METHODOLOGIES FOR ANALYSING SELECTED ECONOMIC EFFECTS CAUSED BY INDUSTRY 4.0 INNOVATIONS

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Abstract

This paper identifies the nature and selected business economic effects caused by the substitution of labour by a technique. It belongs to one of the main phenomena of Industry 4.0. The paper presents two alternative methodological approaches for quantifying selected economic effects (positive and also negative) of this production factors substitution. The outcomes of methodological procedures are selected indicators of changes in the level of effects (measures of profitability and cost effectiveness) and changes in the mass of effects (measures of profit and cost). Firstly, the methodological procedure based on traditional financial business data and indicators is described. It works with the principles of traditional hierarchical indicator systems and traditional analytical tools. Secondly, the methodological procedure working with a new analytical apparatus is presented. It enables to use traditional business analyses together with the extended potential of economic variables and indicators based on economic cost and economic profit. Subsequently, the selected advantages and disadvantages of both methodological procedures are identified and described in the paper. It is provided from the point of view of differences in potential informative ability and of differences in the demand on input data.

Key words: substitution of labour by a technique, Industry 4.0, business efficiency

JEL Code: M21, O33

Introduction

The term Industry 4.0 refers to the new development phase of innovations in industry. These innovations do not affect only industry sector, but they evoke a complex social change that causes changes in the thinking and attitudes of society as a whole. According to Lasi et al. (2014) the term Industry 4.0 itself was not originally designed worldwide. The country of origin is Germany and therefore Germany and related countries used the term as the first. Alternative term could be smart industry.

At present, we are no longer at the beginning, but in the middle of this new development phase. Significant remarkable changes have been brought by Industry 4.0 and these changes are not limited only to technologies. However, as technological changes are at the heart of this development phase, existing research has focused primarily on the technical and technological issues (Kiel et al., 2017). Rüßmann et al. (2015) pointed out that the implementation and development of Industry 4.0 is driven by nine following technological areas. The areas include Autonomous robots, Simulation, Horizontal and vertical system integration, The Industrial Internet of Things, Cybersecurity, The cloud, Additive manufacturing, Augmented Reality, Big data and analytics. These technological issues are especially connected with huge amount of investment mitigating the risk of losing business competitive advantage. Kiel et al. (2017) emphasized, in spite of enormous cash expenditures, economic discussion is still in its infancy. This issue has not been economically discussed and researched in detail yet, although more and more enterprises are already introducing new technologies (Romberg, 2016).

There are not many research works focusing on quantitative estimations or verification of Industry 4.0 consequences for employment, profit, and productivity. First estimations were provided by Rüßmann et al. (2015), McKinsey Global Institute (2015). Some verifications based on real data could be found in Dalenogare et al. (2018), Brendel (2018), Erdei (2018), and Čámská and Klečka (2020). The last work mentioned examined and analysed the nature and economic effects of Industry 4.0 innovations, specifically inputs substitution in logistics companies in the Czech Republic.

A research gap has been clearly identified. There is the need of research works verifying impacts of Industry 4.0 on real companies and their economic measures. This contribution should provide some tools and indicators which can be applied on the corporate data to verify consequences. The presented tools will be available in general as well as extended form.

Next subpart will introduce the idea analysed by indicators based on traditional accounting data presented in subpart 2 and by indicators combining traditional accounting data with new economic measures presented in subpart 3. Conclusion is dedicated to the repetition of main concepts.

1 Economic consequences of inputs substitution in the case of Industry 4.0 innovations

The Industry 4.0 innovations presented above are mainly associated with enormous cash expenditures into fixed assets in tangible as well as intangible form (Zühlke et al., 2013). Technical issues discussed above lead to replacement of human labour (Rotman et al., 2013) by modern machines (Barreto et al., 2017).

As is clear from the previous text, the Industry 4.0 innovations have the potential to lead businesses to higher profits and to achieve better overall economic performance. This is especially important for those enterprises belonging to sectors in which Industry 4.0 has appeared already or will be significantly implemented later on. There is an extreme risk that especially small and medium enterprises have not caught the new development phase (Sommer, 2015) and they could lose their competitiveness.

In the following parts of the text, selected tools and indicators will be presented. They have the potential to verify from real economic data the direction, intensity and economic effects caused by inputs substitution. The core change of the Industry 4.0 innovations is the substitution of (part) human labour with new equipment and technologies. The analysed current time period is compared with the base time period and it is verified if the labour has been already replaced by new technologies. The main attention is paid to the economic impacts of this substitution.

2 Indicators based on traditional accounting data

As previously mentioned, the introduction of Industry 4.0 innovations leads to the replacement of production factors (inputs). On one side, there is the reduction of human labour. On the other side, there is the increase of other production factors such as robots and other tangible and intangible components.

The indicators presented are constructed according to the data included in official corporate financial statements. Their construction is based on selected ratios of financial analysis and their combination which is subordinated to the needs of reflection described in this paper.

Relevant cost items include personnel costs and depreciation plus amortization. Personnel costs consist of wages, salaries and insurance paid by employers obligatory. Depreciation and amortization present allocating the cost of fixed assets over their useful life or life expectancy. If the business grows, there will be pressure to increase expenses. It should be noted that in this case the expenses grow in absolute numbers but there is a huge effort to keep their relative growth smaller than the sales growth. The use of ratio indicators solve the issue of the absolute versus relative growth.

Equation 1 presents the indicator A which describes the absolute change in depreciation and amortization costs over sales. It serves as a subsidiary indicator.

$$A = \frac{DaA_1}{Sales_1} - \frac{DaA_0}{Sales_0} \qquad (1)$$

Where

DaA – depreciation and amortization (in CZK);

Sales – total revenues from selling finished goods, resold goods and services (in CZK);

0 – base period;

1 – current period.

The indicator A has the potential to express (or at least approximate) a partial increase in the expenses of sales (or generally in revenues), and thus a partial decrease in the profitability of sales caused by the increased consumption of inputs which substitute the others. This approximation is as accurate as the current value of the measured increase in the expense. This increase in the expense corresponds only to the increase in depreciation and amortization, which express simplified inputs replacement here.

If additional internal information is available, this indicator can be redefined and the result would be more accurate. Not only depreciation and amortization will present the inputs used for the replacement but other relevant types and quantity of expenses will be also added into consideration. This applies analogously to all other indicators listed here containing the component of depreciation and amortization.

Equation 2 presents the indicator B which describes the absolute change in personnel costs over sales. It serves as a subsidiary indicator.

$$B = \frac{PersC_1}{Sales_1} - \frac{PersC_0}{Sales_0} \qquad (2)$$

Where

PersC – personal costs (in CZK);

meaning of other variables remains the same.

The indicator B has the potential to express (or at least approximate) a partial decrease in the expenses of sales (or generally in revenues), and thus a partial increase in the profitability of sales caused by the decreased consumption of inputs which are substituted by the others. This approximation is as accurate as the current value of the measured decrease in the expense. This decrease in the expense corresponds only to the decrease in personnel costs, which express simplified inputs replaced here.

If additional internal information is available, this indicator can be redefined and the result would be more accurate. Not only personnel costs will present the replaced inputs but other relevant types and quantity of expenses will be also added into consideration. This applies analogously to all other indicators listed here containing the component of personnel costs.

Equation 3 presents the indicator C which describes the substitution of personnel costs by depreciation and amortization over sales. It is not a subsidiary indicator anymore and its construction is based on the indicators A and B.

$$C = \left(\frac{DaA_1}{Sales_1} - \frac{PersC_1}{Sales_1} \right) - \left(\frac{DaA_0}{Sales_0} - \frac{PersC_0}{Sales_0} \right) \qquad (3)$$

The indicator C has the potential to express (or at least approximate) the direction and size of substitution of labour by technology. It compares the development (change) of the shares of the relevant cost types in the value structure of production. It follows from the logic of this indicator that if C > 0, there was the substitution (or substitutional dominance) of labour by technology. It is a typical kind of substitution in the case of Industry 4.0 innovations and higher indicator value means higher extent. The value of C = 0 indicates that no substitution took place. The value of C < 0 proves that the opposite substitution took place in the company analyzed. The technology has been replaced by labour, which is not typical for Industry 4.0 innovations. It should be repeatedly pointed out that expense variables such as personnel costs and depreciation plus amortization are only the simplified indicator of expressing the consequences of the analyzed substitutions (unless specified internal data can be used). The accuracy of the indicator C also depends on the situation how the used cost characteristics describe the changes caused by the substitution analyzed.

Equation 4 presents the indicator D which describes the partial absolute change in profitability. It is not a subsidiary indicator anymore and its construction is based on the previously discussed indicators.

$$D = (-1) \times \left(\frac{DaA_1 + PersC_1}{Sales_1} - \frac{DaA_0 + PersC_0}{Sales_0}\right) \qquad (4)$$

Indicator D is based on the logic of expressing the absolute partial change of the synthetic indicator caused by changes in analytical indicators. The analytical indicators are in the form of the additive composition. Indicator D has the potential to reflect (or at least approximate) the partial change in sales profitability caused by the substitution of inputs in the case of Industry 4.0 innovations. Sales profitability can be expressed by equation 5 and it is the form before taxation.

$$Profitability = \frac{EBT}{Sales} \qquad (5)$$

Where

EBT – Earnings before Taxes.

Indicator D is able to reflect the changes in the cost characteristics used for description of the substitution analyzed. Its accuracy depends on the situation if the changes of the cost characteristics used overlap with the changes actually induced by the type of substitution analyzed. This indicator expresses (or approximates) a positive, zero or negative change in the sales profitability due to the substitution monitored. Regardless, the substitution itself has the required or opposite attribute. This makes possible to synthesize the results of indicators C and D.

3 Indicators combining traditional accounting data with new economic variables

The increase of the explanatory power may be achieved not only with the optional indicators' refinement aforementioned but also with the use of new economic variables such as economic costs and economic profit, expressed, for example, by the indicator EVA – economic value added. The description of EVA can be found in Jordan, Westerfield & Ross (2011).

This enables to include in the used cost characteristics also the change in the costs of capital employed (binding costs), which is also a typical consequence of inputs substitution monitored here. The previously described subsidiary indicator A can be thus modified to indicator A* presented by equation 6.

$$A^* = \frac{DaA_1 + FbC_1}{Sales_1} - \frac{DaA_0 + FbC_0}{Sales_0} \qquad (6)$$

Where

FbC – fixed binding costs (in CZK) or costs of capital employed, which can be calculated as follows.

$$FbC = FA \times WACC/(1-t) \qquad (7)$$

Where

FA – fixed assets (in CZK),

WACC – weighted average cost of capital, described in in Jordan, Westerfield & Ross (2011),

t – corporate tax rate.

The previously described subsidiary indicator B usually does not need to be modified because the use of living human labor usually does not cause the costs of capital employed (in significant values). In some cases, however, this may occur, for example, when workers are equipped with fixed assets (machines and tools significant in value) that will no longer be needed after the substitution of live labor by robots. It is possible to modify the indicator B to B* if it is worked with more precise internal data, which reflects the detailed situation of the company. The modification is analogical as in the case of indicator A*. The FbC component included in indicator B* than refers to the costs of capital employed which are related to live labor and which have to be disjunctive with respect to the costs of capital employed included in indicator A*. It means they are disjunctive with the respect to the FbC component included in indicator A*.

Indicator C can be also modified to C* which reflects the substitution of personnel costs by depreciation, amortization and fixed binding costs over sales. The indicator modified is described by equation 8.

$$C^* = \left(\frac{DaA_1 + FbC_1}{Sales_1} - \frac{PersC_1}{Sales_1}\right) - \left(\frac{DaA_0 + FbC_0}{Sales_0} - \frac{PersC_0}{Sales_0}\right) \qquad (8)$$

It could be pointed out that even in this indicator it is possible to use the transformation B to B* and take into consideration the cost of capital employed associated to live labor.

Indicator D can be modified to indicator D* which reflects the partial absolute change in economic profitability and is expressed by equation 9. Equation 10 is understood as economic profitability in this paper. It is the form before taxation.

$$D^* = (-1) \times \left(\frac{DaA_1 + FbC_1 + PersC_1}{Sales_1} - \frac{DaA_0 + FbC_0 + PersC_0}{Sales_0}\right) \qquad (9)$$

$$Economic\ Profitability = \frac{EVA/(1-t)}{Sales} \quad (10)$$

Where

EVA – economic value added

It can be added that the indicator D* can be also based on the transformation B to B* and take into consideration the cost of capital employed associated to live labor.

Conclusion

This paper has presented and described indicators of direction and intensity of the input substitution (indicators C and C*) and indicators of the overall economic corporate effect of this type of substitution (indicators D and D *). As already mentioned, the indicator D (respectively D*) expresses (or approximates) a positive, zero or negative change in the sales profitability caused by the substitution monitored. It does not matter if the substitution itself has the typical character for Industry 4.0 innovations or not. The results of indicators C (respectively C*) and D (respectively D*) can be synthetized as in Čámská and Klečka (2020). This paper used indicators C and D for the analysis of the substitution in logistics companies in the Czech Republic analyzing the period 2014-2017. The analysis discovered a significant positive correlation between the typicality (for Industry 4.0 innovations) and the size of substitution (both measured by indicator C) on one hand and the positive effect of the substitution monitored on the sales profitability (measured by indicator D).

The current paper also outlines specific trade-offs options between the analysis accuracy and the requirements of input data and their availability. This is the difference between indicators A to D described in subpart 2 compared to their more sophisticated and accurate but more data required modifications A* to D* presented in subpart 3. In addition, these modified indicators can also take into consideration the costs of capital employed, which can significantly improve the economic characteristics of the substitutions monitored. However, they also depend on the data not included in financial accounting which are needed to complete the WACC and EVA calculations.

Another trade-off described in this paper is based on the choice, respectively possibilities, of working with standard usually available financial data describing selected cost types, which enable only the approximation of the real consequences of input substitution, in comparison to data more accurately describing the effects of substitution. This data can be obtained almost exclusively on the basis of detailed internal information analyzes and which is usually inaccessible, especially to external analysts.

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