways to improve the current state of the system,
- technical, which is a measure of the efficiency of the system.

The study of enterprise productivity mainly focuses on assessing productivity due to inputs to the production process, i.e. capital, labor, energy and material (Myronenko, 2012; OECD, 2021; OECD, 2024). However, logistics processes in manufacturing enterprises are becoming increasingly important (Szymonik, 2011; Twaróg, 2003).

The authors Dubey *et al.* (2022) show that some implications of new technologies in logistics processes can increase productivity. The use of automation and robotization contributes to reducing the employment of human labor in process execution.

A good example was presented in the papers (Grencikova *et al.,* 2020; Yang *et al.,* 2023). The employment or number of working hours is a component of the measure of labor productivity (Ergül and Göksel, 2020).

Reducing the execution time of individual processes, or the execution of work by robots and cobots, affects the number of labor hours in the enterprise in production. On the other hand, processes are being automated and robotized, which requires capital investment to all resources (Bettiol *et al.,* 2023; Rostek 2024).

In a manufacturing company, taking into account the phase division of logistics, it stands out (Blanchard, 2004; Christopher, 2016):

- distribution – to spread the product throughout the marketplace such that a large number of people can buy it,
- production - this process includes managing raw mate-rials to form a product, it mainly includes organising materials in chronological order,
- reverse logistics - waste management is included in this process, the journey of a product from a company to the storage,
- supply (purchasing) - management and logistics for production materials,
- transport - this stage refers to the transportation of stored goods to the destination, it basically tracks the journey from warehouses to the client, resources to the company and also inside the manufacturing company,
- warehousing - the process of storing physical inventory for sale or distribution.

The proposed productivity study cycle (Figure 1) was developed with a special focus on logistics processes in the company. In the presented model, 5 stages can be distinguished (Rostek and Knosala, 2018):

1) classification of processes,
2) preparation of data for analysis,
3) analysis and evaluation of productivity,
4) development of an improvement program,
5) control.

Productivity surveys with special emphasis on logistics processes in a company can be implemented as one of the management processes in a company. Before undertaking such a process, it is necessary to decide who will be responsible for performing the productivity assessment of logistics processes. It is best to engage several people for this task who are very familiar with the enterprise and the processes implemented in it.

The department in charge of logistics processes and/or the departments of the enterprise that are responsible for the implementation and proper operation of individual logistics processes are engaged in the classification of the logistics processes being implemented. This is the first stage of the proposed method for studying productivity in manufacturing enterprises with special emphasis on logistics processes.

The second stage, and partially the third stage of the method presented, is carried out by a team that studies logistics processes. To this team should be appointed people who are associated with the implementation of individual logistics processes in the company.

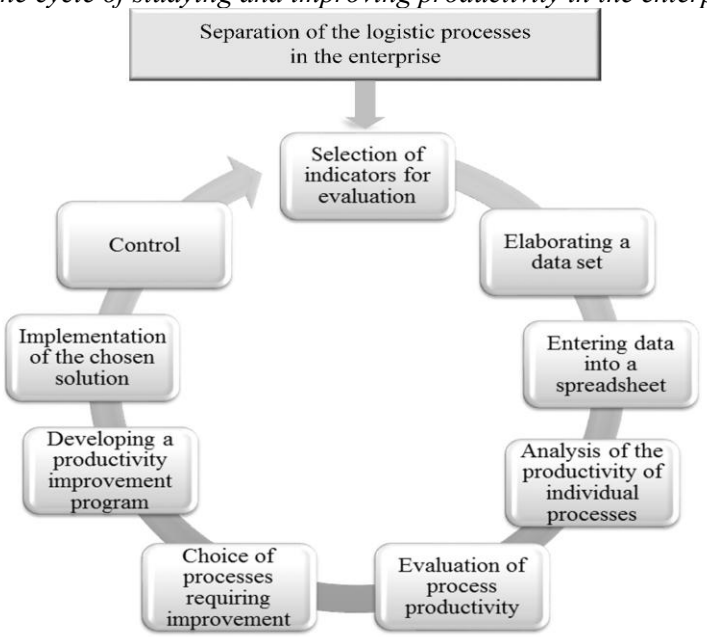
It is advisable that the team should include at least one person involved in each area of logistics, i.e., one representative each associated with procurement, distribution, production logistics, warehousing, transportation, handling reverse logistics.

Stage two begins with the selection of indicators for analysis. The author's method proposes two classifications of productivity indicators. The basis for the first way of distinguishing partial indicators was the resources used.

Wanting to study productivity with a special focus on logistics processes, it was decided to propose a second way, in which the basic criterion for the division of indicators is the logistics processes carried out in the enterprise, and the next level of detailing concerns the resources used to carry out individual logistics processes (Figure 2).

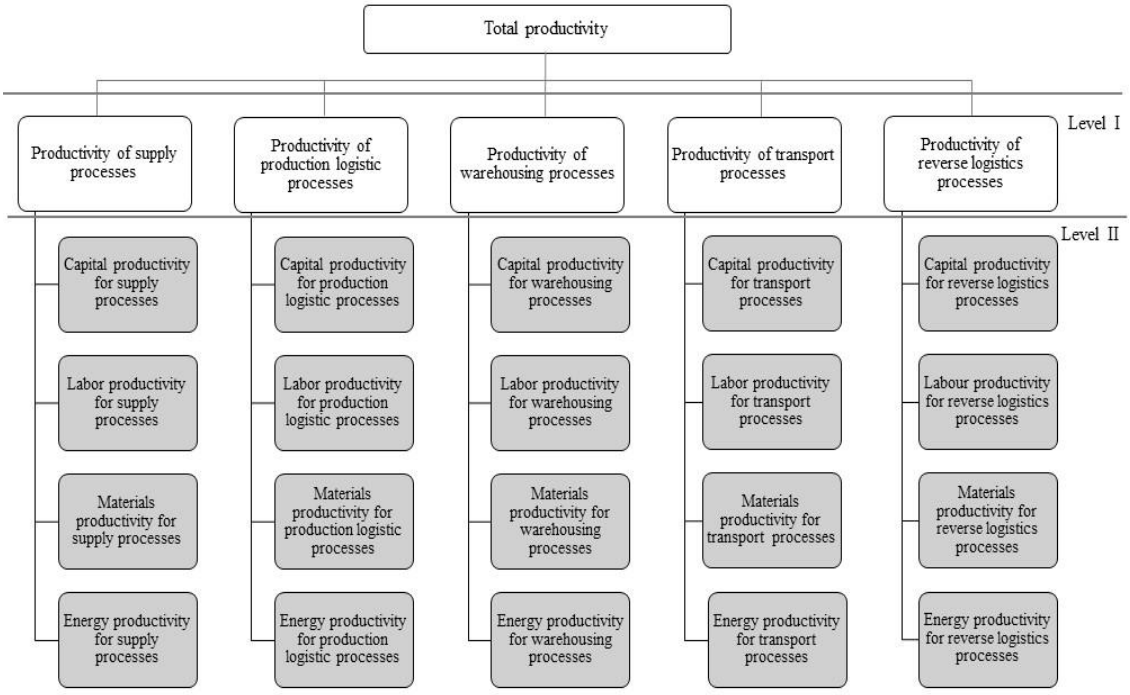
Sets of productivity indicators for the proposed divisions were developed. These are universal sets, containing indicators that are applicable to most enterprises. It is suggested to choose one indicator for each logistics process. If necessary, a more detailed analysis should be made, in which level II indicators are determined for at least one process.

Figure 1. *The cycle of studying and improving productivity in the enterprise*



Source: *Rostek and Knosala, 2018.*

Figure 2. *Division of productivity indicators due to logistics processes*



Source: *Rostek and Knosala, 2018.*

A compiled list of data required for analysis, that is, to determine the indicators to be analyzed, is submitted to the controlling department. This list is compiled by the productivity study team. Those responsible for controlling in the company, after receiving the list, are tasked with preparing the set of required data. A tool has been developed for this purpose.

Piętowska-Laska (2019) presents a sample sheet that can be adapted to the needs of the analysis being performed. For each process occurring in the enterprise, a sheet of logistics process inputs and outputs should be completed. The data should be entered into the spreadsheet by a team of logistics process analysts, and after determining the values of the indicators, should be analyzed in terms of the productivity of the enterprise with special attention to logistics processes.

The next step is to assess the productivity of the mentioned processes, based on which a process requiring improvement is selected. An improvement solution is developed for this process. A decline in the productivity of a logistics process in the long term, or instability, indicates the need for intervention.

The last stage of the method presented is the inspection, which is carried out by the company's controlling department. The inspection should end with a final report with conclusions. After this stage, the cycle of productivity survey in the enterprise for logistics processes is completed.

According to the process management approach, it is advisable to perform the survey again. Therefore, the established logistics process examination team can be disbanded, changed or operate continuously.

3. Research

3.1 Case 1: Medium-Sized Food Enterprise

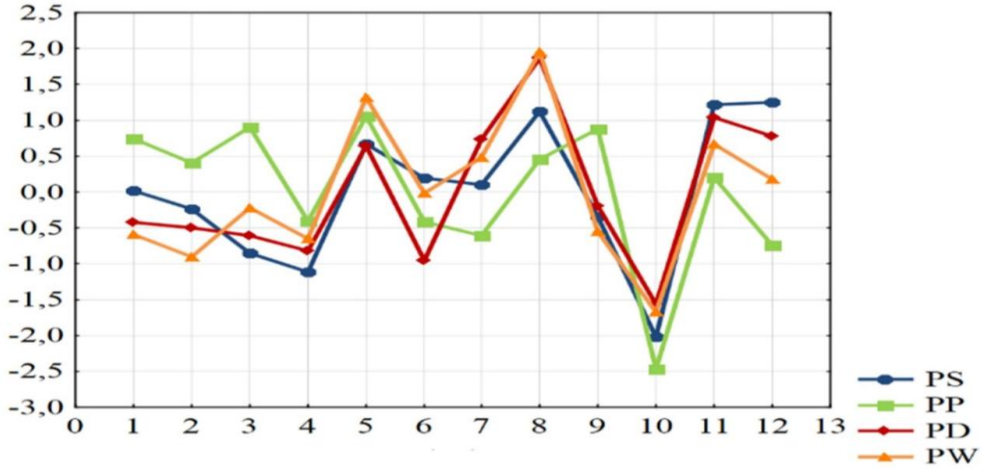
In the first enterprise, the survey was conducted according to the method described. All the steps were implemented, starting with adapting the general procedure to the conditions at the enterprise. In the company under study, after learning about the processes and the possibilities of collecting data, it was decided to determine indicators for 12 months.

In addition to determining the total productivity of the company, it was decided to determine the following partial productivities for logistic processes distribution (PD), production (PP), warehouse (PW) and procurement (PS) (Figure 3). The study of partial productivity showed that opportunities for changes in distribution should be sought.

The manager of the study, being familiar with the processes and knowing that energy fluctuations depend primarily on the state of the warehouse, which are

dependent on orders and the way distribution processes are carried out, decided to think about opportunities for improvements in distribution processes first.

Figure 3. *Partial productivities for the first company taking into account the breakdown due to logistics processes - values after standardization*



Source: *Author's study.*

Among several ideas, it was decided to think in detail about hiring an additional employee. This was a viable solution from the point of view of the company's management. This solution would allow to streamline the work of the existing team and focus on obtaining new orders. An additional person in the team could help raise the level of customer service.

On the negative side, an increase in costs associated with hiring a new employee was noted. Improving the operation of distribution processes will reduce energy costs if it leads to a reduction in the use of the warehouse, that is, it will reduce the cost of energy consumed and should improve productivity. The solution was accepted.

The solution was implemented from the sixteenth month (Figure 4). An inspection after three months showed that positive trends were already evident in the following months, that is, a gradual increase in the productivity of distribution processes, up to 14% per month.

In addition to the increase in process costs, which was expected, there was also an increase in sales revenue of just under 20% compared to the month before the improvement.

For the total productivity index, an increase in value was recorded after a slight slump. In addition to distribution processes, total productivity is affected by other processes, so the increase was not significant.

3.2 Case 2: Large Energy Company – Example 1

In the second enterprise, the procedure was adapted to the conditions at the enterprise before the productivity survey cycle was implemented. The step of classifying logistics processes was omitted, as this had already been done at the enterprise. The productivity survey was then carried out according to the subsequent steps of the method described. The second division of productivity indicators was applied. It began with the determination of indicators of total productivity and partial productivity for the following processes (Figure 5): procurement (PS), production (PP), distribution (PD), warehouse (PW) and transportation (PT).

Figure 4. *Total productivity for company one – standardised values*

Source: *Author's study.*

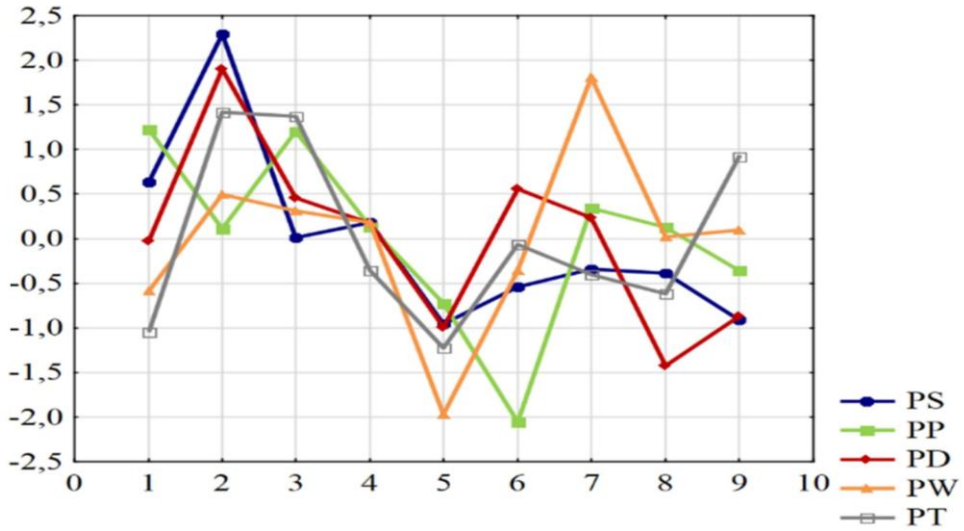
Analysis of partial productivity shows that all indicators collapsed in the fifth month, except for manufacturing, which recorded the largest decline in the sixth month. A significant decrease in the value of the partial productivity index was recorded for procurement processes - by 3.4 units, which is more than 25%. These processes are also characterized by high volatility, almost 20%. The productivity of warehousing processes has improved over the nine months and is the most stable, as its index of variation is about 10%. Transportation processes stand out for having the highest variability, over 25%.

There was an increase in the productivity of transportation processes for nine months. The highest decrease in the value of the productivity index for procurement

processes is a sufficient argument for selecting these processes for further analysis, with the aim of finding a logistics weak spot.

During the development of the improvement solution, the focus was on better supply planning. It was decided to verify suppliers and employees working on unloading deliveries. The unloading zone of deliveries was described more clearly, which made it easier for employees to find the destination of a given raw material and led to a reduction in unloading time. The unloading zone was allowed to be planned by the employees who unloaded.

Figure 5. *Partial productivities for the second company taking into account the breakdown due to logistics processes - values after standardization*



Source: *Author's study.*

It was decided to conduct the audit four months after the fully prepared recommendations began to be applied. After collecting data for a period of fifteen months, the validity of the implemented changes was verified. From the results presented, it can be seen that procurement processes show higher productivity. In the last month of the controlled period, the value was comparable to the second month.

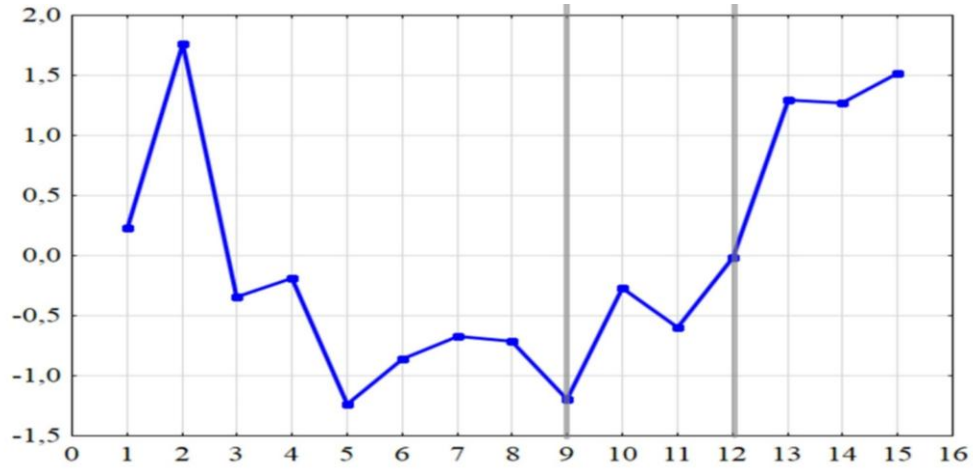
This gives an increase of 68% compared to month nine. Total productivity (Figure 6) in the same period increased by 4.5%. It is worth noting that since the implementation of the improvements (month 12) for the total productivity index there has been no drop below the value recorded for the twelfth month.

3.3 Case 3: Large Energy Company – Example 2

Another example to verify the developed productivity survey method, with a special focus on logistics processes, was carried out in the second company as well, after the

inspection stage of the first improvement. The productivity study cycle began with the preparation of data for analysis. This step consisted of updating the earlier data set with values for the following months. The second cycle of the study involved analyzing and evaluating productivity over a fifteen-month period. The first partial indices determined in the company, in addition to total productivity (PC), were the productivity values of procurement (PS), production (PP), distribution (PD), warehouse (PW) and transportation (PT).

Figure 6. *Total productivity for company two for example 1 - standardised values*



Source: *Author's study.*

In order to make better management decisions in the selection of processes for improvement, it was decided to make forecasts for productivity indicators, since inference based on the coefficient of variation did not clearly identify the logistics process that could be considered the weakest link. For total productivity, the forecast was determined based on the Holt model.

The lowest errors are characterized by the model with parameters $\alpha=0$ and $\beta=0$. The average absolute error indicates that it is slightly underestimated. The sub-indices were forecast based on a 4 element moving average. Forecasts were made for 2-, 3-, 4- and 5-element moving average models. In each case of sub-productivity, the 4-element moving average allowed to build forecasts with the smallest error.

Based on the projected values (Table 1) and from the analysis of the change in the values of the indicators in the subsequent period, it was decided that the logistic storage processes needed improvement. Despite their slight stabilization, a 22% decrease in the sixteenth period is predicted.

The focus was on solutions to reduce inventory maintenance costs. In order to improve warehouse operations, an ABC/XYZ analysis of inventory held in the

warehouse was performed. It made it possible not only to group inventories and make appropriate management decisions, but prompted management to revise the quantities of inventory held. First of all, the maintained levels of group C, or occasionally used, inventory were reduced. The company has a work-in-progress warehouse.

This warehouse should theoretically contain raw materials, materials, semi-finished products that will be necessary for the final production process, which is assembly. In this regard, it was decided to reorganize the work at this site and provide semi-finished products immediately before their use. This resulted in a reduction of inventory costs for work-in-progress. Production was also adjusted to this solution.

Table 1. Forecast of productivity indicators in the second company - results

	PC	**PS**	**PP**	**PD**	**PW**	**PT**
ME	-0.00030	0.20020	0.06757	-0.01964	-0.12599	-0.08338
MPE	-1.37%	0.09%	0.24%	-1.12%	-4.92%	-6.41%
MAPE	7.51%	9.82%	15.78%	8.98%	15.02%	15.68%
MSE	0.00004	2.39092	0.82184	0.18090	1.86632	0.08726
RMSE	0.00641	1.54626	0.90655	0.42532	1.36613	0.29539
Forecast	0.06887	15.04418	5.70701	4.36093	7.31076	1.39980
Change	-0.00026	-1.21456	0.57833	-0.24717	-2.07800	0.03430
Change in percentage	-0.37%	-7.47%	11.28%	-5.36%	-22.13%	2.51%

Source: Author's calculations.

After three months of operation of the new rules, a stage of control of the achieved results was carried out. All partial productivity indicators for a period of twenty months were collated together. The implemented rules made it possible to reduce the cost of work-in-progress inventory by 12% over a period of four months. There was a 20% decrease in the total value of materials stored in warehouses. Production levels have increased in recent months (Figure 7), hence the slight increase in overall warehouse costs.

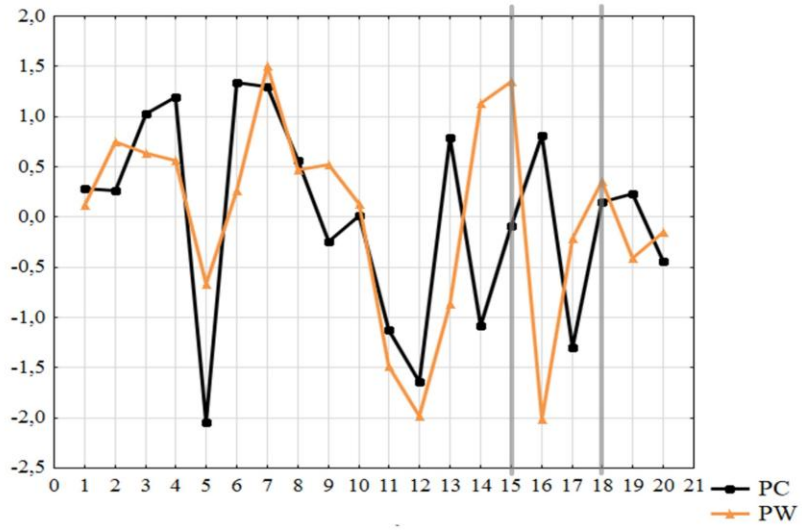
Overall, the productivity of warehousing, as well as transportation, improved during the period under review. An improvement in the productivity of production processes has been noted in recent months. This situation is indicative of increasingly better use of the resources at hand. In this case, logistics processes are analyzed, hence the conclusion that the functioning of logistics processes is getting better.

3.4 Case 4: A Medium-Sized Enterprise in the Automotive Industry

A third company was verified. This is a medium-sized enterprise in the automotive industry. This enterprise is engaged in the production of trailers based in one of the Polish provinces. It is thriving in its field. Verification of the developed method was

carried out at the second medium-sized enterprise, where logistical processes related to procurement, production, transportation, storage and waste management are carried out. Successive stages were carried out in accordance with the proposed method for studying the productivity of the enterprise. Each of these stages was carried out according to the developed productivity study procedure for a third-party enterprise.

Figure 7. *Total productivity (PC) and partial productivity for the warehouse (PW) for company two for case three - standardised values*



Source: *Author's study.*

Productivity analysis and evaluation was carried out at two levels over a period of 12 months. First, productivity indicators were determined: total and partial productivity indicators for the implemented logistics processes: procurement (PS), production (PP), warehouse (PW), transportation (PT) and waste management (PR). The results for a whole research are shown in Figure 8. And then the process with the greatest potential in improving the company's productivity is analyzed in detail. The last two months have been characterized by declines in the values of total as well as partial productivity indicators.

In order to better analyze productivity and make the right decision as to which process needs improvement, it was decided to make forecasts of individual indicators (Table 2).

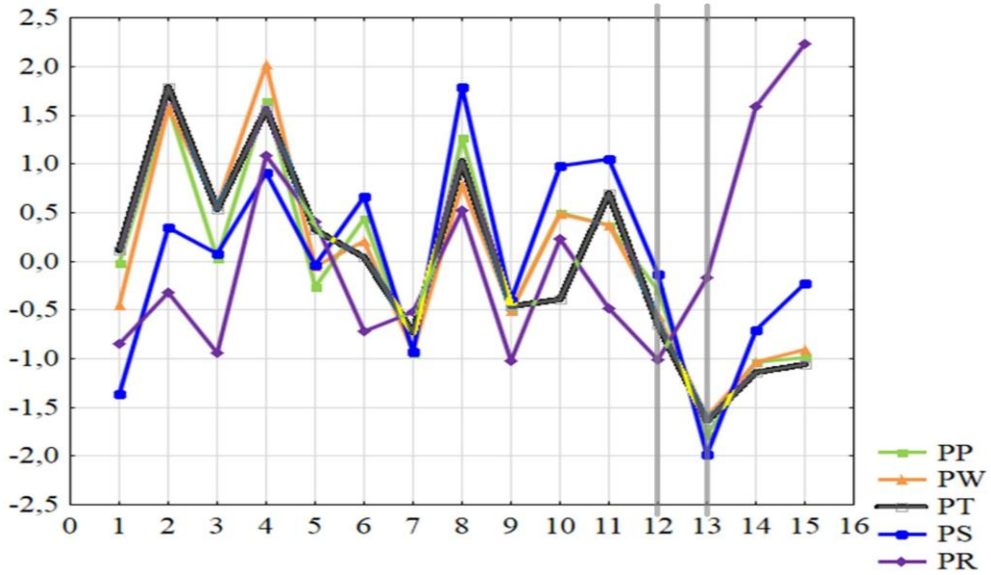
In the case of this enterprise, forecasts were built based on a linear trend model for indicators of total productivity and productivity of production, warehousing and reverse logistics processes. The formulas for each model are as follows:

- for total productivity y_t^*= -0.1189*t+6.5226, (1)

- for production processes y_t^*= -0.1331*t+7.3558, (2)
- for storage processes y_t^*= -3.8623*t+151.7900, (3)
- for reverse logistics processes y_t^*= -124.7600*t+9389.9000, (4)

where: t - time [1,2,3...,n].

Figure 8. *Partial productivities for the third company – values after standardization*



Source: *Author's study.*

For the other indicators, the moving average 4-element method has the lowest errors. The high value of the RMSE index indicates that the quality of forecasts is not the best. In view of this, it was decided to build an econometric model to assess which process significantly affects productivity.

The selection of variables for the model began with a preliminary analysis of the data. The coefficients of variation are at a level indicating medium variation in the data and, in the case of waste management, high variation in the data.

There is no quasi-constant variable, i.e., all partial productivity indicators can potentially explain the behavior of the total productivity indicator. In order to better select variables for the econometric model, the correlation between individual indicators was examined, from which it was concluded that production processes (PP) should be included in the model as an explanatory variable.

The scatter plot of total productivity against production logistics productivity shows a linear relationship. Hence, a linear regression model was chosen. Available tools in spreadsheets were used to determine the model formula and the coefficient of

determination, which indicates the extent to which the model explains reality. The model has the form:

$$PC = 0.0158+0.8835*PP. \quad (5)$$

The coefficient of determination is 0.9985. That is, the model is a very good fit to the empirical data (Table 2).

Table 2. *Forecast of productivity indicators in the second company - results*

	PC	**PP**	**PW**	**PT**	**PS**	**PR**
ME	0.000	0.000	-0.004	-6.290	11.008	-0.00723
MPE	-6.103%	-6.171%	-0.090	-3.659%	7.272%	-34.902%
MAPE	22.625%	22.784%	27.134%	24.554%	18.422%	62.250%
MSE	1.932	2.476	1361.143	896.060	2974.380	22675271
RMSE	1.390	1.574	36.894	29.934	54.538	4761.856
Forecast	4.977	5.626	101.580	109.980	262.664	7768.02
Change	0.408	0.406	14.225	20.228	34.766	4278.635
Change in percentage	8.918%	7.776%	16.284%	22.537%	15.255%	122.619%

Source: *Author's calculations.*

Productivity indicators were determined and analyzed for the second level of detail, that is, the productivity of logistical production processes: capital, labor, materials and energy. The first two months are characterized by a very large amplitude of fluctuations. In the case of energy consumption, it shows stabilization after this period. The consumption or use of the other analyzed inputs fluctuates. There is no noticeable downward or upward trend and no stabilization. At this stage of the analysis, it was considered worthwhile to analyze holistically the activities performed in the implementation of logistic processes related to production.

In connection with the development of the enterprise, it was decided to implement the theory of constraints (TOC). Process improvement using the TOC method requires the identification of bottlenecks. It was shown that the bottleneck in the effort to improve productivity is the organization of production. Changes are being made in the company on a continuous basis and affect many areas. In line with the goal of the analysis, it was proposed to reorganize the rules related to receiving materials from the warehouse.

Now, once a week, the order of the production tasks to be carried out is determined and it is decided when the buffer warehouse is to receive the relevant materials. In addition, the buffer warehouse must be replenished before the next stage of production begins (it used to vary). In addition, the company has introduced the Poka-Yoke method. Robots are not used in production, so in order to eliminate the mistakes of the welding shop workers, the structures have special holes to make it easier to assemble the parts and weld them in the right place.

The introduction of TOC has also involved warehousing. However, the reorganization of warehouses is still underway. Among other things, it was decided to organize storage space and organize materials on racks. Until now, materials, raw materials went into storage according to the principle: where there is space. Now the warehouse has been planned and equipped with the right racks for storage. The warehouses are being prepared for the introduction of barcode-based warehouse management systems.

Three months after the start of the improvements, the validity of their implementation was verified by analyzing productivity indicators. All indicators recorded a gradual increase in value. The most noticeable increase was recorded for waste management, however, it should be borne in mind that this is a highly variable process and the indicator is sensitive to small fluctuations in costs associated with the implementation of waste management processes. The remaining processes show a similar pattern to total productivity.

4. Conclusion

The main objective of the article was to present a method for studying productivity in manufacturing enterprises with a special focus on logistics processes and to show that improving logistics processes can lead to improvements in enterprise productivity. The results of productivity studies resulting from several years of cooperation with enterprises engaged in production were presented.

The study did not end with merely identifying improvement solutions and giving recommendations to enterprises, but made improvements and verified the effects of the measures taken. In view of the inclusion of a results control stage in the developed method, it was decided to extend the study and in enterprises select an improvement to be implemented and later verify it.

The benefits that can be observed after applying the presented method are:

- detailed analysis of logistics processes,
- increase in productivity,
- increase in competitiveness,
- systematization of the logistics processes of the enterprise,
- increased awareness of the condition of the enterprise and its productivity,
- increase in innovation of the enterprise,
- experience and knowledge in productivity research.

On the basis of the research and verification of the developed method, the following conclusions were made:

- There is an increase in the awareness of enterprises and their employees

regarding productivity knowledge, and above all, its importance in enterprise management.
- There is a rationale for conducting research on the productivity of logistics processes from the perspective of their management.
- The classification of realized logistics processes in manufacturing enterprises requires an individual approach.

In contrast to the productivity survey methods presented in the literature, the developed method includes a comprehensive system of indicators taking into account logistics processes.

- Small changes in logistics processes can bring tangible benefits to the enterprise.
- There is a need to make transformations of productivity measurement and analysis methods in order to more effectively build productivity improvement programs in enterprises.
- An important criterion of the developed method for enterprises is its user-friendliness and simple application, i.e., no advanced knowledge is required and it is based on the use of the most popular calculation tool and little advanced analytical methods.
- It is planned to adapt the productivity of logistics processes for application in logistics services.

References:

A Guide to Productivity Measurement. 2011. Singapore: Spring.

Bendkowski, J., Matusek, M. 2013. Logistyka produkcji praktyczne aspekty. Część I Planowanie i sterowanie produkcją. Gliwice: Wydawnictwo Politechniki Śląskiej.

Bettiol, M., Capestro, M., Di Maria, E., Ganau, R. 2024 . Is this time different? How Industry 4.0 affects firms' labor productivity. Small Business Economics, Vol. 62, pp. 1449-1467. doi: https://doi.org/10.1007/s11187-023-00825-8.

Blanchard, B.S. 2004. Logistics engineering and management. Pearson Prentice Hall, New York.

Christopher, M. 2016. Logistics and Supply Chain Management. Pearson Education/ Financial Times.

Croxton, K.L., García-Dastugue, S.J., Lambert D.M., Rogers, D.S. 2001. The Supply Chain Management Processes. The International Journal of Logistics Management, Vol. 12 Issue 2, 13-36. DOI: 10.1108/09574090110806271.

Dubey, G., Gupta, R.K., Kumar, S., Kumar, M. 2022. Study of industry 4.0 pillars and their uses in increasing productivity and reducing logistics defects. Materials Today: Proceedings, Volume 63, 2022, pp. 85-91. https://doi.org/10.1016/j.matpr.2022.02.335.

Ergül, Ö., Göksel, T. 2020. The effects of technological development on the labor share of national income. Economic Modelling, 87, pp. 158-171. https://doi.org/10.1016/J.ECONMOD.2019.07.015/

Grencikova, A., Kordos, M., Berkovic, V. 2020. Impact of Industry 4.0 on labor productivity in the Slovak Republic. Problems and Perspectives in Management, 18(2), pp. 396-408. https://doi.org/10.21511/ppm.18(2).2020.32.

Kosieradzka, A. 2012. Zarządzanie produktywnością przedsiębiorstwa. Warszawa: C.H. Beck.

Michlowicz, E. 2012. Zarys logistyki przedsiębiorstwa. Kraków: Wydawnictwo Akademii Górniczo-Hutniczej.

Myronenko, Y. 2012. Productivity – measurement and improvement. Stockholm. http://www.diva-portal.org/smash/get/diva2:551581/fulltext01.pdf.

OECD. 2021. OECD Compendium of Productivity Indicators 2021. OECD Publishing. https://doi.org/https://doi.org/10.1787/f25cdb25-en.

OECD. 2024. OECD Compendium of Productivity Indicators 2024. OECD Publishing. https://doi.org/10.1787/B96CD88A-EN.

Piętowska-Laska, R. 2012. Doskonalenie produktywności we współczesnych przedsiębiorstwach. Ekonomia i Zarządzanie, no 2/2012, pp. 82-91.

Piętowska-Laska, R. 2019. Productivity management in the contemporary enterprise - analysis, evaluation and improvement. Humanities and Social Sciences, XXIV (26(4/2019)), 115-125.

Rawat, G.S., Gupta, A., Juneja, C. 2018. Productivity Measurement of Manufacturing System. Materials Today: Proceedings. 2018, Volume 5, Issue 1, s. 1483-1489. DOI: 10.1016/j.matpr.2017.11.237.

Rostek, M. 2024. Impact of new technologies on total factor productivity in the context of Industry 4.0. Zeszyty Naukowe Organizacja i Zarządzanie Politechnika Śląska, No 197, pp. 481-492. DOI: 10.29119/1641-3466.2024.197.26.

Rostek, M., Knosala, R. 2015. Mapa procesów logistycznych w przedsiębiorstwie produkcyjnym w aspekcie oceny jego produktywności. In: M. Karkula (Ed.), Zarządzanie przedsiębiorstwem. Teoria i praktyka, pp. 165-176. Kraków: Wydawnictwo Akademii Górniczo-Hutniczej.

Rostek, M., Knosala, R., 2018. Verification of the method for assessing productivity, taking into account logistical processes in manufacturing companies. In: Hamrol, A., Ciszak, O., Legutko, S., Jurczyk, M., Advances in Manufacturing. Lecture Notes in Mechanical Engineering. Springer, Cham, 57-66. DOI: 10.1007/978-3-319-68619-6_6.

Schwab, K. 2016. The Fourth Industrial Revolution. World Economic Forum.

Szymonik, A. 2011. Logistyka i zarządzanie łańcuchem dostaw. Część II. Warszawa: Difin.

The Conference Board. 2015. Productivity Brief 2015.

Twaróg, J. 2003. Mierniki i wskaźniki logistyczne. Poznań: Instytut Logistyki i Magazynowania.

Yang, G.Z., Si, D.K., Ning, G.J. 2023. Does digital transformation reduce the labor income share in enterprises? Economic Analysis and Policy, 80, pp. 1526-1538. https://doi.org/10.1016/J.EAP.2023.10.025.