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AN ANALYSIS OF THE EFFICIENT USE OF MACHINERY IN AN ALUMINUM EXTRUSION PLANT

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Abstract
This paper discusses the impact of various factors on a company's manufacturing efficiency of aluminum alloy products. The research was based on SWOT analysis, Gantt chart and the chart-based graphs showing the production capacity distribution on individual production machines.

1. Introduction

The mechanisms used in the organization of production and company management constitute important elements of a company's strategic planning. If utilized appropriately, they can strengthen a company's position in the markets and increase its levels of production. Proper management solutions employ different practices whose aim is to regularly evaluate the condition of a company, to analyze the market, to develop plans, and to find methods to reach these goals. Importantly, SWOT analysis is often used to effectively evaluate a company's condition. It helps to gauge the company's position from a global perspective and takes into account not only external, but also internal factors, which leads to an ongoing monitoring and forecasting of production. This article employs this methodology as a means of measuring the manufacturing efficiency of aluminum alloy products, and to address the fundamental question of how to increase the efficiency of production.

Companies' levels of innovativeness have an impact on the development of their innovative potential. Research conducted in this field in Poland shows that a low level of corporate innovation in the metal industry is the result of insufficient state supported innovativeness, and the absence of an innovativeness-oriented corporate culture [12]. The study also indicates that some factors which impact corporate innovativeness result from objective reasons, whereas others follow from an approach taken by the entrepreneurs. At this juncture, it is necessary to point out that it is difficult to interfere in company matters, especially in private corporations'. It is not possible if entrepreneurs themselves show an interest and a willingness to improve their companies' situation, and therefore introduce changes.

It is necessary to point out that the efficiency of the production process has a direct impact on a company's profits, and as such is one of the key elements which inspires an entrepreneur's interest in innovation, and encourages them to introduce structural changes to production. More efficient methods of production are not only determined by technological factors, but also by changes or improvements which lead to an increase in profitability of the company. However, there are areas frequently underestimated which do not require a great deal of substantial financial commitment, but which may nevertheless significantly boost efficiency. These are concerned with the evaluation of current production management, risk evaluation of upcoming changes, and the analysis of the economic environment. They are based on the monitoring and the organizational supervision of the production process.

Productivity is defined as "a measure of effective functioning of an operating system and an indicator of a company's efficiency and competitiveness" [6]. Efficiency is also a basic index which reflects an organization's profitability and its capability of surviving on the market.

According to experts, labor productivity may be enhanced through:

1. the improvement of operational activities,
2. the increased level of employee engagement.

Productivity is calculated in monetary units utilizing the ratio: Productivity of employee= production output/direct labor input.

Corporate performance management (CPM) involves the monitoring and management of an organization's performance having regard to such key performance indicators as as profit, return on investment, as well as operating costs. CPM systems include such modules as forecasting, budgeting and planning. The use of CPM makes it possible to follow the results of particular units by monitoring performance indicators.

It is not possible to make wise decisions without a reliable, up to date, and efficient system which collects and processes data concerning a unit and its environment [14]. In order to be able to properly analyze and compare the planned results with the actual ones, it is necessary to collect data and information which make the evaluation of key performance indicators feasible. There are various methodologies which affect the performance of management e.g. Six Sigma, Balanced Scorecard, Activity-based Costing, Total Quality Management or Theory of Constraints.

The position of companies on the national, European and global markets largely depends on the determination of managers to modernize technologies, to keep up with the demands of the market, and to monitor the means of production which significantly affect company productivity. SWOT analysis is one of the oldest and most effective methods used to evaluate the potential of production ventures [8, 9]. SWOT is an efficient tool to assess the strengths and weaknesses of a company, or segments of its production. It is also used to draw conclusions based on the current state of a company and to show ways of improving the structure of its production methods.

With the use of SWOT analysis it is possible to evaluate the potential of a company on the basis of the following four variables:

- S – strengths,
- W – weaknesses,
- O – opportunities,
- T – threats.

SWOT analysis offers several approaches to the analysis of a situation. The first approach postulates to treat strengths and weaknesses as internal factors, and opportunities and threats as external ones. The second approach sets out to specify strengths and weaknesses as factors pertaining to the present, and opportunities and threats as those affecting the future. The third approach considers strengths and weaknesses to be subjective factors, and opportunities and threats as those beyond our control. In order to carry out a full and complete examination of a situation, it is necessary to employ an analysis of the interrelation between these factors.

SWOT analysis can be a useful tool to evaluate the performance of departments or units in a company, to analyze the competition, to assess market attractiveness, to assess the potential of employees, to choose an appropriate strategy for an organization of production, to assess production risk, etc.

This article uses SWOT analysis to evaluate a segment of the manufacturing process of aluminum alloy products. It also proposes changes to the structure of the organization in order to increase production capacity.

2. SWOT analysis used in the production of aluminum alloy profiles

The four-field matrix presented below illustrates the classification of factors affecting the strategy of manufacturing aluminum alloy profiles (Table 1).

The matrix distinguishes between factors controlled by a company and factors beyond its control. SWOT analysis is subjective and therefore, may fail to cover all the factors affecting the analyzed area.

The stability of technology is considered a strength, and ensures the long-term, consistent production of the same products. This may, in turn, reduce production costs. After all, constant changes and short-term production methods generate higher costs. Another production strength is the company's own machine shop because having such an asset makes it possible not only to quickly deal with new orders, but also to keep newly developed solutions within the company. Another strong point includes the company's own presses operated by a group of qualified employees possessing extensive experience and trained to fulfill various orders for different types of products. It is very beneficial because this increases production and export potential. Employing workers with the necessary professional education and showing a willingness to invest in their qualifications is also regarded as a very positive strong point. Last but not least, the company's cooperation with various research centers also motivates management to raise their qualifications, and promotes their initiatives.

The weaknesses include employee turnover especially in lower level positions, as well as errors which inevitably occur in a huge manufacturing enterprise. A particular lack of management flexibility is also regarded as a weakness. After all, it may result in a decrease in productivity and work performance. Technological problems coupled with an excessive use of equipment are also regarded as a serious weakness which may hinder order fulfillment.

The factors presented above may be eliminated and their negative impact diminished through some appropriate management actions. Obviously, apart from the factors which may be controlled by a company there are also elements which lie beyond a company's control. The latter ones could pose a threat to the company as they could possibly hamper its development and lead to a loss in profitability.

Table 1. Matrix of factors which impact the efficiency of the manufacture of aluminum alloy profiles – SWOT analysis.

	SWOT	
	Strengths (S)	Weaknesses (W)
Factors controlled by the entrepreneur	1. Stability of technologies 2. Having one's own machine shop 3. Ability to match production to meet customer demands 4. Extensive potential to produce and export 5. Substantial staff experience 6. Constant development of staff qualifications 7. Facilitating the optimization of technologies and service productivity 8. Ability to implement new solutions	1. Lack of flexible management at lower levels 2. Excessive use of machines 3. Staff failure to maintain technological regimes/standards 4. Staff fluctuations 5. Risk of mismatching technology to orders 6. Failure to meet deadlines as a result of technical problems 7. Restrictive environmental regulations (energy, environmental protection)
	Opportunities (O)	Threats (T)
Factors beyond the company's control	1. Rising demand for a range of aluminum products 2. The company's global contacts 3. Increase in innovation – cooperation with research units and experts 4. Order stability 5. A range of products with special features	1. Ethical standards of the entrepreneurs' market 2. Increase in competition among producers 3. Downturn in the global demand for the product 4. Downturn in the currency market 5. Price fluctuations 6. Problems with the quality of the purchased base materials 7. Problems with the availability of raw materials

Table 2 below illustrates the matrix of interrelations between these factors. The interrelationship between them highlights the most serious threats which might limit or decrease the company's projected profitability.

Table 2. Matrix of interrelation of factors (S – strengths, W – weaknesses, O – opportunities, T – threats).

	O1	O2	O3	O4	O5	T1	T2	T3	T4	T5	T6
	Rising demand for a range of aluminum products	The company's global contacts	Increase in innovation – cooperation with research units and experts	Order stability	A range of products with special features	Ethical standards of the entrepreneurs' market	Increase in competition among producers	Downturn in the global demand for the product	Downturn in the currency market	Price fluctuations	Problems with the quality of the purchased base materials
S1	2	2	2	2	1	1	0	0	1	1	2
S2	2	1	2	2	2	0	0	0	0	0	0
S3	2	0	2	0	1	0	0	0	0	0	0
S4	2	2	2	2	2	0	1	0	1	0	1
S5	2	0	2	2	2	0	0	0	0	0	0
S6	0	0	2	0	1	0	0	0	0	0	0
S7	2	1	1	1	2	0	0	0	0	0	0
S8	2	2	2	0	2	0	1	0	0	0	0
W1	0	0	1	0	1	0	1	0	0	0	0
W2	1	0	0	2	0	0	0	0	0	0	0
W3	2	0	0	0	0	0	0	0	0	0	0
W4	1	0	0	1	0	1	1	0	0	0	0
W5	2	2	0	2	2	0	2	1	0	1	0
W6	2	0	0	2	2	0	1	0	0	1	0
W7	1	2	0	0	0	1	1	0	0	0	0

1 – weak impact, 2 – strong impact, 0 – no impact

Table 3. SWOT table of the company strategy.

	Opportunities	Threats
Strengths	Aggressive strategy	Conservative strategy
	1. Strengths determined by the company's strategy prevail in the company, and in its environment there is plenty of opportunity for the increase of the production. 2. The assets of the company are the following: cooperation with research units and employees' qualifications as well as experience, modern machinery park, new technological solutions, competent management and continuous monitoring of the organization of the production.	1. The company has a number of strengths and is capable of dealing with external threats. 2. A number of strengths do not correspond with the opportunities to increase the production, but in certain conditions the strengths are able to overcome the threats.
Weaknesses	Competitive strategy	Defensive strategy
	1. The company's weaknesses outweigh the strengths, but due to the fact that the company operates in a conducive environment, it is capable of maintaining its market position. The internal weakness does not allow the company to make the most of the opportunities offered by the external environment.	1. The weaknesses of a company for example low demand and other external threats may cause the company bankruptcy.

The matrix of the interrelationship between these factors shows that the impact of the factors which pose a threat to the manufacturing of aluminum alloy products is negligible under the current state. Boxes T1-T6 largely have no impact on the other factors. Nevertheless, the stability of technology is affected by the changing parameters of order requests. In order to satisfy them, it is necessary to introduce technological modifications to the machinery In addition, the matrix shows an interrelation between the weaknesses W5-W7 (i.e. the risk of mismatching the technology to the orders, failure to meet deadlines as a consequence of technological problems, restrictive environment) and the threats.

In the light of the conducted analysis it was possible to create a table presenting the evaluation of the company strategy based on the data received (Table 3).

The analysis of various factors which help to determine the condition of the company and the interrelation of these factors helps us to reach the conclusion that the company assumed an aggressive strategy. Such a strategy guarantees the company a positive position in the market and will lead to the added development of productivity in the future.

3. Analysis of the company's production capacity

The timely and flexible fulfillment of orders which keeps up with market demands is an important factor in determining the condition of a company.

This analysis deals with the processing capacity of the company which has two separate units equipped with machines capable of producing a similar range of products. The analysis focuses on a selected segment of the external order fulfillment. Importantly, these units are managed independently of each other. The former is equipped with four machines, whereas the other with only two. It should be stressed that the machines in these two units are capable of performing their production tasks interchangeably and on any of these machines. The fact that the machines are managed separately may lead to an uneven distribution in the production process. On the one hand, this situation may lead to downtime in one unit; while on the other hand, the overuse of another unit can lead to a delay in the timely fulfillment of orders.

The Gantt chart below is an illustration of the distribution of the workload among the machines over a period of six months. This analysis seeks to identify a possible uneven distribution of the workload among the machines.

Table 4 shows the first unit composed of four machines, whereas Table 5 presents the second unit composed of two machines.

The first group consists of a unit with four machines. As illustrated above, within the first month the production capacity of the first machine was already exceeded. This over-production on the first machine resulted in the failure to fulfill the order requests in a timely manner, thus causing a delay in the order fulfillment. The second machine stands in stark contrast to the first one because the order load was far too low in relation to production capacity. The comparison of these two machines and the above graphic illustration of the order fulfillment processes constitute the first step towards a smoother and more effective distribution of the workload. This should lead to a more balanced distribution of the workload on the machines, and consequently ensure that orders are fulfilled in a more efficient and timely manner.

The workload and the distribution of orders in group 2 with two available machines are also disproportionate.

Figure 1 shows the workload of the machines in group 1 over the period of six months. The main line (bold) illustrates the overall ratio of production capacity to the order volume in this group. The result shows that order overload in the fourth month of the production led to the overload of the overall production capacity. Consequently, the fifth and sixth months saw a shift of the production to the following months, and a delay in the order fulfillment.

Figure 2 represents the overload of the machines in group 2 over the period of six months. The main line (bold) depicts the overall ratio of production capacity to the order volume in group 2. The results indicate that the increased order volume in the fifth month of the production brought about the overload of the production capacity in the fifth month, one month later than in group 1.

Table 4. Production capacity in group 1.

	Group 1				
	Orders [%]				
Month	Machine 1	Machine 2	Machine 3	Machine 4	Total for group 1
1	155	20	65	97	87
2	117	16	40	87	67
3	157	22	80	103	93
4	150	17	107	102	97
5	168	15	128	112	111
6	185	44	66	123	101

Table 5. Production capacity in group 2.

	Group 2					
	Machine 1		Machine 2		Total for group 2	
	Capacity [%]	Orders [%]	Capacity [%]	Orders [%]	Capacity [%]	Orders [%]
Month 1	100	67	100	97	100	83
Month 2	100	37	100	89	100	63
Month 3	100	39	100	106	100	73
Month 4	100	51	100	105	100	78
Month 5	100	87	100	123	100	105
Month 6	100	105	100	121	100	113

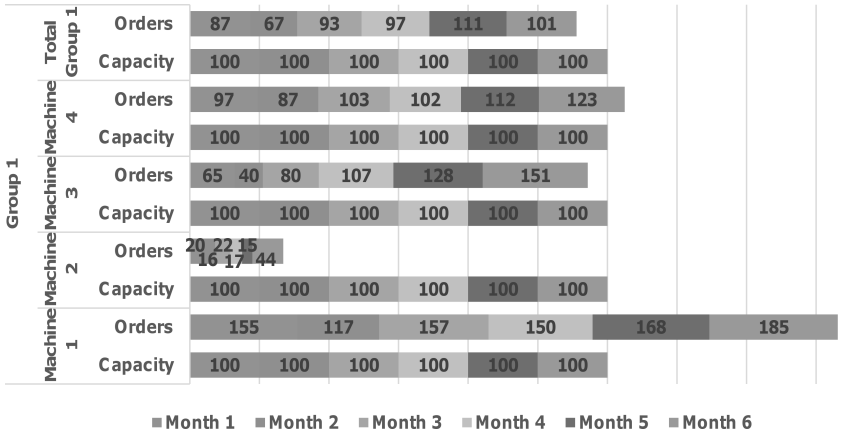

Fig. 1. Production capacity in group 1 (in %).

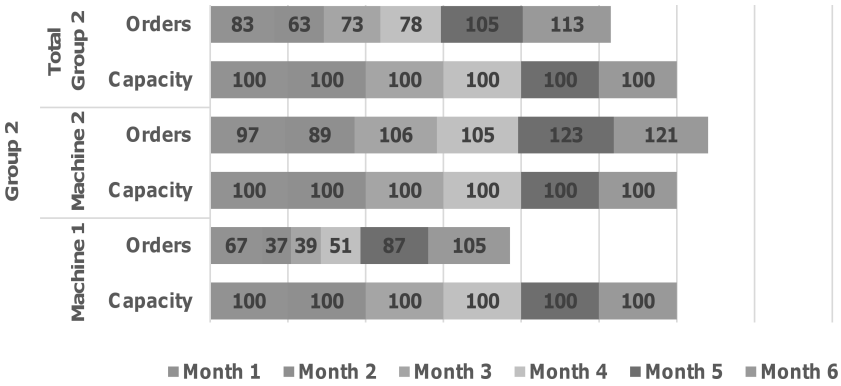

Fig. 2. Production capacity in group 2 (in %).

The data shows that even if the workload had been distributed in a more balanced way on the machines in group 2, the production capacity would still have been overloaded in the fifth month.

If the machine workload was distributed more evenly between the two groups from the very beginning of the analyzed period, the fourth month in both groups would also see a more balanced workload distribution. This would also lead to a more proportionate machine workload distribution in the following months. The analysis proves that the Gantt charts are effective tools to schedule production, and to identify the most troublesome areas in production throughout the industry.

Figures 3 and 4 show that the uneven distribution of the production workload causes downtime on some machines and overuse on the others. For example the failure to fully utilize the production capacity of machine 2 in group 1 leads to unnecessary downtime which leads to the company's loss of profits. The excessive workload on machine 1 in group 1 leads to a failure to deliver products on time to the client. This may, in turn, lead to the loss of that client. The consequences of losing a client are a loss in profitability and the risk of financial penalties. In order to ensure balanced management it is necessary to guarantee the proper management of the machinery sector. This is one of the pillars of a successful enterprise and its proper management ensures added profits for the firm.

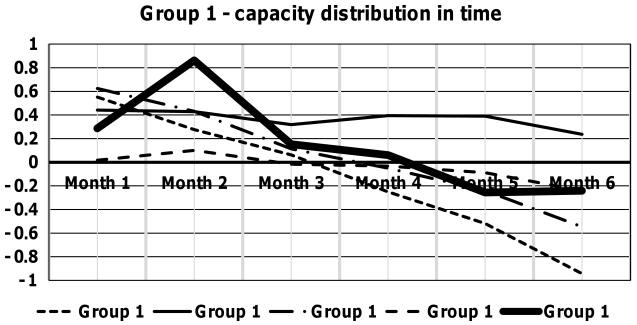

Fig. 3. The distribution of shifts which results from the difference between the production capacity and order load on individual machines in group 1. The bold line illustrates the course of the overall production capacity of this group.

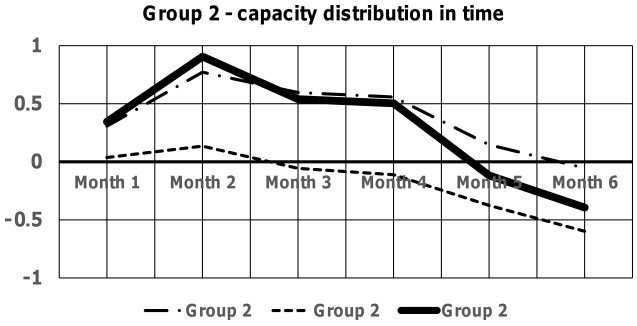

Fig. 4. The distribution of shifts which results from the difference between the production capacity and order load on individual machines in group 2. The bold line illustrates the course of overall process of production capacity of the group.

A more detailed economic analysis of this dynamic includes the evaluation of the downtime cost and the increased costs due to the delayed production. This six-month analysis showed production capacity underused by 7% in group 1, and by 14% in group 2. On the other hand, the machines in groups 1 and 2 were excessively overloaded, and this led to the need to extend the set time limits for the order to be fulfilled. In the case of group 1 the set time limits were extended by 14 % and in the case of group 2 by around 4%. It can be estimated that the potential loss on the EBIDTA indicator may range from 1.3% to 2.5% p.a.

The analysis shows that the uneven distribution of production on individual machines is economically unsound, as it leads to downtime for some machines and overuse of others. This overuse can lead to a delay in the required time of delivery of products which could negatively affect the company's relationship with its clients.

4. Summary

The issues related to productivity were first written about by the Scottish economist Adam Smith. In his book entitled, "An Inquiry into the Nature and Causes of the Wealth of Nations" [13], published in 1776, he remarked that, "The annual produce of the land and labor of any nation can be increased in its value by no other means, but by increasing either the number of its productive laborers, or the productive powers of those laborers who had before been employed". The economic productivity of labor is defined as the ratio of output produced per each measurable time unit of labor: i.e. per hour, day, month, or year. It can also be defined as the ratio of output produced or services provided per a fully employed worker. On the macro scale, the productivity of work is measured by the ratio of national income per capita and is an important indicator of the development of a nation's economy [5]. Taking into account productivity per hour of work, as calculated in euro, Poland occupies a lower place in the rankings [11]. However, between 1995–2013, Poland managed to increase the results from 5.2 euros to 10.6 euros. A similar development took place in Lithuania. Despite a high rate of economic growth in 2013, Poland still lags far behind such countries as Norway – 69.6 euros, Denmark – 53.4 euros. Unfortunately, Poland also falls below the EU average which is three times higher – 32.1 euros [11].

Apart from the human element, the efficiency of production is impacted by the implementation of specified methods of monitoring the machinery and technical equipment in a company. This also requires a cyclical evaluation of the effectiveness of the implemented actions, as well as the condition of the production equipment [1, 2]. The authors cited in [1, 2] present the factors which assess how effectively a manufacturing equipment functions. One means of examining these factors is known as, Overall Equipment Effectiveness (OEE).

OEE is the result of the examination of three parameters: availability, performance efficiency and quality. OEE indicators are process-oriented: i.e. accounting for the time of actual machine availability, but also performance efficiency (nominal performance vs. real performance) and a ratio regarding the quality of production (the number of properly manufactured products/the whole output produced). An OEE score exceeding 85% is considered world-class. The importance of the OEE metric was stressed by G. Chand and B. Shirvani [4] and other researchers in their numerous publications on the effectiveness of production [3, 7, 10].

The analysis of a selected segment of the production line focuses on crucial parameters which affect the efficiency of production, and consequently a company's profitability. From this point of view, the analysis should be an ongoing element of the corporate strategic planning, as it safeguards the company against logistical errors in the production processes. Furthermore, the condition of the company is also determined by its relationship with its clients in the economic environment. Maintaining a good rapport with them helps the company prosper in the economic environment, and facilitates their joint cooperation. A positive relationship between the company and other entities in the economic environment cannot be measured; nonetheless it has a great impact on the order fulfillment.

There is no golden rule which would ensure a completely smooth fulfillment of orders without any delays. Nevertheless, all the improvements to the process, even the tiniest ones, will add up to an increase in the company's profitability. In the light of the conducted analysis, it is the balanced distribution of the workload on all the machines in groups 1 and 2 which is required to properly fulfill the order requests.

The benefit of utilizing this analysis is that the decision making process is based on an increased number of reliable factors which can help to diminish the risk of production errors. One possible solution to the problem of maintaining a reliable manufacturing process which ensures the timely production and delivery of goods is making further investments in added machinery.

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References

[1] Antosz K., Stadnicka D., *TPM in large enterprises: study results*, World Academy of Science, Engineering and Technology, International Journal of Industrial Science and Engineering, October 2013; Issue 82, Barcelona, 3, pp. 320–327, ICIESM 2013: International Conference on Industrial Engineering and Systems Management. Barcelona, Spain October 14–15, 2013.

[2] Antosz K., Stadnicka D., *The results of the study concerning the identification of the activities realized in the management of the technical infrastructure in large enterprises*, Eksploatacja i niezawodnosc – Maintenance and Reliability, 16, 1, 112–119, 2014.

[3] Anvari F., Rodger E., Starr A., *Evaluation of overall equipment effectiveness based on market*, Journal of Quality in Maintenance Engineering, 16, 3, 256–270, 2010.

[4] Chand G., Shirvani B., *Implementation of TPM in cellular manufacture*, Journal of Materials Processing Technology, 103, 149–154, 2000.

[5] Dowgiałło Z. [Ed.], *Dictionary of economics for an entrepreneur* [in Polish], Wydaw. "Znicz", Szczecin, 1996.

[6] Gilbert R.D., James Stoner A.F., Freeman Edward R., *Management* [in Polish], Wydawnictwo Naukowe PWN, Warszawa, 2011.

[7] Kumar P., Shetty R.,Rodriques L., *Overall equipment efficiency and productivity of a news paper printing machine of a daily news paper company – a case study*, International Journal of Engineering Practical Research (IJEPR), 3, 1, February 2014, doi: 10.14355/ijepr.2014.0301.04.

[8] Łobodzińska D., *SWOT analysis – the first stage in designing* [in Polish], http:/mamstartup.pl/commons/1290/analiza-swot-pierwszy-etap-wprojektowaniu.

[9] Rdzeń K., *SWOT analysis and business plan – choice of model, industry, product, E-business Bible* [in Polish], Biblia e-biznesu, M. Dutko [Ed.], Gliwice, 2013.

[10] Samat H.A., Kamaruddin S., Azid I.A., *Maintenance performance measurement: a review*, Pertanica J. Sci. and Technology, 19, 2, 199–211, 2011.

[11] Sawicki L., *Shaping labour productivity in Poland at the beginning of the 21st century* [in Polish], Przedsiębiorstwo i Region, 7, 201, doi: 10.15584/pir.2015.7.10.

[12] Skrzypek S., Dąbrowski K., *Some reasons for the low level of innovativeness in Polish manufacturing companies in the metal and automotive industries* [in Polish], Zarządzania Przedsiębiorstwem, 2, 20–25, 2017.

[13] Smith A., *An inquiry into the nature and causes of the wealth of nations*, Volume One, 1776.

[14] Spoz A., *Accounting in the management of a modern enterprise* [in Polish], Zeszyty Naukowe Uniwersytetu Szczecińskiego, no. 879, Finanse, Rynki Finansowe, Ubezpieczenia, 77, 423–431, 2015.