LABOR PRODUCTIVITY INDEX DECOMPOSITION ANALYSIS AND THE INNOVATION-DRIVEN METHODS OF ITS IMPROVEMENT ON SUGAR PLANT

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In recent years, Ukraine has lost its leading position in the global sugar production and export-oriented industry has evolved into an import-dependent one, whose production is concentrated only to meet the needs of the domestic market. Today the Ukrainian sugar is uncompetitive due to the low efficiency of utilization of production capacity and outdated technology. One of the major drawbacks of sugar factories is the lack of incentives to innovate that inhibits productivity growth and development in general. The relevance of the study is the importance of identifying the labor productivity growth factors of sugar factories for catching sector and to improve its competitiveness. The purpose of the article is to conduct an index decomposition analysis of sugar plant’s labor productivity and provide practical recommendations to improve productivity through innovation in sugar industry. A structural logic model of the innovation-driven improvement of labor productivity is proposed.

Keywords: innovation, labor productivity analysis, organizational innovations, sugar industry, technological innovations.

JEL Codes: L25, C67, O31.

1. Introduction

Sugar production constitutes one of the basis for numerous food production branches and impacts the national economy deeply. The Ukrainian beet sugar production volume growth has always had strategic importance for national export capabilities. Steady development of Ukrainian sugar production spans numerous decades. In nearest past the country used to export 60% of its sugar production. About 6 million tons per year produced by 192 plants used to place Ukraine among the leading sugar-exporting courtiers of the world. Thus sugar industry has a strategic importance for the national economy (Sakhats’ky, 2013).

Nowadays the sugar production industry faces a set of significant and complex problems. Decline of the output during the last several years has turned Ukraine into an importing country whose internal market consumes all the domestically produced sugar.

The main factors hindering the industry's development are: reduction of the planting acreage; decimation of sugar factories; monopolization of the market by a
narrow circle of sugar companies; excessive production costs due to obsolete equipment; low yield and sugar content of sugar beets; the seasonality of the market; growing cost of technical and material resources and lack of working capital. In recent years the lack of raw material has been causing severe underutilization of sugar plants. On top of that the average duration of sugar beet processing cycle gets significantly less than the most cost-efficient 90–100 days period.

In 2012 Ukraine owned 63 active sugar plants with total daily processing capacity of 212.88 tons of beet. Apart from that up to 26 inactive plants could be either put into operation in case of need or reoriented to biofuel production. For example Uzynsky Sugar Plant produces both sugar and bioethanol. In 2012 Ukrainian sugar plants received 17.55 tons of beets with average sugar content of 16.1%, 17.17 million of which were transformed into 2226.38 tons of sugar. The average sugar yield in 2012 was 12.9% compared to 13.5% in 2011 (Yarchuk, 2012).

Labor productivity is the subject of research of many Ukrainian and foreign scientists. In particular, O. Grishnova gives the most generalized classification of factors influencing labor productivity (Grishnova, 2011), L. Marmul' and L. Tranchenko (Marmul', 2011), V. Diyesperov (2003) propose specific factors for agricultural labor productivity growth; B. Grabovetsky, O. Moroz and L. Blagodyr (Grabovetsky, 2008), A. Petrov (2003), O. Burliai and O. Pytel (Burliai, 2003) estimate the contribution of factors to productivity growth based on economic and statistical modeling and others. The issues concerning with productivity of sugar industry improving belong to M. Sakhs'tky (2013), M. Yarchuk (2012), C. Blume (2002) and others.

The primary causes of contemporary Ukrainian sugar industry's uncompetitiveness are: underutilization of production capacities, outdated technology and relatively low yield and sugar content of beets. These factors are significantly increasing the cost of sugar production.

Given the above, the importance of in-depth analysis of sugar factory functioning for the purpose of quick and efficient elimination of impediments for the reduction of producing cost is obvious. That task requires planning and taking all the expedient steps for labor productivity improvement.

The problem of the research. The study is aimed at quantification of the underlying factors causing changes in labor productivity at the enterprise level.

The purpose of the article is to conduct an index decomposition analysis of sugar plant’s labor productivity and provide practical recommendations to improve productivity through innovation in sugar industry.

In order to address the aim of the research the following specific tasks should be fulfilled:

- reveal the essence and significance of labor productivity index decomposition analysis;
- identify factors that influence dynamics of labor productivity in sugar enterprises;
- specify the place of innovation in a system of factors that raise labor productivity;
- propose the structural logic model of labor productivity index decomposition analysis;
• offer recommendations concerning improving labor productivity through the use of innovation in sugar industry.

The subject of the article is a complex of theoretical and practical issues of labor productivity growth on account of innovation.

The object of the article is improving labor productivity in national sugar plants.

Method of index decomposition analysis is used to estimate the contribution of factors to labor productivity growth at Salyvonkovsky Sugar Factory PJSC during the period of 2011–2012.

2. Theory and methodology

The labor productivity is determined by tightly interdependent factors of different nature whose strength of influence widely varies. The most widespread method of studying and tapping the hidden reserves of labor efficiency is index decomposition analysis.

Index decomposition analysis (IDA) is a decomposition method that is used to assess the effect of certain driving forces on indicator changes. Historical data are used, usually from two periods, to analyze which determinant changes have contributed most to a change in an indicator (Rutger, 2003). Labor productivity index decomposition analysis is a statistical method for analyzing the impact of individual factors (aspects) on labor efficiency. Apart from establishment of the causal relationships between the efficiency and the given factors it allows to estimate the influence of such relationships quantitatively.

A comparative analysis of labor productivity and factors affecting it, is a foundation for decisions aimed at the improvement and optimization of profitability, technical and organizational management, human resource management, assessment of competitiveness, pricing policies, business priorities, foreign economic relations and so on.

The most general indicator of labor productivity is the average output per employee. Its value depends on the hourly output of the working personnel, their share in the total number of the staff, the number of working days and the duration of latter (Fig. 1).
Average annual output per employee can be calculated by the formula (Petrov, 2003):

\[ E_E = d_p \times D \times WDD \times E'_W. \]  \hspace{1cm} (1)

where \( E_E \) – average annual output per employee; \( d_p \) – share of technical staff in total number of employees; \( D \) – number of days worked by one worker per year; \( WDD \) – work day duration; \( E'_W \) – average hourly output per worker.

Change in the average employee's output by changing:

- share of technical staff in total number of employees

\[ \Delta E_{Ed_p} = (d_{p1} - d_{p0}) \times D_0 \times WDD_0 \times E'_{W0} \]  \hspace{1cm} (2)

- number of days worked by one worker per year
\[ \Delta E_{Ed} = d_{p1} \times (D_1 - D_0) \times WDD_0 \times E'_W_0 \] (3)

- work day duration

\[ \Delta E_{E_WDD} = d_{p1} \times D_1 \times (WDD_1 - WDD_0) \times E'_W_0 \] (4)

- average hourly output per worker

\[ \Delta E_{E_WS} = d_{p1} \times D_1 \times WDD_1 \times (E'_{W_1} - E'_W_0) \] (5)

Change of the average worker's output depends on the number of days worked by a worker, the average work day duration and hourly output per worker:

\[ E_W = D \times WDD \times E'_W \] (6)

3. Research results and discussion

Let’s define the influence of the particular factors on labor productivity in Salyvonkivsky Sugar Plant PJSC taking into account data shown in Table (using data from annual report of Salyvonkivsky Sugar Plant).

Public Joint Stock Company ‘Salyvonkivsky Sugar Plant’ is an up to date modernized enterprise occupying a leading position among the Ukrainian sugar producers. Accordingly to historic records Salyvonkivsky Sugar Factory was built in 1873 by Count Branitsky with initial production capacity of 180 tons of sugar beet per day. Due to reconstruction in 1880s the capacity has reached 466 tons per day adding to annual 2820 tons of sugar produced. In 1881 the factory burned down, but in 1883 the Countess Branitska has built a new one producing 2032 tons of sugar per season.

The thorough reconstruction of 1914 has introduced modern and much more powerful equipment and improved processing schemes thus transforming Salyvonkivsky factory into one of the biggest sugar making enterprises worldwide prior to the First World War.

During the Second World War Salyvonkivsky sugar factory has been destroyed. The rebuilding which took place as late as in 1951 made possible the average processing of 1136 tons of raw per day. In 1971–1975 Salyvonkivsky sugar plant has been thoroughly reconstructed – or rather torn down and built anew – and its capacity has reached 5000 tons of beets per day. The year of 1996 has seen the beginning of processing of raw sugar imported from Brazil, Taiwan and Cuba. 113140.4 tons of raw sugar has been transformed into 108,967 tons of white sugar.

Currently the plant’s administration modernizes the automatic processes. In 2012 organizational and technological innovations allowed to increase the production volume by 1.5%. Except sugar the main products of Salyvonkivsky plant are beet
pulp and molasses. Lime, heat and electric power created with help of auxiliary production lines form a minor share in the total amount of marketable production.

Table. The Source data for labor productivity factor analysis in Salyvonkovsky Sugar Plant PJSC during 2011–2012

<table>
<thead>
<tr>
<th>Index</th>
<th>2011</th>
<th>2012</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Total staff:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1. Technical staff</td>
<td>327</td>
<td>345</td>
<td>+18</td>
</tr>
<tr>
<td>1.2. Administrative staff</td>
<td>267</td>
<td>285</td>
<td>+18</td>
</tr>
<tr>
<td>2. Share of technical staff in total number of employees (d_p)</td>
<td>0.8165</td>
<td>0.8261</td>
<td>+0.0096</td>
</tr>
<tr>
<td>3. Number of days worked by one worker per year (D):</td>
<td>335</td>
<td>323</td>
<td>–12</td>
</tr>
<tr>
<td>4. Number of hours worked per year:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.1. By all technical staff</td>
<td>715560</td>
<td>736440</td>
<td>+20880</td>
</tr>
<tr>
<td>4.2. By one worker</td>
<td>2680</td>
<td>2584</td>
<td>–96</td>
</tr>
<tr>
<td>5. Average work day duration (WDD), hours</td>
<td>8</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>6. Average output, 1000 UAH</td>
<td>105.257</td>
<td>125.529</td>
<td>+20.272</td>
</tr>
<tr>
<td>7. Average annual output per employee (E_E), 1000 UAH</td>
<td>321.9</td>
<td>363.9</td>
<td>+42</td>
</tr>
<tr>
<td>8. Average annual output per worker (E_W), 1000 UAH</td>
<td>394.2</td>
<td>440.4</td>
<td>+46.2</td>
</tr>
<tr>
<td>9. Average daily output per worker (E_W'), UAH</td>
<td>1176.8</td>
<td>1363.6</td>
<td>+186.8</td>
</tr>
<tr>
<td>10. Average hourly output per worker (E_W'), UAH</td>
<td>147.1</td>
<td>170.45</td>
<td>+23.35</td>
</tr>
<tr>
<td>11. Nonmanufacturing working time, hours</td>
<td>-</td>
<td>82080</td>
<td></td>
</tr>
<tr>
<td>12. Time saved due to technological modernization, hours</td>
<td>-</td>
<td>11046.6</td>
<td></td>
</tr>
<tr>
<td>13. Reduction of production cost due to the structural changes, 1000 UAH</td>
<td>-</td>
<td>12331</td>
<td></td>
</tr>
</tbody>
</table>

Despite the plant's production process are automated by 85%, the role of an employees as the controllers is increasing. Even a small human error can lead to drastic economic consequences so the factors related to individual productivity of each worker can hardly be overestimated.

Accordingly with Table, in 2011–2012 the average output per employee grew by 42000 UAH (363900 minus 321900 UAH). Its increase by 4000 UAH has been caused by the increase of the share of technical staff in total staff on 0.96%. On the other hand, growth of the average hourly output of an employee has positively influenced the average annual output of a worker. Namely, the average annual employee's output increase by 50000 UAH has been caused by the average hourly worker's output increase by 23.35 UAH. Shortening of the working period by 12 days has dimin-
ished the average annual employee's output by 12000 UAH. Thus the surplus of 42000 UAH is reflecting the total influence of the mentioned factors.

Index decomposition analysis of the average annual worker's output reveals positive influence of the average hourly output of a worker and negative influence of shortening of the working period. Namely, shortening of the working period by 12 days has diminished the average annual output of a worker by 14100 UAH. On the other hand, the increase of the average hourly output of a worker by 23320 UAH has increased the average annual output of a worker by 60300 UAH. The sum of the aforementioned factors has increased the average annual output by 46200 UAH.

Being a true reflection of efficiency the dynamics of the average annual output is a key index accounted in labor productivity index decomposition analysis. It depends on a vast set of factors including level of mechanization; implemented technologies; economic conditions; employees' qualification, age and length of employment as well as organizational and motivational aspects of human resource management etc. The method of consecutive substitutions is used to calculate the impact of factors on the hourly output. It allows processing the chains of dependent parameters by substituting them with values derived from data accumulated during the report period.

The average hourly output depends on factors related to the dynamics of labor intensity and to the monetary estimation of the latter.

In turn, the labor intensity is determined by technological and organizational innovations and by the amount of nonproductive time losses. The product pricing depends on the volumes of regular, new and substantially improved production as well as on the level of relationships with suppliers, customers, research and development establishments.

These two groups of factors are calculated by means of further consecutive substitutions taking into account the influence of three partial indexes.

The first partial index of the average hourly output is calculated as the reported output corrected by the magnitude of its change as a result of structural changes (ΔQstr), while the amount of working time needs to be corrected by the nonmanufacturing time (Tn) and unplanned economy of time due to implementation of innovations (Te). The first partial index is calculated as follows (Grabovetsky, 2008):

\[
O_{y,\text{part.1}} = \frac{Q_1 - \Delta Q_{str}}{T_1 - T_n + T_e}
\]

(7)

where: \(O_{y,\text{part.1}}\) is the first partial index of average annual output; \(Q_1\) – output obtained in the reported year; \(\Delta Q_{str}\) – output variation defined by the structural changes; \(T_1\) – total amount of time worked by technical staff during the period reported; \(T_n\) – the amount of nonmanufacturing time; \(T_e\) – the amount of time saved due to implementation of innovations.

Thus the corrected average hourly output of a worker is

\[O_{y,\text{part.1}} = 170.12\text{ UAH}\]
The difference between the obtained result and the base period data reflects the changes in the output caused by the implementation of innovations:

$$\Delta O_{\text{INT}} = 170.12 - 147.10 = 23.02 \text{ UAH}$$

The second partial index unlike the first one does not take into account the unplanned economy of time due to implementation innovations:

$$O_{y,\text{part.2}} = \frac{Q_t - \Delta Q_{\text{str}}}{T_1 - T_{n}}$$

$$O_{y,\text{part.2}} = 173.00 \text{ UAH} \quad (8)$$

The difference between the last couple of result shows change of the average hourly output due to introduction of technological innovations.

$$\Delta O_{\text{INN}} = 173.00 - 170,12 = 2,88 \text{ UAH}$$

The third partial index does not take into account the registered amount of nonmanufacturing time:

$$O_{y,\text{part.3}} = \frac{Q_t - \Delta Q_{\text{str}}}{T_1}$$

$$O_{y,\text{part.3}} = 153.7 \text{ UAH.} \quad (9)$$

The difference between the third and the second indexes is a measure of influence of the nonmanufacturing time amount onto the average annual output.

$$\Delta O_{\text{nonmtime}} = 153.7 - 173.0 = -19.3 \text{ UAH}$$

The balance of factors is: $23.02 +2.88 - 19.30 = 6.60 \text{ UAH per hour.}$ Thus all the factors except the third one influence the workers’ labor productivity positively (Fig. 2). It is easy to see that organizational innovations influence the average hourly output and total labor productivity most of all.

Time-saving organizational and technological innovations constitute an important reserve of labor productivity growth for Salyvonkivsky sugar factory. One of the characteristic drawbacks of numerous sugar plants including Salyvonkivsky one is the lack of organizational structure capable of paying the adequate attention to the management of innovations. Proper innovation development involves the use of advanced scientific and technological achievements of domestic and foreign companies and a comprehensive and effective use of the in-house intellectual capital (including the innovations proposed by the employees).
Factors influencing the average hourly output of a worker

Non-productive use of working time decreases the level of labor productivity. Though the partial introduction of technological innovations has allowed to increase the output and to diminish the amount of nonmanufacturing time, it failed to eliminate it completely. Significant share of faulty production is caused by the inferior quality of raw. E. g., recent data indicate that the share of mechanically damaged raw material in period of 2010–2012 was 25.8% including 11.8% of severely damaged beets.

4. Conclusions

Strongly damaged root crop, significantly diminished sugar beet acreage (5207.3 ha in 2012 vs. 7129.5 ha in 2007) and decreased yield (40.12 kg/ha in 2012 vs. 46.11 kg/ha in 2007) make labor productivity issues extremely important for the contemporary sugar factories. The main vector of labor productivity improvements is pointing towards the innovative development. The traditional approaches towards the further development of sugar industry implying intense mechanization, fertilization and use of pesticides are falling short of expectations. Contemporary state of sugar plants and their labor productivity call for the following measures:

1. Deep analysis of every single processing stage and elimination of factors causing time losses, interruptions and other problems decreasing the average hourly and annual output.

2. Constant monitoring of factors influencing the level of labor productivity and analyzing their fluctuations over time in order to reveal the reserves for further improvements which could be used as rationale for constructive management decisions.

3. Introduction of benchmarking into the sugar plants operation in order to facilitate the access to the best practices, methods and standards developed by similar enterprises which in turn can increase labor efficiency, decrease production costs, shorten production cycles, improve logistics etc.

4. Establishment of an innovative development department responsible for shaping of the innovative development strategy, preparation of reports and recommendations based on monitoring of innovations within the sugar industry, bringing
the useful technical proposals made by the employees to fruition and mobilization of costs necessary for the innovative development.

References

DARBO NAŠUMO FAKTORINĖ ANALIZĖ IR JO DIDINIMO GALIMYBĖS REMIANTIS INOVACIJOMIS
(cukraus pramonės pavyzdžiu)

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Kijevo Taraso Ševčenkos nacionalinis universitetas

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Santrauka


Reikšminiai žodžiai: inovacijos, našumas, analizė, cukraus pramonė, technologinės naujovės.