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## SOME CONSIDERATIONS ON THE USE OF LEONTIEF'S MODELS IN NEW ECONOMIC REALITIES

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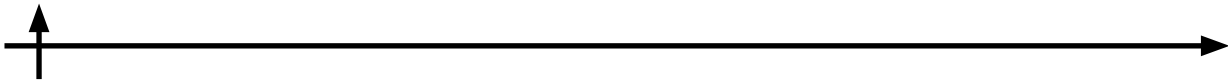
**Abstract.** Today's researchers periodically refer to the extensive scientific heritage of Wassily Leontief, one of the outstanding economists of the 20th century, in order to find solutions to individual problems, both in the global and in the economies of individual countries. The object of consideration of this article is the Leontief differential model. The authors substantiate the need for further development of this model and offer specific forms of its mathematical interpretation. A new reading of Leontief's differential model, the authors believe, will reveal the impact of investment flows from developing countries and emerging markets on various national economies and their groups.

**Keywords:** Leontief differential model, investment flows, transitional economies, economic policy

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## НЕКОТОРЫЕ СООБРАЖЕНИЯ ОБ ИСПОЛЬЗОВАНИИ МОДЕЛЕЙ ЛЕОНТЬЕВА В.В. В НОВЫХ ЭКОНОМИЧЕСКИХ РЕАЛИЯХ

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**Аннотация.** Исследователи наших дней периодически обращаются к обширному научному наследию Василия Леонтьева, одного из выдающихся экономистов XX века, с целью поиска решений отдельных проблем, как в глобальной, так и в экономиках отдельных стран. Объектом рассмотрения данной статьи является дифференциальная модель Леонтьева. Авторы обосновывают необходимость дальнейшего развития данной модели и предлагают конкретные формы ей математической интерпретации. Новое прочтение дифференциальной модели Леонтьева, как полагают авторы, позволит выявить воздействие инвестиционных потоков из развивающихся стран и формирующихся рынков на различные национальные экономики и их группы.

**Ключевые слова:** дифференциальная модель Леонтьева, инвестиционные потоки, переходная экономика, экономическая политика

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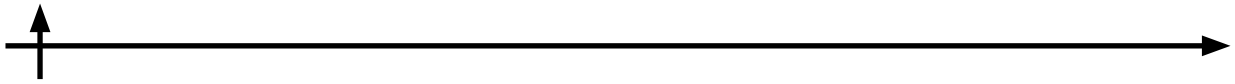
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### Introduction

The scientific legacy of the outstanding economist of the 20th century, Nobel Prize winner in economics, Wassily Leontief, is multifaceted and diverse. In addition to the theory and methodology of input-output balance, he left remarkable works in such areas of economic science as the efficiency of production concentration, economic evaluation and the choice of directions of technical progress, relations between developed and developing countries (Granberg, 1999). It should be noted that the input-output method proposed by him is widely used today in economic research to solve various problems of economic practice, including in the post-Soviet space ((Ksenofontov et al., 2018); (Cherniavsky and Chepel, 2021)). American researchers have used this method to assess the environmental impact of industrial activities (Duchin, 1992). However, as academician Granberg A.G. noted, “The input-output method in the form in which it was developed by W. Leontief himself and his students has some “generic” restrictive features” (Granberg, 1999). Here, first of all, he meant the use of linear dependencies, the absence of optimization models and intersectoral models of economic development.

With the transition of Western economies to monetarist theories and recipes, articles devoted to intersectoral balance models (IBI) have practically ceased to be published in the special economic lit-



erature. And if there were references to them, then to a greater extent, as some relic approaches that are no longer possible in the context of globalization processes.

To a certain extent, this corresponded to the objective processes that have taken place in the developed economies of the world in the last 30-40 years, when the free movement of capital, goods, technology and labor has become one of the main drivers of economic development. The apotheosis of this trend was the American manufacturing industry, where between 2000 and 2010 the number of employed people decreased from 12 to 8.2 million people, i.e. by about one third. If we take longer time intervals, we can note that in 1970 the share of manufacturing in GDP ranged from 21% (Canada) to 30% (Japan), but by 2015 this figure was much lower: 22% (Germany) and 10% (Great Britain and Canada) (Gorbashko et al., 2021). The most recent data from the UNCTAD statistical database shows that in 2020 this figure at the global level was 16.5%, including in the UK - 9.6%, Germany - 16.0%, Canada - 10.5%, USA - 11.1% and Japan - 20.5% (“UNCTADstat,” n.d.). To date, a non-trivial situation has developed in the world economy, when China has become the world leader in the production of industrial goods, in fact, taking on the burden of the “workshop of the world”.

Geopolitical changes of recent times are laying a new trend in world economic development. Now several centers are being formed in the world, which will follow different scenarios of economic policy. It can be argued that a process of limited globalization has begun, with some return to the “rules” of discrete production. In the conditions of such a new “watershed” of the world economy, a completely natural question arises: what areas of research by V. Leontiev can be in demand in the new economic realities and under what conditions?

It seems that the development of V. Leontiev's differential model, proposed by B. Khusainov in 2005, may be of some interest in this context (Khusainov, 2005). In particular, the implementation of the model will reveal the impact of investment flows from developing countries and emerging markets on various national economies and their groups.

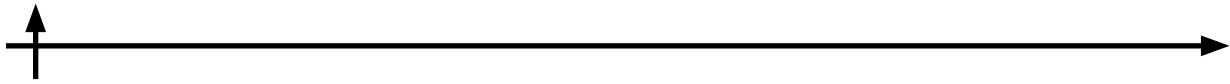
### **New reading of Leontief's differential model**

W. Leontief's differential model aims to assess the impact of foreign capital on the economic growth of the recipient country (Leontief, 1990). Leontief's simple dynamic system describes in a simplified aggregated form dependencies between capital value, transferred from developed countries to developing, rate of savings and investments in both group of countries and their growth rates. Statistical information that is available is used in the system. General values of coefficients “capital-output” and rate of savings for developed and developing countries, as well as share of gross national product of developed countries, transferred to developing countries, are assumed constant for the ten-years period for which economic growth is calculated.

Since aggregated values of the coefficient of capital intensity and rate of savings could be assessed especially for developed countries - only with significant error, and also taking into account that the goal is assessment of potential influence of change in values of foreign capital, received by developing countries, on their growth rates, in Leontief's model not one, but several choices are considered. All of them are calculated based on the same equations, however, each is defined by own hypothetic combination of values of structural parameters mentioned above.

It is acknowledged, that Leontief's dynamic model made an important contribution to the understanding of patterns of international economic interaction of different countries. At the same time, it has several issues that excessively unfit the economic reality. In the aggregated view disadvantage of the given model could be shown as the following.

1. Scale of exported capital from country-donor directly linked to the rates of the economic growth. Recently, it became obvious that it is not always true. The most illustrative example of this dependency was displayed during world financial crisis of 1997-1998 when significant capital overflow took place, including foreign, from Asian-Pacific countries to North America, in particular to the US. This thesis also



could not be applied to the countries with transitional economy. Indeed, stable high level of export of national capital abroad was typical for several countries (Russia, Kazakhstan, and others) of this group exactly during deep economic crisis. Thus, relation between production growth rates in countries, that export and import capital, turns quite ambiguous. Hence, Leontief's model could be weakly applied to the analysis of the modern tendencies.

2. Imported capital assumed homogeneous. At the same time countries with transitional economies "illustratively demonstrate that truth, that not only values of imported capital are important but its structure. Thus, for instance, considerable part of foreign investments in Russia was spent on purchase of short-term government-papers and not allocated to the real sector of the economy" (Balatskyi, 1999). This thesis is also supported by research of authoritative Russian scientists ((L'vov, 1999); (L'vov, 2000); (Glinkina, Kulikova, 2006)). Understandable that such financial investment favor most likely to slow-ing down rather than to acceleration of economic development of the country-recipient. In this sense applied calculations on Leontief's differentiated model could strongly misinform researcher on real role of foreign investment.

3. National and foreign investments are assumed of the equal effect. In this case W. Leontief assumes that foreign capitals - are just supplementary financial resources, return on which is defined by national conditions of production. But this case does not match today's reality. Firstly, deep economic meaning of foreign capital attraction is the following: together with foreign capital new technologies are coming to the national economy as well as new organizational forms of production, that give absolutely different economic effect comparing to domestic entrepreneurship. At the same time experience of transitional economies on foreign capital attraction witnesses that foreign investors are not trying to reach these goals. Moreover, market of countries with transitional economies often becomes base for "trash" of obsolete technologies and manufactures. Secondly, experience of system transformation in the countries with transitional economy shows that at the certain stage of economic development of the national economies foreign capital plays determinative role due to limited opportunities of domestic public savings, lack of own capital, deepening of crisis processes in the mentioned period. However, as far as growth of the economy and accumulation of own investment resources ratio of foreign investments in total value of investments to the main capital is certainly decreasing (World Development Report 2005, 2004). Saying in this situation that effect of domestic capital is lower than effect of foreign capital is hardly reasonable (Khusainov, 2005).

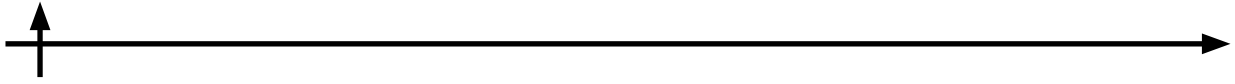
4. When Leontief's model was under development crucial demonstrations of modern stage of development (for instance, globalization of the world economy, impetuous development of its transnational sector and etc.) were not playing such an important role on dynamics of economic growth of different countries. However, registration of these factors including influence of globalization on development of national economies through its crucial demonstrations becomes extremely important task in order to develop adequate economic policy and assess subsequences of taken decisions.

5. Finally, given model pays great demand to the informational supply. In particular, apart from national statistics, availability of statistical data on many countries is needed. And this could be serious technical obstacle for the realization of the given model.

### **Our interpretation of the differential Leontief's model**

From the moment of development of the model in the world economic system certain changes had happened (in particular, caused by globalization) and appeared absolutely new group of countries, classified as transitional economies. Taking this into account, appropriate changes were introduced to the development of Leontief's dynamic model by the author (Khusainov, 2005), in particular, system of equations was included, which reflect influence of capital flows from developed and developing countries on dynamics of economic growth of transitional economies.

Let's use the following set of aggregated variables (in each moment of time  $t$ ) (table 1) in order to



describe state of economy of three groups of countries - developed, developing and transitional economies.

**Table 1. Aggregated variables of W. Leontief's modified model**

Variables	Developed countries	Developing countries	Transitional economies
Gross domestic product (GDP)	$Y_1(t)$	$Y_2(t)$	$Y_3(t)$
Industrial investments (total value)	$I_1(t)$	$I_2(t)$	$I_3(t)$
GDP growth rate $\bar{Y}(t)/Y(t)$	$r_1(t)$	$r_2(t)$	$r_3(t)$
Capital transfer from developed countries to transitional economies	$H_1(t)$		
Capital transfer from developing countries to transitional economies	$H_2(t)$		

*Developed and developing countries*

Let's use the following theoretical dependencies to derive and solve equations, which describe growth in developed and developing countries:

Equation of savings for two groups of countries:

$$I_1(t) = i_1 Y_1(t) \quad (1)$$

$$I_2(t) = i_2 Y_2(t) \quad (2)$$

where  $i_1, i_2$  – rate of investments to GDP in developed and developing countries.

Accelerator's principle:

$$\bar{Y}_1(t) = I_1(t) / b_1 \quad (3)$$

$$\bar{Y}_2(t) = I_2(t) / b_2 \quad (4)$$

where  $b_1, b_2$  – coefficients of capital intensity (ratio of capital to output), that is value of capital investments needed to produce additional unit of annual GDP in respective group of countries.

Equation of the growth rates, received based on (1) – (4)

$$\bar{Y}_1(t) = (i_1 / b_1) * Y_1(t) = 0 \quad (5)$$

$$\bar{Y}_2(t) = (i_2 / b_2) * Y_2(t) = 0 \quad (6)$$

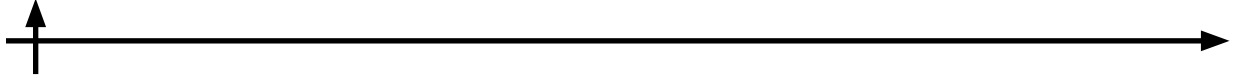
Exponential growth equations, received based on (5) and (6):

$$\bar{Y}_1(t) = Y_1(0)e^{\lambda_1 t}, \lambda_1 = i_1 / b_1 \quad (7)$$

$$\bar{Y}_2(t) = Y_2(0)e^{\lambda_2 t}, \lambda_2 = i_2 / b_2 \quad (8)$$

where  $Y_1(0)$  and  $Y_2(0)$  – GDP value in base year 0.

$\lambda_1, \lambda_2$  – GDP growth rate, that remains constant at fixed  $i_1, i_2$  and  $b_1, b_2$ .



According to the conditions of dynamic model it is assumed that value of capital transferred to transitional economies from developed and developing countries form constant shares  $h_1$  and  $h_2$  out of GDP of the countries that export capital.

Thus, increase of values of transferred capital  $H_1(t)$  and  $H_2(t)$  received from (7) and (8) will have the view of exponent with the growth rate that equals GDP growth rate of developed and developing countries.

Ratio of the value of transferred capital from both groups accordingly:

$$H_1(t) = h_1 Y_1(t) = h_1 Y_1(0) e^{\lambda_1 t} \quad (9)$$

$$H_2(t) = h_2 Y_2(t) = h_2 Y_2(0) e^{\lambda_2 t} \quad (10)$$

#### *Countries with transitional economies*

According to the logic of Leontief's model let's assume that industrial investments in countries with transitional economies are formed based on three sources: rate of savings ( $i_3$ ) of their own GDP  $Y_3(t)$  and imported capital  $H_1(t)$  and  $H_2(t)$ :

Equation of investments:

$$i_3(t) = i_3 Y_3(t) + H_1(t) + H_2(t) = i_3 Y_3(t) + h_1 Y_1(0) e^{\lambda_1 t} + h_2 Y_2(0) e^{\lambda_2 t} \quad (11)$$

Accelerator's principle:

$$\bar{Y}_3(t) = I_3(t) / b_3 \quad (12)$$

where  $b_3$  – coefficient of capital intensity, that shows value of investments needed for the production of additional unit of annual GDP in this group of countries.

Equation of the growth rates, calculated based on (11) and (12):

$$\bar{Y}_3(t) - (i_3 / b_3) * Y_3(t) - (h_1 / b_3) * Y_1(0) e^{\lambda_1 t} + (h_2 / b_3) * Y_2(0) e^{\lambda_2 t} = 0 \quad (13)$$

at that  $(i_3 / b_3) \neq \lambda_1 \neq \lambda_2$ .

Equation of growth that was received as a result of solution of differentiated equation (13):

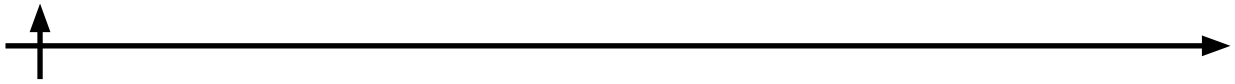
$$\begin{aligned} \bar{Y}_3(t) = & [Y_3(0) - H_1(t) / (b_3(\lambda_1 - \lambda_2))] e^{\lambda_1 t} + [Y_3(0) - H_2(t) / (b_3(\lambda_2 - \lambda_3))] e^{\lambda_3 t} + \\ & + H_1(t) e^{\lambda_1 t} / (b_3(\lambda_1 - \lambda_3)) + H_2(t) e^{\lambda_2 t} / (b_3(\lambda_2 - \lambda_3)) \end{aligned} \quad (14)$$

To check adequacy of the last equation it is possible to substitute its right side in its first derivative in (13). Expression in the left side of the equation (13) will turn into 0.

#### **Conclusion**

The growth of the economy in transitional countries could be described by combination of three components, each of which is changing on exponential dependency. First reflects effect of domestic savings, second - contribution of investments, transferred to the economy from developed countries, third - contribution of investments, which are financed by import from group of developing countries (Lehtonen, 2004; Mayer, 2001; Rudskoy et al., 2019). Respectively, growth rate of the first component depends on rate of domestic savings and coefficient "capital - output", while the second and third are growing along with GDP growth rates of the developed and developing countries.

Certainly, observed comments do not contradict the possibility of adaptation of the Leontief's model for the macroeconomic analysis. Its adaptation is quite reasonable, especially in order to identify qualitative characteristics of the development of international relations by country groups (or regions). But for detailed quantitative calculations by each certain country, we believe, usage of the other model is preferable.

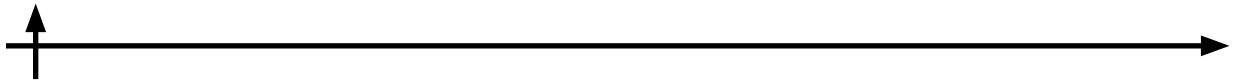


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