APPLICATION OF MPI TO MEASURE THE PRODUCTIVITY OF THE METAL PRODUCTION SECTOR IN POLAND COMPARED TO OTHER MANUFACTURING INDUSTRIES

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Abstract

The main purpose of this paper is to compare the productivity of the metal production sector with other manufacturing industries in Poland. Estimation of the productivity was carried out using the Malmquist Productivity Index (MPI), which is based on a deterministic approach. Moreover a decomposition of calculated Malmquist index has made it possible to identify which factors (technological progress or changes in technical efficiency) determine the productivity change in metal production sector in Poland.

Keywords: Productivity, processing industries in Poland, metal production sector, Malmquist Productivity Index (MPI)

1. INTRODUCTION

Efficiency is the main criterion for a comprehensive assessment of activities of an entire industry sector [1] and individual economic operators [2], [3]. Efficiency is one of the sources of wealth of nations and various methods of defining and measuring it are proposed. A macro-economic approach to economic efficiency refers to how well the economy allocates scarce resources to meet the needs and demand of consumers [4]. Following the microeconomic approach, the efficiency of company is its capacity to transform expenditures into effects, where higher value of productivity indexes is indicative of a higher efficiency of a particular economic entity [5].

Productivity growth is necessary to produce higher quality goods in a more efficient method, which results in lower costs for consumers, and also to per capita incomes growth over time. Traditionally productivity has been considered as an important factor of the development process, allowing countries to increase production volumeat lower cost and release resources to other sectors [6]. There are two partial productivity measures - the labor productivity and the capital productivity. The Malmquist Index is a bilateral index that can be used to compare the productivity of two economies, sectors or companies. For the survey, Malmquist Index approach was used to identify metal industry efficiency and productivity. Unlike conventional production functions or other index approaches, the Malmquist Index can distinguish two sources of productivity growth: changes in technical efficiency and technical change. When applied to panel data, this approach can also identify the innovator sectors over time. The Malmquist approach does not require the assumption of efficient production, but instead identifies the ‘best-practice’ countries or sectors in every period, which gives an efficient production frontier, and measures each country's or sector’s output relative to the frontier.

Efficiency of industry sectors is a very complex economic issue and the methods used in its analysis have a few advantages and limitations. The integrated approach must be used - based on various methods that implement each other and therefore allow for formulation of even more credible conclusions [7].

In this study the “industry” is considered as three primary areas of economic activity which, according to the Polish Classification of Activiies (PCA) are formed by the following sections: - Mining and extraction, - Processing industry, - Electricity, gas and steam manufacturing and supply. The research encompasses 23 sectors classified as industrial processing which formed 16.7% of the GDP in Poland in 2013. Processing industry constitutes 84% of industrial production sold in Poland, 55% of tangible assets gross value and 83% of employment in industry as total. The metal industry sector is part of the processing industry and in the Polish

Classification of Activities (PCA) it is present in two sections: Manufacture of basic metals and Manufacture of metal products. In 2013 both sections was responsible for over 10% of industrial production sold in Poland, about 7% of the gross value of tangible assets in industry and 12% of employment in industry [8].

2. MATERIAL AND METHODS

The Malmquist Productivity Index (MPI) was adopted in order to compare the productivity of the metal production sector with other processing industries in Poland.

Malmquist Productivity Index is the most frequently used approach to quantification of changes in total factor productivity. Färe et al. [9] decomposed the MPI into two terms, as shown in eq. (1) that makes it possible to measure the change of technical efficiency and the shift of the frontier in terms of a specific DMU. This implies that productivity change includes changes in technical efficiency (EFCH) as well as changes in production technology (technical change TECH).

$$M(y_{t+1}, x_{t+1}, y_t, x_t) = \underbrace{\frac{D^t(y_{t+1}, x_{t+1})}{D^t(y_t, x_t)}}_{EFCH^{t+1}} \cdot \left[\underbrace{\frac{D^t(y_{t+1}, x_{t+1})}{D^{t+1}(y_{t+1}, x_{t+1})} x \frac{D^t(y_t, x_t)}{D^{t+1}(y_t, x_t)}}_{TECH^{t+1}} \right]^{\frac{1}{2}} \tag{1}$$

where x_t and x_{t+1} are input vectors of dimension l at time t and $t+1$, respectively y_t and y_{t+1} are the corresponding k-output vectors. D^t and D^{t+1} denote an input - oriented distance function with respect to production technology at t or t+1.

M measures the productivity change between periods t and t + 1, productivity declines if M < 1, remains unchanged if M = 1 and improves if M > 1.The first term on the left hand side captures the change in technical efficiency (EFCH) between periods t and t + 1. EFCH > 1 indicates that technical efficiency change improves, while EFCH <1 indicates efficiency change declines. The second term measures the technology frontier shift (TECH) between periods t and t + 1. A value of TECH >1 indicates progress in the technology, a value of TECH < 1 indicates regress in the technology. TECH = 1 indicates no shift in technology frontier. The technical efficiency change can further be decomposed into scale efficiency change (SECH) and pure technical efficiency change (PTEC) [10].

A simple example in the case of single input and output technology is illustrated in **figure 1**. The change in technical efficiency (EFCH), changes in production technology (TECH) and Malmquist Index in an input-orientation can be computed as [11]:

$$EFCH(P) = \frac{\frac{BD}{BP_2}}{\frac{AC}{AP_1}} \tag{2}$$

$$TECH = \sqrt{\frac{AC}{AE} \frac{BF}{BD}} \tag{3}$$

$$MPI = \frac{AP_1}{BP_2} \sqrt{\frac{BF}{AC} \frac{BD}{AE}} \tag{4}$$

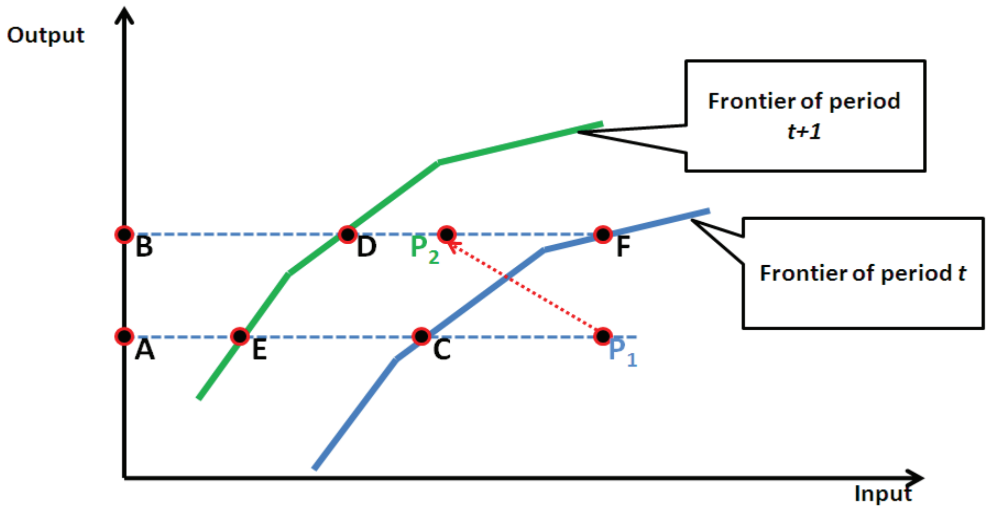

Figure 1 The Malmquist Productivity Index
Source: Cooper W., Seiford L., Tone K., 2007

3. RESULTS

The studies undertaken cover the 23 manufacturing sectors (processing industries) in Poland in years 2010-2014. The study was based on source data collected in the databases of Central Statistical Office of Poland [12] regarding the following processing industries:

- Manufacture of textiles;
- Manufacture of leather and related products;
- Manufacture of coke and refined petroleum products;
- Manufacture of other transport equipment;
- Manufacture of wearing apparel;
- Manufacture of products of wood, cork, straw and wicker;
- Repair and installation of machinery and equipment;
- Printing and reproduction of recorded media;
- Manufacture of machinery and equipment n.e.c.;
- Manufacture of rubber and plastic products;
- Manufacture of food products;
- Manufacture of furniture;
- Manufacture of chemicals and chemical products;
- Manufacture of pharmaceutical products;
- Manufacture of paper and paper products;
- Manufacture of basic metals;
- Manufacture of metal products;
- Manufacture of other non-metallic mineral products;
- Manufacture of beverages;
- Manufacture of electrical equipment;
- Manufacture of motor vehicles, trailers and semi-trailers;
- Manufacture of tobacco products;
- Manufacture of computer, elekctronic and optical products.

In order to determine factors for changes in total productivity of Polish processing industries, the Malmquist Productivity Index was used. The calculated model uses the following variables:

- effect - sold production in mln PLN,
- input 1 - average paid employment in thous.,
- input 2 - gross value of fixed assets in mln PLN.

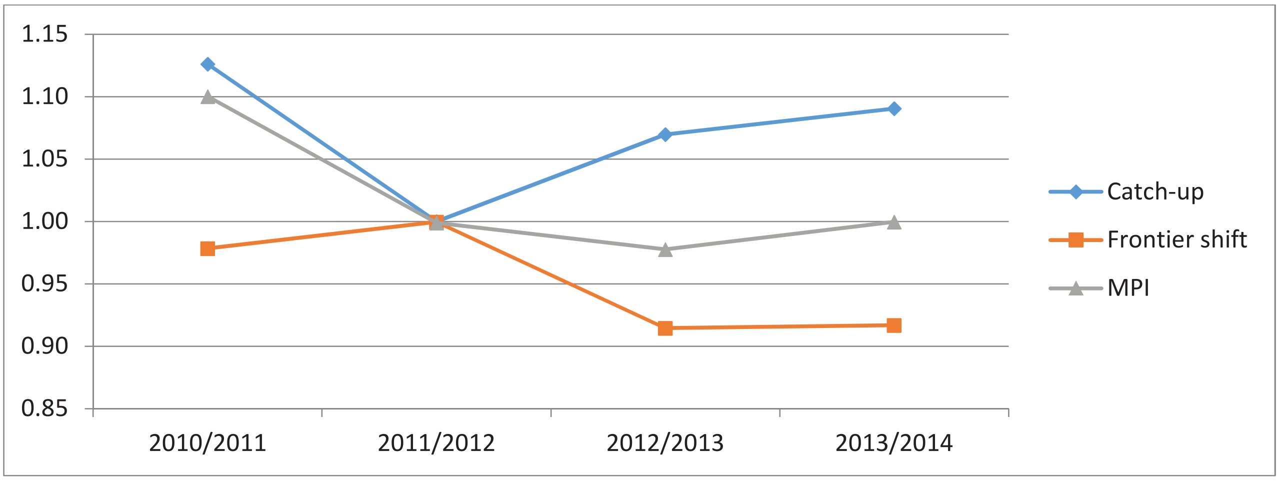

Figure 2. Malmquist Productivity Index, changes in technical efficiency (catch up), changes in production technology (frontier shift) calculated for processing industry in Poland

Source: Own calculations

The average annual Malmquist Productivity Index for the processing industry in Poland for the years 2010-2014 ranged from 0.90 to 1.10. The highest average annual changes in productivity in the sector was recorded at the turn of 2010/2011 (**Figure 2**). In the next three periods, the sector was characterized by a decline in average productivity (MPI<1).

Taking into account the individual components of the MPI index one, can observe that changes in technical efficiency (EFCH) were different to changes for the entire MPI index. Only in the years 2011/2012 the sector has not recorded improve technical efficiency (**Figure 2**). Meanwhile, the average annual change in technological progress in the years 2010-2013 was less than 1.

When analysing the average level of the Malmquist Index (MPI) in individual sectors one should consider that respectively, 16 out of the 23 sectors improved overall productivity over the studied period. The highest average annual increase in productivity was recorded in the following sectors: manufacture of textiles (10%), manufacture of leather and related products (9%), manufacture of coke and refined petroleum products (6%), manufacture of other transport equipment (6%), manufacture of wearing apparel (5%), manufacture of products of wood, cork, straw and wicker (5%) with the lowest in manufacture of computer, electronic and optical products (-10%). MPI for manufacture of basic metal (1%) and for manufacture of metal products (0%) was under average annual Malmquist Productivity Index for the processing industry in Poland for the years 2010-2014 (2%) (**Figure 3**).

The highest average indices of changes in technical efficiency (EFCH-catch up) were recorded in manufacture of textiles (1.18), manufacture of leather and related products (1.15), manufacture of other transport equipment (1.15), manufacture of wearing apparel (1.11), manufacture of products of wood, cork, straw and wicker (1.11), manufacture of machinery and equipment n.e.c. (1.11). In turn, the lowest (less than 1) annual average indices of changes in technical efficiency were observed in manufacture of computer, electronic and optical products (0.93). Manufacture of basic metal (1.04) was under average of technical efficiency for the processing industry in Poland for the years 2010-2014 (1.07) (**Figure 3**).

The largest average annual increases in the index of technological change (TECH-frontier) were recorded in Manufacture of coke and refined petroleum products (1%). In 22 out of the 23 sectors decreased index of technological change over the studied period (**Figure 3**).

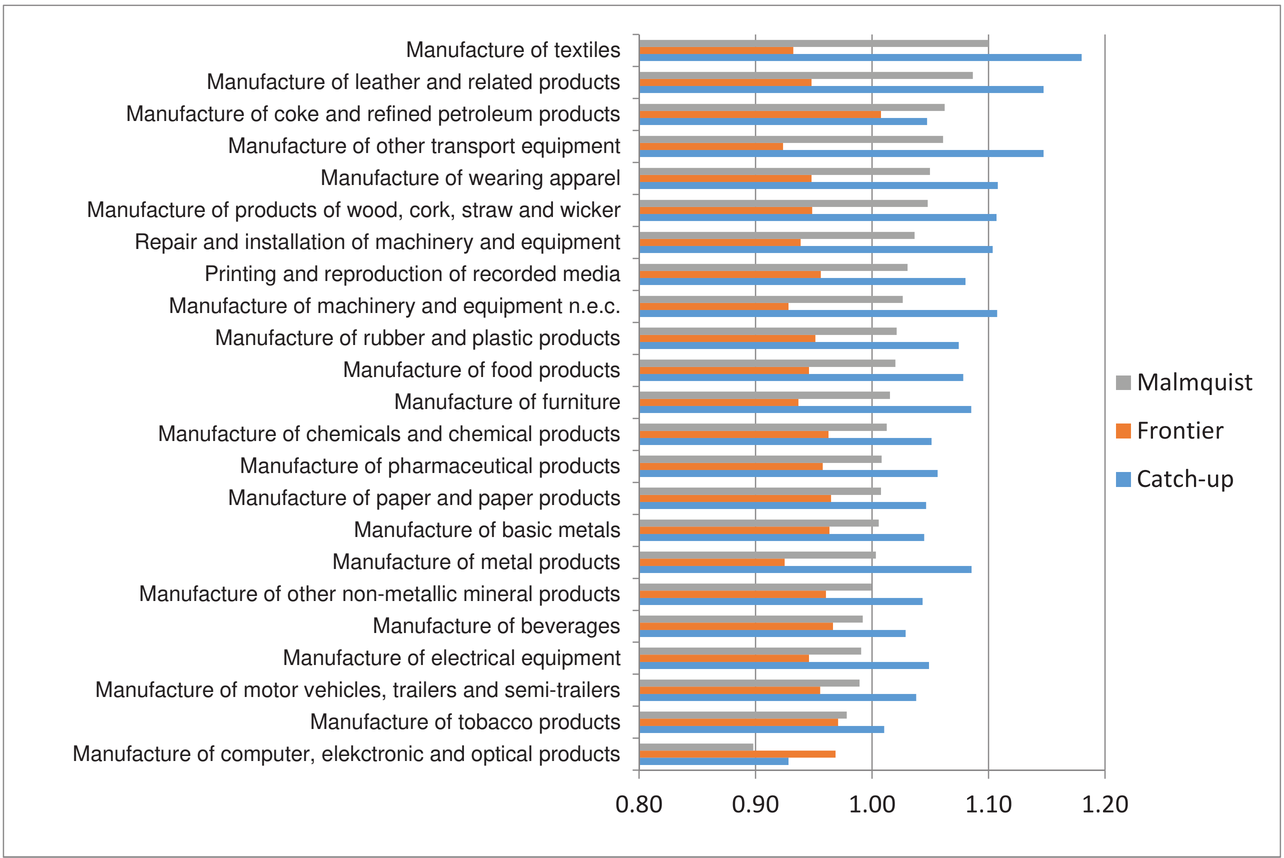

Figure 3 Average annual Malmquist Productivity Index (MPI), changes in technical efficiency (EFCH-Catch up), changes in production technology (TECH-Frontier) calculated for processing industry in Poland

Source: Own calculations

4. CONCLUSIONS

The analysis of the changes in the productivity of Polish processing industries in the years 2010-2014 was conducted using the Malmquist Productivity Index.

The results of the study allowed to indicate the general trend in the change of productivity in processing industry at the national level and for individual sectors. The results of the analysis indicate that in the years 2010-2014 the productivity in processing industry increased by 22% on average. In 16 out of the 23 Polish processing industries the average MPI index for 2010- 2014 period was higher than one, which indicates an increase in sectors productivity.

However, between individual periods both increases and decreases in productivity were observed. The highest average MPI were seen in: manufacture of textiles (10%) and manufacture of leather and related products (9%). MPI for manufacture of basic metal (1%) and for manufacture of metal products (0) was above average of the Malmquist Productivity Index in the processing industry in Poland for the years 2010-2014 (2%).

A decomposition of calculated Malmquist Index allowed to identify which factors determined the change in Polish Processing industries. It was found that the change in technical efficiency was the main factor influencing the change of productivity in Polish processing industries in the 2010-2014.

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