A CAUSAL MACROECONOMIC MODEL OF DEVALUATION AND INFLATION IMPACT ON THE ECONOMY OF UKRAINE

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Abstract. *The macroeconomic model of Ukraine, based on a complete system of real microeconomic mechanisms (formation of prices, costs, salary, manufacturers' and state incomes, taxes, etc., trade and transfers among all agents) has been developed. The groups of goods, producers and consumers behaving equally in the conditions of devaluation and inflation have been formed. The core of modeling the interrelation between price, cost price and income is dividing all goods into those of final and intermediate consumption. The traditional macroeconomic hypotheses (equilibrium, SNA balances, influence of money supply, etc.) turned out to be particular cases. The model can be modified for any country. It was has been found that both devaluation and inflation always reduce the real GDP. Conditions of the growth of the value added of exports have been defined. A relationship among emission, devaluation, and inflation has been derived.*

Key words: *macroeconomic model, microeconomic mechanisms' system, intermediate consumption, non-equilibrium, new goods' aggregation, devaluation, inflation*

1. Introduction

There have been built a great variety of macroeconomic models that represent the behavior of the main economic indicators of national economies. They differ in estimation procedures, time account, the degree of aggregation, structuration, interrelations among the elements, etc.

Also, one of the main features of macroeconomic models is the presence of microeconomic backgrounds in its basis. So, according to this feature, all macroeconomic models can be divided into two types: models that have microeconomic foundations and he other one those that have not. Let's consider the existing macroeconomic models in this context.

Such simple theoretical models as IS-LM, the Mundell–Fleming and Solow models (Romer, 2001; Blanchard, 2000) incorporate the variables that represent economic aggregates but don't take into account the individual choices of economic agents. Neither

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the first empirical national macroeconomic model, developed by Jan Tinbergen in the Netherlands (Tinbergen, 1952, 1981) also had microeconomic foundations (similar models were built also for the USA and UK economies). In 1976, in the article "Econometric policy evaluation: a critique" (Lucas, 1976), Robert Lucas has asserted that the prediction of the effects of changes in the economic policy only on the basis of relationships among the economic indicators is not correct. He has proved that this idea has made untenable recommendations on economic policy, based on the conclusions resulting from the large-scale macroeconomic models. Because the parameters of these models were not structural, i.e. not indifferent to the economic policy, they would have to necessarily change when someone changes policies (rules).

Therefore, the conclusions of economic policies based on such models could be misleading. They prejudice the dominance of large-scale econometric models not based on the dynamic economic theory.

Lucas' critique suggests that if we want to predict the consequences of economic policy, we need to include in the model the "deep parameters" (related to preferences, technology and resource constraints) that determine individual behavior. This allows predicting the individuals' behavior taking into account the change in policy and then summarizing the individual solutions for the calculation of the macroeconomic impact of policy changes. This idea was important not only because it had prejudiced many of the existing models, but also because it pushed macroeconomists to create the microeconomic foundations for their models. Until Lucas' microeconomic foundations were desirable, he convinced many economists that they were necessary.

Economists started to build macroeconomic models with microeconomic foundations; also, there were earlier papers with such backgrounds (Phelps, 1970). These models operated with such economy agents as households, firms, and governments, as well as with their preferences, technology and budget constraints. Such macroeconomic models based on microeconomic interactions of rational agents are often called models of dynamic stochastic general equilibrium (DSGE) (Kydland, Prescott, 1982; Krussell, Smith, 1998; Evans, Honkapohja, 2001; Cooley, 1995, Rotemberg, Woodford, 1997; Woodford, 2003, etc.). For example, the followers of theory of real economic cycles since the appearance of the outstanding paper by Finn Kydland and Edward Prescott (Kydland, Prescott, 1977) have focused on studying the microeconomic foundations of macroeconomic models.

In our opinion, the main drawbacks of these models are:

1) when creating models (DSGE, ACE, ASPEN), economists incorporate in them their views on the state's economy, monetary policy, equilibrium, etc. Most of the known models analyze only one particular case – equilibrium subset, but don't analyze the infinite number of real no-equilibrium situations;

2) the models don't reflect all systemic relationships inherently specific to a real economy;
3) GDP (not output) was used as a primary result of production. When creating our model, goods of intermediate consumption were not included in them, so system interrelations among price, cost price, income, and changes of economy efficiency (GDP per unit of intermediate consumption) under devaluation and inflation could not be modeled (for example, in the balance model "input–output" which characterizes the inter-industry production relationships in the economy (relation between output in the same industry and the cost of spending on all products necessary to support this output) intermediate consumption is calculated, but it is not used to calculate the actual costs (Leontief, 1986));
4) the standard international trade theory considers only one factor – the equilibrium export price automatically adjusted under devaluation; e.g., two factors (export/import price and devaluation) have been identified as one. It is only a particular case, too. In fact, the exporter can set any price under the same devaluation;
5) supporters of the classical dichotomy set in their model the mechanism of inflation appearing as a consequence of devaluation, Keynesians set the mechanism of neutralizing the emission by idle resources, but we do not know a model in which these options exist simultaneously.

As a result, any model is not completely adequate to real economy.

2. The main principles of the model (differences from the known ones)

We have not put forward the traditional economic hypotheses that a priori rigidly define the behavior of the economy. We have used a more adequate way (used in the theory of control systems' synthesis): to simulate only the control object, i.e. the microeconomic mechanisms and processes that undoubtedly exist in the economy. Only the hypothesis of a technical nature, which does not specify the behavior of the model a priori, has been accepted.

In particular, to explore all possible situations and not just the equilibrium, we abandoned the association of the equation of supply and demand in the system, i.e. the hypothesis of equilibrium. Equilibrium was only a small subset of a much stronger set of nonequilibrium situations that do not fall into the field of view of traditional theories.

Thus, before the devaluation, three basic balances of SNA in the model were performed:

- the GDP produced (which is the sum of salary, gross profit, and taxes less subsidies) is the consumed GDP;
- the GDP consumed, in turn, is equal to the sum produced (excluding exports) and imported consumer and investment goods and net exports;

- the sum of produced (excluding export) and imported goods of intermediate consumption equals the sum of goods used in production.

However, after the devaluation these restrictions in the model are absent.

Hypotheses of Keynes, monetarists and others are entered into the model, but the model is done in the way that the correctness of each of these hypotheses can be, at least approximately, checked in the model by changing the degree of influence of each of these hypotheses from zero to one. For example, the rule of the Fischer bank interest rate after inflation can be determined by classically adding all percentage of inflation, but we may add only part of it.

Models "macro from micro", in which the macroeconomic level of the economy is connected with the microeconomic one, are not yet completed.

In our model, the behavior of the whole economy is caused by a more detailed and complete system of the basic micro- and macroeconomic mechanisms (formation of prices, cost, producers' and state incomes, taxes, emission, bank rates, transfers, etc.). The system turns out because the mechanisms are interconnected (all roles (functions) of the same elements in different mechanisms were considered). For example, the salary and taxes are reflected as i) part of the cost price, ii) as incomes of hired workers and the state, and iii) as sources of consumption, accumulation, and investments.

To transit to the macro level of the economy, the goods should be aggregated into groups in order not to lose the examined aspects of economic behavior. For example, to study the income, one has to determine the cost, so he cannot aggregate the final and intermediate consumption goods.

It seems to us that in this model the optimum level of aggregation was selected, optimal in the sense that groups of goods, producers and consumers behaving equally under devaluation and inflation were formed[1]; however, a too excessive specification on branches, like in Leontieff's works, was omitted. The core for a correct modeling interrelation among prices, cost price, and income is the division of all goods into those of final and intermediate consumption and of financial services. These groups are:

a) the number of manufacturers' groups and thus the types of goods extended from 3 in the "model of dependent economy" (Frenkel and M. Mussa, 1985) or 4 in the ASPEN model (Basu, Pryor, Quint, 1998):
   1) non-tradable consumer goods and services (index $j=1$ lower in formulas);
   2–4) consumer, intermediate and investment import (IM_4, IM_5, IM_{5N}),
   5–7) import distribution and retail ($j=4, 5, 5_N$);
   8–9) consumer and intermediate export ($j=2_E, 3_E$);

[1] For the economy development model, other groups will also be included, for example, durable and non-durable goods as in the ASPEN.

10–12) consumer, intermediate and investment tradable goods sold domestically (index $j = 2, 3, 3_N$);

13–14) consumer goods' distribution and retail ($j = 2_D, 2_R$);

15) the budget sphere;

b) final consumers are usually the state ($j = DU$) and households. In the present model, the latter ones are divided into 15 groups: 1–12) employees of all 12 – types of enterprises (without imports), 13) business owners ($j = BG$), 14) pensioners ($j = PN$), 15) public servants (civil servants, teachers, doctors, etc.) ($j = BD$). The model takes into account the individual choices of each of these economic agents according to changes of their incomes;

c) users of intermediate goods are 12 producers of the group a without import;

d) consumers of investment goods are business owners and state.

To explore all possible situations, the hypothesis of equilibrium was excluded. According to the existing theories, before devaluation both basic SNA balances take place in our model:

a) the volume of produced GDP equals the volume of consumed GDP;

b) consumed GDP in turn equals the amount of produced (less exports) and imported consumption and investment goods plus net export.

However after devaluation, the model doesn't provide these balances automatically because of the lack of sufficient grounds.

In countries with transition economies, the relationship between monetary aggregates and inflation is weak (Mishkin, 2000); Danylenko (2000) states that the interest rate in Ukraine, on the one hand, cannot be an instrument of influence on prices and, on the other hand, through the lack of the stock market it does not reflect the impact of monetary policy on economy. Indeed, changes of bank rates on loans and GDP deflator in 2001–2006, instead of being collinear, were almost opposite, so the classical scheme of inflation due to money supply and bank regulatory response rates of Irving Fisher (Fisher, 1906) didn't work in Ukraine.

Therefore, without hypotheses about what really worked in Ukraine (the classical dichotomy, Marx's bypass channels (Marx, 1983) or the Keynesian emission neutralized by free capacities), our model displays direct production output changes only when emission goes to production, and indirect changes because of changes in working capital loans (due to bank rate changes).

Production output in physical terms was used as the primary index, as a direct result of the economy functioning. As the secondary index, GDP was calculated as the difference between the output and intermediate products (which are absent in the known models). In fact, GDP is the goal of this functioning, and GDP per unit of intermediate consumption

characterizes the ultimate operational efficiency of the economy (or the efficiency of separate manufactures) from the national point of view (from the point of view of other economic subjects, efficiency is measured as follows: for business owners – profit on capital or on cost, for employees – salary on the costs of working time, etc.).

In this model, cost inflation and demand inflation have been formed from the actually existing microeconomic mechanisms.

Under devaluation, the model can consider other factors: export/import prices, elasticity, and prices of all goods sold domestically.

Due to the monopolistic nature of many Ukrainian markets, sellers raise prices without any market reasons; so, in the model price changes are primary and mostly exogenous factors and the quantity of sales endogenous ones.

The exchange rate depends on the balance of payments. In Ukraine in the recent years, changes of the balance of payments are due to drastic changes of the financial account and changes in its composition are caused by changes in the short-term capital. These changes are caused by both economic and political factors, most likely because the economic factors have mainly a speculative basis. Thus, these changes are difficult and perhaps impossible to associate with economic mechanisms, so it would be best to set the index of devaluation exogenously.

The model includes the shadow production.

All parameters of the model are made variable. This allowing to explore not just the interrelations but also their character, as well as to determine the extent to which this character is preserved.

This approach was applied for the modeling of the Ukrainian economy under devaluation and inflation. As devaluation and inflation develop quickly, their long-term aspects (like long-term investments) are not reflected in the model; technologies (and hence norms of material costs per unit of product), fees for resources, depreciation rates, tax rates, etc. were adopted unchanged.

However, when modeling the economy, the development of these aspects should be accounted for.

The factors that indicate the adequacy of this model:

- the dynamics of changes of all economic indicators in a variety of exogenous factors in a wide range is logical;
- the discarded views will make particular cases in it;
- the model was identified according to data of 2006; the results of calculations for 2007 and 2008 have coincided with the actual indicators of Ukraine's economy by 90%.

3. Description of the model

The model allows optimizing the strategies of the 12 manufacturers (each or all of them) using major (maximum added value) and supplementary a (maximum gross profit, market expansion and many others) criteria by the algorithm of the multicriteria compromise (Vasylenko, 1983).

The price model consists of the non-devaluation I_{nj} and devaluation $a_j \cdot (I–1)$ components of inflation. The *j*-th product owner raises the price more or less than the devaluation index I (coefficient a_j and index I_{nj}):

$$I_j = (I_{nj} + a_j \cdot (I - 1)),\ j = 1, 2, 2_D, 2_R, 2_E, 3, 3_N, 3_E, 4, 5, 5_N.$$

The owner has to rise salary under devaluation, but he sets wages (I_{vj}) usually lower than price (I_j ($b_j < 1$)):

$$I_{vj} = 1 + b_j(I_j - 1),\ j = 1, 2, 2_D, 2_R. \tag{2}$$

The cost of the *j*-th product unit was modeled as a sum of conditionally variable and constant (the last summand) expenses for domestic and imported materials, wages, contributions to pension and social insurance funds with the norm c (being changed due to devaluation), amortization am_j and taxes which have been aggregated into groups with a homogeneous devaluation behavior of their bases (value added t_{DWj}, natural resources t_{Rj}, excise and import duties $t_{IM,}$ and others taxes t_{INj}):

$$s_j = I_3 \cdot z_{30} \cdot n_{3,j} + I_5 \cdot z_{50} \cdot n_{5,j} + (I_{vj} + c) \cdot w_{j0} \cdot p_j + am_3 + t_{DWj0} \cdot I_{DWj} - \\ - t_{Rj0} - t_{INj0} \cdot I_{Wje1} + S_{jc0} \cdot K_{j0} / K_j, \tag{3}$$

where n_{3j}, n_{5j}, p_j is the amount of domestic and imported materials and person-years required for the *j*-th product unit production, and w_{j0} is the average annual salary, and the index $_0$ corresponds to the base period (before devaluation).

The net profit per unit of product, which remains at the disposal of the company's owner depends on prices (1) and cost (3), on tax, on profit $t_{Dj,}$ and on interest on loans for the working capital t_{krj}:

$$d_3 = z_3 - s_3 - t_{FOj0} \cdot I_{vj} - t_{krj}. \tag{4}$$

Predesigns on the model have shown that devaluation and inflation always reduce the real GDP rather more than the existing theories show. To be assured in it, we have entered the best variant into the model: 1) production output is equal to the sum of purchases of all consumers; 2) the model does not take into account imbalances in the transition process during which the "invisible hand" of Adam Smith balances the market, not immediately, but after many underproductions and overproductions of goods that will never find a buyer. This is done to maximize the confidence in the negative effect of

devaluation. If such "best" model shows a negative effect, in fact it could be only worse, but a positive result may be the same or substantially weakened, or not happen.

The model of the j-th good purchase by the k-th consumer K_{kj} is oriented to the price (1) and to a specific k-th consumer income I_{Vk} (not to the average CPI): the consumer demand curve shifts from the nominal price on a specified income change (the size of shift f_k can be varied).

On the supply side, production is limited to the growth of interest on loans for the working capital t_{krj} and its shortages caused by the increasing cost I_{sj} due to devaluation, but the supply is growing due to the part d_{Kj} of emission EM_3 for the development of production:

$$K_{kj} = l_{kj} \cdot (z_k / (1 + f_k \cdot (I_{Vk} - 1)))^{mk} \cdot (1 - h_j \cdot t_{krj} / t_{krj0}) / (1 + g_j \cdot (I_{sj} - 1)) \cdot (1 + d_{EM} \cdot EM_3 \cdot d_{Kj} \cdot ob / S_{j0}), \quad (5)$$
$$j = 1, 2_R, 4, \quad k = 1, 2, 2_D, 2_R, 2_E, 3, 3_N, 3_E, 4_P, 5_P, 5_{PN}, BG, PN, BD, DU,$$

where ob is the velocity of money.

First we took the sedate demand functions and then the linear ones. The results were similar.

For tradable goods *2,* the effect of the substitution of import Im_{40} by output W_{20} in part r_2 is considered:

$$K_{2j}^{IM} = K_{2j} \cdot (1 + r_2 \cdot (1 - K_4 / K_{40})) \cdot Im_{40} / W_{20}. \quad (6)$$

The production output is made of j-th product sales (5) to all consumers; the whole economy output is made of all products.

Production and the import of intermediate goods *3* and *5* are determined by the demand of all 11 producers, while export – by that of the outside world. When a manufacturer buys his own goods, there is a vicious circle: the volume of purchase depends on his salary which, from the manufacture volume, equals the purchases volume. In the model, there are many such recurrent equations' systems. They are solved iteratively: at the first step, any values of all unknown variables are substituted in the equations and the first results are defined. On the second step these first results are substituted in the equations and their second approximations are defined, etc. The authors did not investigate the convergence of the recurrent procedure, but already at the 5th–6th steps the error did not exceed 0.001 %.

Also, we have applied the same iterative process to the solution of the equation systems that are not recurrent and difficult to solve; it has converged to the correct solution. The offer for lazy scientists from here was born: in general, to refuse the mathematical methods of solving the problems and to transfer their solution to the computer upon organizing the corresponding iterative process. Even for the scientists that know these

methods, probably it will be easier to create an iterative process than to check up the adequacy of a method for the given problem (i.e. to find out the conformity of the scope of the method for a given problem) and then to apply this method.

CPI is determined not for goods' "basket", but for all consumer goods (the difference makes no more than 8–10%):

$$I_{sz} = (I_1 \cdot W_1 + I_2 \cdot W_2 + I_4 \cdot Im_{4I}) / (W_1 + W_2 + Im_{4I}). \quad (7)$$

State revenues consist of tax and non-tax revenues and contributions to social insurance funds. Devaluation adds to them a variable part of emission:

$$D_{DU} = I_V \cdot T_{FO0} + I_D \cdot T_{D0} + I_{DW} \cdot T_{DW0} + T_{R0} + I_W \cdot T_{IN0} + I_{IM} \cdot T_{IM0} + \\ + u_D \cdot EM_D + u_2 \cdot EM_2 + EM_{3DU}, \quad (8)$$

where I_{DW}, I_{ChD}, I_W are indices of added value, net income and production throughout the country, T_{FO} is the income tax, and T_{IM} is excise and import duties.

Whereas inflation has been almost always an occurrence in Ukraine, devaluation happened only sometimes (moreover, a revaluation took place in 2001–2006). Therefore, it is expedient to divide the total emission into parts:

1) the first one causes the devaluation I:

$$EM_D = (I - 1) \cdot IM_0 / ob; \quad (9)$$

the devaluation in turn causes inflation:

$$I_{szD} = 1 + EM_D \cdot ob / (W_0 + IM_0 - Ex_0); \quad (10)$$

2) the second part is related to non-devaluation inflation:

$$EM_2 = (I_{sz} - 1) \cdot (W_0 + IM_0 - Ex_0) / ob - EM_D; \quad (11)$$

3) the third part (as part q_3 of $M2$) which the government directs to the social sector or to production as "short" investments that allow a rapid growth according to the last factor in (5):

$$EM_3 = q_3 \cdot M_2. \quad (12)$$

Trivial equations like $D_j = K_j \cdot d_j$ or $VVP = (V + D + AM + T)$ are not given.

All parameters of the model are made variable. This gives the possibility to investigate not only dependences, but also characters and to define the range of their invariance.

4. Modeling the effects of devaluation

The model allows to study the devaluation dynamics of nominal and real indices for different goods and across the country: the cost, the gross and net profit, the rate and amount of wages, value added, production output, GDP, the share of wages in the cost,

unemployment, pensions, the tax and non-tax revenues of the budget, salaries of budget employees, foreign exchange earnings from intermediate and consumer exports, the physical volume of exports, physical volumes and currency expenses on intermediate and consumer imports, trade balance, the structure of export and import, the share of import in intermediate and final consumption, producer and consumer prices, manufacturing GDP per unit of intermediate consumption, which characterizes the ultimate operational efficiency of economy from the national point of view, the production efficiency of some goods in terms of other economic performers (of the production owner – the ratio of gross or net income to capital cost, of the employee – salary costs to working time, etc.), changes in the structure of the contribution of the production of different types of goods to the GDP, etc.

When modeling you can change the price, salary and price elasticity of demand and supply for each product, the level of de- or revaluation, in- and deflation and their correlation, the level and cost structure of each product (the share of wages, intermediate import, credit for working capital, etc.), the rate of loan, the share of conditionally fixed costs, the tax and deduction rate; exchange rate in the base period, the ratio among the cost of production, distribution and retail sales, population structure; the degree of influence of rate loan, excess emission, the shortage of working capital on the production; the distribution of excess emission among the social sphere, "short" investments in the production of various goods (final or intermediate consumption or exports) and banks, the degree of import substitution of domestic products.

Let us consider the Ukrainian economy at the devaluation of 20%. To cause such a devaluation, according to equation (9) the emission has to be $EM_D = (1.2 - 1) \cdot 269200 / 5.374 = 10019$ mln UAH. According to (10), it causes the inflation of $1+10019 \cdot 5.374/(1378554+269200-253707) = 3.86\%$. The inflation 5–10% higher than the devaluation is traditional for Ukraine. Thus, let all manufacturers increase their prices by 30%. To support no devaluation inflation at $30 - 3.86 = 26.14\%$, according to (11), additional emission has to be $EM_2 = (1.3 - 1)\cdot(1378554+269200 - 253707) / 5.374 - 10019 = 67805$ mln UAH.

Let the wage rate increase by 3%, i.e. by 90% lower than the price growth.

According to the theory, let us establish the equilibrium levels of export prices in foreign currency. Thus, in the local currency they are by 13–14% lower than in the base period. On the contrary, because of higher prices of intermediate goods (by 30%), the costs of export and of all other goods according to formula (3) are increasing. This growth is not considered in the known models. It is the reason for a strong reduction of producers' incomes, especially those of exporters.

According to the increasing prices of consumer goods, the number of their sales according to formula (5) decreases. Thus, the number of purchases of domestic producers

and importers of goods, whose amount of wages, as shown below, is reduced, is decreasing more. But the number of purchases of export manufacturers whose wages are rising is less, because the denominator in the first parentheses first decreases and then grows. The purchases of this product by entire economy are reduced by 17%.

Because the cost and price have increased almost equally but the value prices have raised more, the nominal gross profit per unit of this product increases by 36%, and the gross profit sum via the reduced production of this commodity increases by 12%.

Similarly, the total salary is reduced by 15%, which reduces the total value added by 5% despite the growth in gross profits. The GDP created in this product manufacturing (i.e. the added value plus taxes) reduces by 3% and the GDP per unit material costs by 14%.

The change of this product through multiple direct and inverse relationships which are reflected in the model additionally influences the behavior of all other goods in two ways: 1) they alter the overall results across the economy, which cause changes in the production of other goods in the nominal dimension, firstly the volume of sales, 2) the price change of this product, according to formula (7), further increases the CPI, which reduces the real figures and, according to Irving Fischer (Fisher, 1906), increases the loan rate, which in turn increases the cost in accordance with (4). These two factors reduce the working capital and thus, according to (5), reduce the production of commodities.

Therefore, simulation has revealed an unexpected phenomenon: the financial status of almost all types of employees and owners deteriorates (especially exporters suffer more than others), because the very low price in local currency does not cover the increasing costs[2]. Only importers have profited, but 11–23% of the market share has been lost. However, this is possible only when the price grows by 4–10pp more than devaluation.

The economy results are worsening. The narrowing of the domestic market is higher than the rise of export, so the real output is reduced by 12%, the GDP by 20%, the GDP per unit of intermediate consumption by 8%, the total gross profit by 24%, the amount of salary by 28%, the share of wages in the cost by up to 15%. Reducing the amount of salary deductions causes an automatic reduction in the pension and insurance funds, so pensions will reduce by 14% henceforth. The tax revenue has decreased by 19%, so wages in the budget sphere have decreased at least by the same rate, the revenues of government sector by 2%, although an emission took place. The fall of foreign exchange earnings from the intermediate export is greater than its growth from consumer goods, so in general it has decreased by 14%, despite the fact that the physical volume of total exports has increased by 3%. The currency to import reduced by 15% at the reduction of

[2] Reasons for the actual incomes of Ukrainian exporters are various government subsidies, so many anti-dumping processes in Ukraine constantly lose.

volume by 16%, the foreign trade balance becomes better, but mostly because of reducing the import.

Devaluation and inflation theorists consider the factors of economic development. However, the model shows that at the devaluation of 20% and inflation of 1% the GDP has reduced by 14%. The reason is a sharp increase in the imbalance between the volumes of produced GDP and the output and import of consumer goods which earlier, in the absence of this model, was not known. At a low inflation, the domestic prices of import are very low and the prices of exports are 0.4–3% above the base; thus, the revenues from import have converted to large losses and those from export and other goods to a small cost growth. At the devaluation of 1%, the GDP reduces by 1%.

At equilibrium prices (which rise by 3.86% in response to a 20% devaluation) the situation does not differ fundamentally from two cases shown above: the indexes' changes are among the two examined variants.

These examples confirm the adequacy of our model and the reasons for its difference from the known ones (price rise of intermediate consumption goods).

5. Results

Based on this model, we have received new knowledge, at least about Ukraine.

1. The interrelation among emission, devaluation and inflation is deduced. As follows from equations (9–11), if inflation is caused only by devaluation, it is as less than devaluation as import is less than production output minus net exports. Large devaluation of 50% causes only a 9.7% inflation, even at a very great openness of Ukraine to the entire world (e.g., for large import). Other inflation is caused by monopolistic sellers and inflation expectations of people. In Ukraine, the other (not devaluation) inflation is rather a devaluation inflation.
2. If the emission is directed to banks for currency speculation, the inflation is maximal. If the emission is directed to production, to the public sector or even to the social sphere, the economy deterioration is considerably lower.
3. Contrary to the existing theories, both devaluation and inflation always reduce the real GDP and deteriorate the financial position of almost all producers and consumers. At any elasticity, these factors will never become positive. This conclusion differs from traditional ones because in our model the rise in the price of intermediate consumption goods is more precisely reflected. Thus, the important factors of the Ukrainian economy downturn in 2009 were two significant emissions directed to banks, which resulted in both devaluation and (through considerable inflation expectations) inflation.
4. Devaluation causes unemployment or/and decreases wages by reducing the production.

5. Devaluation destroys the SNA balances that have existed in the base period: the GDP becomes lower (or higher) than the production and import of consumer and investment goods. Thus, over- or insufficient production takes place. Therefore, businesses' income and the GDP are actually (also in the model) lower than in the theory according to which all produced goods are consumed. Traditional models do not allow obtaining this conclusion because: a) instead of production output they use the GDP as a primary effect; b) they do not differentiate goods into consumer, intermediate and investment ones.
6. This imbalance of the GDP arises due to the reduced efficiency of the economy: if, as a result of devaluation, there is less added value in each unit of goods, then one will produce a lower GDP. Now, households can buy only part of the produced goods for the new GDP. This implies that the balance between the GDP and goods (i.e. the foundation of all economic theories) exists only in one special subset of the values of economic efficiency[3]. A much more powerful set of unbalanced positions of economy is beyond the eyesight of these theories.
7. One must consider measuring the unrealized products (over specifications) and imbalances in the SNA. Their dramatic increase could be an indicator of future crises.
8. One producer can improve his position by raising the price above those of other producers, but when all others do the same, their status and the position of the country will be even worse. However, even this single improvement leads only to reducing the losses, so the devaluation and inflation worsen the position of most producers and consumers only (besides importers) at high prices.
9. The Keynesian postulate about the necessity of inflation for the economic development of Ukraine in a short period hasn't been confirmed.
10. Important for exporters: the indices of foreign trade are changing under devaluation as in the standard theory only when prices are at an equilibrium level. In other cases, our simulating model (which reflects all the complex relationships accurately and indicates the real consequences of exchange rate changes in different conditions and at different behavior of producers, consumers, banks, etc.) has changed the paradigm of the export analysis. As such, the exchange rate doesn't fully define even exports' foreign exchange earnings as it is only a secondary factor for expenses of foreign currency on import and the trade balance. The main factors that determine the position of economy, exporters and importers are changes of domestic and export/import prices and elasticity. Raising domestic and import prices always reduces exporters' income.

[3] Not a single value, so that a balance can be achieved by different proportions of intermediate goods production efficiency, final consumption, and net exports.

In more detail:

a) currency proceeds to basically depend on foreign prices and export elasticity (the case of devaluation is considered below): if the current price is lower than the base one, sales are increasing, the revenue from inelastic goods is decreasing and from elastic ones is growing, but it is unprofitable for exporters through increasing the physical volume despite price dropping (the theory conceals this fact);
b) If the price increases, the picture is not quite the opposite, because the price cannot be really increased by more than 10–15%. Then sales will be reduced by 1–18%, and so foreign exchange earnings from inelastic goods will raise by 8–9% and from the elastic ones will reduce by 3–10%. In situations a) and b), the rates of changes are the greater, the higher the elasticity. The revenue dynamics is equivalent for elastic goods and opposite for inelastic ones;
c) price growth of all domestic goods (both through devaluation and other) reduces foreign exchange earnings and sales slightly, but greatly reduces the real export value added. For each elasticity of export, there is a limit of domestic prices increase (under this limit the added value increases after devaluation (at the optimum export price) and over it decreases);
d) now, let's consider the second factor, i.e. devaluation. When we have a great devaluation at the same prices for export, domestic commodities almost do not change the foreign exchange earnings and sales, but decrease the added value;
e) the added value reduces at devaluation for any elasticity and price if domestic prices are higher than the devaluation at least by 10 pp. It is hard to develop the formula of the necessary and sufficient conditions of the added value growth, but the model calculates them.

   For example, at a 50% devaluation, for consumer export the conditions are: 1) for its elasticity –1.1, it is the backlog of the domestic prices index from the devaluation by 10 pp and decreasing of the export price from the base level no more than 6.5%, or the domestic prices lagging by 5 pp and export prices growing over the base level; 2) for export elasticity –2, it is the lag of the domestic prices index from the devaluation by 10 pp and reducing the export price from the base level by no more than 14.2%, or the lag in domestic prices by 5 pp and the export growth rates above the base by no less than 1%, or the internal prices' gap by more than 4 pp and increase of export prices more than 10%.

   For intermediate export: 1) with the elasticity –0.1, it is the backlog of the domestic prices index from the devaluation by 10 pp and reducing the export price from the base level by no more than 1.06%, or domestic prices lag by 5 pp and export prices growth over the base level by more than 3.5%, or the gap in domestic prices by at least 2 pp and export prices increasing over the base level by more than

6.3%. It is possible that even domestic prices grow faster than devaluation by no more than 2%, but the export price increase must be more than 10%; 2) for the elasticity of –0.9, it is the lag of the domestic prices index from the devaluation by 10 pp and reducing the export price from the base level by no more than 1.5%, or the lagg of domestic prices by 5pp and export growth rates above the base level by no less than 5%, or the lag of domestic prices by more than 2 pp and export prices increase over the base level by more than 9.4%;

f) devaluation decreases export losses if its foreign price is above the equilibrium level (defined by the standard theory) and if all domestic prices are lower; for import, the situation is opposite – the currency price is lower and the domestic one is higher.
Thus, devaluation is usually harmful to exporters and all others, contrary to the theory which traditionally considers devaluation as a tool to improve export and the GDP. At equilibrium prices, the harm is less, but not zero.
Devaluation may worsen the position of domestic exporters less than of foreign manufacturers. Therefore, it can serve as a means to gain the foreign markets, provided that a) exporters will have enough money, and b) foreigners again will not increase production in the future;

g) if inflation is caused only by devaluation and the export prices are at an equilibrium level, growth of internal prices reduces both the GDP and the foreign trading balance (Lindert, 1992) at which the necessary conditions (sufficient conditions haven't been ensured for) the GNP improvement and balance are close. But if there is no devaluation and inflation also exists, its influence on the GDP and on the balance becomes directed to opposite sides[4]. Of course, there are measures that improve both the GDP and the balance, but it is not devaluation. It may be, for example, the development of export or the replacement of import.

6. Conclusions

Thus, there is no illustration in the existing theories (hence the terms of the (Lindert, 1992) type) that the GDP grows at devaluation. For Ukraine, we should finally conclude that devaluation reduces the real GDP always at any level of inflation. Only a non-market moratorium on prices or deflation improve the economy. Export prices are to be not equilibrium ones but as high as possible. This conclusion does not contradict the theory: the study is suitable only for Ukraine.

The nature of the impact of devaluation on the economy in a wide range of the possible values of elasticity, prices, volumes and other parameters is almost constant.

[4] Let's remind that it is a question of short-term actions against devaluation. Long-term dynamics requires another model.

The classic dichotomy hypothesis (in our model – only when emission is directed to banks), the Keynesian thesis of the money influence on production (in our model – only when emission is directed to the production as "short" investments that provide for a rapid growth (no long-term process of economic development is modeled)), the balance between the production and consumption of goods (in a small subset of options when it is provided by a certain efficiency of goods production) and the equilibrium between supply and demand are partial cases of the reality which is much more complicated than these hypotheses. However, the simulation model, which is not limited by excessive restrictions, reflects all sets of variants of the real economy.

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