Direct and Indirect Impact Analysis of Ukrainian Industries on Gross Output and Labor Market in Leontief Model

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Abstract. In the paper are compared direct and indirect impact analysis of Ukrainian industries production on employment of labor market, profitability and gross output in 2010, it is developed recommendations for state policy to support of priority industries.

Keywords. Input-output model, industries, direct and indirect influence, gross output, final demand, externality, multiplier.

Key Terms. DecisionMaking, MathematicalModel, Industry, Macroeconomics, MatrixApproach.

1 Introduction

Input-output model (IOM) distributes gross output on intermediate and final demand. Algebraic input-output method allows simultaneously taking into account production costs of goods with consideration of technological interconnection. The matrix of technological coefficients demonstrates direct costs of industries on production, and matrix of multiplicators shows complete costs of industries on production of their goods (with consideration technologically linked costs of the others industries). A difference between complete and direct costs forms indirect costs.

In article [3] the fraction of indirect costs of industry is calculated by means the language Octave [4] with the using of technological coefficients matrix and eigenvector of matrix.

For the input-output matrix is solved both direct problem (for the calculation of GDP), and indirect problem (for estimation of the gross value added) after the types of economical activities [5] with using existent restrictions (material, labor etc).

2 Problem Statement

Industry priority is determined by the state on the size of budget revenue in the state budget, by the increasing of employment, by the raising of gross output, that is after

explicit (direct) indexes, not taking into account the indirect influencing (external effect), which industry is diffuses on the other industries of country.

Purpose of this article is to define direct and indirect influence (external effect) of every industry of Ukrainian economy on the gross output of country for application of state support for priority development industries.

3 Results

At construction of interindustry balance take into consideration interdependence between separate economical industries and their links with final demand, that is represented into table 1 (xij – production output of i-th industry, that is used for manufacture of the products of j-th industry; Xj – gross output of j-th industry; Yj – final demand on the products of j-th industry) [6]:

Table 3. Table of interindustry balance (IOB) with labor costs.

Industries-producers	**Industries-consumers**					Final demand	Gross output
	1	**2**	**3**	**…**	**n**		
1	x_{11}	x_{12}	x_{13}	…	x_{1n}	Y_1	X_1
2	x_{21}	x_{22}	x_{23}	…	x_{2n}	Y_2	X_2
3	x_{31}	x_{32}	x_{33}	…	x_{3n}	Y_3	X_3
……..							
n	x_{n1}	x_{n2}	x_{n3}	…	x_{nn}	Y_n	X_n
Labor cost	L_1	L_2	L_3	…	L_n	-	L

Let us to denote cost of labor for production of j-th industry good through L_j, where j=1,2,…,n – number of industry, and output production of this product (gross output) through X_j, then direct labor cost on unit of *j*-th type of product (coefficient of direct labor-intensiveness) are determined by a formula:

$$t_j = \frac{L_j}{X_j}, j = 1, ..., n. \tag{2}$$

A general needs in labor resources for n industries is determined after a formula:

$$L = \sum_{i=1}^{n} L_i = \sum_{i=1}^{n} t_i \cdot X_i = t_1 \cdot X_1 + t_2 \cdot X_2 + ... + t_n \cdot X_n \tag{2}$$

From a formula $X = B \cdot Y$ (B - matrix of multipliers or complete costs) we will get the following values of industries production output:

$$\begin{aligned} X_1 &= b_{11} \cdot Y_1 + b_{12} \cdot Y_2 + \ldots + b_{1n} \cdot Y_n, \\ X_2 &= b_{21} \cdot Y_1 + b_{22} \cdot Y_2 + \ldots + b_{2n} \cdot Y_n, \\ &\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ X_n &= b_{n1} \cdot Y_1 + b_{n2} \cdot Y_2 + \ldots + b_{nn} \cdot Y_n. \end{aligned} \tag{3}$$

Then labor cost can be presented as follow:
$L = t_1 \cdot (b_{11} \cdot Y_1 + b_{12} \cdot Y_2 + \ldots + b_{1n} \cdot Y_n) + t_2 \cdot (b_{21} \cdot Y_1 + b_{22} \cdot Y_2 + \ldots + b_{2n} \cdot Y_n) + t_n \cdot (b_{n1} \cdot Y_1 + b_{n2} \cdot Y_2 + \ldots + b_{nn} \cdot Y_n)$

We will rearrange the elements regarding to final demand on the industries products, we will obtain:
$L = Y_1 \cdot (b_{11} \cdot t_1 + b_{21} \cdot t_2 + \ldots + b_{n1} \cdot t_n) + Y_2 \cdot (b_{12} \cdot t_1 + b_{22} \cdot t_2 + \ldots + b_{n2} \cdot t_n) + Y_n \cdot (b_{1n} \cdot t_1 + b_{2n} \cdot t_2 + \ldots + b_{nn} \cdot t_n)$

From the last equation we will calculate the complete labor costs:

$$\begin{aligned} T_1 &= b_{11} \cdot t_1 + b_{21} \cdot t_2 + \ldots + b_{n1} \cdot t_n, \\ T_2 &= b_{12} \cdot t_1 + b_{22} \cdot t_2 + \ldots + b_{n2} \cdot t_n, \\ &\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ T_n &= b_{1n} \cdot t_1 + b_{2n} \cdot t_2 + \ldots + b_{nn} \cdot t_n. \end{aligned}$$

We will rewrite indirect labor costs as a matrix by the following formula: $T_{1\times 11} = t_{1\times 11} \cdot B_{11\times 11}$,

$$B_{11\times 11} = (E - A)^{-1}_{11\times 11} \tag{4}$$

where

- t_i - coefficients of direct labor cost maintenances in i-th industry, persons/1000hrn.;
- T_i - coefficients of complete labor cost maintenances in i-th industry, persons/1000hrn;
- L_i - employed workers in industry, persons/1000hrn;
- $t_{1\times 11}$ - matrix of direct labor costs;
- $T_{1\times 11}$ - matrix of complete labor costs;
- $B_{11\times 11}$ - matrix of multipliers of input-output model;
- A - matrix of technological coefficients of IOM;
- E - unitary matrix.

Difference between direct t_i and complete T_i labor costs consists in that direct labor costs show an additional (marginal) needs in labor resources for i-th industry after unit increasing of final demand on the products of i-th industry, and the complete labor costs show an additional (marginal) needs in labor resources for all n industries after the unit increase of final demand on the products of i-th industry.

On the basis of direct and complete labor coefficients are developed interindustry labor costs balances for available labor resources. These balances are built as matrix models, and all indexes in them (interindustry links, final product etc) are expressed in labor measurer (amount of persons).

For reduction of matrix model dimension without the loss of generality of its conclusions we reduced the number of Ukrainian industries from 15 to 11 by regrouping, after that we yield:

List of industries:

1. Agriculture, hunting, forestry, fishing, fish-farming.
2. Mining industry, processing industry, production and distributing of electric power, gas and water.
3. Building.
4. Trade; repair of cars, common manufacture and individual commodity, activities of hotels and restaurants.
5. Activity of transport and communication.
6. Financial activity.
7. Operations with the real estate, lease, engineering and rendering of services for entrepreneurships.
8. Public administration.
9. Education.
10. Health protection and social service.
11. Public and individual service; culture and sport activity.

Values of table 2 columns for the gross output and final demand are got on the basis of Statistics state committee data [1], employment after industries is received from statistical collection [2], and the gross value added is calculated by the means of MS Excel on the basis of IOM [6].

Table 4. Macroeconomic indexes of Ukraine for 2010 year.

Number of industry	**Gross output X, millions of UAH1**	**Final demand, millions of UAH2**	**Gross added value, millions of UAH**	**Number of employees L, thousand of persons**
1	228103	109580	82431	3152,2 (16%)
2	1848780	891629	782256	3546,9 (18%)
3	104137	98183	37751	966,2 (5%)
4	324780	25348	183795	4729,1 (23%)
5	254345	116333	155914	1387,9 (7%)
6	55786	4346	31005	351,4(2%)
7	142802	30816	60396	1148,9 (6%)
8	10220	180	-10476	1078,6 (5%)
9	2221	1042	-26018	1698,4 (8%)
10	5236	2255	-16910	1348,1 (7%)
11	24667	7150	6718	783,8 (4%)

The structure of employment for each industry is presented on fig.1 (numeration corresponds previous list of industries above).

[1] Gross output consists of intermediate product and final demand

[2] Final demand includes: final consumer consumption, gross investments and net export

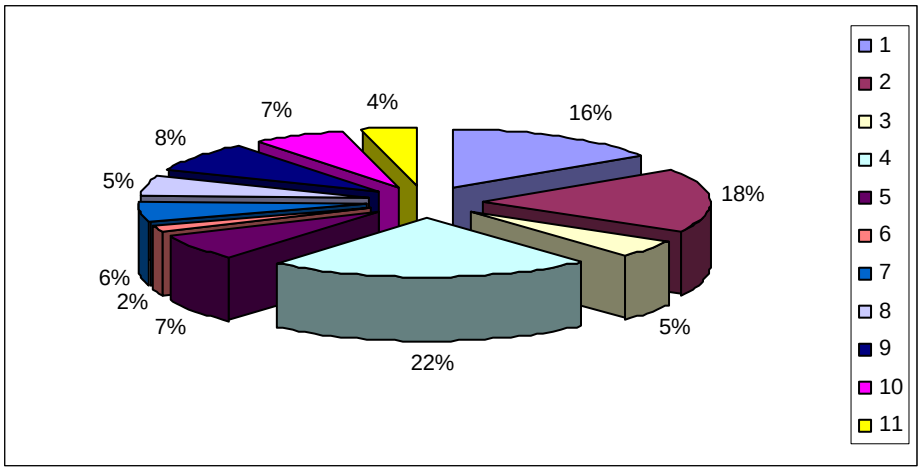

Fig. 15. Structure of employment for Ukraine industries in 2010.

By means of technological coefficients $A = \{a_{ij}\}$, calculated on the basis of table 1, we will get the indexes of profitability of each from 11 industries (table 2):

Table 5. Description of Ukrainian industries.

Number of industry	**Profitability of industries, %**	**Multipliers of industries**	**Part of products for final demand**
1	36,1%	2,45	48,0%
2	42,3%	2,27	48,2%
3	36,3%	2,45	94,3%
4	56,6%	1,99	7,8%
5	61,3%	1,91	45,7%
6	55,6%	1,93	7,8%
7	42,3%	2,35	21,6%
8	-102,5%	7,13	1,8%
9	-1171,5%	61,11	46,9%
10	-323,0%	11,13	43,1%
11	27,2%	2,92	29,0%
Average	43%	x	x

We got from the indexes of profitability (fig. 2), there are three unprofitable industries in 2010, which give such public benefits as state administration, education and health protection. These industry require considerably greater financing on own activities, than they earn. However finally to make decision about their influence on an economy as a whole it is possible only taking into account externality, i.e. their influence on the other industries of Ukrainian economy.

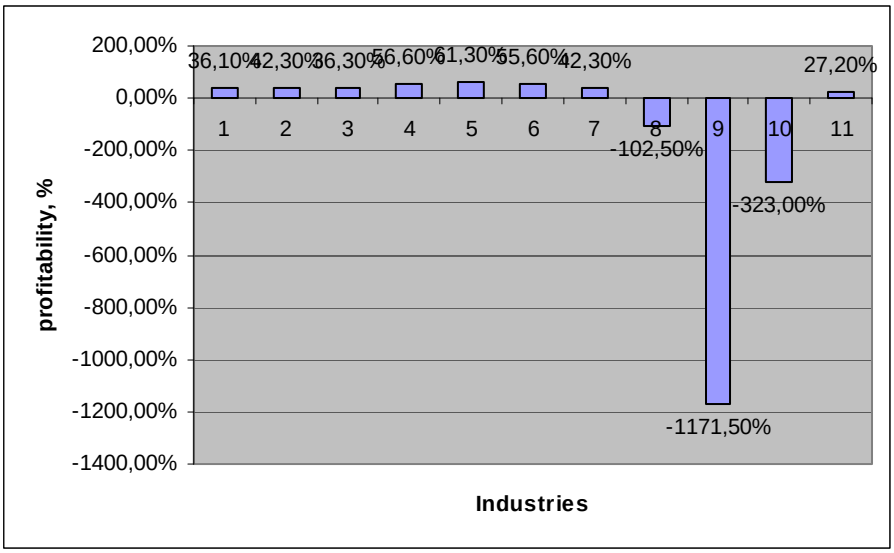

Fig. 16. Profitability of Ukrainian industries in 2010.

After calculation of industries multipliers from matrix B we will get that a most increase of GDP is induced exactly by those industries which are financed from the state budget. Every hryvnya invested in state administration; education and health protection is enhanced gross output in Ukraine on 7 hrn.; by 61 UAH and 11 UAH accordingly, that with surplus covers direct costs of state on these industries activities. Educational industry has most significant influencing and there is reserve for the increasing of country gross output. Education stimulates a positive GDP dynamics. So after a direct effect this industry on every invested hryvnya gets a loss in size of 10 to UAH, and after indirect get profit in 26 UAH (multiplication of average profitability on multiplier), that together gives the positive influencing in 16 UAH on the gross value added of Ukrainian industries.

Thus the crisis phenomena in the economy of country are not to stipulate the cost decreasing after all directions in same proportion. The state adjusting of industry has to base on that return which is had by every industry and proportionally to its influence on an economy not to decrease, and in the some cases, taking into account their external effects, to increase state costs for them for stimulation of gross output of all linked industry.

After finding relation of final demand to the gross output X (from table 1) we will get what measure of each industry is oriented into final, and which is on intermediate demand (fig. 3). We have, that build industry (3) is most oriented on final demand (94,3% whole product), and • trade industry, activity of hotels and restaurants (4); • financial activity (6) and • state administration (8) are most oriented on intermediate demand (100%-7,8%=92,2%, 92,2% and 98,2% accordingly).

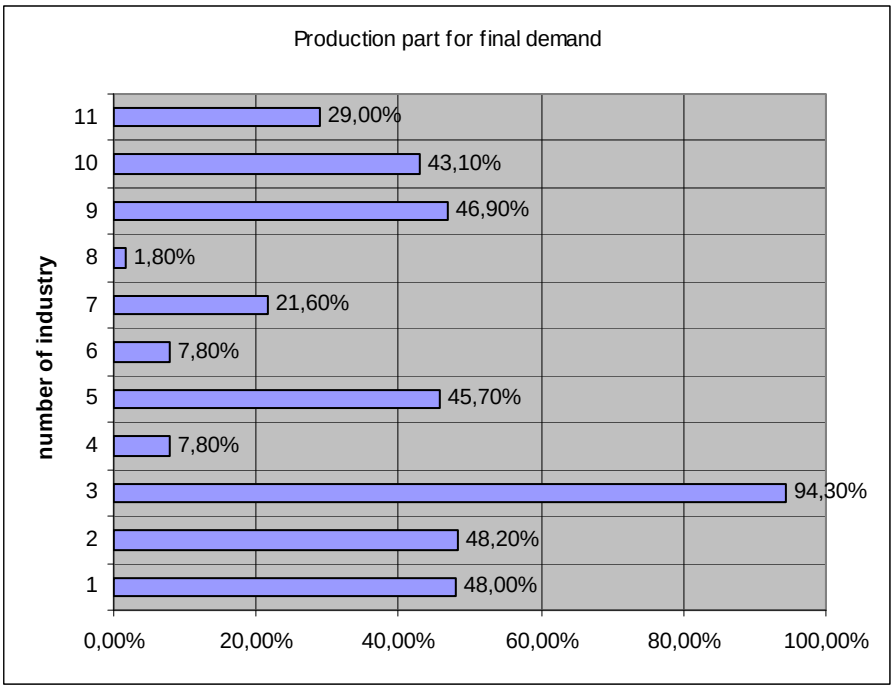

Fig. 17. Product part of Ukrainian industries for final demand.

We will consider application of interindustry balance method for direct and indirect influence on Ukrainian industries' production on a labor market. The important analytical possibility of this method is determination of direct and complete labor cost on product unit and development the recommendations in relation to state support of priority development industries for the stimulation of employment growth of country.

After the calculations after formulas (1) and (4) we will present results as table 4:

Table 6. Labor cost indexes analysis for products' manufacturing by Ukrainian industries in 2010.

Industries	**Direct labor cost coefficients**	**Complete labor cost coefficients**	**Complete / direct ratio T/t**	**Indirect labor cost coefficients T-t**
1	0,014	0,027	1,921	0,013
2	0,002	0,011	5,587	0,009
3	0,009	0,017	1,860	0,008
4	0,015	0,023	1,564	0,008
5	0,005	0,012	2,254	0,007
6	0,006	0,013	2,096	0,007
7	0,008	0,019	2,388	0,011
8	0,106	0,193	1,828	0,087

Industries	**Direct labor cost coefficients**	**Complete labor cost coefficients**	**Complete / direct ratio T/t**	**Indirect labor cost coefficients T-t**
9	0,765	2,095	2,740	1,331
10	0,257	0,330	1,281	0,072
11	0,032	0,058	1,810	0,026

We will analyze indexes above. Agriculture and fishing industry of (1) during production of own goods increases whole labor cost almost twice in comparison with its own direct labor cost. More, than twice the indirect labor cost are increased in such industries as a transport and communication is in 2,25 times (5), financial activity at 2,1 times (6), operations with the real estate in 2,4 times (7), education in 2,74 times (9).

Indirect labor cost increases at 5,6 times in processing industry (2). It means that this industry is priority so it has a primary importance for stimulation of employment in all industries of Ukrainian economy.

The least stimulation of indirect labor cost (due to growth of industry output) is observed in industry of health protection and social service (10).

4 Conclusions

Taking into account obtained influence of each industry gross output for determination of state policy strategy it follows to take into consideration results of indirect industries influencing on stimulation of employment, gross output and profitability of both individual industry and whole economy. For example, education industry after the direct influencing was unprofitable, and after indirect was profitable, so its net gross value added was positive.

Further it is planned to explore and compare the direct and indirect influencing of Ukrainian industries activity and Countries of Independent States for development of effective state policy proposals in the field of national economy.

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