INDICATORS MEASURING THE LEVEL AND DEVELOPMENT OF ENTERPRISE PRODUCTIVITY

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Abstract

This paper focuses on indicators measuring the level and development of enterprise value productivity (total as well as partial productivity). The indicators can be used for individual businesses and their subsystems and they can be also aggregated for more businesses. The value productivity reflects the level and changes in the technical economic efficiency of production factors. It is an important factor in achieving the corporate goals, performance and competitiveness. The paper works with the value productivity in the contemporary concept which works not only with the efficiency of inputs consumption but also with the efficiency of capital employed (inputs binding). The inputs consumption is expressed as a relation of output value and accounting costs. The efficiency of inputs binding is based on output value and costs of input binding, derived from the costs of total capital employed. It means that it is working with variables as modified economic costs and modified economic profit. This contribution consists of different versions of these indicators. The indicators vary with the degree of analyticity and with the details of available input data (eg. version for only input and output in value terms or in physical volumes and prices etc.)

Key words: value productivity, total productivity, partial productivity, economic profit

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Introduction

The value productivity is a key factor in achieving the corporate goals, performance and competitiveness. The most known indicator of productivity is traditionally labour productivity. Employees could be an important business factor and they were a hidden source for coping with the recent crisis (Čámská, 2012) and therefore the business has to invest in its employees but measuring impacts of employees' education as a long term tool for increasing productivity is not an easy task (detail solved in Scholleová, 2012). The topic of employees is important not only from the corporate economic perspective but also from social perspective and regional or national economic perspective (Pavelka, 2007 or 2012). The total productivity

can be affected by market turbulences (Volatility during crisis period is analysed by Scholleová (2011).) and therefore it is necessary to detect factors which effect changes in total productivity. The development of value productivity on the level of national economy can be compared the position of the Czech Republic in competitiveness rankings whose theme is solved by Nečadová and Scholleová (2011).

1 Productivity – basic remarks

Productivity can be generally defined as the efficiency of using production factors in manufacturing process, or widely in a production process, whose results are tangible as well as intangible outputs (Craig and Harris, 1973). The productivity can be generally measured as a ratio, in the production process for a given time period, expressed by equation 1.

$$\text{productivity} = \frac{\text{output}}{\text{input}} \qquad (1)$$

Two basic types of productivities can be distinguish – value productivity working with monetary dimension, which is more important for managing economy, and technical productivity. Other differentiation depends on the complexity of used input and therefore it is spoken about total productivity and partial productivity (type of input, eg. labour productivity).

This paper deals with indicators measuring the level and development of enterprise value productivity (expressed as total as well as partial productivity). The total productivity is an aggregated value of partial productivities of all inputs. The indicators can be used for individual businesses and their subsystems and they can be also aggregated on the level for more businesses. The value productivity reflects the level and changes in the technical economic efficiency of production factors. It is an important factor in the business value creation which is nowadays a basic corporate goal. The paper is based on the value productivity in the contemporary concept which works not only with the efficiency of inputs consumption but also with the efficiency of capital employed (inputs binding). It can be achieved by using not only traditional (accounting) costs but also economic costs and therefore the difference between the values of output and input is not the traditional[1] (accounting) profit but economic profit (respectively economic value added). This extension working also with the effectiveness of inputs binding is suitable not only for businesses with

[1]This approach adds to traditional concept costs of equity (entrepreneur capital) because even traditional concept is working with part of binding costs (costs of debts).

traditional (functional, operational) organizational concept and production management but also for businesses whose organization and production management are based on the process concept. It means for lean businesses and businesses implementing rules of lean management. Innovations in these businesses are significantly and often dominantly based on the improvement of inputs binding efficiency but even in these businesses the level of consumption efficiency is crucial.

This contribution consists of different versions of these indicators.

2 Productivity indicators based only on the value data

Productivity indicators based only on the value data work with revenues and costs expressed in the monetary dimension. It means that revenues and costs are not distinguished further in prices and physical volumes. The application of these indicators can be found in Klečka (2013).

2.1 Total productivity indicator

Total productivity can be expressed by the equation 2 and it measures the overall productivity of analysed unit during the given time period.

$$\text{Total productivity} = \frac{\text{Total revenues}}{\text{Costs of consumption and binding of inputs}} \qquad (2)$$

where

$$\text{Costs of consumption and binding of inputs} = \text{Costs (accounting)} - \text{interests} + \frac{WACC}{1-t} \times \text{Total assets} \qquad (3)$$

WACC (Weighted Average Costs of Capital) are the costs of total[2] capital[3] in a relative term, which are here used for valuation of opportunity costs of input binding (the amount of assets[4]).

[2]WACC in the expression $\frac{WACC}{1-t} \times \text{Total assets}$ show the costs of total capital. It means that they contain also interests (the costs of debts) and therefore interests have to be subtracted from the accounting costs in the equation 3 otherwise interests would be counted two times. WACC are divided by (1-t), where t is the corporate income tax, and it shows the level before taxation. This step is necessary for consistency because WACC have to be consistent with other cost variables (costs of consumption). WACC are generally used in the version after taxation.

[3]WACC are expressed in a relative term and if they are multiplied by total capital the result is total costs of capital (costs if binding) in the absolute value.

[4]The value of WACC is generally related (in other analyses than productivity analysis) to equity and debts which are connected with payments to the lender as interests, coupons etc. In the case of the productivity analysis the costs of capital are related to all used assets, or in other words to the whole capital which is marked as C*. If the

The aforementioned indicator of the total productivity deals with all kinds of output as well as input. It is from the perspective of their consumption (and depreciation) as well as their binding (components of assets which are de facto recalculated in the related flow of capital costs). Indicators of productivity have a specific benefit which appears in the analysis of the development (in the comparison). That will be described further.

The total productivity indicator can work with a differently defined input and output. It can contain production, production factors and their efficiency in the broadest sense – not only for the operational but also for financial and extraordinary business activities.

2.2 Partial productivity indicators

The indicators of partial productivity are constructed for valuation of efficiency one kind (or their set) of input. They have importance in the analysis of their development or their comparison.

$$\text{Partial productivity} = \frac{\text{Total revenues}}{\text{Costs of consumption and (or) binding of one kind (or complex) input}} \tag{4}$$

If the indicator is evaluated without the context of other indicators of partial productivity it has a sense to narrow the indicator. The narrowness decreases the impact of factors which are not connected with the efficiency of the analyzed partial input. The traditional example of this approach can be detected in the case of the labour productivity which is measured value added (not the whole output).

2.3 Development productivity indicators – time indices of productivity

Static measures of value productivity have comparable explaining power as indicators used in financial analysis which are in practise more used. On the other hand, dynamic measures of value productivity reflect the development of two or more time periods by index or difference comparison. They even have a potential to show the level and economic value of impacts of changes in productivity. They show technical economic rationality (efficiency) of input transformation into outputs – abstracted from other value created factors as they are impacts of changes in production volumes or prices. This can be analyzed only in the case of available

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values of C and C* differ in the analysed production system it is necessary to use in the connection with C* the recalculated value WACC* which is equal to $WACC^* = WACC \times \frac{C}{C^*}$.

input data which should contain information about inputs and outputs in physical volumes and prices and not only in value terms from accounting profit and lost statement. The paper will discuss this type of measures further.

If there are not available data about inputs and outputs in physical volumes and prices, using only ratios of productivity and only index comparison is able to partly abstract from the impact of changes in prices and physical volumes of production which is for the analysis of productivity development crucial. The changes in prices are partly compensated. The level of this compensation depends on the development of prices of inputs and outputs. If this development is similar the level of compensation is higher. Further the impact of changes in prices is possible to smooth using time fixation of binding costs (using stable value of WACC). The changes in prices are not compensated perfectly using this approach but at least they are not overlooked. It is used relevant standard time chain or basic indices for expressing development of productivity.

3 Indicators of productivity using data of physical volumes and prices

If there are available data about inputs and outputs in physical volumes and prices the measures of development of productivity can be constructed and counted and they take fully into account impacts of changes in prices and physical volumes of production. Then not only index comparison of ratio productivity measures (productivity indices) but also absolute indicators measuring the value of economic effect caused by changes in productivity can be constructed for analysing the development of productivity (as eg. a consequence of innovations). The absolute measures show a partial[5] change in EVA caused by the change in productivity. It is only a partial change in EVA because the total value of EVA could be changed also due to changes in prices and physical volumes of production.

The apparatus solving contemporary analysis of value productivity, one factor in achieving corporate goals, is described by Klečka (2007).

Further mentioned equations, analyses and measures are working with variables defined here in advance which are able to construct measures of productivity using data differentiated in prices and physical volumes:

- for output (revenues) in analysed time period:
  - prices of one unit of outputs p_j (resp. p) for the output j (j = 1, 2, …, m),
  - volumes of outputs q_j (resp. q) for the output j,

[5]The partial change can be smaller as well larger than total change in EVA because individual factors (change in productivity, prices or physical volumes of production) can affect oppositely.

- for input (economic costs[6]):
  - prices (costs) of one unit of inputs $p_{v,i}$ for the input i (i = 1, 2, …, n) (consumed or binded), price for binded components of input is derived from the costs of capital (WACC),
  - amounts of consumed and binded units of inputs $v_{i,j}$ (resp. v_i), it is consumed amount in the case of components of consumption and in the case of binded components it is the the monetary value of their average amount in the analysed period.

The **partial productivity** is expressed as

$$\frac{q_j}{v_{i,j}} \qquad (5)$$

and **total productivity** as

$$\frac{\sum_{j=1}^{m} p_j * q_j}{\sum_{i=1}^{n}\sum_{j=1}^{m} p_{v,i} * v_{i,j}} \qquad (6)$$

and **economic value added** (EVA) can be expressed by the equation 7 (it is a structure necessary for productivity calculations.

$$\sum_{j=1}^{m} p_j * q_j - \sum_{i=1}^{n}\sum_{j=1}^{m} p_{v,i} * v_{i,j} \qquad (7)$$

3.1 Measures and calculations of impacts of productivity and other factors on the EVA creation when data about inputs are limited (unavailable data about inputs belonging to each differentiated output separately)

According defined variables above the level i about inputs is available but not the level j. The described analyses of productivity and the EVA creation still can be realised but their analytical explaining power is (a little bit) lower.

Following measures were constructed from the decomposition of total absolute change in the EVA creation using principles of Montgomery indices[7].

[6] It is a modification or simplification of economic costs because it takes into account only opportunity costs related to equity and not other opportunity costs. It is consistent with the construction of EVA.

[7]The usage of principles of Montgomery indices is de facto an application of logarithmic decomposition which brings with many advantages compared with another methods of decomposition also computing problems in the case of zero values (in denominators or in arguments of logarithms) or of negative values (in arguments of

Index of total productivity (in the case of limited specification about inputs)

$$\left(\frac{\sum_{i=1}^{n} p_{v,i,1} * v_{i,1}}{\sum_{i=1}^{n} p_{v,i,0} * v_{i,0}} \right)^{\frac{\alpha}{\sum_{i=1}^{n} p_{v,i,1} * v_{i,1} - \sum_{i=1}^{n} p_{v,i,0} * v_{i,0}}} \qquad (8)$$

where α is the equation (10)[8].

Index of partial productivity (in the case of limited specification about inputs)

$$\frac{\left(\frac{\sum_{j=1}^{m} p_{j,1} * q_{j,1}}{\sum_{j=1}^{m} p_{j,0} * q_{j,0}} \right)^{\frac{\sum_{j=1}^{m} \frac{\ln \frac{q_{j,1}}{q_{j,0}}}{\ln \frac{p_{j,1} * q_{j,1}}{p_{j,0} * q_{j,0}}} * \left(p_{j,1} * q_{j,1} - p_{j,0} * q_{j,0} \right)}{\sum_{j=1}^{m} p_{j,1} * q_{j,1} - \sum_{j=1}^{m} p_{j,0} * q_{j,0}}}}{\frac{v_{i,1}}{v_{i,0}}} \qquad (9)$$

The difference in the EVA creation between the time periods 1 and 0 due to changes in total productivity (in the case of limited specification about inputs)[9]

$$-\ln \frac{\left(\frac{\sum_{j=1}^{m} p_{j,1} * q_{j,1}}{\sum_{j=1}^{m} p_{j,0} * q_{j,0}} \right)^{\frac{\sum_{j=1}^{m} \frac{\ln \frac{q_{j,1}}{q_{j,0}}}{\ln \frac{p_{j,1} * q_{j,1}}{p_{j,0} * q_{j,0}}} * \left(p_{j,1} * q_{j,1} - p_{j,0} * q_{j,0} \right)}{\sum_{j=1}^{m} p_{j,1} * q_{j,1} - \sum_{j=1}^{m} p_{j,0} * q_{j,0}}}}{\frac{v_{i,1}}{v_{i,0}}}}{\ln \frac{v_{i,1}}{v_{i,0}}} * \left(p_{v,i,0} * v_{i,0} - p_{v,i,1} * v_{i,1} \right) \qquad (10)$$

The difference in the EVA creation between the time periods 1 and 0 due to changes in partial productivity (in the case of limited specification about inputs)is equal

logarithms). Some problems can be solved using l'Hopital rule - detail in Klečka (2007) or it is possible to use the other method of decomposition – measures of productivity constructed by the method of gradual changes are described in Klečka (2008).

[8]The substitution by α is used in the equation 8 because of technical reasons due to limited possibilities of equation editor in this text.

[9]The displayed version of equations 10, 9 and some others is possible to rewrite mathematically (especially simplify ratios) but this version is more visible.

to the measure expressed by equation 10 which consists only of relevant component i (connected with analysed type of partial productivity).

3.2 Measures and calculations of impacts of productivity and other factors on the EVA creation when data about inputs are not limited (available data about inputs belonging to each differentiated output separately)

According defined variables above the level i about inputs is available as well as the level j.

These measures can be also used for the analysis of production whose output is homogenous and therefore there is only one type of output j.

Following measures were constructed from the decomposition of total absolute change in the EVA creation using principles of Montgomery indices.

Index of total productivity

$$\left(\frac{\sum_{i=1}^{n}\sum_{j=1}^{m} p_{v,i,1} * v_{i,j,1}}{\sum_{i=1}^{n}\sum_{j=1}^{m} p_{v,i,0} * v_{i,j,0}} \right)^{\frac{\sum_{i=1}^{n}\sum_{j=1}^{m} \frac{-\ln\frac{\frac{q_{j,1}}{v_{i,j,1}}}{\frac{q_{j,0}}{v_{i,j,0}}}}{\ln\frac{p_{v,i,1} * v_{i,j,1}}{p_{v,i,0} * v_{i,j,0}}} * \left(p_{v,i,0} * v_{i,j,0} - p_{v,i,1} * v_{i,j,1} \right)}{\sum_{i=1}^{n}\sum_{j=1}^{m} p_{v,i,1} * v_{i,j,1} - \sum_{i=1}^{n}\sum_{j=1}^{m} p_{v,i,0} * v_{i,j,0}}} \qquad (11)$$

Index of partial productivity is equal to the measure expressed by equation 11 which consists only of relevant component i (connected with analysed type of partial productivity).

The difference in the EVA creation between the time periods 1 and 0 due to changes in total productivity

$$\sum_{i=1}^{n}\sum_{j=1}^{m} \frac{-\ln\frac{\frac{q_{j,1}}{v_{i,j,1}}}{\frac{q_{j,0}}{v_{i,j,0}}}}{\ln\frac{p_{v,i,1} * v_{i,j,1}}{p_{v,i,0} * v_{i,j,0}}} * \left(p_{v,i,0} * v_{i,j,0} - p_{v,i,1} * v_{i,j,1} \right) \qquad (12)$$

The difference in the EVA creation between the time periods 1 and 0 due to changes in partial productivity is equal to the measure expressed by equation 12 which consists only of relevant component i (connected with analysed type of partial productivity).

Conclusion

The contemporary impact on the efficiency of inputs consumption as well as efficiency of their binding asks a relevant reflection from the system of measuring and indicators of productivity. It is also necessary to valuate productivity and distinguish the impact of its changes in the EVA creation and further in the achieving corporate goals and to distinguish consequences in the technical economic rationality of production factors whose can be expressed by productivity itself. This paper provides mathematical apparatus of different productivity indicators which are able to be used in the corporate sector for valuating productivity of business, its subparts or even on the level of several businesses. The measures are mentioned in two basic versions – one for the case of data limitation and second for available data about inputs belonging to each differentiated output separately. The data requirements are specified and barriers are discussed.

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