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Method for Assessment of Sectoral Efficiency of Investments Based on Input-Output Models[1]

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Abstract

Stable economic development requires the balance of many economic factors that include interests of producers and consumers; invested amounts, their periods, efficiency and prices; prices, expenses, risks; private and economic interests.
The author of this work proposes to determine the existence of such balance on the basis of the calculation of financial and “sectoral” efficiency of investments. Sectoral efficiency is a type of economic efficiency calculated for an “average sectoral” investment project.
To take into account full effects, input-output models are used. As a result, sectoral efficiency is assessed based on the index of specific value increment speed (IS). This index assesses also financial efficiency more exactly (as compared with net present value).

Keywords. Input-Output Models. Cost-Benefit Analysis. Balance in economy.

Introduction

Crises that regularly shake the world economy make us look for their causes and methods of their easing. One of the conditions of crisis prevention is balance in economy. The convention is that we discuss economy without import and export. It would seem to be an absolutely theoretical structure, but such economy exists in

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reality – it is the world economy. Despite the fact that it is currently a norm that governments carry on international trade (i.e. they are connected with export-import), all provisions described in this article can be applied to their economy.

Economy develops as a system consisting (in a most general description) of companies grouped in a sector and of final consumers (including households and the state). But, along with the final consumption, industries have to manufacture products for investments done by other companies. It turns out (in a most general description) that there are two flows of products in the economy – one for the final consumption, the other – for investments. Economists used to divide economy into two sectors, noting that some sectors make products for the final consumer, some other produce equipment and some other - production means for these industries.

Companies manufacture things intending to sell their products at such a price that will ensure some return on the invested capital. This profitability is different in each industry and depends much on the risk. If volatility of company's revenue would have been smaller, the risk would have been smaller, consequently, the prices would have been smaller too. On the other side, returns on investments depend also on economic characteristics of the investments: on the combination of the equipment cost, its capacity and service life.

Balance in economy means balance of all its components, i.e. the balance of the two product flows, economic characteristics of investments and prices for products. And this balance has to exist not within a certain sector, but in the whole economy, i.e. in the system of sectors. In addition, there has to be a balance between private and social interests. In the opinion of the author of this article, it is possible to trace and analyze all above connections only with the help of the input-output models (Eurostat. 2008, United Nations. 1999.) These models met with wide and deserved recognition. We are going to describe such a model for some conditional economy to illustrate author's ideas.

Description of a Input-Output Model for Some Conditional Economy

Let's accept that this economy consists of n=5 sectors (Table 1) and is characterized by the input coefficients described in Tables 2, 3.

Table 1: Output and consumption in economy, bln rub[2].

Manufacturing industries	User industries					Total FD (y_i)	Output (x_i)
	Industry 1	Industry 2	Industry 3	Industry 4	Industry 5		
Interbranch consumption (x_{ij})							
Industry 1	3300	600	390	2800	1200	2710	11000
Industry 2	2200	4800	780	980	150	3090	12000
Industry 3	440	600	5200	280	1500	4980	13000

[2] This model was used by the author in the work (Kogan. Cost Benefit Analysis, 2015.)

Industry 4	770	1200	1950	2800	3750	3530	14000
Industry 5	220	120	390	560	3000	10710	15000
Total IC	6930	7320	8710	7420	9600		
Gross value added (vac_{kj})							
Profit	814	936	1073	1974	810		
Depreciation	204	702	215	329	540		
Other GVA	3053	3042	3003	4277	4050		
Total GVA (vac_j)	4070	4680	4290	6580	5400	25020	
Total (x_j)	11000	12000	13000	14000	15000		65000

Note: FD – final demand.

Table 2: Input-Output coefficients

Manufacturing industries	User industries				
	Industry 1	Industry 2	Industry 3	Industry 4	Industry 5
Direct material cost coefficients (a_{ij})					
Industry 1	0.3	0.05	0.03	0.2	0.08
Industry 2	0.2	0.4	0.06	0.07	0.01
Industry 3	0.04	0.05	0.4	0.02	0.1
Industry 4	0.07	0.1	0.15	0.2	0.25
Industry 5	0.02	0.01	0.03	0.04	0.2
Total (a_j)	0.63	0.61	0.67	0.53	0.64
Input-Output coefficients of GVA (a_{kj}^{vac})					
Profit	0.07	0.08	0.08	0.14	0.05
Depreciation	0.02	0.06	0.02	0.02	0.04
Other GVA	0.28	0.25	0.23	0.31	0.27
Total (a_j^{vac})	0.37	0.39	0.33	0.47	0.36
Grand total	1	1	1	1	1

Table 3: Coefficients of full material cost

Manufacturing industries	User industries				
	Industry 1	Industry 2	Industry 3	Industry 4	Industry 5
Industry 1	1.56	0.23	0.22	0.43	0.32
Industry 2	0.57	1.80	0.30	0.32	0.22
Industry 3	0.17	0.18	1.74	0.12	0.27
Industry 4	0.26	0.29	0.41	1.38	0.51
Industry 5	0.07	0.05	0.10	0.09	1.30
b_j	2.62	2.55	2.77	2.33	2.62

Indicators of Return on Investment Assessment

Any industry develops as a result of investment projects implementation. The projects require investment of money (costs) and getting some periodic profit in the future. Companies do business only if they are efficient. There are several types of efficiency. Financial efficiency is evaluated from the positions of a certain company, social efficiency is evaluated from the positions of the whole society (government). Evaluation of these two types of efficiency is sometimes called the cost-benefit analysis.

There are official guidelines for the cost-benefit analysis in many countries (European Commission, 2008; World Road Association, 2012.) They suggest *Net Present Value* (*NPV*) as the main characteristic for the evaluation of financial efficiency; for the evaluation of social efficiency - *Economic Net Present Value* (*ENPV*). The following formulas are used to calculate these characteristics:

$$NPV = \sum_{t=0}^{n} \frac{NCF_t}{(1+k)^t}, \qquad (1)$$

where n is the accounting period of the investment project, years;
NCF_t is the net cash flow at the end of the t-th period of time;
k is the discount rate, %.

$$ENPV = \sum_{t=0}^{n} \frac{S_t}{(1+r)^t} = \sum_{t=0}^{n} \frac{EcB_t - EcC_t}{(1+r)^t}, \qquad (2)$$

where S_t is the balance of social benefits and social costs;
EcB_t are social benefits at the end of the t-th period;
EcC_t are social costs at the end of the t-th period;
r is the social discount rate;

The author of this article proves in some of his works (Kogan, The Criticism, 2014) that *NPV* is not applicable for the comparison of the efficiency of projects with diverse parameters. Projects with with diverse parameters mean projects that have three different main parameters: investments, calculated period and annual results. It is obvious that any investment project can be implemented by different methods allowing different combination of these three parameters. It means that any investment project has to be considered as a set of diverse-parameter alternatives. To evaluate and compare efficiency of projects with diverse parameters, the "index of specific value increment speed" *(IS)* was developed. It is calculated according to the following formula (Kogan, The Criticism, 2014):

$$IS = \frac{NPV}{n \sum_{t=0}^{n} \frac{EcC_t}{(1+r)^t}}, \qquad (3a)$$

The economic index of specific value increment (*EIS*) will be calculated according to a similar formula:

$$EIS = \frac{ENPV}{n\sum_{t=0}^{n}\frac{EcC_t}{(1+r)^t}}, \quad (3b)$$

This index connects two main economic aims: “more” and “quicker”. A project is efficient, if *IS* is higher or equal to 0. In the case of several alternative projects, the one that has highest *IS* wins. This index can be used to solve the following tasks:

1) evaluation of financial efficiency of investments (Kogan, The Criticism, 2014);
2) forming of an optimum portfolio of real investments (Kogan, Basis of the Choice, 2015);
3) determining of optimum economic characteristics of innovative products (Kogan, A New Way, 2014);
4) evaluation of social efficiency of investments (let’s consider it father).

Sectoral Efficiency of Investments

In the opinion of the author of this work, balance in economy can be assessed by calculating the financial efficiency of investments in industries and the “sectoral efficiency” of these investments. If an investment project has both financial and sectoral efficiency, it means that there is the above balance of private and economic interests. Sectoral efficiency is a special type of social efficiency. Proposals of the author concerning the calculation of sectoral efficiency are described below. Before talking about them, let us determine four types of investments:

	Direct	Full
Investment in the project, rub.	inv_{proj}	inv_{proj}^{full}
Investments in supporting industries, rub.	$inv_{\sup}$	$inv_{\sup}^{full}$

“Supporting industries” are industries that provide supplies for the output (manufacture of products) for the analyzed control instrumentation. Direct investments consist of products (and services) of different sectors, as well as of GVA. As a result, to calculate social cost, it is necessary to determine the cost of all products manufactures in economy for investments in the project under analysis and the industries supporting the project. Economical cost(*EcC*) will be calculated (at the end of respective *t*-th periods) according to the following formula

$$EcC = inv_{proj}^{full} + \sum_{\sup=1}^{n} inv_{\sup}^{full}, \quad (4)$$

where $inv_{\sup}^{full}$ are full investments in supporting industries;

inv_{proj}^{full} are full investments in the analyzed project calculated according to the following formula

$$inv_{proj}^{full} = \sum_{j=1}^{n} y_j^{inv(proj)} \times b_j + vac_{proj}^{inv(direct)}\ , \qquad (5)$$

It is proposed to calculate full investments in the supporting industries according to the following formula

$$inv_{\sup}^{full} = \sum_{j=1}^{n} y_j^{inv(\sup)} \times b_j + vac_{\sup}^{inv(direct)}\ , \qquad (6)$$

where $y_j^{inv(\sup)}$ is the output of the *j*-th industry that is purchased from residents of the region economy to create production facilities of the supporting industry (at the stage of investments);

$vac_{\sup}^{inv(direct)}$ is GVA that is formed directly during investments in the supporting industry (for example, payments for the service of customer-contractor, taxes, payment for the land lot, etc.) It is calculated according to the data from the business plan.

Characteristics of Investments

The amount of direct investments in the *j*-th industry[3] (inv_j) can be determined based on specific investment coefficients (g_j)

$$g_j = \frac{inv_j}{x_j^{inv}}\ , \qquad (7)$$

where x_j^{inv} is the annual output of products of the *j*-th industry manufactured as a result of investments in this industry, rub.

Investments can be also characterized using coefficients of direct investment costs a_{ij}^{inv} that are determined according to the formula

$$a_{ij}^{inv} = \frac{y_{ij}^{inv}}{inv_j}\ , \qquad (8)$$

where y_{ij}^{inv} is the output of the *i*-th industry consumed for investments in the development of the *j*-th industry (where control and instrumentation are realized or which is a supporting one), rub.;

inv_j is the investments in the development of the *j*-th industry (where control and instrumentation are realized or which is a supporting one), rub.

Let us determine coefficients of direct costs of GVA in investments (the share of the *i*-th element of the added value in investments in the development of the *j*-th industry) according to the formula

$$a_{kj}^{vac(inv)} = \frac{vac_{kj}^{inv}}{inv_j}\ . \qquad (9)$$

[3] It can be both a supporting industry or some industry where the analyzed project is implemented.

where vac_{kj}^{inv} is the value of the k element of GVA in the total amount of the investments.

For conditional economy, these coefficients are given in Table 4.

Table 4: Coefficients of costs connected with investments

Costs	Output				
	Industry 1	Industry 2	Industry 3	Industry 4	Industry 5
Coefficients of direct investment costs a_{ij}^{inv}					
Industry 1	0.01	0.02	0.01	0.04	0.03
Industry 2	0.25	0.35	0.3	0.25	0.3
Industry 3	0.2	0.15	0.1	0.30	0.25
Industry 4	0.05	0.06	0.08	0.24	0.2
Industry 5	0.01	0.01	0.03	0.00	0.01
Total a_{ij}^{inv}	0.52	0.59	0.52	0.83	0.79
Coefficients of direct costs of GVA in investments $a_{kj}^{vac(inv)}$					
Profit	0.05	0.04	0.05	0.05	0.02
Depreciation	0.02	0.02	0.02	0.01	0.01
Other GVA	0.41	0.35	0.41	0.11	0.18
Total $a_{j}^{vac(inv)}$	0.48	0.41	0.48	0.17	0.21
Grand total	1	1	1	1	1

Characteristic of an "Sector Average" Project

Let us illustrate the method of ***sectoral efficiency*** evaluation that is proposed by the author of this work. To do it, we are going to describe a big "sector average" investment project, i.e. a project that is typical for the analyzed industry.

Let us assume that the amount of investments required for the analyzed "sector average" control and instrumentation that will manufacture products in industry 4 (inv_4^{proj}) ***is equal to 15 bln rub***. Using coefficients a_{i4}^{inv} and b_j, we determine the components of direct and full investments (the results are given in Table 5).

As a result, full investments for the project will be

$$inv_{proj}^{full} = 31.95 + 2.55 = 34.5 \ bln \ rub, \quad (10)$$

Table 5: Components of direct and full investments for a “sector average” control and instrumentation

Characteristic	Components of direct investments	Components of full investments
Output of industries	$y_{i4}^{inv(proj)} = inv_4^{proj} \times a_{i4}^{inv}$	$y_{i4}^{inv(proj)} \times b_{j=i}$
Industry 1	0.60	1.57
Industry 2	3.75	9.55
Industry 3	4.50	12.44
Industry 4	3.60	8.38
Industry 5	0.00	0.00
Total	12.45	31.95
GVA	$vac_{k4}^{inv} = inv_4^{proj} \times a_{k4}^{vac(inv)}$	
Profit	0.77	
Depreciation	0.13	
Other GVA	1.66	
Total, GVA	2.55	

Investments in Supporting Industries

To manufacture products within “sector average” control instrumentation (done in the *j*-th industry) in the planned volume ($x_j^{prod(proj)}$), the *i*-th supporting industry has to supply a certain volume of products ($x_i^{prod(\sup)}$), that can be determined according to the data from the input-output model as follows:

$$x_i^{prod(\sup)} = x_j^{prod(proj)} \times a_{i,j}\,. \tag{11}$$

The amount of direct investments in the supporting industry ($inv_i^{\sup}$) can be determined according to the data from the input-output model based on the values of specific investments coefficients:

$$inv_i^{\sup} = x_i^{prod(\sup)} \times g_i\,. \tag{12}$$

Let us assume that the annual output of “sector average” control instrumentation $x_4^{prod(proj)}$ ***is 32 bln rub***. Let us set the investment service life and specific investments coefficients g_i, determine the volumes of supplies of the supporting industries $x_i^{prod(\sup)}$ based on the a_{i4} set above, and calculate $inv_i^{\sup}$ according to formula (12) (the results are given in Table 6).

Table 6: Characteristics of output and direct investments of supporting industries

Supporting industry	Service life	g_i	Output for control instrumentation $x_i^{prod(\sup)}$	Direct investments to ensure output for control instrumentation $inv_i^{\sup}$
Industry 1	5	0.30	6.40	1.92
Industry 2	5	0.35	2.24	0.78
Industry 3	10	0.37	0.64	0.24
Industry 4	10	0.47	6.40	3.00
Industry 5	10	0.45	1.28	0.58
Total			16.96	6.52

Note. "Service life" is a period during which means of production in the *i*-th industry can be used. In other words, it is the calculation period of investment projects in the respective industry.

Based on a_{ij}^{inv}, let us determine the structure of direct investments in the supporting industries (the results are given in Table 7).

Table 7: Structure of direct investments in the supporting industries, bln rub.

Costs	Output				
	Industry 1	Industry 2	Industry 3	Industry 4	Industry 5
Consumption of products of the *i*-th industry for investments in the *j*-th industry ($y_{ij}^{inv(\sup)}$)					
Industry 1	0.02	0.02	0.00	0.12	0.02
Industry 2	0.48	0.27	0.07	0.75	0.17
Industry 3	0.38	0.12	0.02	0.90	0.14
Industry 4	0.10	0.05	0.02	0.72	0.12
Industry 5	0.02	0.01	0.01	0.00	0.01
Total	1.00	0.46	0.12	2.49	0.46
GVA in investments in the *j*-th industry $vac_{kj}^{inv(\sup)}$					
Profit	0.09	0.03	0.01	0.15	0.01
Depreciation	0.05	0.02	0.01	0.03	0.01
Other GVA	0.78	0.27	0.10	0.33	0.10
Total GVA $vac_j^{inv(\sup)}$	0.92	0.32	0.11	0.51	0.12
Grand total $inv_j^{\sup}$	1.92	0.78	0.24	3.00	0.58

Now, knowing $inv_j^{\sup}$ and b_j, it is possible to determine full investments in the supporting industries ($inv_{\sup}^{full}$) according to formula (6) (the results are given in Table 8).

Table 8: Full investments in the supporting industries, bln rub.

Characteristic	Industry				
	Industry 1	Industry 2	Industry 3	Industry 4	Industry 5
Full output of industries $y_{ij}^{inv(\sup)} \times b_{j=i}$					
Industry 1	0.05	0.04	0.01	0.31	0.05
Industry 2	1.22	0.70	0.18	1.91	0.44
Industry 3	1.06	0.33	0.07	2.49	0.40
Industry 4	0.22	0.11	0.04	1.68	0.27
Industry 5	0.05	0.02	0.02	0.00	0.02
Total	2.61	1.20	0.32	6.39	1.17
GVA $vac_j^{inv(\sup)}$	0.92	0.32	0.11	0.51	0.12
Grand total $inv_{\sup}^{full}$	3.53	1.52	0.43	6.90	1.29

Calculation of Social Costs and Benefits

As a result, social costs connected with the analyzed control instrumentation determined according to formula (4) will be

$$EcC_0 = 34.5+3.53+1.52+0.43+6.9+1.29=48.17 \text{ bln rub.} \qquad (13)$$

Index 0 shows that these investments are done at the beginning – at the 0 (“current”) moment of time. But the service life of investments in industry 4 (given in Table 6) is 10 years, and in industries 1 and 2 it is two times shorter – 5 years. It means that the society will have to repeatedly invest in industries 1 and 2 to ensure supplies for control instrumentation during years 5 through 10 of its operation. Having accepted that the period of investments implementation is one year, we have to plan repeated investments at the end of year 4. As a result, the total investments of economy that are required for the realization of control instrumentation at this moment of time will be

$$EcC_4 = 3.53+1.52=5.05 \text{ bln rub.} \qquad (14)$$

Having understood the social costs, we have to evaluate social benefits. The author of this work considers that social benefits can be evaluated both on the basis of final consumption growth and on the basis of the gross value added growth. Let us use the first factor. We will introduce a description of the final demand structure in addition to the input-output model described above (see Table 9). The growth of final demand as a result of realization of “sector average” control instrumentation is determined based on the output for control instrumentation and the share of the final consumption of products of industry 4 in the output of this industry: 32 × 3530/14000 = 8.07 bln rub.

Table 9: Final demand structure

Manufacturing industry	Final consumption	Net export	Total, final demand	Output
Industry 1	3710	-1000	2710	11000
Industry 2	3090	–	3090	12000
Industry 3	7980	-3000	4980	13000
Industry 4	1530	2000	3530	14000
Industry 5	5710	5000	10710	15000
Total			25020	65000

Note: the negative value in column "Net export" means that the demand in the products of respective industry is satisfied partially due to import. The positive value in this column means that the products of the respective industry is exported. "-" means absence of value.

Calculation of Private and Social Flows of Effects for "Sector Average" Control Instrumentation

Based on the calculated investments, let us assess financial and social efficiency of control instrumentation. We will do the assessment with the help of effect flow discounting.

Let us develop private and social flows of effects of the analyzed control instrumentation (the results are given in Table 10.) The private flow will consist of direct investments in the project (15 bln rubles) and annual values of profit and depreciation (5.26 bln rub.) The annual amounts of profit and depreciation are determined as multiplication of output for control instrumentation (32 bln rub.) and coefficients of direct costs of GVA (a_{kj}^{vac}) for depreciation and profit (0.02 + 0.14).

Let us accept that investments are assimilated within a year. As a result, at the end of the 1st year the investor will not get either profit or depreciation – they will begin from the 2nd year. The discount rate was set to be 15%.

The flow of social effects will consist of social costs (48.17 bln rub. at the 0 moment of time and 5.05 bln rub at the end of the 4th year) and social benefits that the society will get annually as a result of the operation of the control instrumentation (8.07 bln rub.) The social discount rate is set to be 10%.

Table 10: Flows of private and social effects emerging as a result of realization of control instrumentation

Characteristic	Project interval					
	0	1	2	3	4	5	6–10
Private flow of effects (net cash flow)							
Profit (proceeds)			5.26	5.26	5.26	5.26	5.26
Costs (payments)	15.0						
Balance	–15.0	0	5.26	5.26	5.26	5.26	5.26
Social flow of effects							
Social benefits			8.07	8.07	8.07	8.07	8.07
Social benefits (total investments in economy), including:	48.17				5.05		
- full investments in project	34.5						
- full investments in supporting industry 1	3.53				3.53		
- full investments in supporting industry 2	1.52				1.52		
- full investments in supporting industry 3	0.43						
- full investments in supporting industry 4	6.9						
- full investments in supporting industry 5	1.29						
Social balance	–48.17	0.0	8.07	8.07	3.02	8.07	8.07

Note. Annual effects during years 6 through 10 (the cash flow value) do not change, that is why they are given in one column.

Assessment of Efficiency of "Sector Average" Control Instrumentation

Discounted values of private and social flows of effects are given in Table 11. The analyzed control instrumentation has the following financial activity characteristics (calculated according to formulas 1, 2, 3a, and 3b): $NPV = 6.84$ bln rub., $IS = 0.046$ rub./rub. per year. Characteristics of sectoral efficiency of the given control instrumentation are: $ENPV = -9.37$ bln rub., $EIS = -0.018$ rub./rub. per year. It follows that investments in the industry under analysis have financial efficiency, but don't have sectoral efficiency.

Table 11: Discounted values of private and social flows of effects

Characteristic	Moment (project interval)					
	0	1	2	3	4	5	6–10
Balance of private flow of effects (net cash flow)	-15.00	0	5.26	5.26	5.26	5.26	5.26
Discount coefficients	1.00	0.87	0.76	0.66	0.57	0.50	…
Discounted balance of private flow of effects	-15.00	0	3.98	3.46	3.01	2.62	…
NPV	6.84						
Balance of social flow of effects	-48.17	0	8.07	8.07	3.02	8.07	8.07
Discount coefficients	1	0.91	0.83	0.75	0.68	0.62	…
Discounted balance of private flow of effects	-48.17	0	6.67	6.06	2.06	5.01	…
ENPV	-9.37						

Note. Discount coefficients for the private flow of effects were calculated with the 15% discount rate. Discount coefficients for the social flow of effects were calculated with the 10% discount rate.

Summary

Let us criticize the calculations described above. Assessment of sectoral efficiency depends to a great extent on the discount rate. The same refers to financial efficiency, but discount rate calculation for it was thoroughly developed. In the described example, the ‘sectoral average’ control instrumentation has sectoral efficiency with the social discount rate of 5.85% and less.

Analysis of sectoral efficiency makes it possible to compare average prices for products in the industry with average investments (for the industry), their capacity and service life. It makes it possible to draw certain conclusions about the condition and prospects of the industry as well as about changes required to achieve the target condition. Correlation of prices, investments, their periods and service lives has to ensure profitability characteristic of the respective industry.

Some problems connected with practical assessment of sectoral efficiency have to be pointed out. Industry statistics includes data of both profitable and loss-making companies and shows retrospective, not perspective. It means that statistic data does not reflect the fact that modern investment project are significantly different from those that were implemented in the analyzed industry. The differences are connected not only with the technology used in the project, but also with the correlation of prices, investments, their capacity and service lives. There is also a practical problem with the calculation of investment project characteristic that are average for the industry.

When calculating sectoral efficiency, we used values of final consumption growth for products in the analyzed industry that appears as a result of realization of ‘standard’ control instrumentation in this industry. But some projects can be aimed not at final consumption, but at the intermediate one. If they are assessed according to the contribution to GDP, they will invariably be inefficient, that is why the proposed method is not applicable for all industries. At the end, we would like to say that this critic does not take from the value of the method for sectoral efficiency assessment suggested by the author; it just creates a basis for its further development.

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