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MACROECONOMIC IMPACT OF NUCLEAR POWER PLANT PROJECTS

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Introduction

The article describes the main approaches to assessing multiplier effects from implementation of major international projects. A conventional example considers the distribution of effects between the supplying country and receiving country.

Macroeconomic models have gained widespread acceptance in estimating multipliers for the whole economy in general (Beetsma, 2008; Christiano, 2011). Methods based on the input-output approach are typically applied for estimating effects at the industry level. Among these calculations, it is possible to distinguish three main types, which are as follows:

(1) calculations within general equilibrium models with integrated input-output tables (Burfisher, 2017);
(2) calculations within a static input-output model (Miller, 2009);
(3) calculations within a modified input-output model using econometric dependences for modeling the impact of additional income on total consumption (Ghosh, 2011; West, 1995).

1. Impact analysis of investment projects using an input-output model

The input-output model is one of the most convenient tools for determining multiplier effects from implementation of nuclear power plant (NPP) projects. Hereinafter the “multiplier effect” refers to an increase in one of the macroeconomic indicators (gross output, GDP, budget revenues, etc.) caused by the extension of the initial increase in the output in one of the sectors over the inter-industry relationships[23].

This study deals with the following three types of multiplier effects:

- the output multiplier effect (caused by increase in operating expenses);
- the investment multiplier effect (caused by increase in capital expenditures);
- the value added multiplier effect (caused by increase in value added).

1.1. The methodology of the output multiplier effect assessment

We should first consider the multiplier effect of increasing operating expenses, which is caused by the initial increase in output.[24] To describe the mechanism of this effect formation, an iterative logic can be used. First of all, the increase in the output of industry k predetermines an increase in its operating expenses (other things being equal), which causes an increase in output of the related industries that provide industry k with production resources. Further, the increase in output of the supplying industries results in additional demand for the necessary intermediate consumption resources from these industries. This demand is satisfied by an output increase in the related industries, which causes an increase in intermediate demand and gross output at the following iterations.

The process of the multiplier effect formation can be formalized within the static input-output model. In the case of nonzero imports, the equation of the Leontief static model appears as follows:

$$\vec{X} = (I - A^*)^{-1} \cdot \vec{Y}^* \tag{1}$$

where $\vec{X}$ is a vector of output by industries; $\vec{Y}^*$ is a vector of final demand for domestic products; I is an identity matrix; A^* is an adjusted technical coefficient matrix in which imports were excluded from intermediate consumption as follows:

$$A^* = \begin{pmatrix} a_{11} \cdot (1 - imp_{11}) & a_{12} \cdot (1 - imp_{12}) & \dots & a_{1n} \cdot (1 - imp_{1n}) \\ a_{21} \cdot (1 - imp_{21}) & a_{22} \cdot (1 - imp_{22}) & \dots & a_{2n} \cdot (1 - imp_{2n}) \\ \dots & \dots & \dots & \dots \\ a_{n1} \cdot (1 - imp_{n1}) & a_{n2} \cdot (1 - imp_{n2}) & \dots & a_{nn} \cdot (1 - imp_{nn}) \end{pmatrix}; \tag{2}$$

$$a_{ij} = {}^{X_{ij}}\!/_{X_j}, \tag{3}$$

[23] It is necessary to distinguish the initial output increase in the industry from the resulting gross output increase that includes indirect effects.

[24] In general, this multiplier effect can occur not only because of an output increase, but as a result of a decrease in any industry's material intensity (in other words, due to an increase in its intermediate consumption).

where imp_{ij} is an import share in the intermediate consumption by industry j of industry i products (in flow X_{ij}); and X_j is the output of industry j.

Under the assumption that technical coefficients do not change, and the initial increase in output is caused by an increase in final demand (e.g. by an increase in exports), the resulting increase in output can be estimated as follows:

$$\Delta\vec{X} = (I - A^*)^{-1} \cdot \Delta Y^* = (I - A^*)^{-1} \cdot \Delta\vec{X}^0 = \left(E - A\right)^{-1} \cdot \begin{pmatrix} 0 \\ 0 \\ \dots \\ \Delta X_k^0 \\ \dots \\ 0 \end{pmatrix} = \begin{pmatrix} b_{1k} \cdot \Delta X_k^0 \\ b_{2k} \cdot \Delta X_k^0 \\ \dots \\ b_{kk} \cdot \Delta X_k^0 \\ \dots \\ b_{nk} \cdot \Delta X_k^0 \end{pmatrix} \quad (4)$$

where ΔX^0 is a vector of initial increase in output (assuming that the entire increase is concentrated in industry k); ΔX_k^0 is the initial output increase in industry k; and b_{ik} are column components of the matrix $B^* = \left(E - A^*\right)^{-1}$.

In this case the output multiplier for industry k can be calculated as a sum of the k-th column components of matrix B^*:

$$\mu_k^{prod} = \frac{\Delta X}{\Delta X_k^0} = \frac{\sum_{i=1}^{n}\left(b_{ik}^* \cdot \Delta X_k^0\right)}{\Delta X_k^0} = \sum_{i=1}^{n} b_{ik}^* . \quad (5)$$

In addition, a few important observations should be made.

First, the use of an iterative logic for the description of the output multiplier effect formation does not mean that this effect is a long-drawn-out process. An increase in the output (i.e. an output multiplier effect) can occur only if provided with all the necessary resources. In fact, this means that stocks (formed by *pre*-production in supplying industries or imports) are used. This remark is valid not only with respect to material resources, but also with respect to other inputs (under-utilized facilities, labor). Subsequently, for the initial impulse to be transferred to the next iterations, the stocks are to be recharged by means of additional production and/or imports. Otherwise (if stocks are maintained at a new, lower level), the main part of the multiplier effect is essentially “left” in retrospect, whereas in the reporting period the value of the estimated multiplier effect corresponds only to the initial impulse – the output increase in industry k. Hereinafter it is assumed that stocks are maintained at the same level (i.e. the hypothesis of zero change in stocks is accepted).

Secondly, we should emphasize the dual role of imports. On the one hand, imports that compete with domestic production can be considered as a factor, which reduces the multiplier effect value. On the other hand, complementary imports can fill the shortage of production resources required for an output increase to occur.

1.2. The methodology of the investment multiplier effect assessment

The investment multiplier effect (excluding the output increase effect caused by the creation and loading of new facilities) arises in the *construction phase* due to the increase in output of machinery industries (fund-creating industries). The increase in output of fund-creating industries results in increasing operating expenses of these industries and, consequently, the increase in output of industries that supply the required intermediate consumption resources. Further, the formation of this effect is similar to the one described above for the output multiplier effect.

Thus, an increase in gross output at the first iteration is the increase in output of fund-creating industries, which corresponds to the increase in final demand for *domestic investment products*. This increase in final demand can be determined through the structure of capital expenditures within the given project.

If the detailed information on capital expenditures in the given project is unavailable, the vector of increase in final demand for domestic products can be obtained using a matrix of the fixed capital formation technological structure *T*. Its columns are vectors that reflect the typical structure of capital expenditures within investment projects in various industries. In this case, the vector of increase in final demand both for domestic and imported investment products is defined as follows:

$$\Delta\vec{Y} = T \cdot \overrightarrow{inv} = \begin{pmatrix} t_{11} & t_{12} & \dots & t_{1k} & \dots & t_{1n} \\ t_{21} & t_{22} & \dots & t_{2k} & \dots & t_{2n} \\ \dots & \dots & \dots & \dots & \dots & \dots \\ t_{k1} & t_{k2} & \dots & t_{kk} & \dots & t_{kn} \\ \dots & \dots & \dots & \dots & \dots & \dots \\ t_{n1} & t_{n2} & \dots & t_{nk} & \dots & t_{nn} \end{pmatrix} \cdot \begin{pmatrix} 0 \\ 0 \\ \dots \\ inv_k \\ \dots \\ 0 \end{pmatrix} = \begin{pmatrix} t_{1k} \cdot inv_k \\ t_{2k} \cdot inv_k \\ \dots \\ t_{kk} \cdot inv_k \\ \dots \\ t_{nk} \cdot inv_k \end{pmatrix} \quad (6)$$

where $\overrightarrow{inv}$ is a vector of investments by industries[25]; and t_{ik} is a share of industry *i* in capital expenditures of industry *k*.

[25] When considering the project, the investments are concentrated in the relevant industry. But it is also possible to consider several related investment projects in different industries. In this case, the vector of investments has several non-zero components.

The vector of the increase in final demand for domestic investment products is determined by multiplying the components of vector by the share of domestic production in the corresponding investment consumption flows:

$$\Delta\vec{X}^1 = \Delta\vec{Y}^* = \begin{pmatrix} t_{1k} \cdot inv_k \cdot (1 - imp_{T\,1}) \\ t_{2k} \cdot inv_k \cdot (1 - imp_{T\,2}) \\ \dots \\ t_{nk} \cdot inv_k \cdot (1 - imp_{T\,n}) \end{pmatrix}. \quad (7)$$

At the second iteration, the increase in gross output is caused by the increase in intermediate consumption in fund-creating industries.

$$\Delta\vec{X}^2 = A^* \cdot \Delta\vec{X}^1 = A^* \cdot \Delta Y^*. \quad (8)$$

The output increases at the following iterations are determined by analogy with the previously considered output multiplier effect. By results of all iterations, the increase in gross output is expressed as follows:

$$\Delta\vec{X} = \Delta\vec{X}^1 + \Delta\vec{X}^2 + \Delta\vec{X}^3 + \dots = (E + A^* + (A^*)^2 + \dots) \cdot \Delta Y^* = \\ = (E - A^*)^{-1} \cdot \Delta Y^*; \quad (9)$$

$$\Delta\vec{X} = (E - A^*)^{-1} \cdot \begin{pmatrix} t_{1k} \cdot inv_k \cdot (1 - imp_{T\,1}) \\ t_{2k} \cdot inv_k \cdot (1 - imp_{T\,2}) \\ \dots \\ t_{nk} \cdot inv_k \cdot (1 - imp_{T\,n}) \end{pmatrix} =$$

$$= \begin{pmatrix} \sum_{j=1}^{n} [b^*_{1j} \cdot t_{jk} \cdot inv_k \cdot (1 - imp_{T\,j})] \\ \sum_{j=1}^{n} [b^*_{2j} \cdot t_{jk} \cdot inv_k \cdot (1 - imp_{T\,j})] \\ \dots \\ \sum_{j=1}^{n} [b^*_{nj} \cdot t_{jk} \cdot inv_k \cdot (1 - imp_{T\,j})] \end{pmatrix}. \quad (10)$$

It is easy to see that the investment multiplier of industry k, which shows how much gross output increases due to capital expenditures in industry k, is calculated as a sum of the output multipliers of various industries weighted by the capital expenditures structure within the given project (excluding consumption of imported investment products):

$$\mu_k^{инв} = \frac{\Delta X}{inv_k} = \sum_{j=1}^{n} \left(\mu_j^{prod} \cdot t_{jk} \left(1 - imp_{T\,j}\right)\right) = \sum_{j=1}^{n} \left(\left(\sum_{i=1}^{n} b^*_{ij} \right) t_{jk} \left(1 - imp_{T\,j}\right)\right). \quad (11)$$

The investment multiplier formula underlines the fact that the mechanisms of formation of the output multiplier effect and the investment multiplier effect are similar. The only difference is that in the case of the output multiplier the initial impulse is an increase in the output of any industry, whereas in the case of the investment multiplier the initial impulse is an increase in the output of fund-creating industries (weighted by the capital expenditures structure within the given project). Therefore, the impact on the investment multiplier estimates of such indicators as intermediate demand coefficients or shares of imports is similar to their impact on the output multiplier estimates.

1.3. The methodology of the value added multiplier effect assessment

This effect is formed in the case of additional income for various subjects of the economy (households, government, business) and further increase in spending. This additional final demand predetermines production expansion across a wide range of industries of the national economy. It leads to an increase in operating expenses, which generates the indirect effects described above.

The approach to assess the income multiplier effect uses methodology similar to the one described for the investment multiplier effect. There are two stages of calculations. In the first stage, we should assess the increase in final demand for domestic products due to additional income in the economy (using average ratios between value added and output for different industries, average shares of wages and taxes in value added for different industries, average income elasticities of final consumption by households, by government and by companies). In the second stage, we can use the equation $\Delta\vec{X} = (E - A^*)^{-1} \cdot \Delta Y^*$ to determine the resulting increase in gross output.

We should note that this gross output increase should once again lead to an increase in value added. This additional income can also be spent, which will create another income multiplier effect (at the second iteration of spending). Whether it is appropriate to take into account the effects that arise in the next iterations is a rather complicated question. The fact is that each new iteration of spending implies a management decision to invest or to consume more. In other words, each new iteration is a consequence of the income multiplier effect at the previous iteration. Since an iteration takes a certain amount of time to pass through, only a few iterations occur in a year. In addition, each subsequent income multiplier effect turns out to be smaller than the previous one because the amount of additional value added decreases with a new iteration (since the ratio of value added to output is less than 100 %). Thus, accounting for the first few iterations allows to estimate the resulting gross output increase quite accurately.

The income (value added) multiplier of industry *k* shows how much gross output increases (at the first iteration of spending) due to the increase in value added in industry *k*. It can be determined by analogy with the investment multiplier – as a sum of output multipliers of various industries weighted by the structure of the increase in final demand for domestic products:

$$\mu_k^{\partial c} = \frac{\Delta X}{\Delta va_k^0} = \sum_{j=1}^{n} \left(\mu_j^{prod} \delta_j \right) = \sum_{j=1}^{n} \left(\left(\sum_{i=1}^{n} b_{ij}^* \right) \delta_j \right) \qquad (12)$$

were δ_i *is* the share of industry *i* in the increase in final demand for domestic products:

$$\delta_i = \left(w_k + tr \cdot tax_k \right) \cdot c \cdot \alpha_i \left(1 - imp_{c\,i} \right) + tax_k \cdot gc \cdot \beta_i \left(1 - imp_{gc\,i} \right) +$$

$$+ \left(1 - imp_{T\,i} \right) \sum_{j=1}^{n} t_{ij} \left[tax_k \left(1 - gc - tr \right) \gamma_j + \left(1 - tax_k - w_k \right) binv_k \right]. \qquad (13)$$

1.4. Methodology of the integrated multiplier effect assessment

The combination of the described multiplier effects arising due to the project implementation can be illustrated by the conceptual scheme presented in Fig. 1.

In the construction phase, an investment multiplier effect occurs due to the capital expenditures within the project. The gross output increase caused by this effect predetermines the increase in value added. It leads to a rise of the income multiplier effect. In the phase of production (in the case of an appropriate demand), the output multiplier effect arises, which is also supplemented by the income multiplier effect. The integrated multiplier effect of the given investment project is determined by summing out the indicated “single” effects.

The integral output increase can be represented in the following way:

$$\Delta \vec{X}^{\text{ total}} = B^* \cdot \Delta \vec{Y}_{inv}^* + B^* \cdot \Delta \vec{Y}_{va\,(inv)}^* + B^* \cdot \Delta \vec{X}_{prod}^0 + B^* \cdot \Delta \vec{Y}_{va\,(prod)}^* =$$

$$= (E - A^*)^{-1} \left(\Delta \vec{Y}_{inv}^* + \Delta \vec{Y}_{va\,(inv)}^* + \Delta \vec{X}_{prod}^0 + \Delta \vec{Y}_{va\,(prod)}^* \right) \qquad (14)$$

where $\Delta \vec{Y}_{inv}^*$ and $\Delta \vec{Y}_{va\,(inv)}^*$ are the vectors of the increase in final demand for domestic products due to capital expenditures within the NPP project and due to spending of additional income in the investment phase of the project; $\Delta \vec{X}_{prod}^0$ is the vector of the direct increase in output within the NPP project; and $\Delta \vec{Y}_{va\,(prod)}^*$ is the vector of the increase in final demand for domestic products due to spending of additional income in the production phase.

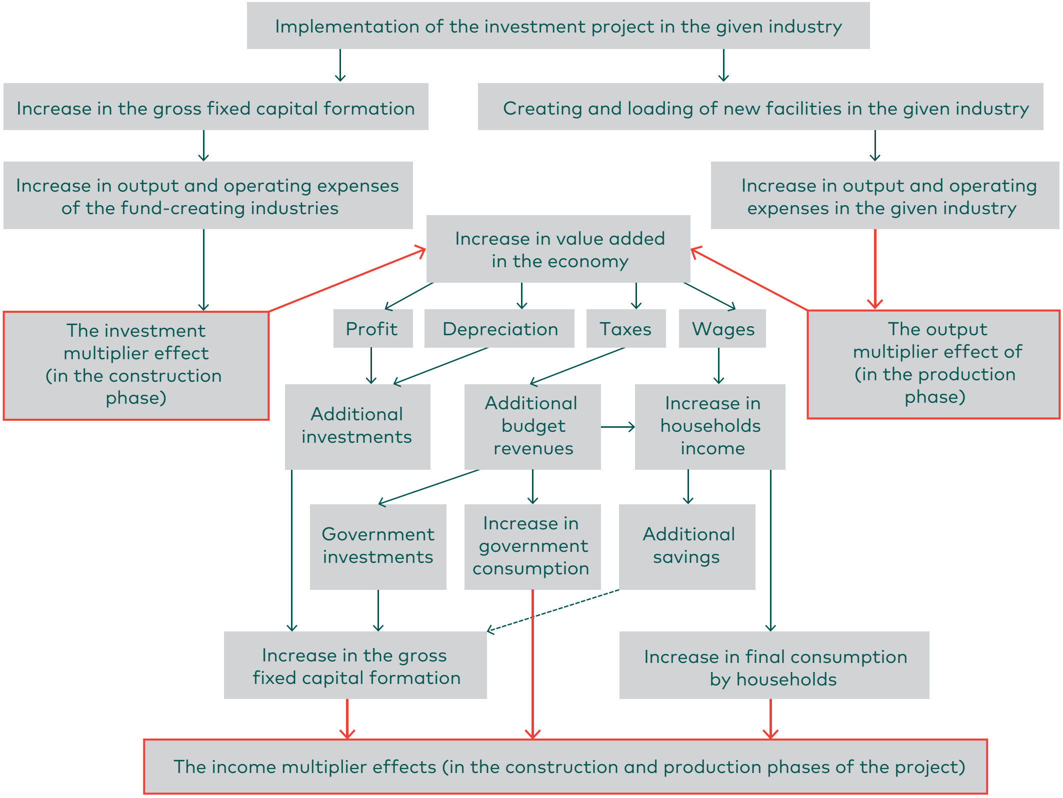

Fig. 1. Formation of multiplier effects during the investment project implementation.

The initial increase in output in the production phase (in industry k where the NPP project is implemented) can be obtained from the feasibility study of the project or expressed through the capital intensity q_k in industry k:

$$\Delta\vec{X}^0_{prod} = \begin{pmatrix} 0 \\ 0 \\ \ldots \\ \Delta X^0_k \\ \ldots \\ 0 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ \ldots \\ \dfrac{inv_k}{q_k} \\ \ldots \\ 0 \end{pmatrix}. \qquad (15)$$

1.5. The procedure for dynamizing calculations

The investment projects in the nuclear power industry have long terms of implementation. During this time, the key parameters involved in the assessment of multiplier effects (in particular, the structure of production costs in the economy, the share of imports and other structural parameters) change significantly. This is a rigid constraint for using the static input-output model within the assessment of the investment project's economic consequences. This constraint is taken off by "splitting" the overall effect during the entire period of the investment project implementation. It lets us consider these effects in specific periods, each of which is characterized by its own structural parameters, corrected in accordance with the trends of scientific and technological development and increases in production efficiency, and the changing of geological and technical characteristics in mining, etc. The methodology described above is used within a year.

An increase of some indicators (output, value added) is understood not as the increase to the previous year level, but an increase to the level within the scenario in which the referred project is not implemented (other things being equal). The assessment of multiplier effects during various years can be carried out in constant prices or with discounting of cash flows (taking into account the time value of money). The splitting of the project implementation period into certain years also facilitates forming a set of input parameters for the calculation, since the data on the annual amounts and structure of capital expenditures and output within the project are traditionally given in the feasibility study.

In order to take into account the long-term changes in structural parameters, we should adjust matrix A by multiplying its elements by the index of productivity for the selected year (it indicates changes in the efficiency of using primary resources in comparison with the basis of 2013). The import matrix is adjusted by multiplying its coefficients by the import substitution index, indicating changes of the share of imports in domestic consumption.

The use of the static input-output model for assessing the multiplier effects is associated with the adoption of several simplifying assumptions, which narrow the field of the correct application of the described methodology in practice. The use of the static model implies that the parameters of calculations (intermediate demand coefficients, the structure of final demand, the structure of value added distribution, etc.) remain unchanged in the year under review. Thus, we assume in the hypothesis that the cumulative effect of the given investment project is incomparable with the scale of the entire economy and therefore does not have a significant impact on its key structural parameters. This means that the additional demand for goods and services, formed due to the implementation of the project, can be covered by loading idle capacities, imports expansion or using stocks (i.e. does not create the shortage in commodity markets and an increase in prices). A similar assumption should be made regarding the impact of the given project on the situation in labor markets and debt capital.

2. Assessment of macroeconomic effects of international NPP projects

2.1. Multiplier effects for the country supplying NPP

In this study the following international NPP project macroeconomic effects for the supplying country are considered:

- the increase of external demand for investment products (corresponding to the share of the country in capital expenditure within the project) and the effects of the output increase in fund-creating industries (the investment multiplier effect with subsequent spending of additional income due to the value added increase);

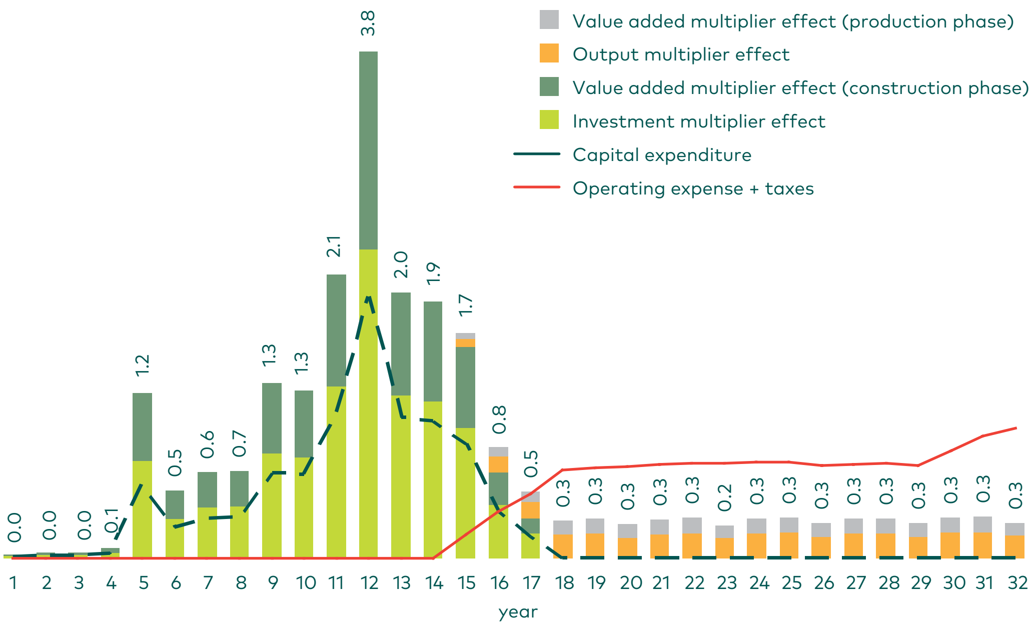

Fig. 2. Estimates of the multiplier effects on gross output of the supplying country by years, billion constant 2013 US dollars. (Source: IEF RAS)

- the increase of external demand for intermediate consumption resources in the production phase (the output multiplier effect with subsequent spending of additional income due to the value added increase).

In principle, the methodology for assessing the international NPP project effects does not differ from the general methodology described above. One of the few differences is the accounting for the direct output increase and value added within the NPP project. Since the project is external to the supplying country, the increases in output and value added within the project do not affect gross output and GDP of the supplying country. Also, we should note that the impact of the project on the supplying country exports is likely underestimated because direct contacts between the supplying country and the country receiving NPP are only considered (although, for example, exports of metals or fuels can increase, required to produce equipment for NPP in any other country).

The main challenge here is to accurately assess the extent of the supplying country's participation in the project (i.e. its shares in the supply of investment and intermediate consumption resources).

Illustrative calculations were carried out based on the real project data to demonstrate the capabilities of the methodology for assessing multiplier effects.

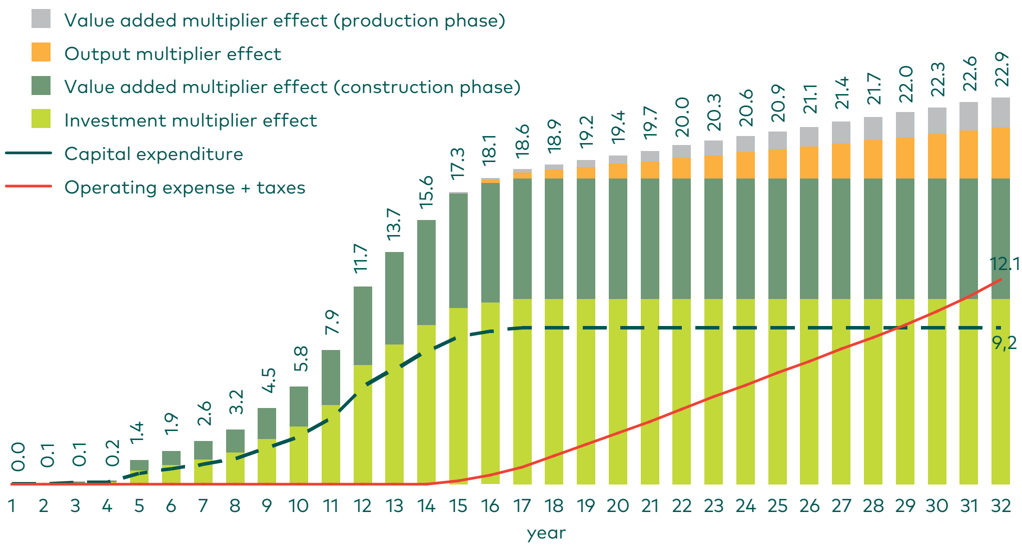

Fig. 3. Estimates of the cumulative multiplier effects on gross output of the supplying country, billion constant 2013 US dollars. (Source: IEF RAS)

In these calculations, the input-output table developed by IEF RAS (for 2013) was applied. The estimates were obtained in constant 2013 US dollars, and discounting was not carried out. The results are shown in Figs. 2 and 3.

It is assumed that Russia is helping to build a nuclear plant in one country. Power station has 2 units, each 1,200 MW, construction period (including preconstruction stage) – 14 years, payback period – 15 years , operation period – 60 years, investment volume – $ 9.2 bln.

According to the results of the calculations, the supplying country receives the largest multiplier effect in the construction phase. The estimates of multiplier effects are strongly correlated with capital expenditure and output within the NPP. The multipliers' estimates decrease (see Fig. 4) due to the increasing efficiency of the primary resources used in the economy. In the construction phase, the investment multiplier (i.e. the ratio of the gross output increase to the amount of annual investment) for the supplying country decreases from 1.37 to 1.12 (without the value added multiplier effect) and from 2.38 to 1.18 (including the value added multiplier effect). In the production phase, the output multiplier (i.e. the ratio of the gross output increase

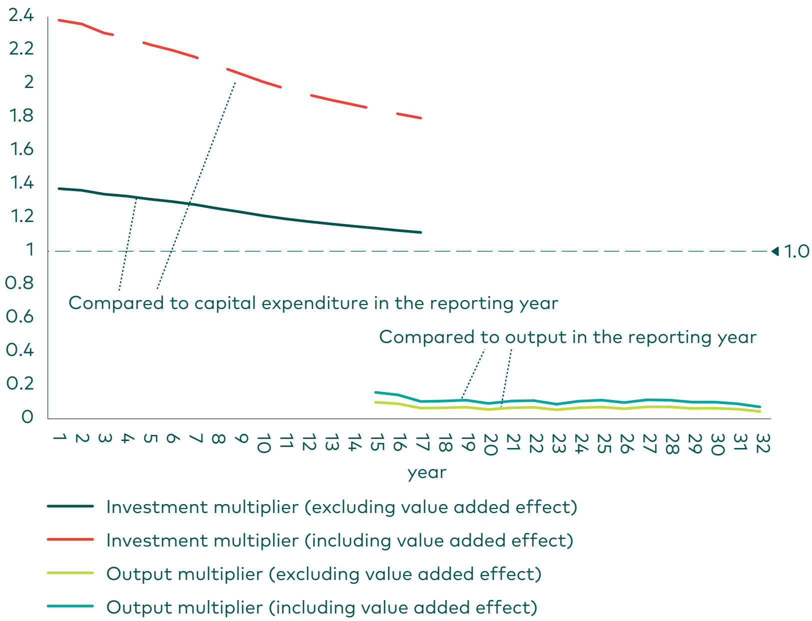

Fig. 4. Multiplier estimates (of gross output) for the supplying country. (Source: IEF RAS)

to the amount of total investment within the project) for the supplying country lowers from 0.10 to 0.04 (without the value added multiplier effect) and from 0.16 to 0.07 (including the value added multiplier effect). The integral multiplier (i.e. the ratio of the cumulative gross output increases during the considered period to the amount of total investment) is 2.48.

Figure 5 presents the structure of gross output increase for the supplying country in the construction phase (for example, in year 12). The largest output increase is expected in manufacture of machinery and equipment.

Also, we can use the proposed methodology to assess multiplier effects on GDP. In the construction phase, the investment multiplier (i.e. the ratio of the GDP increase to the amount of annual investment) for the supplying country decreases from 0.67 to 0.55 (without the value added multiplier effect) and from 1.17 to 0.88 (including the value added multiplier effect). In the production phase, the output multiplier (i.e. the ratio of the GDP increase to the amount of total investment within the project) for the supplying country decreases from 0.05 to 0.02 (without the value added multiplier effect) and 1.08 (including the value added multiplier effect). The integral multiplier (i.e. the ratio of the cumulative GDP increase during the considered period to the amount of total investment) is 1.22.

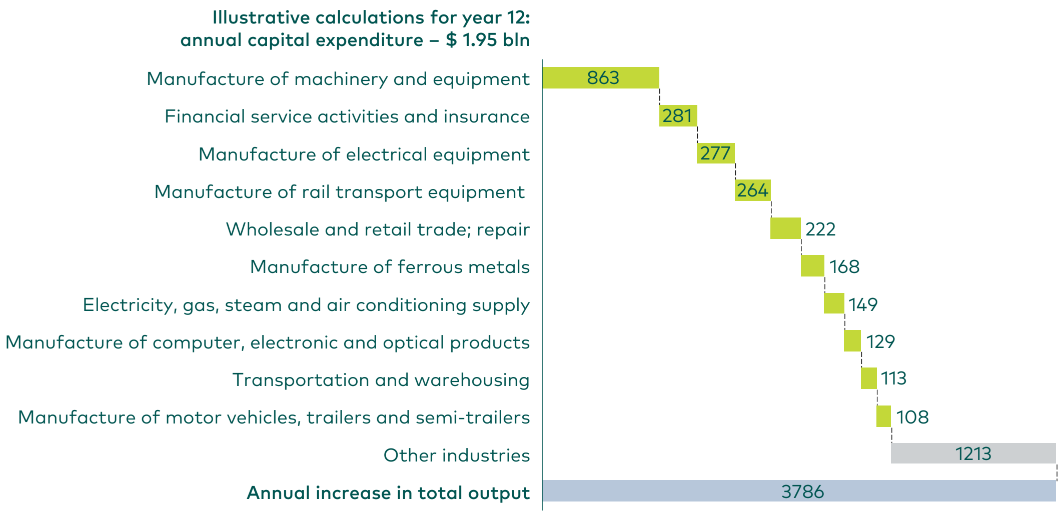

Fig. 5. The structure of gross output increase for the supplying country in the construction phase, billion constant 2013 US dollars. (Source: IEF RAS)

2.2. Multiplier effects for the country receiving NPP

In this study the following international NPP project macroeconomic effects for the receiving country are considered:

- the increase of domestic demand for investment products (corresponding to the share of the country in capital expenditure within the project) and the effects of the output increase in fund-creating industries (the investment multiplier effect with subsequent spending of additional income due to the value added increase);
- the increase of domestic demand for intermediate consumption resources in the production phase (the output multiplier effect with subsequent spending of additional income due to the value added increase).

For the receiving country, the methodology for assessing the international NPP project effects is fully in line with the general methodology (including the impact of investment and intermediate consumption resources imports). The most complex issue is accounting for net profits within the project (or, more precisely, its spending). Since such projects are usually funded mainly by external loans and equity of the supplying company, the net profit goes for payback and depreciation.

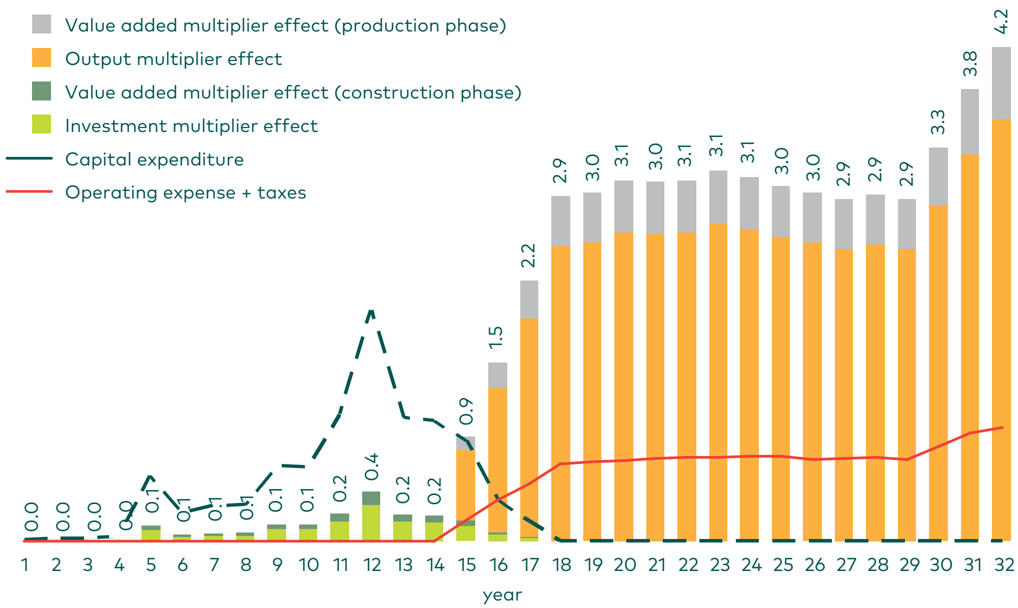

Fig. 6. Estimates of the multiplier effects on gross output of the receiving country by years, billion constant 2013 US dollars. (Source: IEF RAS)

Therefore, these additional revenues should not be taken into account when determining the value added multiplier effect for the receiving country.

The results of assessing macroeconomic effects of the considered NPP project for the receiving country are presented in Figs. 6 and 7.

The largest multiplier effect occurs in the production phase. At the same time, the gross output increase (without the value added multiplier effect) coincides with the increase in electricity production within the project, i.e. the indirect effect of increase in operating expenses is almost zero. It is due to a low share of the receiving country in the supply of intermediate consumption resources for NPP.

The estimates of multiplier effects are correlated with capital expenditure and output within the NPP as in the case with the supplying country. The decrease of multipliers' estimates (see Fig. 8) due to the increasing efficiency of the primary resources used in the economy. In the construction phase, the investment multiplier for the receiving country decreases from 0.18 to 0.15 (without the value added multiplier effect) and from 0.25 to 0.20 (including the value added multiplier effect). In the production phase, the output multiplier for the receiving

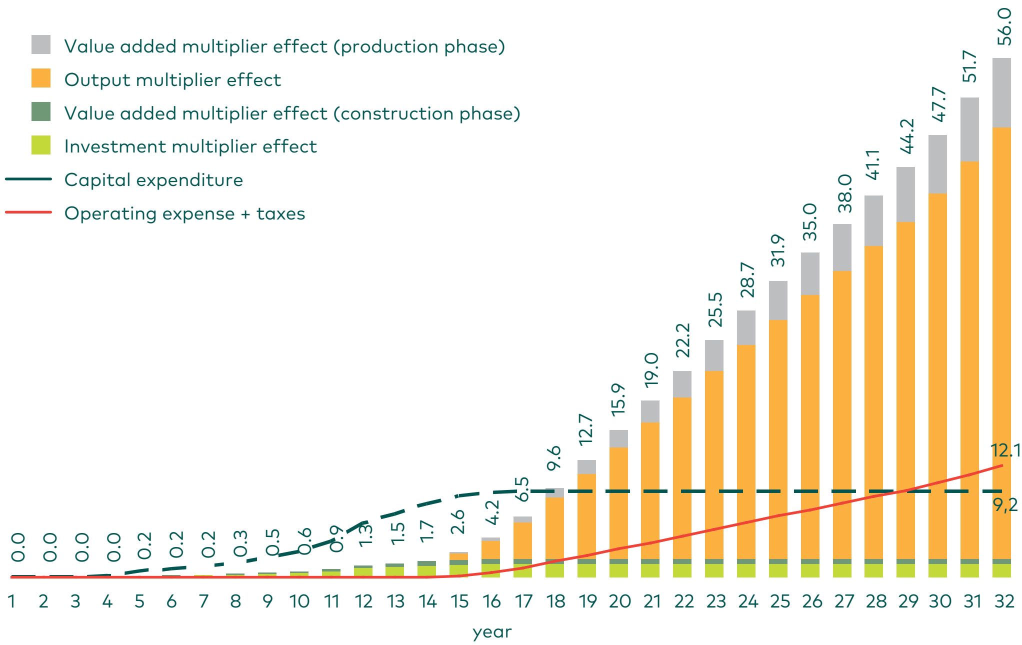

Fig. 7. Estimates of the cumulative multiplier effects on gross output of the receiving country, billion constant 2013 US dollars. (Source: IEF RAS)

country does not change significantly and equals 1.0 (without the value added multiplier effect) and about 1.16–1.17 (including the value added multiplier effect). The integrated investment multiplier (i.e. the ratio of the cumulative gross output increases during the considered period to the amount of total investment) is 6.1.

Figure 9 represents the structure of gross output increase for the receiving country in the construction phase (for example, in year 12). The largest output increase is expected in construction and engineering.

Regarding the multiplier effects on GDP for the receiving country, in the construction phase, the investment multiplier (i.e. the ratio of the GDP increase to the amount of annual investment) for the receiving country is equal to 0.08 (without the value added multiplier effect) and 0.11 (including the value added multiplier effect). In the production phase, the output multiplier (i.e. the ratio of the GDP increase to the amount of total investment within the project) for the receiving country is equal to 0.95 (without the value added multiplier effect) and 1.05 (including the value added multiplier effect). The integral multiplier (i.e. the ratio of the cumulative GDP increase during the considered period to the amount of total investment) is 4.8.

We should note that in the production phase, the estimates of multiplier effects on gross output and on GDP for the receiving country

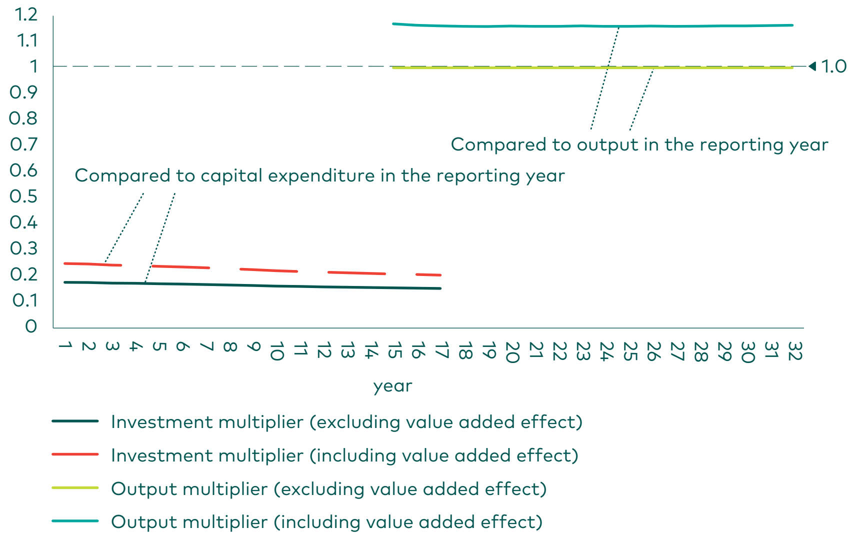

Fig. 8. Multipliers estimates (on gross output) for the receiving country. (Source: IEF RAS)

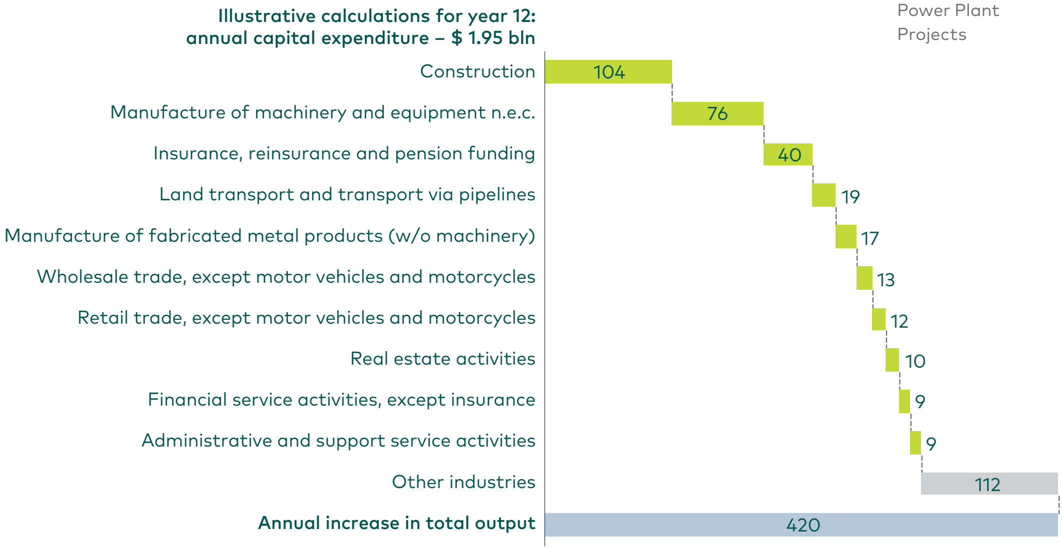

Fig. 9. The structure of gross output increase for the receiving country in the construction phase, billion constant 2013 US dollars. (Source: IEF RAS)
Note: Excluding direct effect of the project on total output in the partner country

are close because of a low share of domestic production in the supply of intermediate consumption resources for NPP, and, therefore, there are small differences between the output and value added in the project (including profit, depreciation, taxes and wages).

Conclusions

The input-output approach is one of the most convenient tools for determining multiplier effects from the development of Nuclear Power Plant (NPP) projects.

In order to take into account the long-term changes in structural parameters of the NPP project period, we should adjust the direct cost coefficient matrix A by multiplying its elements by the index of productivity for the selected year (it indicates changes in the efficiency of using primary resources in comparison with the basis of 2013).

During the construction and operation of the NPP, there are two basic types of effects: investment and operational. In international NPP projects macroeconomic effects are divided between the supplying country (the equipment producer) and the receiving country (where the project is implemented). As a rule, in the case of implementing international projects for the construction of nuclear power plants, the main effects for the country supplying of machinery and equipment are observed at the investment stage, and for the country implementing the project on its territory at the operation stage.

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