THE FACTOR OF QUALITY CHANGE IN VALUE PRODUCTIVITY ANALYSIS

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Abstract

The paper deals with selected possibilities of enterprise value productivity indicators that specifically focus on the economic profit or economic value added creation (EVA). These absolute measures are derived from corresponding total price aggregated indices. These indicators are broadly compatible, and therefore they can be used in the current business environment with a growing number of 4.0 industry innovations, in enterprises implementing lean management practices as well as in the case of traditional operationally designed organization systems. When the development of productivity is analyzed in practice, there is not always the complete stability of all components forming outputs and inputs in compared periods. The authors show and describe the possibility of optional additional adding of changes in the value of production outputs or inputs. These factors do not change quantitatively but qualitatively. These changes are reflected in the value of the indicators through qualitative components of changes in the prices of the inputs and outputs. The separate quantification of the influence of qualitative price changes on EVA creation can be provided. This allows the separation of this partial effect from the total effect of the price changes. This partial effect can be expressed and interpreted individually, or it can be included in the influence of productivity changes.

Key words: enterprise productivity, price changes, qualitative changes

JEL Code: D24, M2

Introduction

This paper discusses possibilities of extension and clarification of an analysis which is focused on changes in enterprise total value productivity and its impact on the economic profit creation. The economic profit can be expressed in practice by the indicator EVA. This kind of analysis is based on the concept and basic productivity measures defined by Craig and Harris (1973) and procedures defined by Hayes (1988). It refers to analytical absolute

indicators derived from aggregate price indices. According to Klečka and Čámská (2018), these indicators are broadly compatible, applicable in the current business environment with the increasing number of Industry 4.0 Innovations (described by Mařík, 2016), even in the environment of lean manufacturing systems as well as in traditional predominantly operational oriented business systems. The efficiency of lean manufacturing systems was analysed, e.g. by Kroes and Manikas (2018) or Hofer, Eroglu and Hofer (2012) and their broader impact for the Czech Republic was discussed by Strachotová and Strachota (2017). Traditional labour productivity in different industrial sectors in the Czech Republic was recently analysed by Scholleová and Nečadová (2018) or Volek and Novotná (2018). On the other hand, the capital employed productivity changes triggered from Industry 4.0 Innovations were not observed on the industry level in the Czech Republic yet, detail in Klečka and Čámská (2018).

The extension discussed in this paper is based on the possible inclusion (in the indicators of productivity change) of any changes in the value of production outputs as well as inputs that are not displayed by changes in quantity but changes in their quality. When analysing the development of productivity and its impacts, in practise, there is not always complete qualitative stability of all components of outputs and inputs in the compared periods. The quality changes described in this paper will be reflected through the qualitative components of the price changes of business inputs and outputs. In this way, it is possible to realize a separate quantification of the influence of the qualitative components of the price changes on the enterprise economic profit creation. This allows the separation of this partial effect from the overall effect of the price changes. Such determined partial impact can be expressed or interpreted either separately, or it can be included in the effect of the productivity changes. The concept of the productivity changes can be expanded, in other words, modified in this way mentioned above.

1 Price changes

A relatively strong distortion factor when the real value productivity development is expressed will usually be just a price movement if prices are just on a current basis, and there is not done any recalculation. The price movement is mostly uneven in terms of individual input and output components. Therefore, the effect of the price changes is normally separated from the effect of the productivity change in time comparisons.

The current prices (it means not calculated to the level of the comparable prices) change over time. According to Klečka and Čámská (2018, p. 129), the total change in the price over time can be decomposed on the example of the price of the output as follows:

$$\Delta p = \Delta p_{NK} + \Delta p_K, \qquad (1)$$

where

Δp – total price change, it means the difference of the current prices;

Δp_{NK} – non-qualitative component of the price change, which does not reflect a change in utility but it is primarily related to inflation;

Δp_K – possible qualitative component of the price change, which expresses the change in utility, this component can be further decomposed for the purpose of separation the effects that are caused by the factors completely outside productivity relationship (such as introduction of complement or substitute on the supply side by another company), Δp_K mentioned in the following text is already adjusted for such effects.

It follows from the aforementioned decomposition that the (total) output change (the same is valid for changes of individual kinds of inputs) in the period 1 compared to the period 0 (periods have the same length) can be expressed by, eg. the index

$$\frac{p_1 \cdot q_1}{p_0 \cdot q_0} \qquad (2)$$

The index reflects not only quantity change q (q is the quantity of output) and p_K but also the change of p_{NK}. p_{NK} is not related to the change of the output (in terms of productivity). It means that the effect of p_{NK} is usually excluded from the productivity indicators.

It is usually very difficult and critical to identify p_K as a part of Δp in practical applications. Especially in short periods, the part Δp_{NK} is dominant. It comes to a simplification when Δp_{NK} is eliminated, but it finished as the elimination of the full part Δp.

Current practical application of the productivity analyses commonly resigns to take into account or even to identify the part Δp_K because this part is also often small in quantity. According to those mentioned above, it does not mean that an analyst cannot decide to extend the analysis and increase the explanatory power. It should be especially done in the case when the qualitative part of the price change can be detected, and it has a bigger impact. The price change should be at least potentially considered. This paper shows possibilities how to achieve it.

2 Impact of qualitative parts of price changes on productivity indicators

The total absolute change of the economic profit between period 1 and 2 generally expressed as $\Delta EP = EP_1 - EP_0$ can be rewritten in detail as

$$\sum_{j=1}^{m} p_{j,1} \cdot q_{j,1} - \sum_{i=1}^{n}\sum_{j=1}^{m} p_{v,i,1} \cdot v_{i,j,1} - \left(\sum_{j=1}^{m} p_{j,0} \cdot q_{j,0} - \sum_{i=1}^{n}\sum_{j=1}^{m} p_{v,i,0} \cdot v_{i,j,0} \right) \quad (3)$$

where

p_j - the price of the output unit j in the reference period;

q_j - the quantity, i.e. the number of output units j, produced in the reference period;

$p_{v,i}$ - the price of the input unit I (in the reference period);

$v_{i,j}$ - the quantity, i.e., the number of input units i consumed or employed for the production the output j (in the reference period);

i = 1, 2, …, n – individual types of inputs;

j = 1, 2, …, n – individual types of outputs;

0 – base period;

1 – current period.

The following equations for partial absolute change calculations are based on the corresponding indices mentioned by Klečka and Čámská (2018, p. 187). This is a version based on the use of Fisher's index principles which is used with a data specification which enables to express a partial effect of productivity changes without including the partial influence of any product portfolio variations on the partial effect of productivity changes. A partial absolute change in economic profit due to a change in (total) productivity $\Delta EP_{q/v}$ is expressed by equation 4.

$$\frac{1}{2} \cdot \left(\sum_{i=1}^{n}\sum_{j=1}^{m} p_{v,i,1} \cdot v_{i,j,0} \cdot \frac{q_{j,1}}{q_{j,0}} - \sum_{i=1}^{n}\sum_{j=1}^{m} p_{v,i,1} \cdot v_{i,j,1} + \sum_{i=1}^{n}\sum_{j=1}^{m} p_{v,i,0} \cdot v_{i,j,0} - \sum_{i=1}^{n}\sum_{j=1}^{m} p_{v,i,0} \cdot v_{i,j,1} \cdot \frac{q_{j,0}}{q_{j,1}} \right) \quad (4)$$

Partial absolute change in economic profit due to the change in output volume ΔEPq can be expressed by equation 5.

$$\frac{1}{2} \cdot \left[\sum_{j=1}^{m} p_{j,1} \cdot q_{j,1} - \sum_{i=1}^{n}\sum_{j=1}^{m} p_{v,i,1} \cdot v_{i,j,0} \cdot \frac{q_{j,1}}{q_{j,0}} - \left(\sum_{j=1}^{m} p_{j,1} \cdot q_{j,0} - \sum_{\acute{\imath}=1}^{n}\sum_{j=1}^{m} p_{v,i,1} \cdot v_{i,j,0} \right) + \right.$$

$$\left. + \sum_{j=1}^{m} p_{j,0} \cdot q_{j,1} - \sum_{i=1}^{n}\sum_{j=1}^{m} p_{v,i,0} \cdot v_{i,j,1} - \left(\sum_{j=1}^{m} p_{j,0} \cdot q_{j,0} - \sum_{i=1}^{n}\sum_{j=1}^{m} p_{v,i,0} \cdot v_{i,j,1} \cdot \frac{q_{j,0}}{q_{j,1}} \right) \right] \quad (5)$$

Partial absolute change in economic profit due to the changes in prices (of outputs as well as inputs) ΔEPp is expressed by equation 6.

$$\frac{1}{2}\cdot\left[\sum_{j=1}^{m} p_{j,1}\cdot q_{j,0} - \sum_{i=1}^{n}\sum_{j=1}^{m} p_{v,i,1}\cdot v_{i,j,0} - \left(\sum_{j=1}^{m} p_{j,0}\cdot q_{j,0} - \sum_{i=1}^{n}\sum_{j=1}^{m} p_{v,i,0}\cdot v_{i,j,0}\right) + \right.$$

$$\left. + \sum_{j=1}^{m} p_{j,1}\cdot q_{j,1} - \sum_{i=1}^{n}\sum_{j=1}^{m} p_{v,i,1}\cdot v_{i,j,1} - \left(\sum_{j=1}^{m} p_{j,0}\cdot q_{j,1} - \sum_{i=1}^{n}\sum_{j=1}^{m} p_{v,i,0}\cdot v_{i,j,1}\right)\right] \quad (6)$$

If there is a need for other optional extension in the case of the productivity reflection the equation 6 will be able to be further decomposed. It leads to the decomposition to a partial absolute change of the economic profit due to non-qualitative component of the price change (outputs and/or inputs) ΔEP_{pNK} (equation 7) and to a partial absolute change of the economic profit due to qualitative component of the price change (outputs and/or inputs) ΔEP_{pK} (equation 8)

$$\frac{1}{2}\cdot\left[\sum_{j=1}^{m}\left(p_{j,0}+\Delta p_{NK,j}\right)\cdot q_{j,0} - \sum_{i=1}^{n}\sum_{j=1}^{m}\left(p_{v,i,0}+\Delta p_{v,NK,i}\right)\cdot v_{i,j,0} - \right.$$

$$-\left(\sum_{j=1}^{m} p_{j,0}\cdot q_{j,0} - \sum_{i=1}^{n}\sum_{j=1}^{m} p_{v,i,0}\cdot v_{i,j,0}\right) +$$

$$\left. + \sum_{j=1}^{m}\left(p_{j,0}+\Delta p_{NK,j}\right)\cdot q_{j,1} - \sum_{i=1}^{n}\sum_{j=1}^{m}\left(p_{v,i,0}+\Delta p_{v,NK,i}\right)\cdot v_{i,j,1} - \left(\sum_{j=1}^{m} p_{j,0}\cdot q_{j,1} - \sum_{i=1}^{n}\sum_{j=1}^{m} p_{v,i,0}\cdot v_{i,j,1}\right)\right] \quad (7)$$

$$\frac{1}{2}\cdot\left[\sum_{j=1}^{m}\left(p_{j,0}+\Delta p_{K,j}\right)\cdot q_{j,0} - \sum_{i=1}^{n}\sum_{j=1}^{m}\left(p_{v,i,0}+\Delta p_{v,K,i}\right)\cdot v_{i,j,0} - \right.$$

$$-\left(\sum_{j=1}^{m} p_{j,0}\cdot q_{j,0} - \sum_{i=1}^{n}\sum_{j=1}^{m} p_{v,i,0}\cdot v_{i,j,0}\right) +$$

$$\left. + \sum_{j=1}^{m}\left(p_{j,0}+\Delta p_{K,j}\right)\cdot q_{j,1} - \sum_{i=1}^{n}\sum_{j=1}^{m}\left(p_{v,i,0}+\Delta p_{v,K,i}\right)\cdot v_{i,j,1} - \left(\sum_{j=1}^{m} p_{j,0}\cdot q_{j,1} - \sum_{i=1}^{n}\sum_{j=1}^{m} p_{v,i,0}\cdot v_{i,j,1}\right)\right] \quad (8)$$

These decompositions do not have residuals. The total change of economic profit can be expressed as equation 9 or equation 10 is valid as well.

$$\Delta EP = \Delta EP_{q/v} + \Delta EP_q + \Delta EP_p \quad (9)$$

$$\Delta EP = \Delta EP_{q/v} + \Delta EP_q + \Delta EP_{pNK} + \Delta EP_{pK} \quad (10)$$

Assuming the analyst considers for the particular cases that the part of the price change having qualitative causes is a part of the total productivity impact on the economic

profit EP generation. The analyst can assign (or even add) to the productivity during the interpretation.

$$\Delta EP_{q/v}' = \Delta EP_{q/v} + \Delta EP_{pK} \qquad (11)$$

$\Delta EP_{q/v'}$ is a partial change in economic profit due to a change in productivity, including the impact of qualitative components of price changes. The impact of qualitative components of price changes will be removed from the effect of price changes, displayed by 12a.

$$\Delta EP_p' = \Delta EP_p - \Delta EP_{pK} \qquad (12a)$$

Therefore we will gain equation 12b, where $\Delta EP_p'$ represents a partial change in economic profit due to impact only of non-qualitative components of price changes.

$$\Delta EP_p' = \Delta EP_{pNK} \qquad (12b)$$

3 Possible means of usage

The above mentioned construction of decomposition allows taking into account components of the price change differentiated for each kind of output (in the case of heterogeneous production), as well as for each kind of input.

It can be determined (qualified) that the change in the price of a particular output that occurred in period 1 compared to period 0 was/would not be caused by normal external reasons. A certain part of the price change could/should be caused by the improvement of the product due to innovations occurring during the analysed period within activities of this production system. In such a case, it may be appropriate to adjust the findings regarding factors causing changes in the EP creation. Therefore the decomposition 10 will be used (instead of the decomposition 9), and the interpretation is based on the partial effects $\Delta EZ_{q/v}'$ and $\Delta EP_p'$ (instead of $\Delta EP_{q/v}$ and ΔEP_p).

This can occur analogically for the case when a certain decrease in the price of input is caused by some innovation in the analysed production system. It may be appropriate to separate this effect (from the effect of the other price changes) to the effect attributed to the change in productivity. It can be illustrated as the innovation which enables to buy and transform cheaper and less quality inputs of a given kind. In this case, the application of the decomposition 10 (instead of the decomposition 9) plays a role. The interpretation is also based on the partial effects $\Delta EZ_{q/v}'$ and $\Delta EP_p'$ (instead of $\Delta EP_{q/v}$ and ΔEP_p). This example follows the change in the price of a certain kind of input and not output, which has been mentioned before.

Conclusion

This paper described possible extensions, modifications of the value productivity analysis based on the distinction of price changes character and reasons. The reader/user should see these extensions as an optional supplement of the analysis. This apparatus does not have to be used at all. If the input price analyses are not sufficiently valid or the analyst is not an expert, not using this apparatus is a less bad choice. In this case, the use could lead to significant distortions or even completely devaluation of the explanatory power of conducted productivity analyses.

It should be pointed out that this extension of the analysis (taking into account the difference between the price change components caused by qualitative and non-qualitative changes) is applicable (also optional) to all other kinds of the productivity analysis described by the authors Klečka and Čámská (2018). These other variants differ in terms of production and input data. The described extension can be applied not only for heterogeneous production but also for homogenous production. This is possible in the analyses and indicators of productivity without including any changes in the product portfolio, as well as with it.

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