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Decomposition of Productivity and Allocative Efficiency in Serbian Industry

In this paper on the sample of 567 enterprises, using the semi-parametric LP approach for estimation of multifactor productivity (MFP), the allocative efficiency was quantified by OP decomposition at the level of Serbia, of the selected regions and industrial sectors. In the observed period from 2005 to 2007, the privatised and new private-owned enterprises showed positive allocative efficiency or positive covariance between the participation in the market and factor productivity. Companies with higher productivity also had larger participation in the output market. The highest degree of allocative efficiency was recorded on the territory of Vojvodina and in terms of industrial sectors, in the tobacco industry, wood industry and metal-processing industry. Negative allocative efficiency, i.e. larger participation of the firms with low factor productivity in the output market was seen in the motor vehicle industry and electrical machinery production.

Keywords: *multifactor productivity, decomposition, allocative efficiency, transition, deregulation.*

1. INTRODUCTION

Extensive empirical evidence consider the hypothesis that in the developed market economies there is a positive correlation between company size and productivity [1-3]. The resources following the productivity show that in certain economic sector larger companies turn out to be more productive as well. Deregulation and removal of administrative barriers is a precondition for allocative efficiency. To prove this hypothesis, empirical decomposition of productivity is necessary. The literature dealing with determinants of market selection shows that low productivity companies are more likely to exit the particular economic sector as well as that the young, newly-established firms, which survived, record faster productivity growth than the incumbents firms [3,4]. Emerging and transitional economies mainly have such a market structure that notably disturbs allocative efficiency in terms of restricting reallocation of resources towards more productive activities [5]. Most significant factors, which disturb allocative efficiency, include incomplete competition, premiums to existing companies, difficult access to credit funds for new and small companies, high costs of opening new companies, undeveloped infrastructure and inefficient implementation of the economic regulations. Political and economic reforms in transitional countries should create an environment for allocation of economic resources towards industries with higher productivity. Deregulation should allow a simpler reallocation of production inputs and outputs from low productivity to high productivity firms or sectors of the economy.

The aim of this paper is to quantify, through empirical research, the allocative efficiency of industrial companies in Serbia in the early post-privatisation period.

The second part of the paper provides an empirical strategy. The third part contains the analysis of the sample and sources of the data. The fourth part presents empirical results. The fifth part brings conclusions.

2. EMPIRICAL STRATEGY

2.1 Productivity measurement concept

For the measurement of productivity at the level of the company, the approach through multifactor productivity (MFP) was applied. Productivity is here defined as a part of the value added that is not a direct result of the used inputs (labour and capital), but of the internal and external environment factors, such as innovations, organisation, deregulation (competition), ownership structure transformation, etc. Statistically, MFP represents a residual from the production function:

$$\delta_{jt} = \ln(y_{jt} - \beta_k)\ln(k_{jt}) - \beta_l \ln(l_{jk}) \qquad (1)$$

where δ_{jt} represents a level of productivity of the company j over time t, ln (y_{jt}), ln (k_{jt}), ln (l_{jt}) are values or quantities of production, capital, labour of firm j in year t.

In the used two-factor production function, the parameters are usually determined by the ordinary least square method (OLS). Given the fact that our sample contains time series data, a problem of correlation between productivity (residual) and production input level is present. If a company observes an increase in factor productivity in a certain time period, it will directly lead to increase in the used inputs. Reversely,

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multifactor productivity decrease leads to decrease in production inputs. There is a problem of so-called simultaneousness, which disturbs conditions of non-biased and consistency of parameters defined by OLS method. For the production function parameters defined by the OLS method to be consistent, productivity (residual) must be independent from the production inputs. Traditional methods for overcoming this problem (fixed effects method, instrumental variables method) are more recently supplemented by two semi-parametric methods – Olly and Pakes (OP) and Levinsohn and Petrin (LP). The fixed effects method resolves the problem of simultaneousness by fixing in the panel sample the error term (MFP) in the observed time interval, whereas the instrumental variables method avoids correlation between productivity and production input level by finding additional variables (instruments) which are correlated with production inputs, but not with productivity. In the absence of adequate instruments, the lagged values and lagged differences of variables are often used. These are basically the same variables (labour and capital), but their value from the previous time interval is taken as an instrument. The OLS method of fixed effects consistently resolves the production function parameters, but there is a question how realistic is the assumption on constancy of error (multifactor productivity) in longer time periods. The OLS method of instrumental variables gives consistent values of production function parameters, but in practice it is very difficult to find appropriate instruments. The lagged variables as a substitute for adequate instruments are problematic in case of short-term intervals where their changes are negligible. The Olly and Pakes [6] method resolves the problem of simultaneousness by introducing investment as a proxy for productivity change. The core of the approach lies in the assumption that a higher value of error (MFP) in a certain year will lead to higher value of investment in the same year, although that investment comes too late to influence the value of the factor capital in the same year. The function parameters are consistently determined by defining first the unknown function for an optimum investment decision:

$$i_{it} = i_{it}(\delta_{it}, k_{it}) \,. \tag{2}$$

Investment function is monotonously increasing, therefore by inversion of this function and by defining a new function $h\,(\,) = i^{-1}\,(\,)$, factor productivity δ may be expressed as:

$$\delta_{it} = h_t(i_{it}, k_{it}) \,. \tag{3}$$

The equation for determination of factor productivity can now be formulated as:

$$y_{it} = \beta_l l_{it} + \beta_k k_{it} + h_t(i_{it}, k_{it}) + \mu_{it} \,. \tag{4}$$

In order to determine consistently a parameter for labour, it is necessary to define a new function:

$$\phi(i_{it}, k_{it}) = \beta_k k_{it} + h(i_{it}, k_{it}) \tag{5}$$

which may be approximated by higher order polynomial function and define as $\bar{\phi}$. In the first phase, the following equation is further defined:

$$y_{it} = \beta_l l_{it} + \phi_t + \mu_{it} \tag{6}$$

based on which it is possible to consistently define a parameter β_l. To be able to define this parameter consistently, it is necessary to use the function $\bar{\phi}$, and/or to determine investment and capital coefficients for the needs of fitting $\bar{\phi}$ values. To determine a parameter for capital, it is necessary to define the function:

$$\Omega_{it} = y_{it} - \beta_l l_{it} \tag{7}$$

and determine the equation:

$$\Omega_{it} = \beta_k k_{it} + g(\phi_{t-1} - \beta_k k_{t-1}) + \mu_{it} \tag{8}$$

where g is an unknown lagged function of the value $\bar{\phi}_{t-1}$ and capital, which is approximated by higher order polynomial function. Due to the lagged value, the above function is solved by the method of non-linear least squares. Thus a consistent value of the parameter β_k is reached. The Olly and Pakes method gives consistent values of production function parameters upon certain conditions. The most important conditions include strict positive investment. In other words, it means that observations with zero value investment shall be excluded. Considering that the number of observations with zero value investment in empirical research can be high, it leads to a significant reduction of the sample based on which the production function parameters are determined. Levibnsohn and Petrin [7] developed an alternative method for determination of production function parameters, using an intermediary input (cost of material) as a proxy variable. This solution has practical implications in the fact that majority of companies are recording in most periods a positive value of the cost of material. This model also assumes the Cobb-Douglas production function, in which the demand for intermediary input depends on capital and productivity:

$$m_{it} = m_{it}(\delta_{it}, k_{it}) \,. \tag{9}$$

As in case of the Olly and Pakes method, the approach of Levinsohn and Petrin starts from the assumption that the function of demand for intermediary inputs is monotonously increasing in productivity δ_{it}. This allows inversion of the demand function and/or productivity may be expressed as the function of capital and intermediary input:

$$\delta_{it} = \delta_{it}(m_{it}, k_{it}) \,. \tag{10}$$

The Levisohn-Petrin method further assumes that productivity follows a first-order Markov process:

$$\delta_{it} = E(\delta_{it} \,|\, \delta_{it-1}) + \xi_{it} \tag{11}$$

where ζ_{it} represents a part of productivity which is not in correlation with k_{it}. If the dependent variable is a value added, the production function may be expressed as:

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \delta_{it} + \mu_{it} \tag{12}$$

and/or

$$y_{it} = \beta_l l_{it} + \phi(k_{it}, m_{it}) + \mu_{it} \quad (13)$$

where

$$\phi(k_{it} m_{it}) = \beta_0 + \beta_k k_{it} + \delta_{it}(k_{it}, m_{it}). \quad (14)$$

After replacing k_{it} and m_{it} by polynomial approximation in the equation of the value added, it is possible to determine a parameter β_l. In the second phase, a coefficient β_k is determined. This part of the procedure starts with calculation of the assessed values for ϕ_{it} by using the following relation:

$$\overline{\phi} = y_{it} - \overline{\beta}_l l_{it}. \quad (15)$$

For each assumed value of β_k^* it is possible to calculate the prediction of the productivity δ_{it} for all observed periods t by using the relation:

$$\overline{\delta}_{it} = \overline{\phi}_{it} - \beta_k^* k_{it}. \quad (16)$$

By using these values, consistent approximation for $E(\delta_{it} | \delta_{t-1})$ is given through prediction of the values from the regression equation:

$$\overline{\delta}_{it} = \chi_0 + \chi_1 \delta_{t-1} + \chi_2 \delta^2{}_{t-2} + \chi^3{}_{t-3} + \varepsilon_{it}. \quad (17)$$

With given values for $\overline{\beta}_l$, β_k^*, $\overline{\delta}_{it}$ production function residual can be determined

$$\mu_{it} + \xi_{it} = y_{it} - \overline{\beta}_l l_{it} - \beta_k^* k_{it} - \overline{\delta}_{it}. \quad (18)$$

The estimated value $\overline{\beta}_k$ from β_k is defined as a solution for

$$\min_{\beta_k^*} \sum\nolimits_t (y_{it} - \overline{\beta}_l l_{it} - \beta_k^* k_{it} - \overline{\delta}_{it})^2. \quad (19)$$

Coefficients β_l and β_k are consistently determined, i.e. the correlation between production inputs and error (multifactor productivity) is avoided. Considering the nature of our data, the factor productivity in our research is defined on the basis of (1) where the production function parameters are estimated by applying Levinsohn-Petrin semi-parametric approach.

2.2 Productivity decomposition

Having determined the factor productivity, it is further used for assessment of allocative efficiency. Quantitative assessment of allocative efficiency implies decomposition of average weighted productivity at the level of the industrial sector on the unweighted average productivity at the level of the company and cross-term (covariance) [6]. Formally, the productivity level is determined as follows:

$$\delta_t = \sum_{i=1}^{N} s_{it} \delta_{it} \quad (20)$$

where δ_{it} represents average weighted productivity at the level of industry, s_{it} participation of company i in the total value of output (sales) of the industry, δ_{it} productivity of the company i over time t and N represents a number of companies in respective industry. This expression can be further decomposed as follows:

$$\delta_t = \sum_{i=1}^{N} (\overline{s}_t + \Delta s_{it})(\overline{\delta}_t + \Delta \delta_{it}) =$$
$$= N_t \overline{s}_t \overline{\delta}_t + \sum_{i=1}^{N} \Delta s_{it} \Delta \delta_{it} = \overline{\delta}_t + \sum_{i=1}^{N} \Delta s_{it} \Delta \delta_{it} \quad (21)$$

where $\overline{\delta}_t$ represents average unweighted productivity, $\overline{s}_t$ average unweighted sales participation, Δs_{it} difference between participation in company sales s_{it} and average sales participation $\overline{s}_t$ and $\Delta\delta_{it}$ difference between company productivity δ_{it} and average productivity at the level of the industry $\overline{\delta}_t$. The second part of (21) represents a multiplication of company productivity deviation from average productivity and/or measure of covariance between company size and productivity. Positive value of this part of the factor productivity means that firms recording higher productivity than average have a larger share in the industry market, while negative value shows that major portion of the sales value accounts for less productive firms. The more positive cross-term value is, the higher allocative efficiency is and the factor productivity of the industry is improved. As deregulation and competition strengthening allow simpler and faster reallocation of resources to more productive industries, for transitional countries cross-term value represents quite a convenient measure of the quality of market and institutional reforms. In the empirical part of the paper, our attention is focused on the value of Olly and Pakes (OP) cross-term.

3. SAMPLES AND VARIABLES

The sample included 567 industrial companies privatised by the end of 2007 from 27 industries in Serbia. Large, medium and small firms, as well as Serbian regions were evenly represented in the sample. Firms without employees and firms that recorded negative value added in any of the observed years for the period 2005 – 2007 were not included in the sample. The value added is calculated on the basis of the value of production and subsidy reduced by costs of tax on products and value of intermediate consumption. Nominal value of the direct costs of material and goods intended for resale is deflated by weight price index of the sector from which the material or goods originate. The value of the capital is measured through value of company's fixed assets. The value of fixed assets in the balance sheets of privatised and private-owned companies is purchase value corrected with the depreciation amounts. The production factor labour is measured as average number of employees (headcount) at the end of each month. Average number of employees is calculated on the basis of working hours. The official financial reports submitted annually and semi-annually under uniform accounting procedures provide information on firm's revenue from domestic and foreign sale, material inputs and firm's capital stock. The financial reports are provided directly from firms, National Bank of Serbia, Belgrade Stock Exchange and from independent auditing firms. Output and capital price deflators come from the Serbian Statistical Office.

4. EMPIRICAL RESULTS

Decomposition of multifactor productivity by the OP method is determined at the level of Serbia, by years, by regions and by industrial sectors. Figure 1 shows positive cross-term (covariate) at the level of Serbia, which indicates improvement of allocative efficiency as a result of institutional and market reforms in the early post-privatisation period. Similar results were recorded in the comparative periods by some other transitional and developing economies [5,8,9].

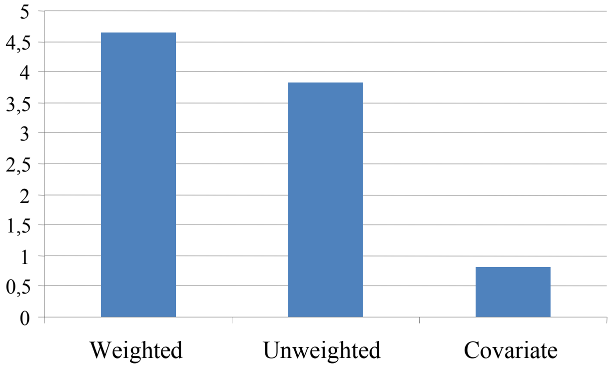

Figure 1. OP decomposition of MFP – Serbia (2005 – 2007)

If observed by years (Fig. 2), allocative efficiency shows a growth tendency, which is in line with the accelerated deregulation measures. Cross-term stagnated in 2005 and 2006, whereas it rose in 2007. Considering the reallocation of resources from less productive to more productive companies takes some time, the observed period represented the time in which the measures of market deregulation and accelerated privatisation in the period 2003 – 2005 were manifested. During this period the barriers to starting a new business were removed, as well as those preventing easier access to credit funds and cutting subsidies to large companies.

Figure 2. OP decomposition of MFP by years

When observed on the regional level (Fig. 3), the highest allocative efficiency was recorded in Vojvodina and the lowest in Belgrade. The explanation for this may be sought in the sector structure of the economy of certain regions. Deregulation and higher degree of competitiveness reduced the market share of low productivity firms in agriculture, food processing industry and base metal production, while firms in metal processing industry with inherited low productivity maintained their market shares thanks to monopoly position or unpreparedness for reallocation of resources to more productive industrial sectors.

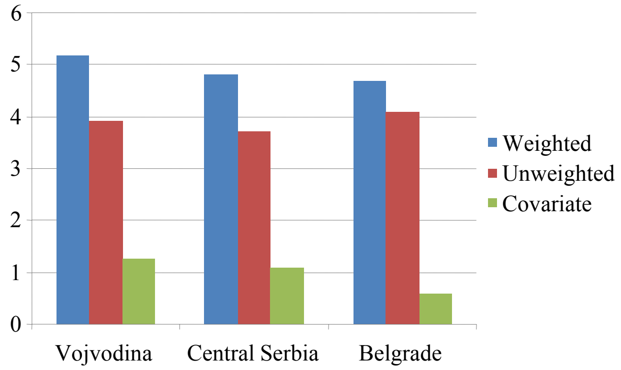

Figure 3. OP decomposition of MFP by regions

When observed by industrial sectors (Fig. 4), the highest allocative efficiency and/or improved factor productivity were seen in the sectors such as metal ore extraction, wood industry, tobacco industry and base metal production. Negative allocative efficiency was recorded by motor vehicle industry and electrical machinery production.

In motor vehicle industry and electrical machinery production, the results of OP statical decomposition of multifactor productivity show that in the observed period resources are allocated to less productive firms and overall sector efficiency deteriorates. At the same time, in the wood and tobacco industries, ore extraction and metal processing the results show high level of allocative efficiency and/or market domination of companies with high factor productivity level.

5. CONCLUSIONS

The main achievement of this research is empirical determination of allocative efficiency of industrial companies in Serbia after ownership transformation. Expectedly, privatisation and liberalisation of market mechanisms have led to higher allocative efficiency at the level of the country, region and industrial sectors. Static Olly and Pakes decomposition of multifactor productivity showed positive allocative efficiency at the level of Serbia, but also at the level of regions. In the observed period 2005 – 2007 the resources were predominantly channelled towards more productive firms and more productive sectors. Regionally viewed, the highest degree of allocative efficiency was seen in Vojvodina, then in Central Serbia and the lowest in the area of Belgrade, though it was positive in all three regions. Positive covariance between productivity and market share was recorded in most industrial sectors, which indicates a relatively favourable trend of transition reforms towards liberalisation of input and output markets, and/or deregulation of institutions. These results are in line with the comparative results recorded in other transitional economies. The limitation of this research comes from a fairly short time period of factor productivity observation and not taking into consideration companies entering or exiting the market in the observed period.

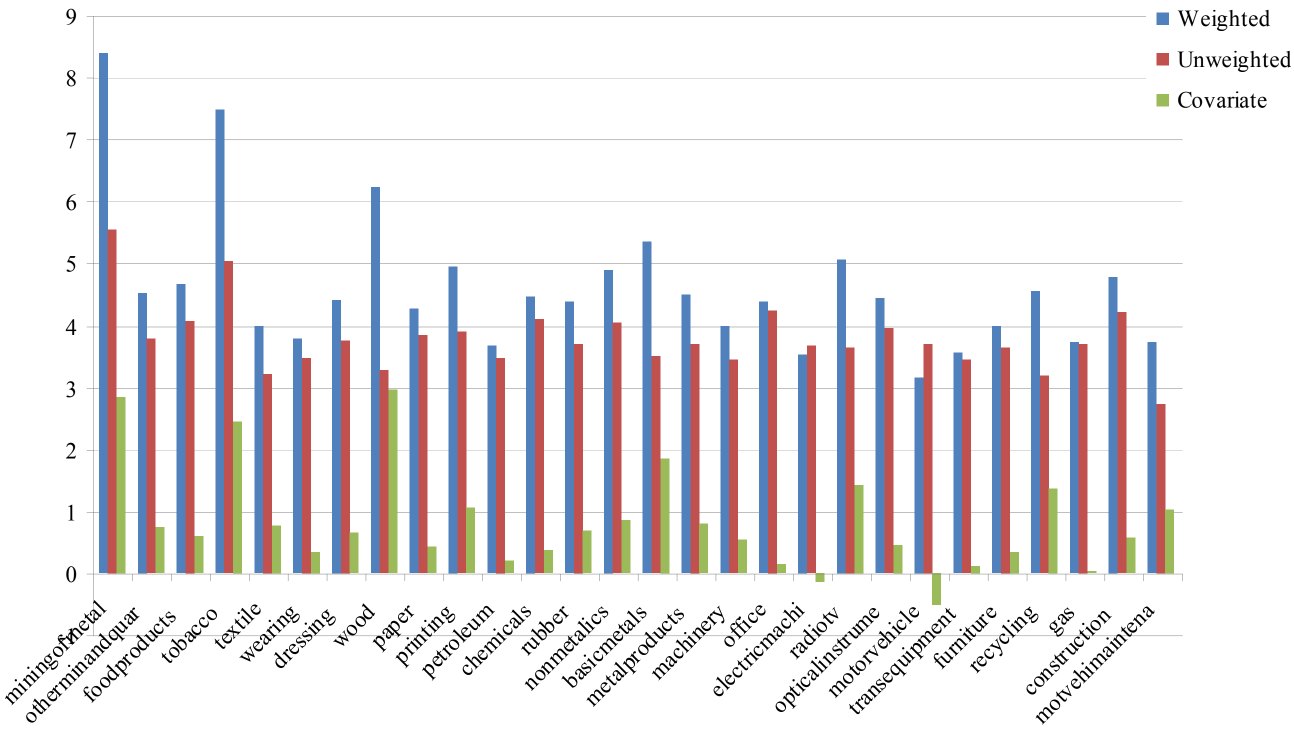

Figure 4. OP decomposition of MFP by industries

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NOMENCLATURE

MFP	multifactor productivity
LP	Levinsohn and Petrin semi-parametric method
OP	Olley and Pakes approach

ДЕКОМПОЗИЦИЈА ПРОДУКТИВНОСТИ И АЛОКАТИВНА ЕФИКАСНОСТ У ИНДУСТРИЈИ СРБИЈЕ

Никола Дондур, Слободан Покрајац, Весна Спасојевић Бркић, Соња Грбић

На узорку од 567 предузећа користећи полупараметријски ЛП приступ одређивања мултифакторске продуктивности (МФП) у раду је ОП декомпозицијом квантификована алокативна ефикасност на нивоу Србије, изабраних региона и индустријских сектора. У посматраном периоду 2005 – 2007 приватизована и нова приватна предузећа показала су позитивну алокативну ефикасност односно позитивну коваријацију учешћа на тржишту и факторске продуктивности. Предузећа са већом продуктивношћу су имала и већа учешћа на тржишту аутпута. Највећа алокативна ефикасност је забележена на подручју Војводине, а од индустријских сектора у индустрији дувана, дрвној индустрији и индустрији прераде метала. Негативна алокативна ефикасност

односно веће учешће на тржишту аутпута фирми са ниском факторском продуктивношћу утврђена је у индустрији моторних возила и производњи електричних машина.