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OPTIMIZATION MODEL OF THE STRUCTURE OF THE UKRAINIAN INDUSTRIAL SECTOR (BY POLISH INDUSTRY PARAMETERS)

MODEL OPTYMALIZACJI STRUKTURY UKRAIŃSKIEGO SEKTORA PRZEMYSŁOWEGO (W OPARCIU O POLSKIE PARAMETRY PRZEMYSŁOWE)

Introduction

One of the key priorities of the Ukrainian government is to create conditions for the transition from raw materials to high-tech economy models. High-tech full-cycle industrial production, focused on import substitution and expanding commodity exports, can contribute not only to reducing unemployment and labor migration, but also to increase social standards, the development of science and education, and the strengthening of the national financial system.

Ukrainian industry in terms of key performance indicators is significantly inferior to the EU industry, in particular, countries with similar industrial potential and economic type. Thus, in 2015, the domestic industry fell by 4.9 in times in terms of output and by 6.2 in times in terms of gross value added [1, 2]. In pre-crisis 2013, such a predominance of Polish industry was smaller and still substantial and amounted to 2.7 and 3.2 in times, respectively. At the same time, in 2013, the number of people employed in industry in Ukraine was higher than in Poland by 1.1 in times (3170 vs. 2843 thousand people), and in 2015 it was 0.88 in times less (2573.9 against 2926.6 thousand people) [3, 4]. The above determines the need to find ways to improve the efficiency of the functioning of the industrial sector of the national economy.

Theoretical and practical aspects of development and ensuring the efficiency of domestic industry are investigated in [5 – 11]. Thus, the assessment of the impact of the Free Trade Area between Ukraine and the EU member-states on industrial activities was carried out by a group of scientists in [5]; the contradiction in the formation of the structure of production and the domestic market in Ukraine is highlighted in [6]; a comprehensive description of the peculiarities of the development of national industry is given in [7]; the state and prospects of industry development, the principles of state strategy and policy in the development of industry are covered in [8 – 10]; the methods of increasing the profit of industrial enterprises and modeling the forecast operating profit based on the effect of the production leverage is proposed in [11]. But in these and other studies insufficient attention is paid to the applied aspects of optimizing the structure of domestic industry as a factor in increasing its socio-economic efficiency. The need for such information for the development and implementation of the latest industrial policy in Ukraine, aimed at increasing the competitiveness of domestic industry, updates the research in this direction.

Presentation of the main research material

The socio-economic efficiency of industry reflects the share of gross value added in the output of this sector of the economy. The higher the value of the indicator, the more efficient the industry functions, as a result of which the social and economic effects are reflected in the components of gross value added – wages of employees, gross profit, mixed income. In terms of the share of gross value added in industry output over 2012-2015, the Ukraine exceeded 5.0 percentage points (or hereinafter – pp.) by the EU-28 (Table 1).

Table 1. The share of GVA in industry output (by types of industrial activity), %

The type of industrial activity	Ukraine				EU-28			
	2012	2013	2014	2015	2012	2013	2014	2015
Industry	**24.18**	**24.78**	**24.95**	**24.63**	*30.24*	*30.24*	*29.88*	*30.23*
Extractive industry and career development	53.93	52.79	50.66	51.10	*60.23*	*59.44*	*56.26*	*50.79*
Manufacturing	18.30	18.76	19.89	19.63	*28.32*	*28.80*	*28.63*	*29.23*
Supply of electricity, gas, steam and air condition	31.52	31.47	30.21	30.20	*31.78*	*31.67*	*31.43*	*31.72*
Water supply; sewage, waste management	29.21	30.99	30.84	29.37	*41.43*	*41.38*	*40.96*	*40.54*

Reed: GVA – gross value added. Source: grouped by [1, 12].

As a result of lowering the efficiency level by 0,32 pp. in 2015, compared to the previous one, the domestic industry has become an outsider in EU, exceeding only Slovakian by 2.21 pp.

Among the different types of industrial activity, the least socio-economic efficiency is characteristic of the processing industry. In Ukraine during 2012-2015, the share of gross value added in the issue of this type of industrial activity exceeds 9.0 pp. was lower than in the EU-28. The domestic processing industry as a whole is the least efficient compared to all EU member states.

The value of the share of the gross value added in the extraction industry and the development of quarries in Ukraine in 2015 for the first time exceeded the EU-28. However, in view of Ukraine's (with great margin) championship among the EU in terms of the share of extractive industry in production and in the gross added value of industry, its 13th place in terms of the value of the share of gross value added in the release of this type of industrial activity is a sign of ineffective use of existing production potential.

During the analyzed period of time, the lag between the value indicators of the share of gross value added in the electricity, the gas, steam and air conditioning supply in Ukraine and the EU-28 constantly increased in favor of the latter and in 2015 reached 1.52 pp. Ukraine fell to the 23-rd place among the countries under review for the effectiveness of this kind of industrial activity, while occupying 13-th place in the share of the latter in the issue and 9-th in the share in gross value added. The value of the share of gross value added in the production of water supply, sewage, waste management during 2012-2015 was lower in Ukraine than in the EU-28, at more than 10.0 pp., which turned it into outsiders among of the EU on the effectiveness of the type of industrial activity.

The similar situation necessitates a revision of the state industrial policy on water supply, sanitation, the waste management with the aim of increasing its potential (taking into account the volumes of water resources in Ukraine) and increasing productivity. For example, the share of gross value added in the release of this type of industrial activity in post-socialist countries such as Croatia, Slovakia, Poland, Bulgaria, Lithuania and Latvia in 2015 was more than 50 per cent. In hence the necessity of deregulation of this kind of industrial activity in Ukraine, in particular, liberalization of tariff policy.

The key indicator that characterizes the growth of efficiency is ratio between the growth rates of gross value added and output. The higher the value of this indicator, the more intense is the increase in efficiency, in the prevalence of gross value added over the issue. In Ukraine, the growth rate of the gross value added of industry in 2014 exceeded the growth rate of output by only 11%, and in 2015 this ratio in general became negative (Fig. 1). Similarly, the situation with increasing efficiency of the domestic processing industry is critical, with the growth rate of its production in 2015 exceeding the growth rate of gross value added by 7% (Fig. 2)
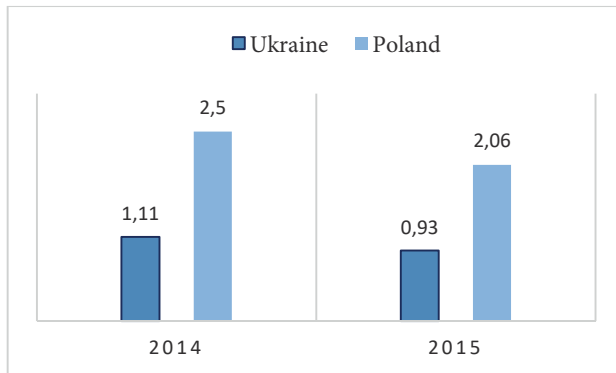
Figure 1. The relationship between the growth rate of GVA and the production of Ukraine and Poland, in times
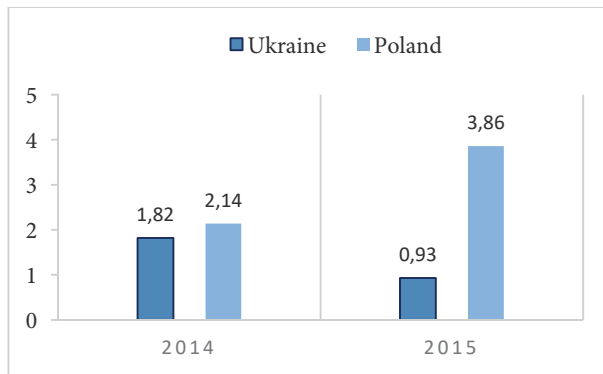

Figure 2. The ratio between the growth rate of GVA and the output of the processing industry of Ukraine and Poland, in times

Source: built by [1, 2].

At the same time, in Poland, the ratio between the growth rate of gross value added and the rate of increase in industrial output exceeds twice, in the processing industry it increased in 2015 to 3.86 (vs. 2.12 pp. in 2014). One of the most important reasons for low socio-economic efficiency of domestic industry is the inefficient economic structure of sector. Such conclusion was the result of comparison of structural indicators of Ukraine and Poland – the neighboring countries, models of the national economy which are similar in socio-economic parameters. It is therefore advisable to take into account the experience of structural adjustment of the industrial sector of the Polish economy.

In the period of time since the signing of the Association Agreement with the EU prior to its accession (by the way, 1994-2004), Poland succeeded in transforming the industry to improve its efficiency. The output of the Polish industry reduced the

share of extractive industry and the development of quarries: from 7.83 in 1995 to 4.85 in 2004, and in 2015 it was 3.74% (Table 2).

Table 2. The structural indices of Ukraine and Poland industry, %

The indicator	Ukraine			Poland			
	2004	2011	2015	1995	2004	2011	2015
Industry (the share in the issue of types of economic activity)	**48.08**	**43.78**	**38.10**	**41.48**	**37.43**	**37.83**	**37.79**
Extractive industry and career development (the share in industry output)	8.15	12.22	11.67	7.83	4.85	5.09	3.74
Manufacturing (the share in industry output)	*83.64*	*77.12*	*75.57*	*82.28*	*83.68*	*83.40*	*84.47*
Supply of electricity, gas, steam and air condition (the share in industry output)	8.20	10.65	11.08	9.05	9.06	8.80	8.82
Water supply; sewage, waste management (the share in industry output)			1.69	0.84	2.41	2.70	2.96

Source: grouped by [1, 12].

Conversely, the share of the processing industry increased from 82.28% to 83.68 per cent, and in 2015 it reached 84.47%.

In Ukraine, during 2005-2014, the share of industry in the production of the economy declined by almost 10.0 pp., but the structure of the production industry has been the opposite of changes in Poland than in Ukraine. Thus, the share of extractive industry and the development of quarries in the domestic industry increased from 8.15 to 11.67%, while the share of processing industry, – on the contrary, – decreased from 83.64 to 75.57%. Such a transformation intensified the raw material orientation of national economy and impacted negatively on the efficiency of its industrial sector.

Thus, initially (in 2005-2007), due to the dynamic growth of the value of the share of gross value added in the industry, Ukraine almost equalized with Poland – in 2007 the difference was only 0.49 pp. in favor of the latter (Fig. 3).
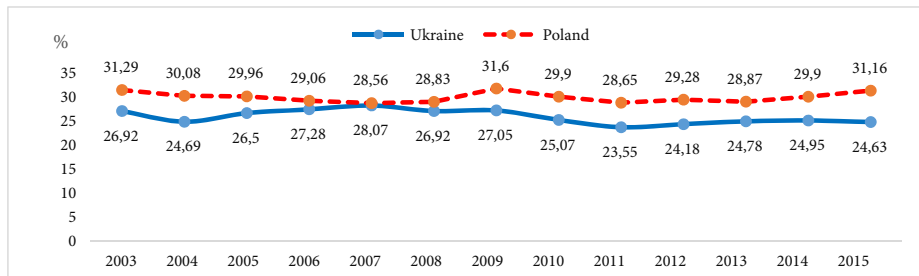

Figure 3. The share of GVA in the Ukraine and Poland industry output during 2003-2015, %
Source: built by [1, 2].

However, since 2008, the decline in the efficiency of the domestic industry, due to the deterioration of the situation on commodity markets under the influence of the global financial crisis. The fall in prices for metal and other industrial products complicated the situation, and in 2011 the share of gross value added in the Ukrainian industry dropped to 23.55%. (or near 1.0 pp.).

At the same time, the industry in Poland, in spite of crisis, which covered the economy of the European zone, was able to keep the value of the gross value added share in the output in 2011 at 28.65% (+5.1 pp., in comparison to Ukraine) and to increase it is up to 31.16% in 2015 (+6.53 pp., in comparison with Ukraine). Such efficiency is explained by the rational structure of the industrial sector of the Polish economy, where, as a result of the restructuring, the production with a high degree of processing dominates.

From the above it follows that the Ukrainian industry has the potential opportunities to achieve the level of efficiency in Poland. One of the key directions of such an achievement is the optimization of the economic structure of this sector of the economy, in the course of which it is necessary to take in account the strategic benchmark of socio-economic development of Ukraine – the transition from raw material to innovation-investment model of the national economy.

According to the experience of the developed countries, the industry, whose gross value added structure is at least 75 per cent, is promising. Under these conditions, three other types of industrial activities should become integral components, (to a certain extent) a resource base for the development of the latter.

The functional link between the share of gross value added in industry output and gross value added structures, industry output (by type of industrial activity) can be represented using an optimization economic and mathematical model (1):

$$\frac{Q}{P} = \frac{q_\alpha + q_\beta + q_\chi + q_\delta}{p_\alpha + p_\beta + p_\chi + p_\delta} = \frac{Q\left(\dfrac{Q}{Q}\right)\left(\dfrac{q_\alpha}{Q} + \dfrac{q_\beta}{Q} + \dfrac{q_\chi}{Q} + \dfrac{q_\delta}{Q}\right)}{P\left(\dfrac{P}{P}\right)\left(\dfrac{p_\alpha}{P} + \dfrac{p_\beta}{P} + \dfrac{p_\chi}{P} + \dfrac{p_\delta}{P}\right)} \to \max, \quad (1)$$

where

Q – the gross added value of the industry;

P – the industry release;

q_α – the gross added value of the extractive industry and the development of quarries;

q_β – the gross value added of the processing industry;

q_χ – the gross added value of electricity, gas, steam and air conditioning supply;

q_δ – the gross added value of water supply; sewage, waste management;

p_α – the extraction industry mining quarry development;

p_β – the output of manufacturing industry;

p_χ – the release of electricity, gas, steam and air conditioning;

p_δ – the release of water supply, sewage, waste management;

$\dfrac{q_\alpha}{Q}$ – the share of extractive industries and the development of quarries in the gross added value of industry;

$\dfrac{q_\beta}{Q}$ – the share of the processing industry in gross value added of industry;

$\dfrac{q_\chi}{Q}$ – the share of electricity, gas, steam and air conditioning in gross value added of industry;

$\dfrac{q_\delta}{Q}$ – the share of water supply; sewage, waste management in gross added value of industry;

$\dfrac{p_\alpha}{P}$ – the share of extractive industries and the development of quarries in the production industry;

$\dfrac{p_\beta}{P}$ – the share of the manufacturing industry in the production of industry;

$\dfrac{p_\chi}{P}$ – the share of electricity, gas, steam and air conditioning in the industry;

$\dfrac{p_\delta}{P}$ – the share of water supply; sewage, waste management in industry.

The target function of optimizing the structure of the industrial sector of the national economy is the value of the share of gross value added in the output at the level of 31.16% (as in Poland in 2015).

The variables of the target function (1) determine absolute indicators, that is, the volumes of gross value added (Q) and production of industry (P) and types of industrial activity $(q_\alpha, q_\beta, q_\chi, q_\delta)$ and $(p_\alpha, p_\beta, p_\chi, p_\delta)$, respectively, as well as structural indicators of output and gross value added of industry $\left(\frac{p_\alpha}{P} + \frac{p_\beta}{P} + \frac{p_\chi}{P} + \frac{p_\delta}{P} \right)$.

In order to achieve the target function and construct such output structures and gross value added that take into account both the desired performance benchmarks and the actual state and capabilities of the Ukrainian industry, the relevant conditions (the system of constraints and criteria) are determined to the optimization function.

1. The sum of the shares of certain types of industrial activity in the output structures and the gross value added of industry is 1:

$$\frac{p_\alpha}{P} + \frac{p_\beta}{P} + \frac{p_\chi}{P} + \frac{p_\delta}{P} = 1; \; \frac{q_\alpha}{Q} + \frac{q_\beta}{Q} + \frac{q_\chi}{Q} + \frac{q_\delta}{Q} = 1. \tag{2}$$

2. It is rational to reduce the share of extractive industry and develop quarries in the output of domestic industry, while simultaneously increasing the share of gross value added in this type of industrial activity from 51.1% (actual data in Ukraine in 2015) to the level of Poland (55.69% in 2015), that is (3) – (4):

$$\frac{p_\alpha}{P} \le 0,1167, \tag{3}$$

$$0,511 \le \frac{q_\alpha}{p_\alpha} \le 0,5569. \tag{4}$$

3. The share of gross value added in the output of the processing industry should increase from 19.63% (actual data for Ukraine in 2015) to the level of Poland (27.62%), that is (5):

$$0,1963 \le \frac{q_\beta}{p_\beta} \le 0,2762. \tag{5}$$

4. The share of gross value added in electricity, the gas, steam and air conditioning in Ukraine should increase from 30.2% (actual for Ukraine in 2015) to the level of Poland (47.4%), that is (6):

$$0,302 \le \frac{q_\chi}{p_\chi} \le 0,474. \tag{6}$$

5. The water supply, sewage, waste management requires systemic modernization, which, in turn, is a long-term capital-intensive process. Therefore, for

the growth of the indicator of gross value added in the release of this type of industrial activity in Ukraine to the level of Poland (52.78%) in the medium term, there is no economic basis. Nevertheless, the necessary condition for increasing the efficiency of the water supply, sewage, waste management is its deregulation, in particular, the liberalization of tariffs. The use of this tool will increase the share of gross value added in the issue compared to the actual value, that is, will make the following optimization constraint real (7):

$$\frac{q_\delta}{p_\delta} \geq 0{,}2937. \tag{7}$$

6. It is important to ensure the intensive growth of the efficiency of both the industrial sector of the national economy as a whole and its key segment – the processing industry. A prerequisite for this is the excess of the growth rate of gross value added over the growth rate of output at least twice (for example of Poland and the other countries in EU that have undergone a transformation path), that is (8):

$$\frac{\Delta Q}{\Delta P} \geq 2 \; ; \; \frac{\Delta q_\beta}{\Delta p_\beta} \geq 2. \tag{8}$$

The proposed optimization model (1) – (8) is solved by the linear programming method using the MS Excel "Decision Search" option.

Based on results of calculations, the following output and gross value added structures were constructed, which ensured the competitiveness (according to the criterion of efficiency, that is, the share of gross value added in the output) of the Ukrainian industry, compared with the Polish one. In particular, achieving the share of gross value added in the output for domestic industry at 31.16%; the extractive industry and career development – 55.69; the processing industry – 27,62%; the electricity, gas, steam and air conditioning supply – 47.44% (Table 3).

Table 3. The results of structure optimization of the Ukrainian Economy industrial sector, %

The type of industrial activity	The actual data			The optimized data			The absolute deviations of optimized data from actual		
	the share in GVA structure	the share in output structure	the share of GVA in issue	the share in GVA structure	the share in output structure	the share of GVA in issue	the share in GVA structure	the share in output structure	the share of GVA in issue
Extractive industry and career development (the share in industry output)	24.20	11.67	51.10	11.65	6.52	55.69	-12.55	-5.15	4.59
Manufacturing (the share in industry output)	60.21	75.57	19.63	73.88	83.35	27.62	13.67	7.78	7.99
Supply of electricity, gas, steam and air condition (the share in industry output)	13.58	11.08	30.20	12.82	8.42	47.44	-0.76	-2.65	17.24
Water supply; sewage, waste management (the share in industry output)	2.02	1.69	29.37	1.65	1.71	30.00	-0.37	0.02	0.63
Industry	**100.0**	**100.0**	**24.63**	**100.00**	**100.00**	**31.16**	**x**	**x**	**6.53**

Reed: x – data missing. Source: grouped by [1].

At the same time:
– an increase in the volume of industrial output of Ukraine by 33.5%, and gross value added – to 68.66%, which is a sign of the intensive growth of the efficiency of this sector of the national economy (the ratio between the growth rate of gross value added and the growth rate of industry output will be twice in time);
– the reduction of the share of extractive industry and the development of quarries in the structure of industry by 5.15 pp., while the share of gross value added in the corresponding structure – to 12.55 pp., which will facilitate the withdrawal of the national economy from the raw material type;
– an increase in the share of processing industry in the structure of industrial output by 7.78 pp., while the share of gross value added in the corresponding structure – to 13.67 pp.;

– the reduction of the share of electricity, the gas, steam and conditioned air supply in the structure of industry output by 2.65 pp., and the share of gross value added in the corresponding structure – to 0.76 pp.

The share of water supply, sewage, waste management in optimized output patterns and gross value added of the industry will remain unchanged.

The results of the analysis provide grounds for asserting the need for further restructuring of the Ukraine's industrial sector. The gradual optimization of the structure of domestic industry should take place simultaneously in 4 directions, that is, to cover all types of industrial activities and their subspecies. A key criterion for such an optimization is the increase in a socio-economic efficiency, which consists in increasing the gross value added and the improving its structure, the share of gross operating profit, mixed income.

On the other hand, in the structure of the industrial sector of the national economy, those types of industrial activity that create the largest amount of value added, but at the same time are not raw materials, should dominate. That is, the development of the processing industry should be the priority of the new industrial policy in Ukraine.

Summary

A comparative analysis of the structural advantages of the industry in Ukraine and the EU member states has been carried out on the indicators of the share of gross value added (GVA) in the industrial output and the share of industry in total output. A similar analysis has been done in terms of industrial activities (mining and quarrying, processing industry, electricity, gas, steam and air conditioning, water supply, sewage, and waste management). Based on the study of Poland's experience in restructuring the industry, the conditions and directions for optimization in the industrial sector (by types of industrial activities) are justified in order to move from the raw-type economy to innovation. With the help of developed economic and mathematical mod-els, the author constructs optimized structures of output and GVA in the Ukrainian industry in accordance with the criteria of increasing the level of profitability and production technology.

Keywords: industry, gross value added, output, efficiency, structure, optimization.

Streszczenie

Przeprowadzono analizę porównawczą przewag strukturalnych branży na Ukrainie i w państwach członkowskich UE nad wskaźnikami udziału wartości dodanej brutto (WDB) w produkcji przemysłowej i udziału przemysłu w produkcji globalnej. Podobną analizę przeprowadzono w odniesieniu do działalności przemysłowej (górnictwo i wydobywanie, przemysł przetwórczy, elektryczność, gaz, para wodna i klimatyzacja, zaopatrzenie w wodę, ścieki i gospodarka odpadami). W oparciu o badania polskich doświadczeń w zakresie restrukturyzacji przemysłu, warunków i kierunków optymalizacji w sektorze przemysłowym (według rodzajów działalności przemysłowej) jest uzasadnione, aby przejść od gospodarki typu surowego do innowacji. Za pomocą opracowanych modeli ekonomicznych i matematycznych autor konstruuje zoptymalizowane struktury produkcji

i WDB w ukraińskim przemyśle zgodnie z kryteriami zwiększania poziomu rentowności i technologii produkcji.

Słowa kluczowe: przemysł, wartość dodana brutto, produkcja, efektywność, struktura, optymalizacja.

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