National University of Kyiv-Mohyla Academy, Department of Finance,
Laboratory of Financial and Economic Research
in cooperation with
System Dynamics Group, University of Bergen
and Ivan Franko National University of Lviv

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MODELING THE VOLUME OF BANK LOANS TO BUSINESS ENTITIES USING SYSTEM DYNAMICS METHODS

One of the important components of ensuring the sustainable economic development of Ukraine is the improvement and further development of bank lending to business entities. Lending to business entities significantly reflects the development of the banking system as a whole, since the share of loans granted to business entities is more than 80% of the total volume of loans granted by banking institutions. That is why the disclosure of the key features of this type of active banking operations is relevant not only in terms of the efficiency of the banking sector, but also in terms of the economic development of the country as a whole. Banks, which occupy a substantial part of the financial, investment and industrial sectors of the economy, form the basis of the banking system. By redistributing temporarily free funds between economic entities, banks redirect them to those economic agents who need to raise additional capital.

For a long time, banking institutions are not able to be a "source of economic viability", acting as an accelerator of economic development of Ukraine. The supply of credit by banks remains significantly restricted due to the lack of own funds of commercial banks, the practical impossibility of raising funds for the long term, instability of passive transactions, etc. Such an unfavorable tendency for the development of bank lending is a consequence of socio-political and economic instability, deficits of the state budget, growth of public debt, low creditworthiness of economic entities, a large share of non-performing loans, etc.

Today, the lending process is still rather limited, first of all, due to the rather high cost of credit resources and high risk of borrowers, although gradual positive trends in lending volumes and creditworthiness of borrowers can be traced. In addition, banks are optimistic about lending prospects, in particular, expect lending to grow and hope to improve credit quality.

It is important to conduct a comprehensive study of the volume of bank loans to business entities, both in terms of analyzing demand for credit resources and in terms of their supply to commercial banks. From the supply side, the main factors that affect the volume of loans granted by banks are:

- the assets of banks: the large banks are usually more diversified, they have large funds and more accessibility to borrowers and they are able to give a greater level of credit facilities;
- the amount of deposits, which is the main sources of funds for banks. The high amount of deposits have a positive impact on the rate of growth in the credit provided to business: bank is able to offer more money that can be lent;
- the rise in the proportion of the non-performing debt to the total loans leads to a decline in the strength of the banking sector and the volume of the loans granted;
- interest rate on loans: the interest rate on loans is considered the most important source of income for the bank. The effect of the interest rate might be

positively or negatively effective on the volume of bank lending because the increase in the interest rate may encourage banks to provide more loans, but at the same time could lead to reduced demand for loan borrowers because of their high interest rates;

- the high inflation leads to an increase in the interest rates on loans because of increase of discount rate of central bank, which cause the decline in the demand for loans.

In order to define the demand side of bank landing, the simplified model with using system dynamics methods was built (Figure 1).

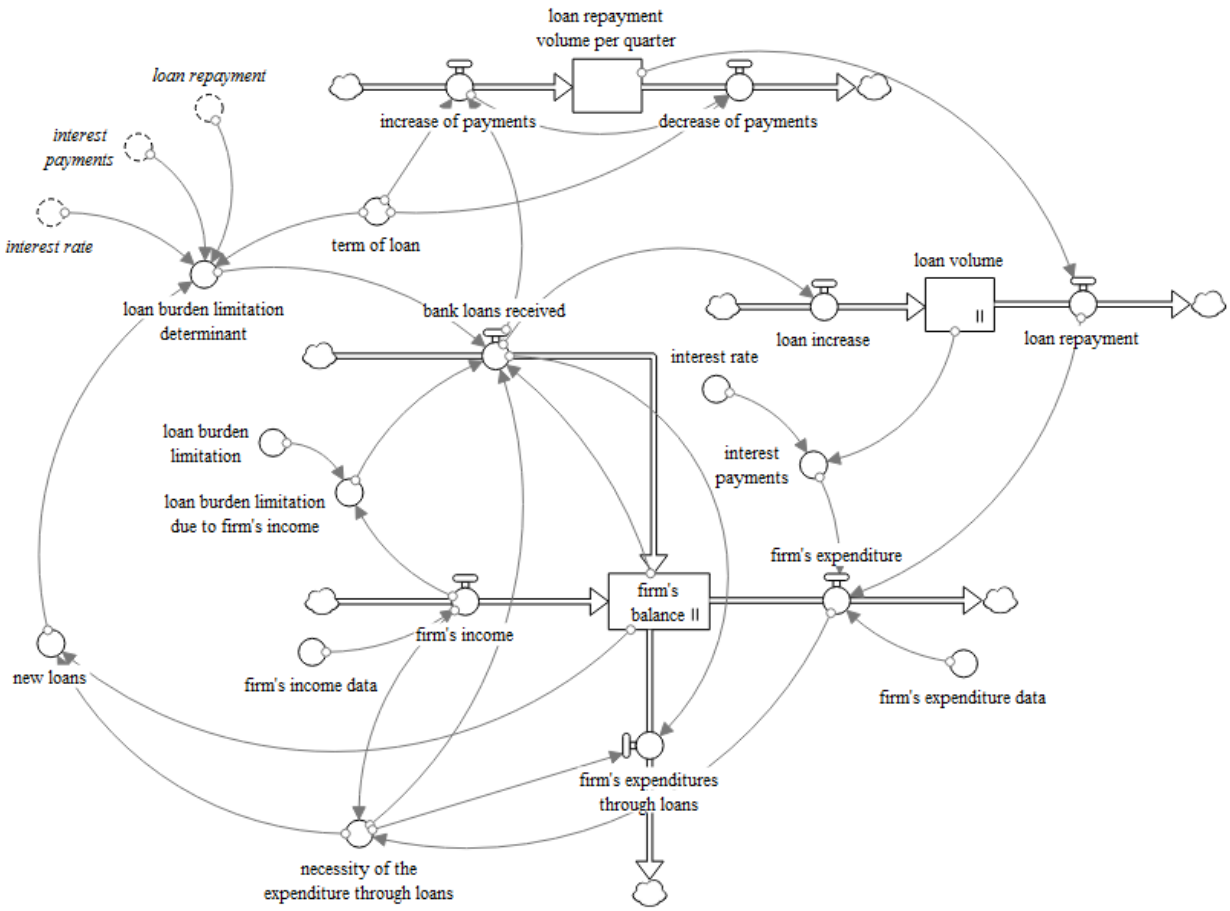

Figure 1. Model of bank lending in terms of business entities' balance sheet using system dynamics methods

Assuming the demand side, the main factors affecting the demand of companies for bank loans are:

- the less interest rate on loans provides greater demand on them, so the amount of loans the business would like to get increases;

- additional financing will effect on increasing of expenditures of companies. For example, they will invest borrowed money in buying new equipment;

- expenditures of companies increase because they have to pay interest payments on using borrowed money;

- the additional financing of business will have positively effect on company's output, so also on the whole output – and will increase the GDP.

Using system dynamics methods allows analyzing the behavior of the system over time, depending on the structure of system elements and their interaction, including causal relationships, feedbacks and possible delay of the impact of one indicator on other. In the model above such main factors were taken into account: the amount of bank loans received by economic entities in accordance with the income and expenses of enterprises, their expected costs from credit funds, as well as interest payments on loans and repayment of loans received.

This model includes three major outflows: the balance of enterprises, the volume of loans received and the volume of loans repaid. The balance of an enterprise as a stock variable increases due to inflows: firm's income and bank loans received. And, accordingly, it is reduced by outflows: firm's expenditures by their own and through loans. Firm's income and expenses are determined on the basis of exogenous variables (quarterly income and expenses). Whereas, credit costs arise when there is a need to raise credit, namely when income is less than expenditures. If the need to obtain loans arises, the company will take new loans to distinguish between the need for credit and the balance of the enterprise. This value will represent the demand for credit from economic entities. The volume of bank loans received is calculated according to the demand for loans, taking into account the fact that the credit received does not exceed the maximum credit load.

According to the amount of the loan received and the term of the loan, the amount of quarterly loan contributions (loan repayments) is calculated. In addition, the amount of borrowings determines the total amount of loans (stock variable), on the basis of which the interest expenses of the enterprises are calculated, which are accordingly included in the total expenses.

References

1. Crigger J. Demand and Supply Side Determinants of Commercial and Industrial LoanVolume: a doctoral dissertation [Electronicresourse] / J. Crigger. – Middle Tennessee State University. – 2001. – P.1-132 // Mode of access: https://jewlscholar.mtsu.edu/handle/mtsu/3807.
2. Hassan F., Qayyum A. Modelling the Demand for Bank Loans by Private Business Sector in Pakistan [Electronic resourse] / F. Hassan, A. Qayyum. – MunichPersonalRePEcArchive. – 2014. – #55366. P. 1-19.
3. Manzhos S. The Situation of Bank Lending in Ukraine: Current Problems and Prospects of Recovery [Electronic resourse] / S. Manzhos – Economics and Menegement. – 2016. – #8 (3). – P. 89-97.
4. Wheat, D. I. (2007). The Feedback Method: A System Dynamics Approach to Teaching Macroeconomics. PhD thesis, University of Bergen.
5. Прімєрова О. К. Особливості монетарної політики в Україні на сучасному етапі // Ефективна економіка: електронне наук. фахове вид. - 2017. - №.
6. Лук'яненко, І., Віт, Д. (2017). Системний аналіз формування державної політики в умовах макроекономічної дестабілізації.

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SYSTEM DYNAMIC MODELING OF IMPACT OF PERMANENT DEMAND SHOCK ON INTEREST RATE AND INFLATION

Stabilization policy is a strategy enacted by a government or its central bank that is aimed at maintaining a healthy level of economic growth and minimal price changes. Sustaining a stabilization policy requires monitoring the business cycle and adjusting benchmark interest rates as needed to control abrupt changes in demand.

In the language of business news, a stabilization policy is designed to prevent the economy from excessive "over-heating" or "slowing down". We consider a natural base model where private behavior is backward- looking.

We suppose that the economy is described by two equations, one characterizing aggregate demand and the other characterizing aggregate supply. The equation of aggregate demand indicates that output depends negatively on the previous period's real interest rate. The equation aggregate- supply suggests that the change in inflation depends positively on the previous period's output. A change in the real interest rate does not affect the output until the next period and does not affect inflation until the period after that. This means that the policy is lagging and that it affects output faster than it affects inflation.

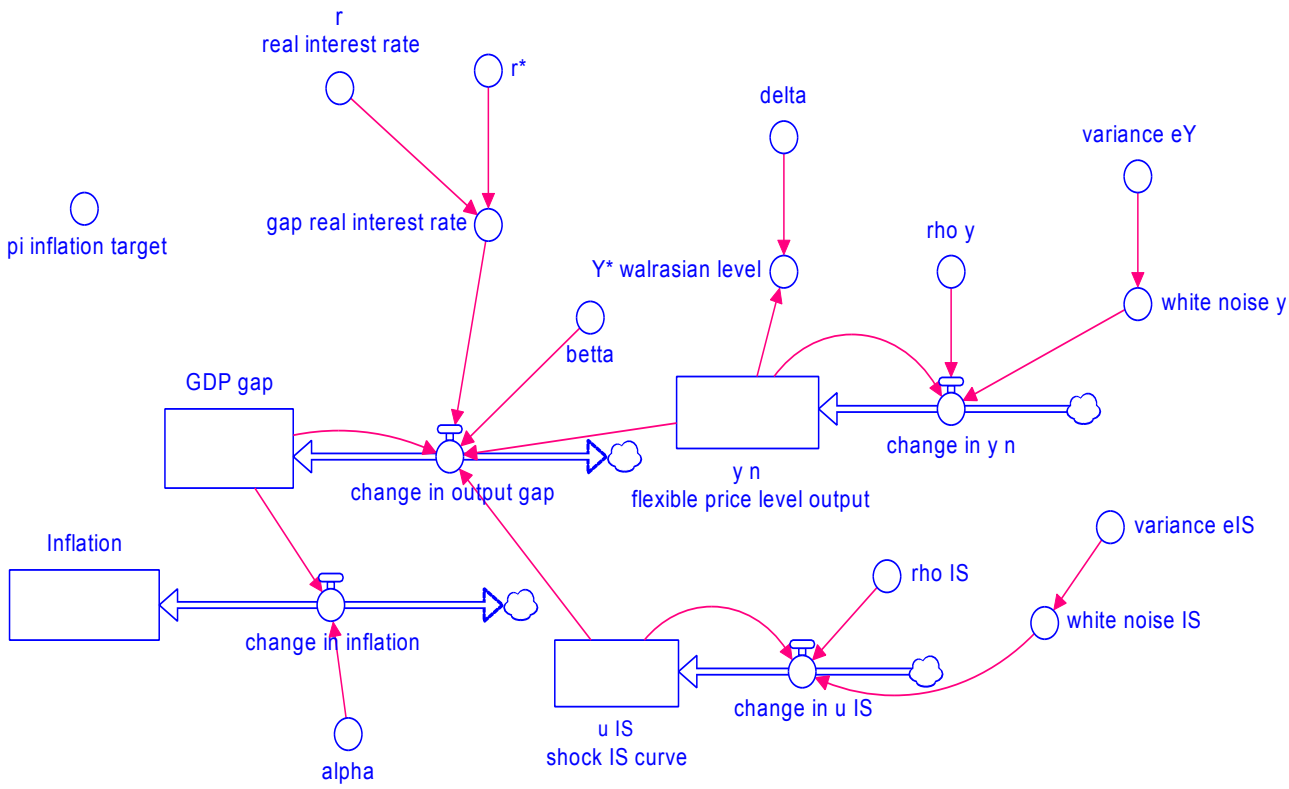

Figure 1. Simple Backward - Looking Model in System Dynamics

The model is described by such system of equation:

change in y^n = (rho y – 1) * y^n flexible price level output + white noise y (1)
change in u^{IS} = (rho IS –1) * u^{IS}shock IS curve + white noise IS (2)
change in output gap = – betta*gap real interest rate + u^{IS} shock IS curve – y^n (3)
flexible price level output – GDP gap (4)
change in inflation = GDP gap*alpha (5)
white noise y = NORMAL(0, SQRT(variance eY)) (6)
gap real interest rate = r real interest rate – r* (7)

Also equation $y_t = -\beta r_{t-1} + u_t^{IS}, \beta > 0$ represent traditional curve IS.

The equation $\pi_t = \pi_{t-1} + \alpha(y_{t-1} - y_{t-1}^n), \alpha > 0$ represent accelerations Phillips curve. The next two equations

$$u_t^{IS} = \rho_{IS} u_{t-1}^{IS} + \varepsilon_t^{IS}, -1 < \rho_{IS} < 1 \quad ,$$
$$y_t^n = \rho_Y y_{t-1}^n - \varepsilon_t^Y, 0 < \rho_Y < 1$$

describe the behavior shocks to the IS curve and to the flexible-price level of output.

We assume that ε_t^{IS} and ε_t^Y are independent white- noise process.

If in this model put permanent shock in ε_t^{IS}, we have such dynamics:

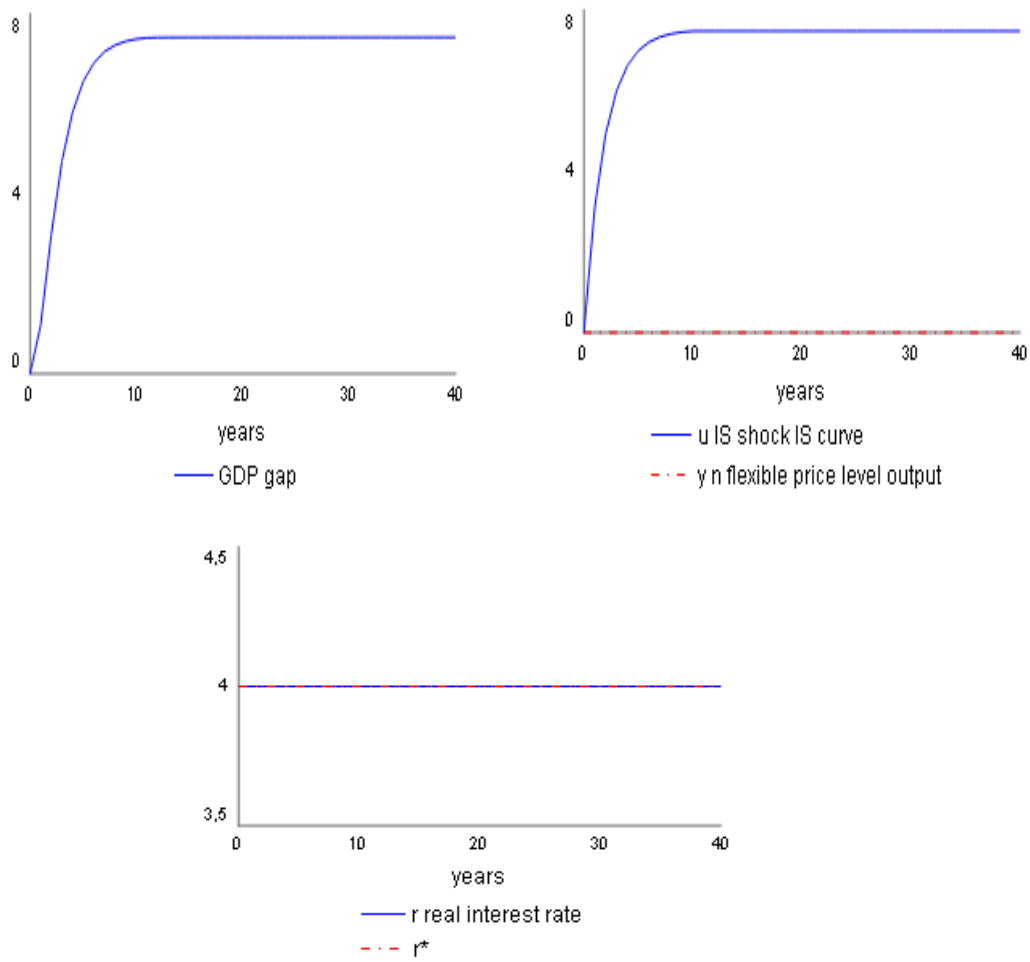

Figure 2. Permanent shock in ε_t^{IS}

Inflation is a quantitative measure of the rate at which the average price level of a basket of selected goods and services in an economy increases over a period of time. So that permanent shock in ε_t^{IS} causes GDP to deviate from its natural level, this leads to higher inflation. As a result, we are moving away from the desired level of inflation (target).

References

1. Romer, D. (2012). Advanced macroeconomics. University of California, Berkeley.
2. Sterman, J. D. (2000). Business Dynamics: Systems Thinking and Modeling for a Complex World. New York, Irwin. McGraw- Hill. 982 p.
3. Shone, R. (2003). An Introduction to Economic Dynamics, Cambridge, New-York, 224 p.
4. Лук'яненко, І., Віт, Д. (2017). Системний аналіз формування державної політики в умовах макроекономічної дестабілізації.
5. Прімєрова О. К. Особливості монетарної політики в Україні на сучасному етапі // Ефективна економіка: електронне наук. фахове вид. - 2017. - №. 10.
6. Iryna Lukianenko, Pervin Dadashova. Monetary and Fiscal policies interaction in Ukraine // Актуальні проблеми економіки. - 2016. - №5 (179).- pp. 295-307.

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MODELLING OF SIMPLIFIED INFLATION TARGETING SYSTEM

In 2015 year in Ukraine was implemented the inflation targeting policy of the National Bank of Ukraine (NBU). This policy is based on the two-side connection between the inflation level, measured as the Consumption Price Index (CPI), and the key policy rate. This connection works due to the monetary transmission mechanism, which acts through the finance, aggregate supply, and GDP gap channels from the rate to the inflation and through the expected inflation backwards. This model is simplified, so that only inflation, key policy rate and expected inflation are interconnected.

Expected inflation is the smoothed inflation, so that it comes with 1-month lag. Inflation gap is also put in this model as the connector between the inflation and the policy rate. It is considered as the difference between the expected inflation and the inflation target, set at 5 as it is in the Ukraine. Also, the model includes the neutral interest rate which is 1% when the inflation is at its target. The adjustment time of inflation changes is put 6 months because inflation slowly adjusts to the rate changes, whether the rate can change much faster, so its adjustment time is 1 month.

This model can show what would be if the NBU wanted to make its inflation target lower. This is modeled with the 1-basis point step of the target in the 6th month, so that the target is 4 after 6th month.

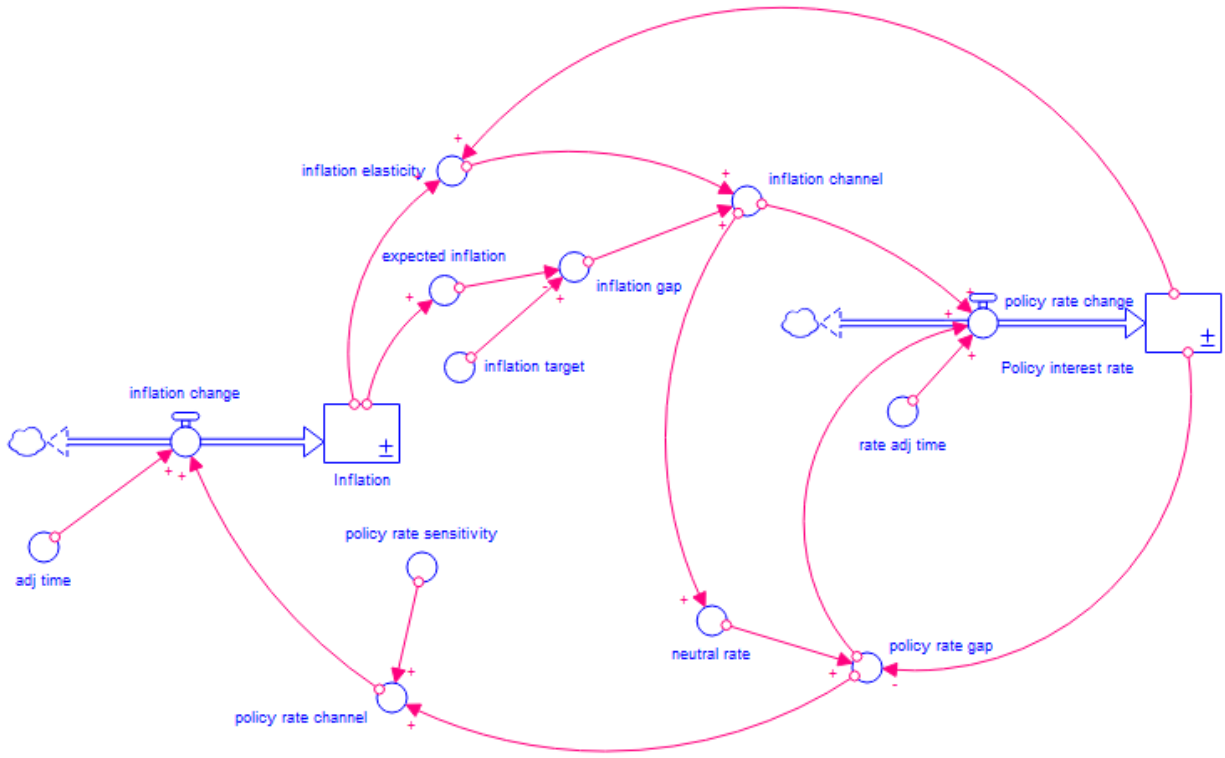

Figure 1. Simplified Inflation Targeting Model

At the beginning, all parameters are at their target levels, so that the inflation is 5, and the key policy rate is 1.

After the target decrease in the 6th month, both expected and real inflation are increasing a bit, because the reaction on the rate changes is lagged. After small increase, inflation begins to fall to its new target. Expected inflation falls more slowly, but to the end of the 3-year modeling period, it is almost near its target of 4.

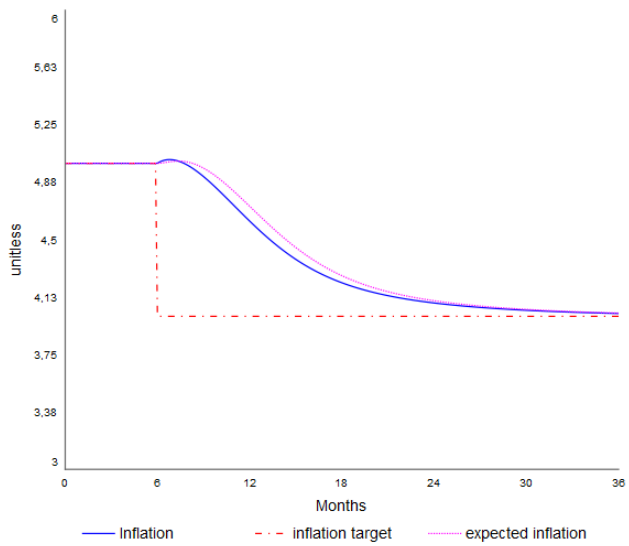

Figure 2. Inflation Behavior

Key policy rate rises very fast almost twice, and after 4 months begins to decrease. It means that inflation is falling to the target fast enough, and there is no more need to keep such high rate. Also, it is seen that because of the need to keep the inflation lower the rate doesn't return to its neutral rate of 1 very fast but remains a bit higher for a long time.

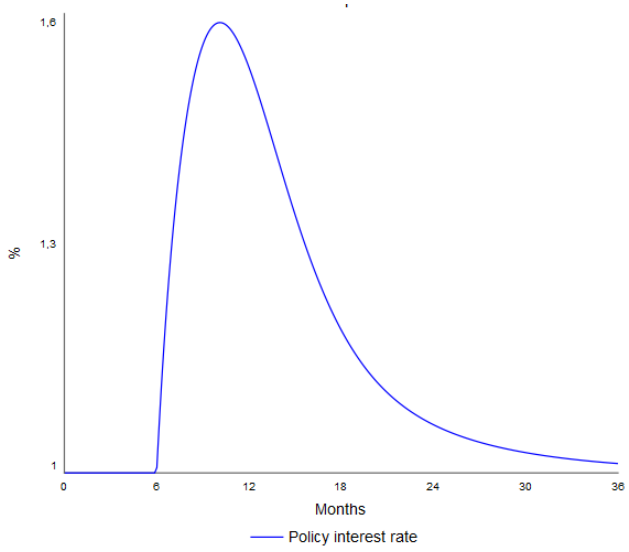

Figure 3. Key Policy Rate Behavior

This model is useful for illustrating in the simplified way how the National Bank should behave in case of increase of the difference between the inflation and its target. It is obvious that inflation targeting doesn't support changing the target, it should remain the same. Otherwise, the inflation expectations would rise, and higher policy rate should be implemented, which negatively influences the economy. But the model also shows that if the inflation gap increases due to some shocks, the key policy rate should be strongly increased and then slowly fall to its neutral level.

References

7. Official site of the National Bank of Ukraine [Electronic Source] – Access mode: https://bank.gov.ua/
8. Monetary Transmission Mechanism [Electronic Source] – Access mode: https://old.bank.gov.ua/control/uk/publish/article?art_id=123451&cat_id=123217
9. Inflation Targeting of the National Bank of Ukraine [Electronic Source] – Access mode: https://old.bank.gov.ua/control/uk/publish/article?art_id=123682&cat_id=123322
10. Wheat, D. I. (2007). The Feedback Method: A System Dynamics Approach toTeaching Macroeconomics. PhD thesis, University of Berg.
11. Лук'яненко, І., Віт, Д. (2017). Системний аналіз формування державної політики в умовах макроекономічної дестабілізації.
12. Прімєрова О. К. Особливості монетарної політики в Україні на сучасному етапі // Ефективна економіка: електронне наук. фахове вид. - 2017. - №. 10.
13. Iryna Lukianenko, Pervin Dadashova. Monetary and Fiscal policies interaction in Ukraine // Актуальні проблеми економіки.-2016.- №5 (179).- pp. 295-307.

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SYSTEM DYNAMICS MODELING OF INVESTMENT AND LABOR PRODUCTIVITY FOR UKRAINE

Productivity, in economics, measures output per unit of input, such as labor, capital or any other resource – and is typically calculated for the economy as a whole, as a ratio of gross domestic product (GDP) to hours worked. Productivity is the key source of economic growth and competitiveness. A country's ability to improve its standard of living depends almost entirely on its ability to raise its output per worker, i.e., producing more goods and services for a given number of hours of work. Economists use productivity growth to model the productive capacity of economies and determine their capacity utilization rates. This, in turn, is used to forecast business cycles and predict future levels of GDP growth. In addition, production capacity and utilization are used to assess demand and inflationary pressures. Capital is one of the basic factors of production along with land and labor. It includes all goods that are made or created by humans and used for producing goods or services.

An investment is an asset or item acquired with the goal of generating income or appreciation. In an economic sense, an investment is the purchase of goods that are not consumed today but are used in the future to create wealth. In finance, an investment is a monetary asset purchased with the idea that the asset will provide income in the future or will be sold later at a higher price for a profit.

Labor productivity measures the hourly output of a country's economy. Specifically, it charts the amount of real gross domestic product (GDP) produced by an hour of labor. It measures how efficiently labor input is combined with other factors of production and used in the production process. Labor input is defined as total hours worked of all persons engaged in production. Labor productivity only partially reflects the productivity of labor in terms of the personal capacities of workers or the intensity of their effort

The figure below shows the stock and flow diagram for the capital and productivity sector of Ukrainian economy. We consider our model in the range from 2006 to 2017 years. We used the following inputs:

- standard hours per worker which is an average hours per worker for considering range (measured in Hours/Year/Person) and equal 2000;
- initial active capital labor ratio is a measures the ratio of capital employed to labor employed. For Ukraine capital utilization was equal 75%, capital = 2.4 trillion, number of Employed = 19 million and active capital labor ratio = 94 thousands UAH per Person;
- initial labor productivity is the amount of GDP produced by one employee. For Ukraine it was equal 58.2 UAH/Year/Person;
- Also we use historical data as a input for number of Employed.

Exogenous variables for our model are:

Average life of capital = 10 years;

Expected delivery delay = 3 years;

Capital assessment delay = 1 year;
Technology shock = 0.004 per year;
Initial technology = 0.4.

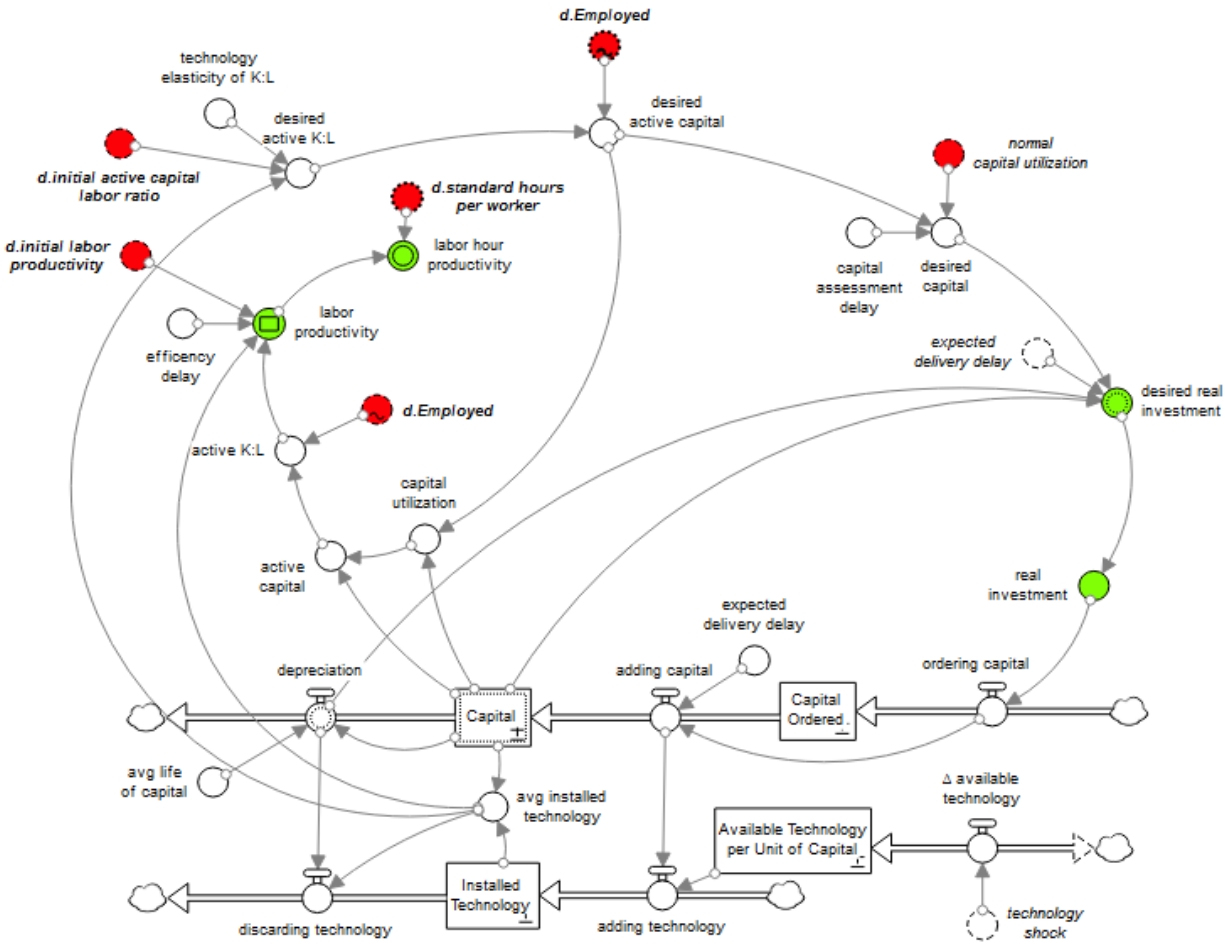

Figure 1. The system dynamics model

The outputs for this model are an Investment and Labor hour productivity. Also using historical data, we can compare with modeling results. For calculating historical labor hour productivity we used historical real GDP and number of Employed. Also using Theil statistics we can calculate the root of mean square error between historical and modeling data.

Figure 2 represents the comparison of historical and modeling data of the real Investment.

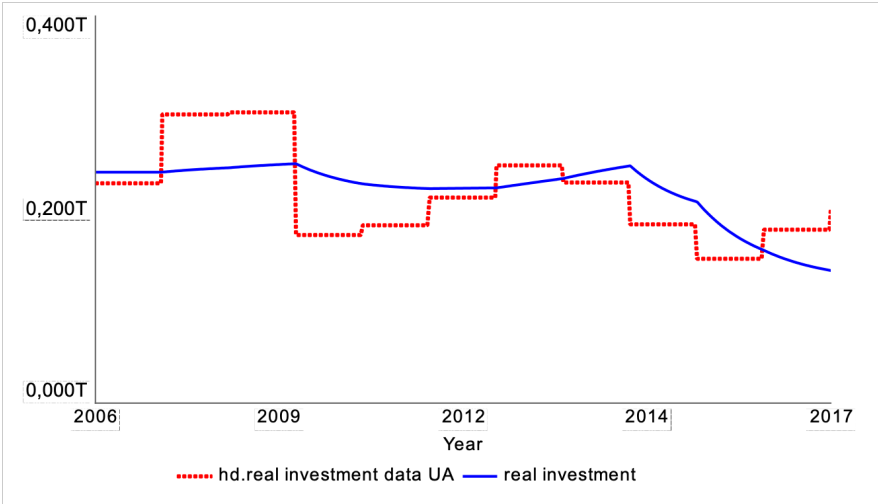

Figure 2. Actual and evaluated by model dynamic of real investment

The graph of error show us that the error is a 23%.

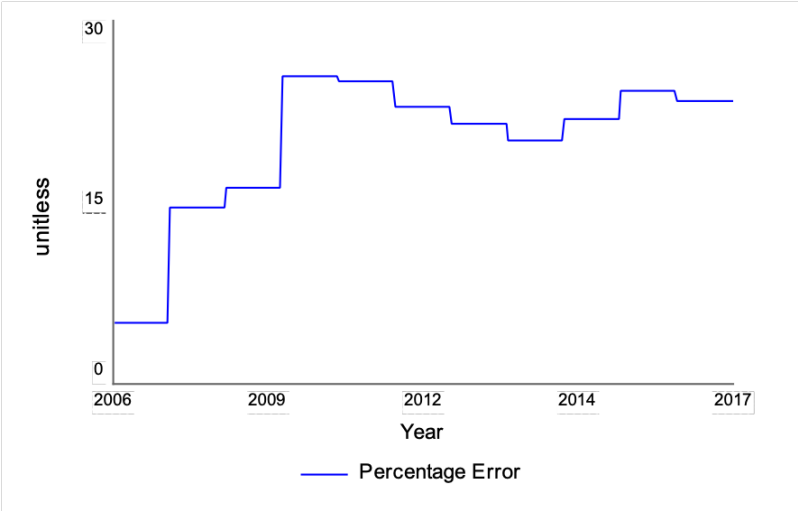

Figure 3. Percentage of error for real investment

Finally comparing data for labor hour productivity, we can say that fit of our model is pretty good.

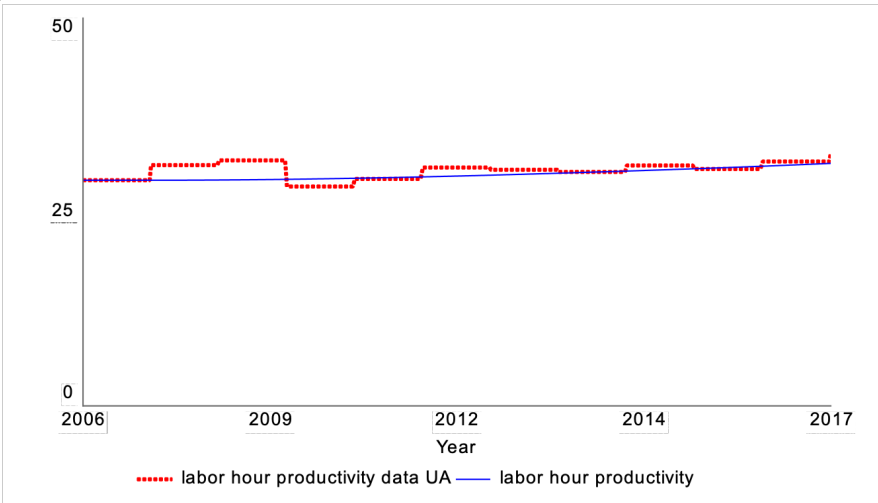

Figure 4. Dynamics of labor productivity

The graph of error shows that the maximum error is only 5%, and in average it's only 3%.

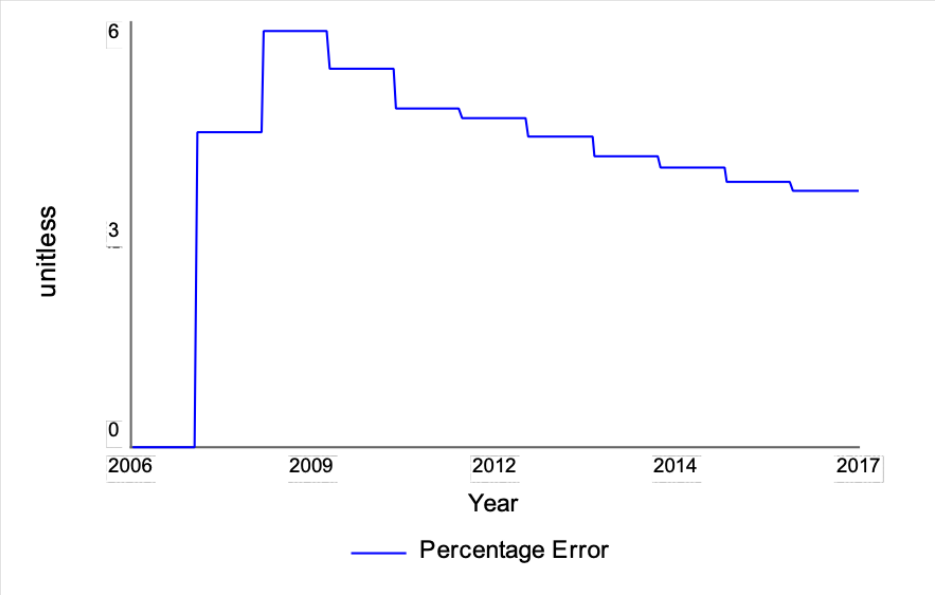

Figure 5. Percentage of error for labor productivity

Thus, the model being built is sufficiently adequate and can be used for further research and policy recommendations. One of the most important goals of the economic policy of any state is to ensure sustainable economic growth, which is understood as the growth of welfare, as well as an increase in the national wealth of the country. Then solving problems and developing mechanisms of measures to achieve this goal more and more attention is paid to the problems of investment and labor productivity and its increase.

References

1. Wheat, I. D. (2007). MacroLab Documentation.
2. Sterman, J. D. (1984). Appropriate summary statistics for evaluating the historical fit of system dynamics models. Dynamica.
3. Sterman, J. D. (2000). Business dynamics: System thinking and modeling for a complex world. Boston: McGraw-Hill.
4. Abakumova, J., Primierova, O. (2018). Globalization, growth and inequality: testing causality and asymmetries. Ekonomicko-manazerske spektrum, 12 (2).
5. Official site of the State Statistics Service of Ukraine [Electronic source] – Access mode: http://www.ukrstat.gov.ua/.
6. Lukianenko I.G. Evidence of asymmetries and nonlinearity of Unemployment and labour force participation rate in Ukraine // Prague Economic Papers. – 26(5). – 2017.– P. 578–601.
7. Abakumova, J., Primierova, O. (2018). Economic Growth, Globalisation and Income Inequality: The Case of Ukraine. Economics, 10, 11th.

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SYSTEM DYNAMIC MODEL OF NEW KEYNESIAN MODEL

The current stage of economic development is characterized by a dynamic, accelerated change in socio-economic phenomena. In this regard, special attention is paid to the ability of government bodies (state, regional, corporate) to take appropriate effective measures in a timely manner, the justification of which is implemented using simulation modeling as a tool for multivariate forecasting and analysis of systems of high complexity.

The most important problems in the national economy are: unemployment (employment), inflation (prices), economic growth. So the question is: what should be the volume of output to address these issues?

Macroeconomics examines the problems of economic growth and economic cycles, employment, inflation, analyzes the state of the state budget and the balance of payments of the country. Coordination of economic agents and the interconnections of different markets, real and monetary sectors of the economy are investigated within the framework of the theory of general economic equilibrium.

Consider a simulation model of the economic cycle, Keynesian dynamic model, which includes the goods market, which presents two economic agents - a household and a company:

$$Y_t = C_t + I_t + G_t \ , \quad (1)$$

$$C_t = gY_{t-1} + C_0 \ , \quad (2)$$

$$I_t = b(Y_{t-1}Y_{t-2}) + I_0 \ , \quad (3)$$

$$G_t = c_1Y_{t-1} + c_2Y_{t-2} + u_t \ , \quad (4)$$

where

$C_t -$ consumption;

$I_t -$ investment;

G_t government spending;

$Y_t -$ national income;

$g -$ marginal propensity to consume;

b – accelerator of monetary policy;

$c_1, c_2 -$ coefficients that describe the proportion of national income used for public consumption (social policy);

$C_0, I_0 -$ autonomous consumption and investment; $u_t -$ random variable.

Equation (1) is an axiomatic identity in macroeconomics. Equation (2) shows that the consumption of the current period is determined by the income of the previous period. Equation (3) is based on the assumption that entrepreneurs make investments after being convinced that national income growth is steady in the previous period.

If investment increases, then, according to the multiplier principle, aggregate demand and income increase. Increase in income causes fluctuations in derivative investments. Thus, the effect of the multiplier causes the action of the accelerator. The behavior of the economic system depends on b and g. The upper limit is the level of full employment. The lower limiter is the amount of depreciation.

Figure 1 shows the system dynamic model that takes into account the structure of relations (1) – (4):

1) Consumption = Consumption Fraction * Output,
2) Government Spending = 0.1 + 0.1*PULSE(4, TIME STEP);
3) Investment = Investment Multiplier*(Output – Previous Output),
4) New Output is modeling of current national income:
New Output = Investment + Consumption + Government Spending;
5) Output is national income of the previous period:
Output = INTEG ((New Output – Output)/TIME STEP, 1);
6) Previous Output is national income at time (t – 2):
Previous Output = INTEG ((Output – Previous Output)/TIME STEP, 1).

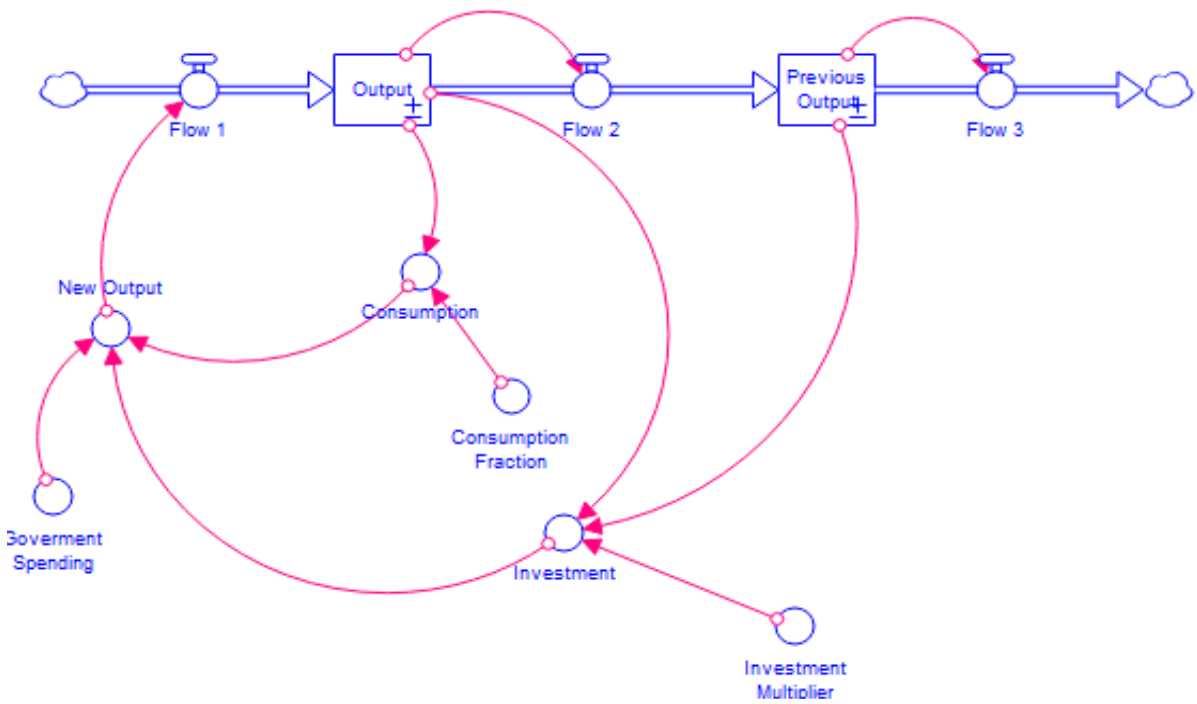

Figure 1. System dynamic model of the economic cycles

Achieving sustainable economic growth is a key element of the economic strategy, a common reference point for the country's economic policies of most states. Indeed, economic growth has always been considered an indicator of the effectiveness of the economic system and remains an important condition for its development. It is associated with the formation of economic and social conditions, in order to ensure changes in the level and quality of life, overcome poverty and reduce economic inequality in the country. This defines the necessity of deeper

research and development of the model being built, that can be used for further research and policy recommendations.

References

1. Barlas, Y. (2007). System Dynamics: Systemic Feedback Modeling for Policy Analysis in Knowledge for Sustainable Development, Oxford, pp. 1131– 1175.
2. Sterman, J. D. (2000). Business Dynamics: System Thinking and Modeling for a Complex World. New York, Irwin. McGraw- Hill. 982 p.
3. Abakumova, J., Primierova, O. (2018). Globalization, growth and inequality: testing causality and asymmetries. Ekonomicko-manazerske spektrum, 12(2).
4. Лук'яненко, І., Віт, Д. (2017). Системний аналіз формування державної політики в умовах макроекономічної дестабілізації.

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SYSTEM DYNAMIC MODEL OF ENDOGENOUS ECONOMIC GROWTH FOR NORTH AND SOUTH COUNTRIES

The large difference in the levels of economic development between the countries has made many views of the world as being divided between the rich North and the poor South. We built the model of endogenous economic growth for these two kinds of countries. The model is based on the relationships between output, Y, knowledge, A, capital, K, and labor, L.

We assume that the output and capital accumulation in region i ($i = N, S$) is given by

$$Y_i(t) = (K_i(t))^{\alpha} \, [A_i(t)(1 - a_{Li}) \, L_i \,]^{1-\alpha} \,, \qquad (1)$$

$$K_i(t) = s_i \, Y_i(t), \qquad (2)$$

where a_{L_N} – fraction of the labor force used in the resources and development sector that is located in North,

a_{L_S} – fraction of the labor force engaged in learning Northern technologies,

a_{L_i} – endogenous and constant,

1–a_{L_i} – fraction of the labor force used in the goods-production sector,

α – elasticity of capital in goods-production sector, so it is a variable that measures the reaction of output to a change in levels of capital,

1-α – elasticity of labor in goods-production sector,

s_i – saving rate.

Technologies or knowledge can be produced at first only in North, after that they become to be available to South. So new knowledge in North are given by third equation:

$$A'_N(t) = Ba_{LN}A_N(t) \quad (3)$$

Improvements in Southern technology, on the other hand, are made by learning from Northern technology:

$$A'_S(t) = \mu a_{LS}L_S[A_N(t) - A_S(t)] \quad (4)$$

Figure 1 represents the economic growth model for Northern economy.

The model includes Stocks for Labor with constant growth rate; Stock of Capital that increases when savings rate is increasing and when depreciation of capital is less than investment; Stock of Knowledge that increases with effect of contribution of labor in R&D and contribution of knowledge. Output increase when contribution of effective labor or contribution of capital increases.

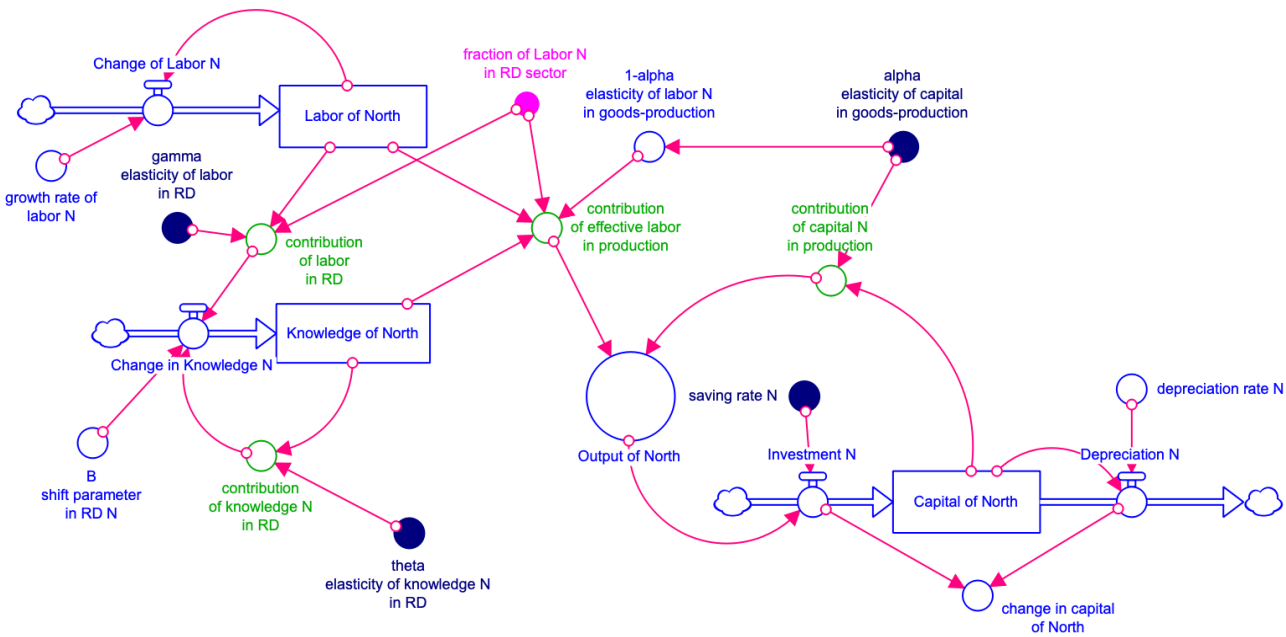

Figure 1. System dynamic model for Northern economy

The model of South economy is basically the same except knowledge accumulation. The full model includes both North and South. In this model there is a connection from Northern stock of knowledge to change in knowledge in South.

Now lets see some dynamics. The Dynamics of Capital for North and South with different initial values for Capital. We assumed that depreciation rate = 0. For the first image we used saving rates = 0.25. In the second image for North $s_N = 0.25$, for South $s_S = 0.5$. From these dynamics, we come to conclusion that stock of capital is rising more quickly when saving rate increases.

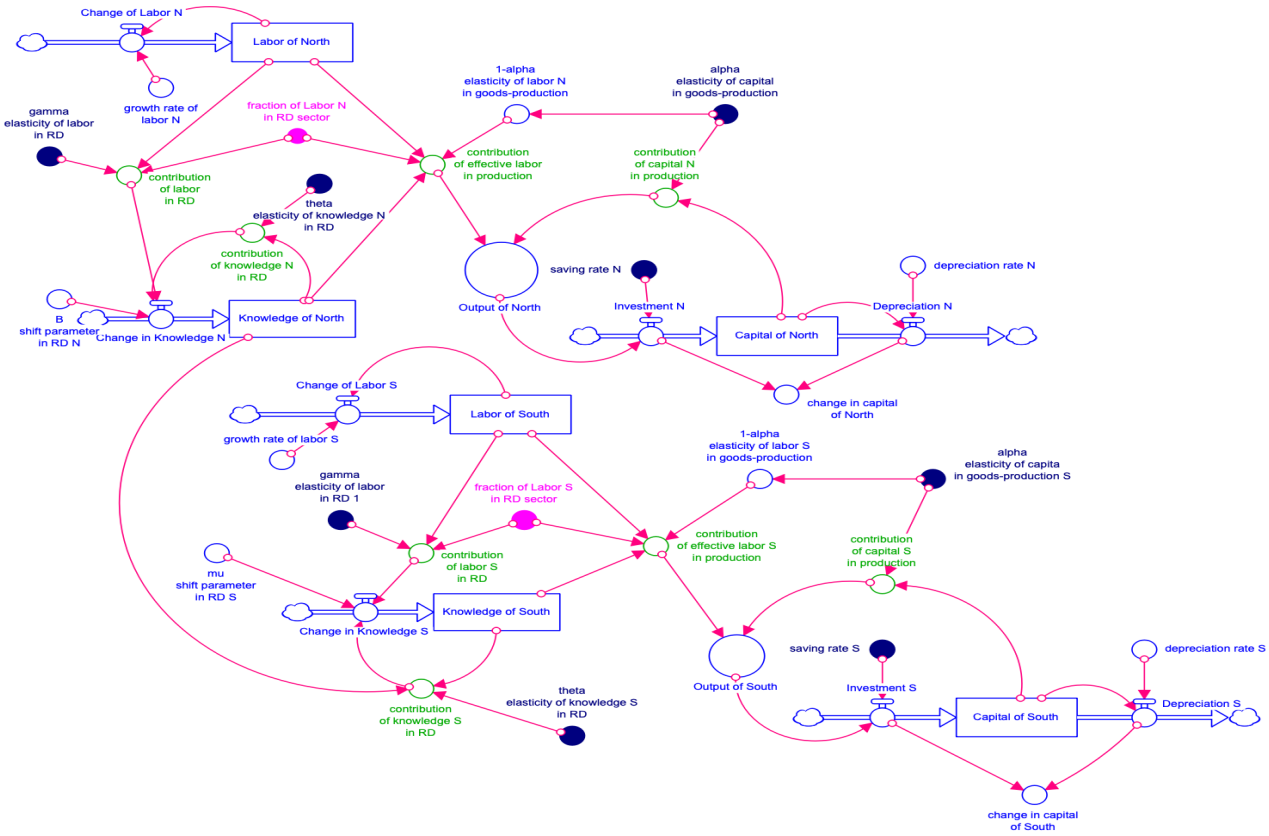

Figure 2. Northern and Southern economy model

The dynamics of Knowledge of North and South with different elasticity of knowledge and labor is presented in the Figure 3.

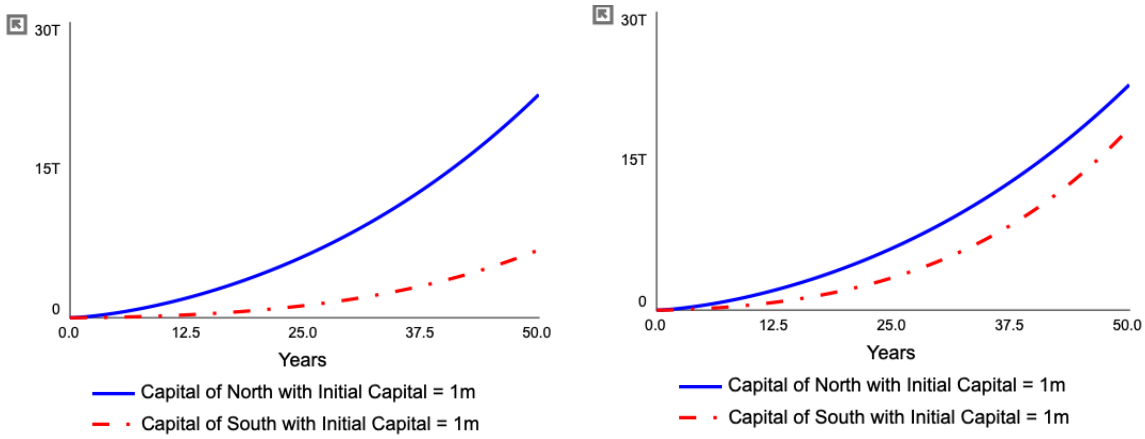

Figure 3. Dynamic of Capital for North and South

From these graphs we can say that speed of knowledge depends on the elasticity of knowledge (when theta increases the knowledge increases).

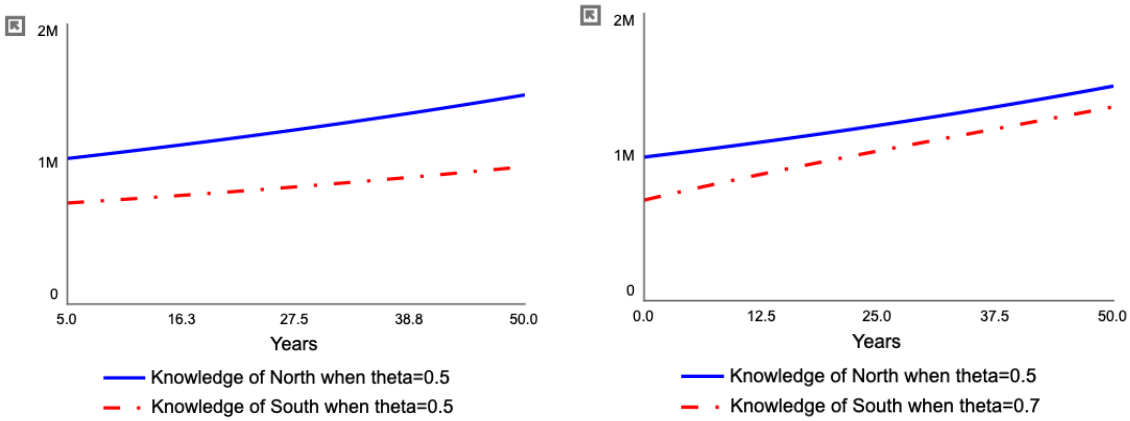

Figure 4. Dynamic of Knowledge for North and South

The dynamics of fraction Knowledge of South to North with different elasticity of knowledge for Southern region is presented in the graph 5. When the elasticity of knowledge for Southern is greater than 0.5, then the division between knowledge approach one. Otherwise the dynamic of the fraction decline.

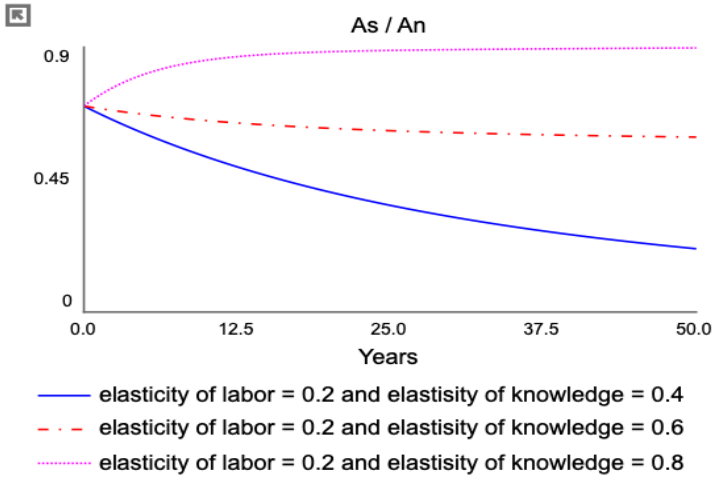

Figure 5. Fraction of Knowledge - South over North

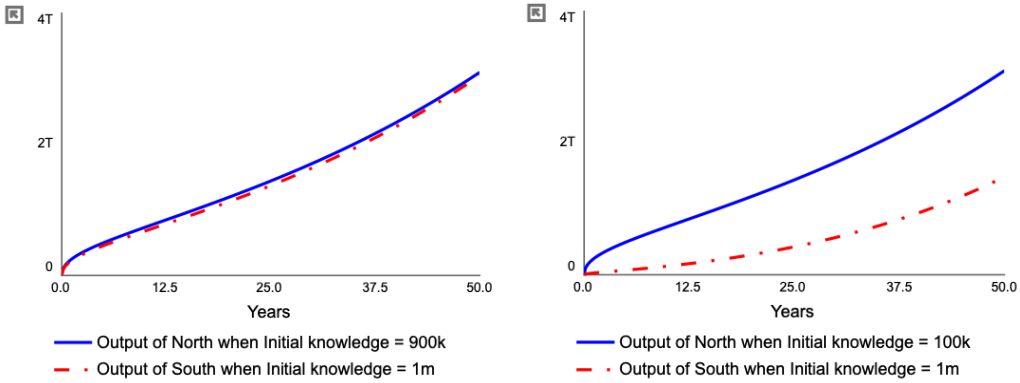

Figure 6. Dynamics of Output for North and South with different initial value of knowledge

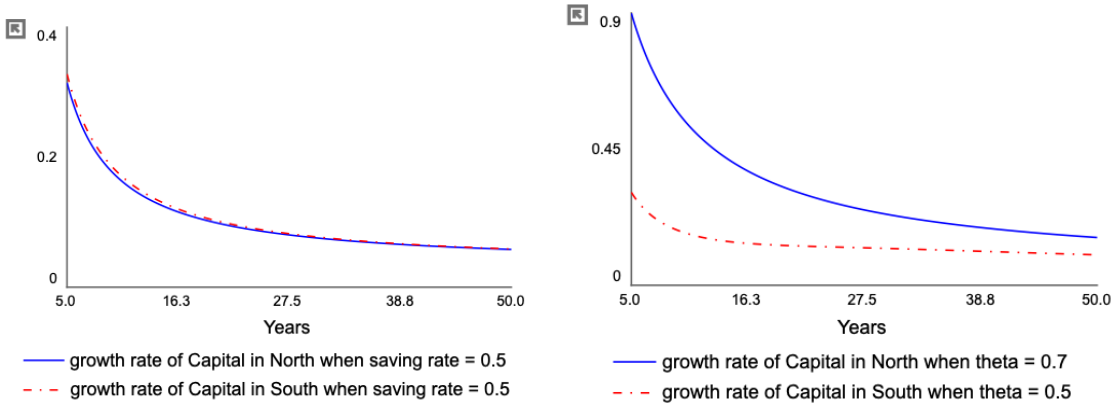

Figure 7. Dynamics of growth rate of capital in North and South

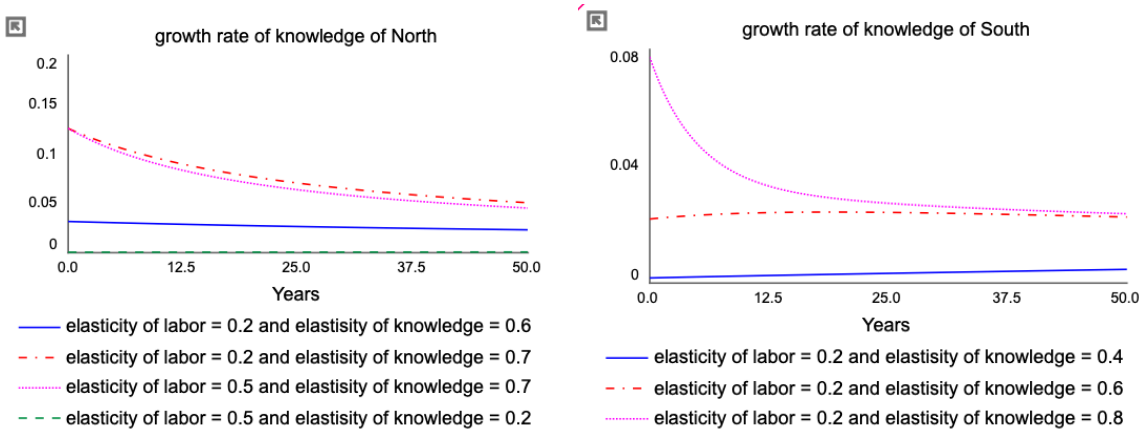

Figure 8. Dynamics of growth rate of knowledge in North and South

The results show that southern growth depends on northern growth and the growth rate of the South is restricted by the growth rate of the North. The model being built is sufficiently adequate and can be used for further research and policy recommendations.

References

1. Shone, R. (2003). An Introduction to Economic Dynamics, Cambridge, New-York, 224 p.
2. Sterman, J. D. (1984). Appropriate summary statistics for evaluating the historical fit of system dynamics models.
3. Romer, D. (2012). Advanced Macroeconomics, The McGraw Hill Companies, Inc.,738 p.
4. Лук'яненко, І., Віт, Д. (2017). Системний аналіз формування державної політики в умовах макроекономічної дестабілізації.
5. Abakumova, J., Primierova, O. (2018). Globalization, growth and inequality: testing causality and asymmetries. Ekonomicko-manazerske spektrum, 12(2), 83-95.
6. Лук’яненко І.Г. Оцінка ймовірності настання кризових явищ в фінансовому секторі України // Науковий журнал „Бізнес Інформ”, Харків, №5(2), 2011(399).- С.50-54.

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SYSTEM DYNAMIC REPRESENTATION FOR NONLINEAR SYSTEMS OF DIFFERENTIAL EQUATIONS

One of the most recent advances in mathematics has been the subject of chaos theory. Dynamic systems can differ dramatically with very small changes to the initial state. Even if the system is deterministic, it can still give the impression of randomness. Chaos does not require random nature. If we have something accidental, it cannot be predicted. On the other hand, the deterministic system is quite predictable. However, if the system depends on the initial conditions and moves quite differently for different initial conditions, even if they are very close, then the system becomes unpredictable. Chaotic systems only occur when we have nonlinearities. The goal was to build differential equations into a system dynamics model. Using the system dynamics model, to solve the differential equations and to investigate the chaotic behavior of the equations.

We considered the nonlinear system of two differential equations that describes the behavior of money supply and inflation. This system includes two variables, which are functions dependent on time, and one parameter.

$$m'(t) = i(t)$$
$$i'(t) = \mu(1 - m^2(t))i(t) - m(t)$$

I represent this system by system dynamics model, and based on this model, investigate the behavior of the solutions of these differential equations.

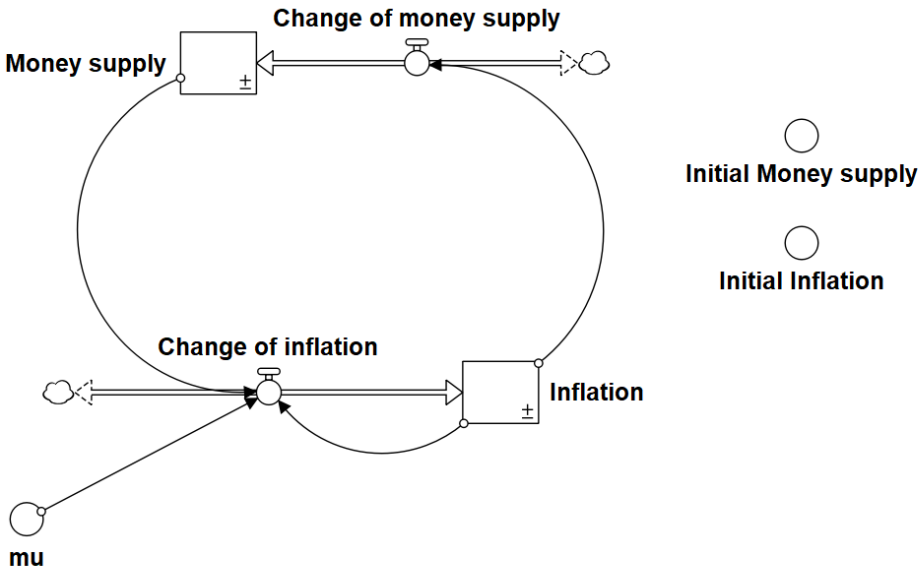

Figure 1. The system dynamics model of differential equations

At first, we set to μ =-2.5. From the Figure 2 we can see that the system is moving clockwise and directly to a fixed point. This result holds for any value of μ that is less than -2 or equal to -2. The point P = (0,0) here is called stable node.

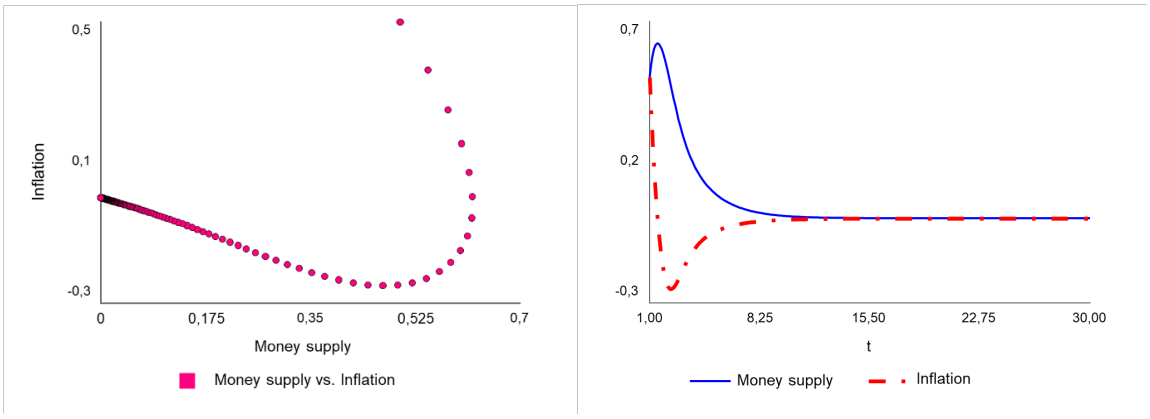

Figure 2. The behavior of the solutions for system with μ=-2.5

Then we take μ a bit higher than -2, for example, -1.5, and the system moves at a fixed point clockwise but in a spiral form.

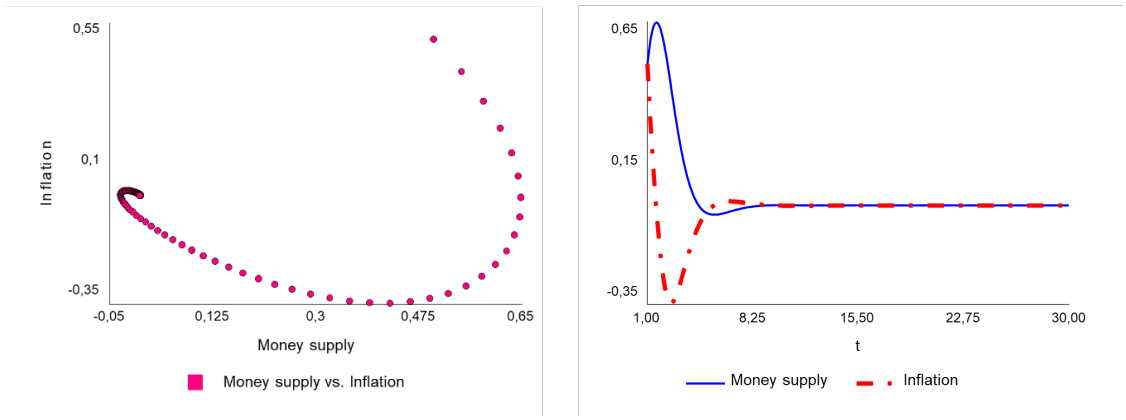

Figure 3. The behavior of the solutions for system with μ=-1.5

The spiral is even more noticeable when set μ= -0.5. This spiral path occurs for all values of μ in the range -2 <μ <0.

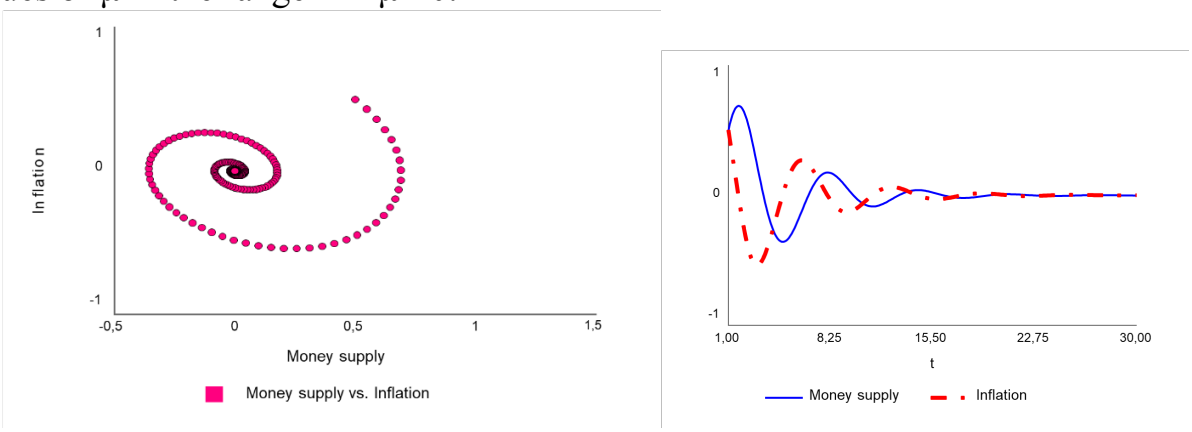

Figure 4. The behavior of the solutions for system with μ=-0.5

For μ= 0 the system has a center. Note, that the path to the system is clockwise.

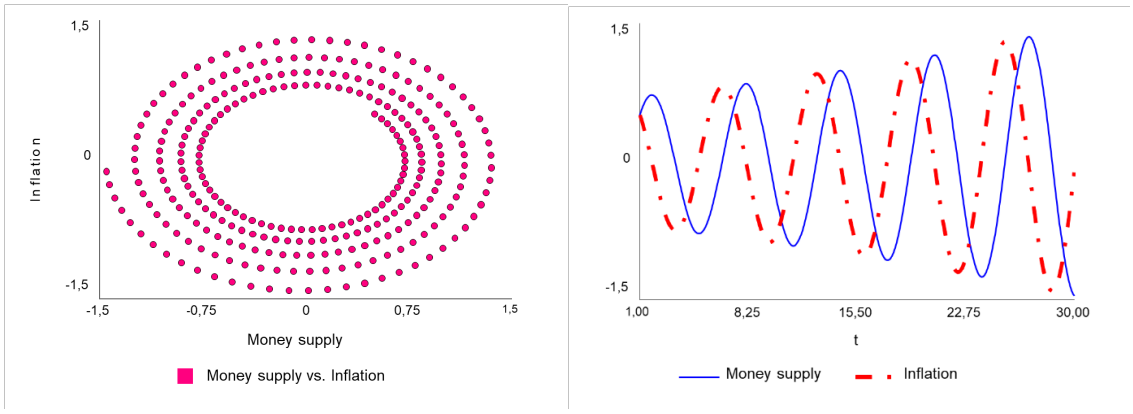

Figure 5. The behavior of the solutions for system with μ=0

For 0 <μ <2 , the system detects an unstable focus. It is unstable in the sense that it moves away from the fixed point P = (0,0) clockwise. However, it converges to the limit cycle. This feature of the boundary cycle occurs at positive values of μ up to about 8, and then the system becomes completely unstable.

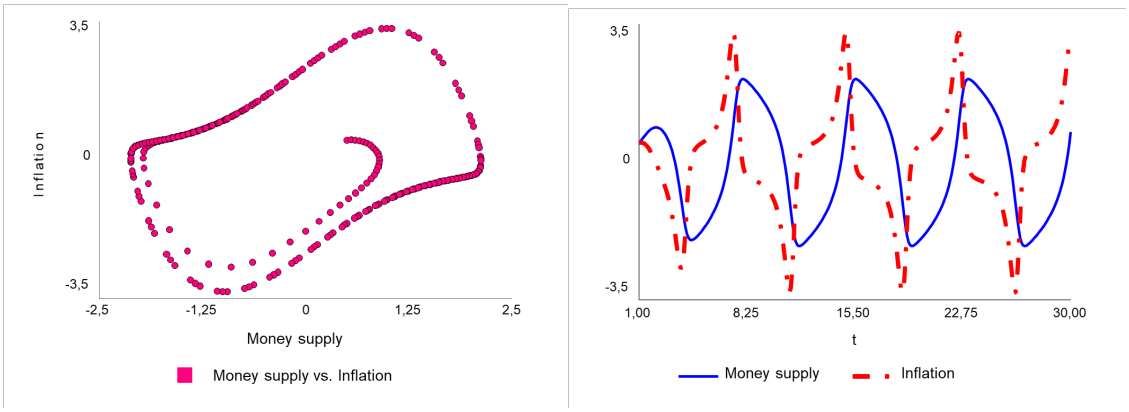

Figure 6. The behavior of the solutions for system with μ=1.5

At μ=0, the system changes dramatically, taking the form of a circle at this value. Then, as μ grows in the positive direction, the system takes a boundary cycle on the plane for any particular positive value of μ whose shape is no longer a circle - about to μ=8. The system changes dramatically as μ passes through zero. Therefore, the system detects bifurcation at the value μ=0. This is an example of Hopf bifurcations.

We considered a nonlinear system that exhibits chaotic behavior and has different types of bifurcations. Using the system dynamics model, I solved the differential equations and investigated the behavior of the solution for different values of parameter. The system dynamics models provide the opportunity to analyze the results of particular parameters interacting and reactions to individual factors changing.

References

1. Shone, R. (2003). An Introduction to Economic Dynamics, Cambridge, New-York, 224 p.
2. Sterman, J. D. (1984). Appropriate summary statistics for evaluating the historical fit of system dynamics models.
3. Lukianenko I., Oliskevych M. (2017). Evidence of asymmetries and nonlinearity of Unemployment and labour force participation rate in Ukraine // Prague Economic Papers. – 26(5). – P. 578–601.
4. Прімєрова, О., Дадашова, П. (2015). Вивчення економіки методами системної динаміки в Національному університеті" Києво-Могилянська академія».
5. Лук'яненко, І., Віт, Д. (2017). Системний аналіз формування державної політики в умовах макроекономічної дестабілізації.

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SYSTEM DYNAMIC MODEL OF CORPORATE INCOME TAX REVENUES IN UKRAINE

Tax competition in the world is increasing year by year, forcing countries to reform their tax systems in order to remain competitive in this sphere. Economic growth of the country is an important indicator of how effective its tax system is. Improving economic situation leads to economic growth of the country. Corporate income tax is a tool of investment and innovation stimulation, it increases production in the country and GDP, which in turn contributes to economic growth and, as a consequence, to filling the state budget with tax revenues.

There is a little reason to expect that different taxes have the same impact on the economy. We will look at corporate income tax which is one of the main budget-forming taxes and which is for more than 12% of total government tax revenues in total account. Rate of corporate income tax can have different impact on tax revenues because of existence of a shadow economy.

According to Laffer Curve, there is an optimum tax rate which are exceeded causes decrease of tax revenues. The Laffer Curve by itself doesn’t say whether a tax cut boosts or lowers revenues. Revenue response to a tax rate change depends on the tax system in place, the time period being considered, the ease of moving into underground activities, the level of tax rates already in place, the prevalence of legal and accounting-driven tax loopholes, and the proclivities oft he productive factors. If the existing tax rate is too high, then a tax-rate cut results into increased tax revenues.

The object of the research is identification of the effect of corporate income tax changes on economic growth in Ukraine. First of all, in the future research it will be necessary to establish the sign of the impact of corporate income tax rate in Ukraine using the econometric tools. The research of the impact of corporate income tax rate on tax revenues in Ukraine may show whether tax rate in our country is at the optimum level, below or above it. The dynamic model of impact of corporate income tax on economic growth in Ukraine will be created after that.

We will focus on corporate income tax rate, corporate income tax revenues and trends that are specific to them. Starting in the second quarter of 2011, corporate

income tax rate had been gradually reduced from 25% to 18% (established in 2014) and is currently one of the lowest in the European Union. Fiscal function of the tax during this time period had also undergone changes, which were influenced by reduction of the rate, the tax reform in 2014-2016 and the crisis in the Ukraine.

From 2004 to 2010, the share of corporate income tax revenues in GDP of Ukraine ranged from 3.57% to 5.27%. From 2011 to 2015, there was a trend towards a gradual decrease in this indicator. Thus, within five years, the share of corporate income tax revenues in GDP of Ukraine fell more than twice (from 4.16% to 1.76%). The gradual recovery of the Ukrainian economy from 2016 made positive effect on corporate income tax revenues (in 2016 the share in GDP increased by 0.52%, in 2017 and 2018 remained almost at the same level).

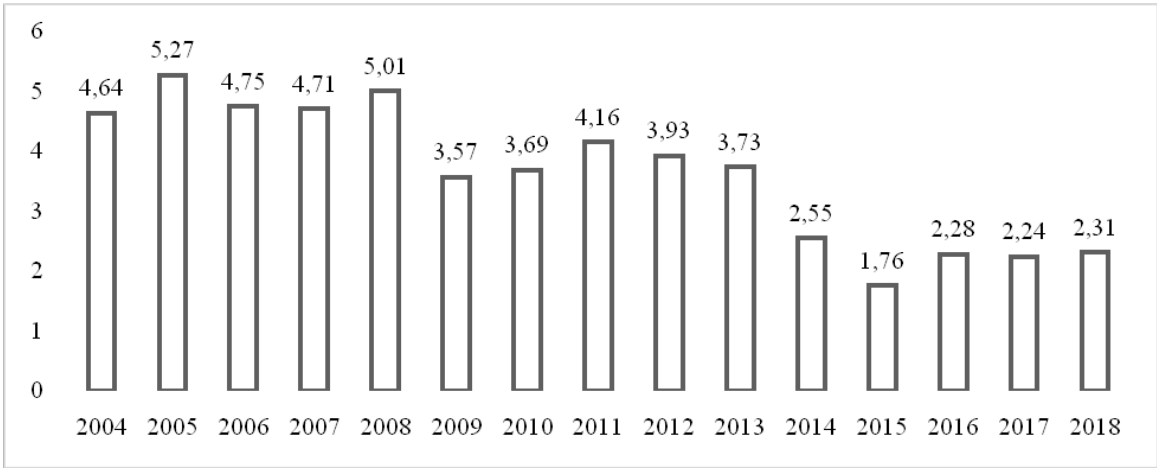

Figure 1. Income from corporate income tax in 2004-2018, % of nominal GDP of Ukraine

Corporate income taxation can directly and indirectly affect economic growth. Thus, various tax benefits (for example, for a particular sector of the economy or for a particular form of enterprise) can both contribute to economic growth and increase the state budget deficit at the expense of unrealized potential tax revenues.

In different countries, the impact of corporate income taxation on economic growth may vary. This is determined by how large the economy is, what type of country it is (highly developed or developing, etc.), the structure of the tax system (which are other taxes and their rates), the method of taxation (progressive, regressive or proportional) and other factors.

Too high corporate income tax rate leads to increase of level of shadow economy in the country and, as a result, corporate income tax revenues decrease. At the same time, increasing corporate income tax rate to optimum level should promote growth of corporate income tax revenues. When tax rate exceeds its optimum level, corporate income tax revenues start to decrease. In turn, growth of corporate income tax revenues promotes increase of total government revenues that also consist of other tax and non-tax revenues. Higher level of government revenues leads to increase of government spending and, as a result, growth of GDP.

Corporate income tax debt and corporate income tax overpayments have impact on size of corporate income tax revenues and, as a consequence, on economic growth. Corporate income tax is one of three taxes that create about 90% of the whole tax debt, which reduces its fiscal importance in the budget-forming process. Corporate income tax overpayments complicate forecasting of tax revenues in subsequent periods and increase the tax burden on taxpayers. The largest share in the total amount of overpayments is from corporate income tax (42.6% in 2018).

Another way of influence of corporate income tax rate is through investments. The higher corporate income tax rate in the country is established, the lower profit of firms after taxes are paid. This means that firms have less capital for investments and, as a consequence, GDP of the country decreases.

In the model we will calculate GDP using expenditure method, that's why we need to add exogenous variables – net export and consumption:

$$GDP = C + I + G + X_n,$$

where C – Consumption (exogenous variable), I – Investments (endogenous variable), G – government spending (endogenous variable), X_n – net export (exogenous variable).

The level of GDP makes it possible to determine GDP growth, which reflects economic growth rate in Ukraine Summarizing all of the above, the initial causal-loop diagram is as follows:

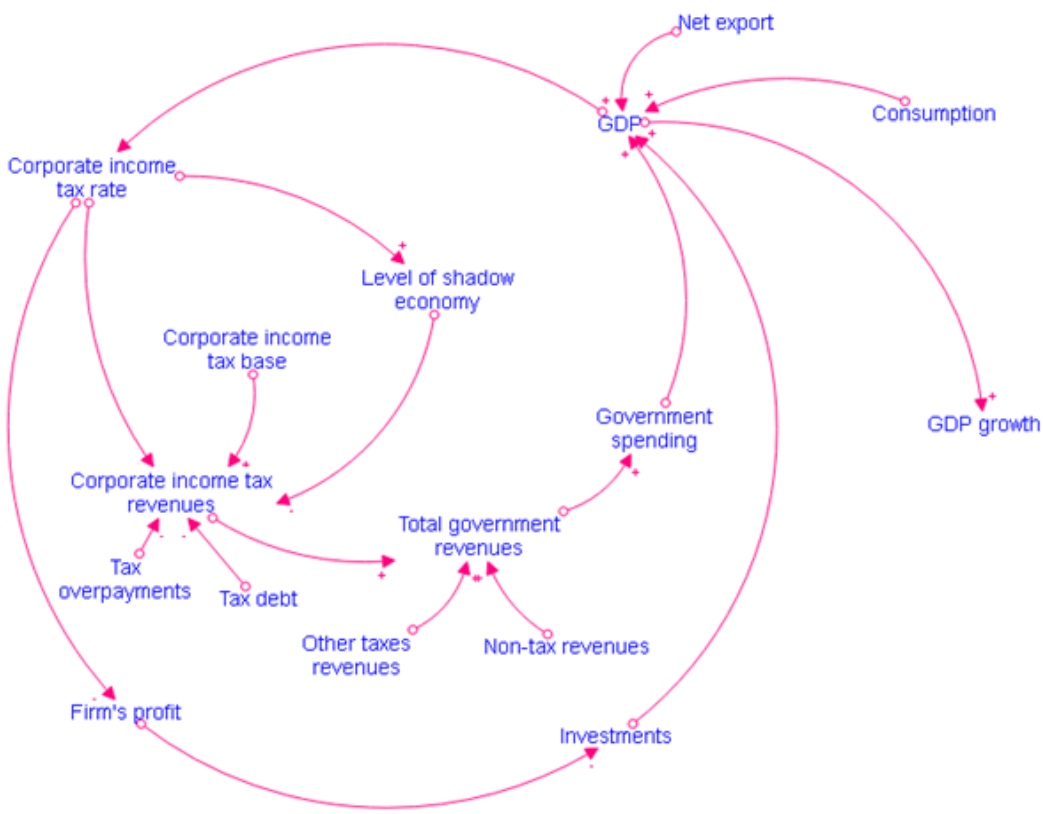

Figure 2. Causal-loop diagram of corporate income tax impact on GDP growth

Initially, we do not identify the effect of corporate income tax rate on corporate income tax revenues and the effect of GDP on corporate income tax rate.

The following research will help to determine whether corporate income tax rate in Ukraine is at the optimum level according to Laffer Curve and how the change in corporate income tax rate can affect economic growth taking into account different ways of taxation impact on GDP.

References

6. Arthur B. Laffer. «When You're Right, Well, You're Right: The Laffer Curve», Thinking Economically, The Texas Public Policy Foundation.
7. Official site of the State Fiscal Service of Ukraine [Electronic source] – Access mode: http://sfs.gov.ua/en/.
8. A site about finances and investments, MinFin [Electronic source] – Access mode: https://minfin.com.ua/ua/.
9. Лук'яненко, І., Віт, Д. (2017). Системний аналіз формування державної політики в умовах макроекономічної дестабілізації.
10. Лук'яненко І.Г .Напрями реформування бюджетно-податкової системи в Україні // Економіка, Фінанси, Право, Київ, 2004.- № 6.- С.26-32.
11. Bui, T. H., Primierova, O. K. (2018). "Tax stimulation of small-size business development in Ukraine", Efektyvna ekonomika, [Online], vol. 9.

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MODELING OF HOURS AND EMPLOYMENT FOR UKRAINE USING SYSTEM DYNAMIC METHOD

The main target of the model is to develop the system dynamics model about hours and employment for Ukraine. The model shows how different parameters such as labour hour productivity, desired production, employment influence on.

The time horizon in this model is 2008-2017. The data is annual. The main source of information on data was the official website of Ukrainian statistics http://www.ukrstat.gov.ua. Some data was also found on https://data.worldbank.org/.

It is important for every business to create a pleasant workplace where employees can work in a safe environment. Setting the rules of employment in advance that clearly stipulate terms and conditions of employment and the standards for treatment, including working hours, wages, rules on personnel and duties, is essential to not cause disputes between an employer and employees.

We can see how our model works (Figure 1). We look at the Hours per worker model and the relationship between our data. At the same time we can see connection between Employment. Labor hour productivity is equal to labor productivity/ standard hours per worker, where:

Labor productivity = real private AD/ Employed

Desired labor hours = Desired production / Labor hour productivity

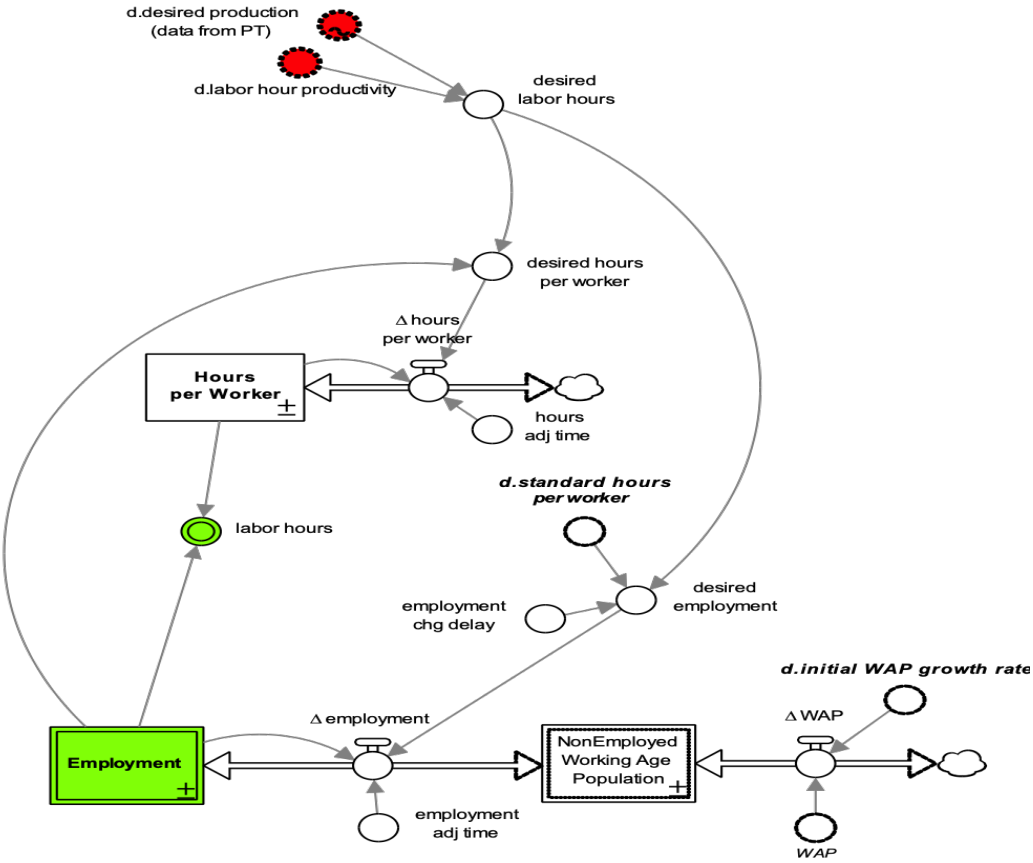

Figure 1. System Dynamics Model of Hours and Employment

The actual labor hours are a product of the number of employment workers and the number of hours per worker. The outputs from this model are a labor hours and Employment. If we want to change desired labor hours the first what we suppose to do is the changing in hours per worker. In Ukraine average standard hours per worker is equal to 2000 hours.

Usually, an adjustment in the number of Hours per Worker can be accomplished relatively quickly, but in Ukraine it takes more time, and we assume that it's around half of the year. Closing gap between current and desired employment takes more time then adjusting the number of hours per worker. It depends on labor market conditions. In Ukraine labor market is tighter, and employment adj time is longer. We assume that it's around 1 year.

In equation of desired employment we use SMTH function because we can't get immediately full effect of desired labor hours. And we assume that it takes half of the year:

Desired employment = SMTH1 (Desired_labor_hours / D.standard_hours_per_worker; Employment_chg_delay)

Figure 2 shows historical data of the labor hour in Ukraine and labor hours, that simulated by model.

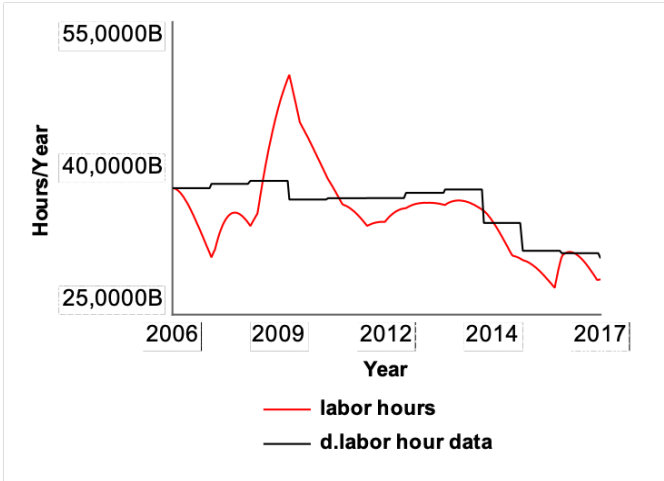

Figure 2. Result of System Dynamics Model for Labor Hours

In Figure 3, we can see connection between stock - Employment and our data Employed.

Figure 3. Result of System Dynamics Model for Employment

Data for 2014 are given without taking into account the temporarily occupied territories of the Autonomous Republic of Crimea and the city of Sevastopol, since 2015 - also without part of the temporarily occupied territories in Donetsk and Luhansk regions. We can test our model using Theil statistics.

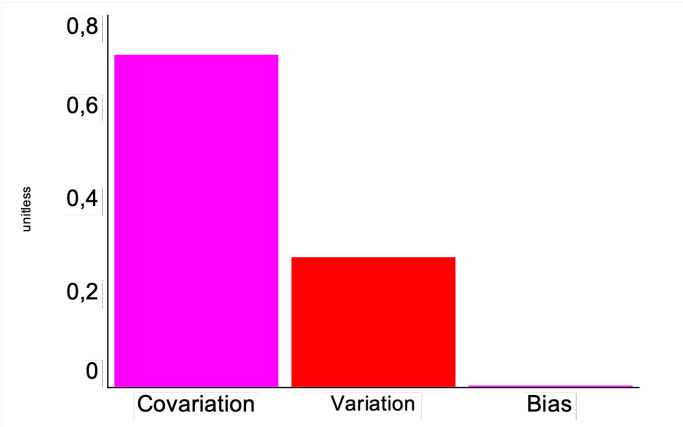

Figure 7. Decomposition of Theil statistics for Hours and Employment model

We have big covariation error 70%, Variation error 28% and Bias 1%.

In conclusion we can say that our models work correct, it show us real behavior of our inflation and taxes but it's hard to collect data, or data didn't show reality. Realized that every parameter in our sub models have big influence on hours and employment.

References

1. Wheat, D. I. (2007). The Feedback Method: A System Dynamics Approach to Teaching Macroeconomics. PhD thesis, University of Bergen.
2. Sterman, J. D. (2000). Business Dynamics. McGraw-Hill Companies.
3. Burdett, K. and Mortensen, D. T. (1998). Wage Differentials, Employer Size, and Unemployment. International Economic Review, 39 (2), 257- 273.
4. Official site of the State Statistics Service of Ukraine [Electronic source] – Access mode: http://www.ukrstat.gov.ua/.
5. Abakumova, J., Primierova, O. (2018). Economic Growth, Globalisation and Income Inequality: The Case of Ukraine. Economics, 10, 11th.
6. Lukianenko I., Oliskevych M. (2017). Evidence of asymmetries and nonlinearity of Unemployment and labour force participation rate in Ukraine // Prague Economic Papers. 26(5).

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MODELING THE INTERACTION BETWEEN MONETARY AND REAL SECTORS USING SYSTEM DYNAMICS METHODOLOGY: CASE OF UKRAINE

The main purpose of the modeling is to develop the structure of the system dynamics model which will replicate the behavior of real economic relationships, so the explanatory model is employed. This type of system dynamics models is based on the rules that explain the past and include today's actual instruments, but not the future ones. By the way, the use of macroeconomic models in the process of estimation of the effects of the monetary policy avoids expensive and sometimes hardly possible practical experiments. In addition, modeling helps to determine the consequences of the implementation of different combinations of use of certain monetary policy instruments.

Low and stable inflation is the foundation for the macroeconomic stability of the country's economy [4]. To reach the inflation target national bank makes changes in combinations of monetary instruments, what also has a significant impact on economic growth. Taking those interconnections into consideration, it is becoming actual to make a contribution to the analysis of how real and monetary sectors in Ukraine are interdependent. That is important because gives some reasoning and quantitative estimates of the main transmission channel from the key policy rate to GDP and prices. Moreover, this research pays attention to the level of shadowing of

the economy, because it is quite significant in Ukraine and reach about 32% of official GDP [3].

With the purpose to analyze the interconnections between the monetary and real sectors, a macroeconomic model of system dynamics was developed. System dynamics is discovering and representing the feedback processes, which, along with stock and flow structures, time delays, and nonlinearities, define the dynamic of the whole system, in the occasion oft his particular research system of the economy of Ukraine [5]. The system dynamics approach has several advantages, namely the ability to produce reliable results using a small sample, the visual representation of simulation results and model structure, and the ability to incorporate elements of state regulation into the model [6]. Besides, system dynamics allows building complex detailed models with a big number of feedback loops.

The entire model is developed on quarterly data from 2007 to the second quarter of 2019 in Stella Architect software. The feedback structure of the system dynamics model is presented on the causal loop diagram on Fig. 1.There are two reinforcing and one balancing feedback loop in the model. The logic of the relationships within the system is the following: key policy rate as the main monetary policy instrument in the framework of the inflation targeting influences on the commercial bank's interest rates on loan and deposits, after on the basis of the total deposits in the banks and money aggregate M2 level of shadowing is calculated. There are a lot of methods for measuring shadowing, but here monetary method according to the Gutmann formula provided by the Ministry for Development of Economy, Trade and Agriculture of Ukraine was used. The rise in shadow activity leads to an increase in unemployment and as a result in the tax rates, what reducing disposable income and therefore consumption.

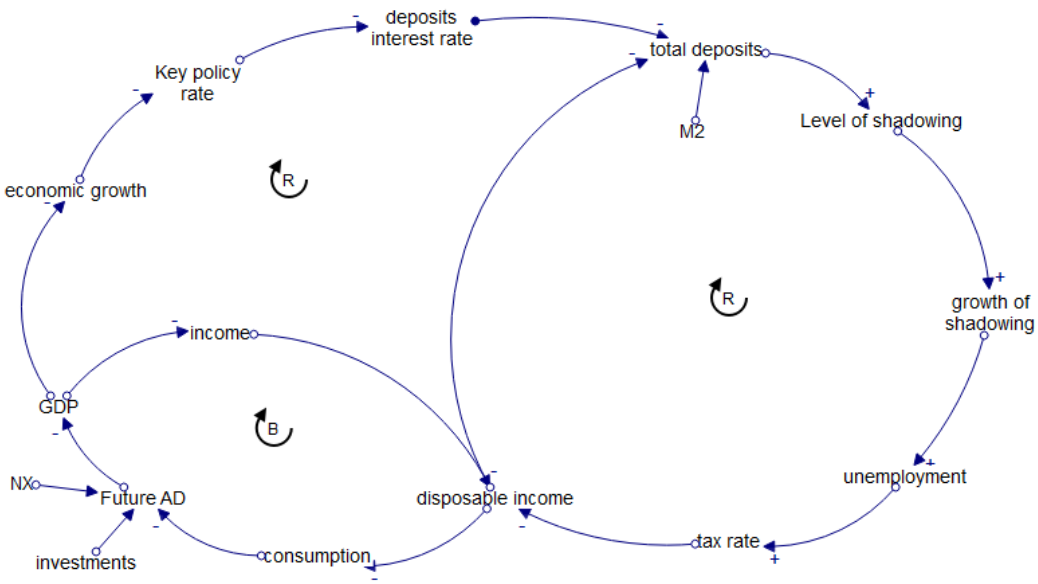

Figure 1. Causal loop diagram of the macroeconomic model

Consumption as one of the components of GDP has an impact on economic growth. Since a change in key policy rate affects not only prices but also GDP, so

usually central banks in decisions about monetary policy take into account current and forecasted economic growth.

The formalization of relationships in the model is based on economic theory and globally recognized formulas. GDP in the model is estimated based on the volume of future aggregate demand which calculates by the classic formula:

$$Y = C + I + G + NX,$$

where C – consumption, I – investments, G – government spending, NX – net exports. Level of shadowing is calculated by the formula according to the Gutmann methodology:

$$LS_t = \frac{1 - f_t}{f_{t-1}}$$

where f is an indicator of the ratio of deposits to the monetary aggregate in the analyzed period. This indicator is defined as:

$$f = \frac{\frac{D}{M2}}{\frac{D_{t0}}{M2_{t0}}} = \frac{\frac{M2 - M0}{M2}}{\frac{M2_{t0} - M0_{t0}}{M2_{t0}}}$$

where M2 is money supply in the relevant period; M0 is money outside the banks in the relevant period; D is bank deposits in the relevant period

The key policy rate is the main monetary policy instrument under the inflation targeting, it is determined on the basis of the Taylor rule, which normally includes retrospective key policy rate, output gap, deviation of expected inflation from the target and parameters [2].

The reproduction of historical data for two main endogenous variables in comparison with model behavior is an important step in diagnostic the adequacy of the developed system dynamics model. Graphical representation of the behavior estimated values and actual values of GDP and level of shadowing are presented on Fig.2. As can be seen from the graph, the model replicates the historical dynamics quite well. Therefore, the macroeconomic model can be considered adequate.

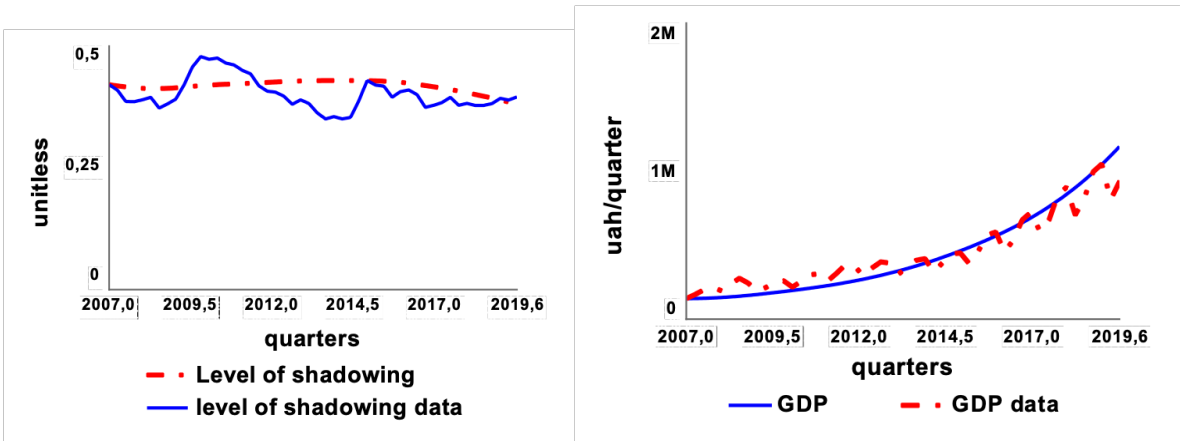

Figure 2.Dynamics of the actual and estimated level of shadowing and GDP

Developing scenarios under different assumptions based on the constructed model helps to evaluate how for example shock is transmitted through the macro

system, as well as to quantify its negative impact on economic indicators. On Fig 3 performed a basic scenario in comparison with the one which assumes a higher key policy rate. To sum it up, a rise in the central bank's key policy rate causes a decrease in GDP and therefore in economic growth.

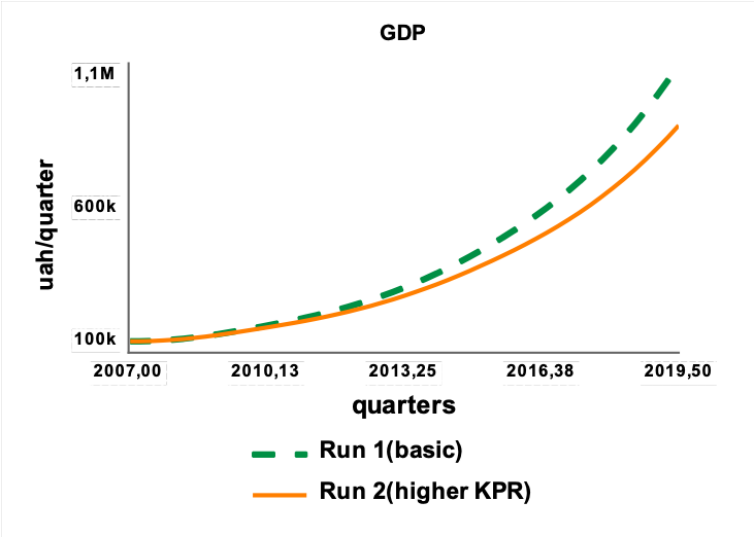

Figure 3. Scenario analysis

Therefore, the model of system dynamics which represents the influence of changes in monetary policy instruments, namely the main one, which is a key policy rate on the real sector (GDP and level of shadowing) in Ukraine was developed. The constructed model differs favorably from others by the presence of level of shadowing, what allows to take into consideration the impact of informal activity in the frame of interconnections of the real and monetary sectors. The conducted scenario analysis is the most important part of the research since it gives the possibility to analyze the sensitivity to changes of certain parameters.

References

1. Lukianenko I., Faryna O. Macro-financial stability: models and methods of assessment. Monograph – K.: «GLIF Media» LLC, 2016. – 187 p. – in Ukr.
2. Nikolaychuk S. Monetary policy transmission: past experiences and current challenges // NBU materials, 2016. – Available at: https://bank.gov.ua/doccatalog/document?id=41015231
3. Official website of Ministry for Development of Economy, Trade and Agriculture of Ukraine [Electronic resource] – Available at: http://www.me.gov.ua
4. Official website of National bank of Ukraine [Electronic resource] – Available at: https://bank.gov.ua.
5. Wheat I.D. The Feedback Method: A System Dynamics Approach to Teaching Macroeconomics: Doctoral Thesis: 04.05.2007. – Norway, University of Bergen, 2007.
6. Прімєрова О. К. Особливості монетарної політики в Україні на сучасному етапі // Ефективна економіка: електронне наук. фахове вид. - 2017. - №. 10.
7. Лук'яненко, І., Віт, Д. (2017). Системний аналіз формування державної політики в умовах макроекономічної дестабілізації.

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MODELING OF SHADOW WAGES FORMATION

At the present stage of economic development, Ukraine is characterized by a high level of the shadow sector in the economy, which affects the effective functioning of all spheres and enhances the slowdown in economic growth. It plays a particular role in the effective functioning and regulation of the labor market through the high share of “black” and “gray” payroll schemes and tax evasion through the use of schemes with the creation of individual entrepreneurs [1]. The shadow economy has a particularly large impact on the efficient functioning of the labor market. The prerequisites for the emergence and functioning of the shadow component are ineffective legislation on the regulation of monetary transactions, which leads to the possibility of tax evasion through the use of schemes with the creation of individuals-entrepreneurs and artificially lowering the "white" share in the share of wages, as well as public distrust of social state guarantees. In this regard, the pension fund receives a smaller share of taxes, which causes a low level of retirement benefits, as well as abolishes social guarantees for employees who receive wages in envelopes.

According to the multiple researches, almost 18% of all the shadow transactions are connected with payment of wages in envelopes, which causes lots of problems for the Ukrainian economy and deprives social security guarantees, which can lead to an effect on the loss of productive working-age population [4]. On the other hand, wages in envelopes help to keep people from moving abroad, which can be a good effect in the short run, but leads to the distrust of governmental institutions in the long run [2]. Before making the policy of enhancing the part of the wages paid in the envelopes, it is important to understand how this system works.

To invade their taxes, the enterprises pay officially the minimum wages to their employees, and as a result, both enterprises and employees pay fewer taxes than they would if they would be paid the full amount and show it in the income statements. According to the Ukrainian legislation, the amounts received on the banking cards should have a clear source, which results in cash payments in envelopes. The estimation of Cash in monetary aggregates in a data provided by National Bank of Ukraine shows that the ratio of M0 (cash) in a monetary aggregate M3 is lower in 2019 than in 2000 but still estimated as approximately 27% in a monetary mass, and approximately 52% in M1 monetary aggregate, which is represented on figure 1. Such a big amount of cash in the economy propels the shadow activity, and it is clear that shadow activity reinforces the use of cash.

After investigation of the main factors which influence the formation of shadow wages, such hypotheses were created:

1. The share of monetary aggregate M0 in the money supply has a positive effect on shadow flows.

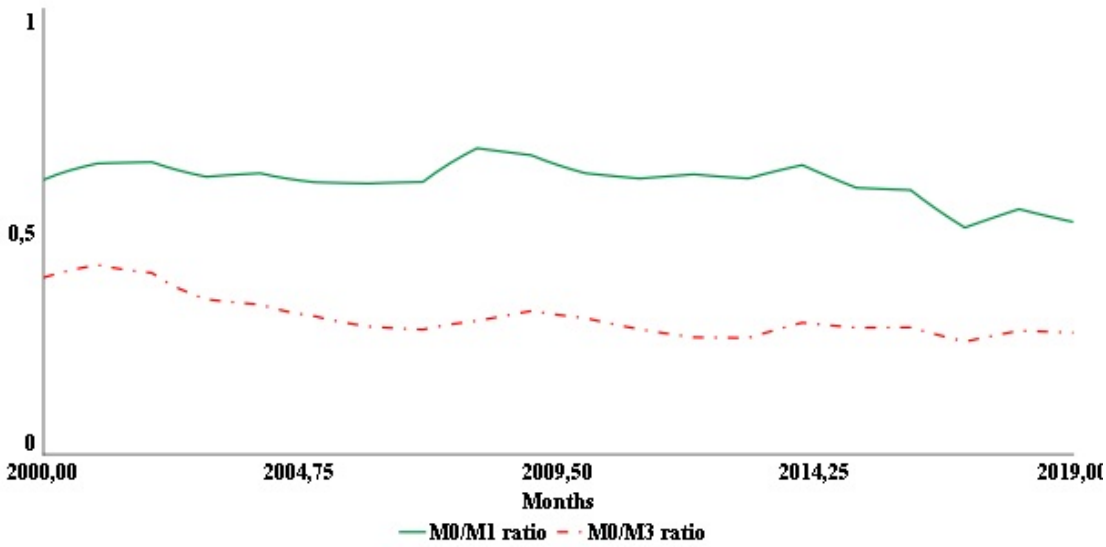

Figure 1. The dynamics of cash weight in monetary mass and M1 monetary aggregate

Source: created by the author based on [1]

2. Increasing the accumulated value of the shadow salary positively contributes to the increase in the share of the monetary aggregate M0 in the money supply/

3. The total wage is calculated as the average on the labor market for such vacancies, thus the shadow wage is defined as the difference between the total and the "white" component.

4. The reduction of the share of shadow money received in the form of salary in envelopes is made by carrying out "white" transactions in cash.

Based on those hypotheses, the system dynamics model of shadow wage formation was created, the stock and flow diagram is represented in figure 2. The main stock in the model is Shadow Wage, which represents all the “envelope” money in the economy. When employees receive wages in envelopes, the shadow wages sector rises, but when they spend the money by consuming products or making payments for the services, the money comes back to the economy and can be calculated.

The growth of shadow wage influences the growth of cash share in a monetary aggregate M1, which leads to the change in M0/M1 ratio, because the scheme has the aim to keep the cash, and the higher amount of M0 in M3 stimulates the growth of shadow fraction. Total envelope wages were estimated as a difference between the average normal earning per employee and the minimum “white” wage [3].

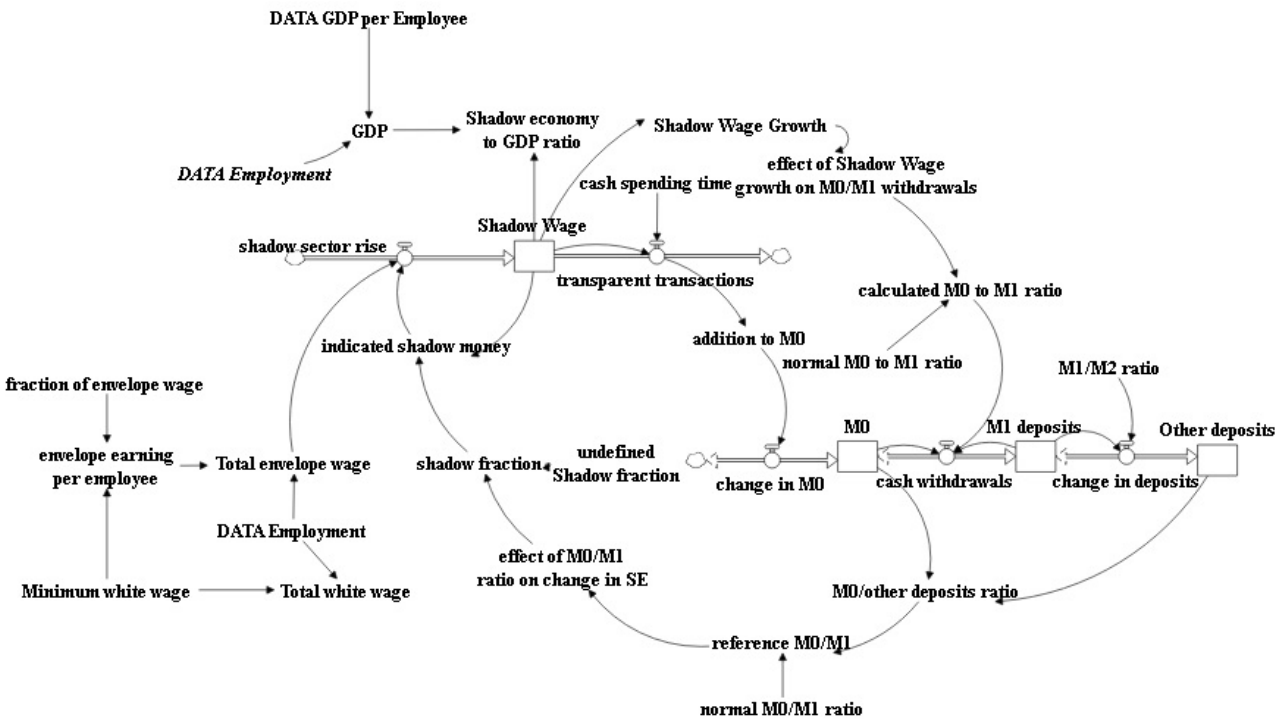

Figure 2. SFD of shadow wages formation in the economy

Source: created by the author in Stella Architect Software

Based on the idea of the model, the higher minimum wage will eliminate the shadow wage part. On figure 3 it is shown that the increase in the minimum wage leads to the decrease of the shadow wage in the economy if the amount of the normal average wage will stay the same.

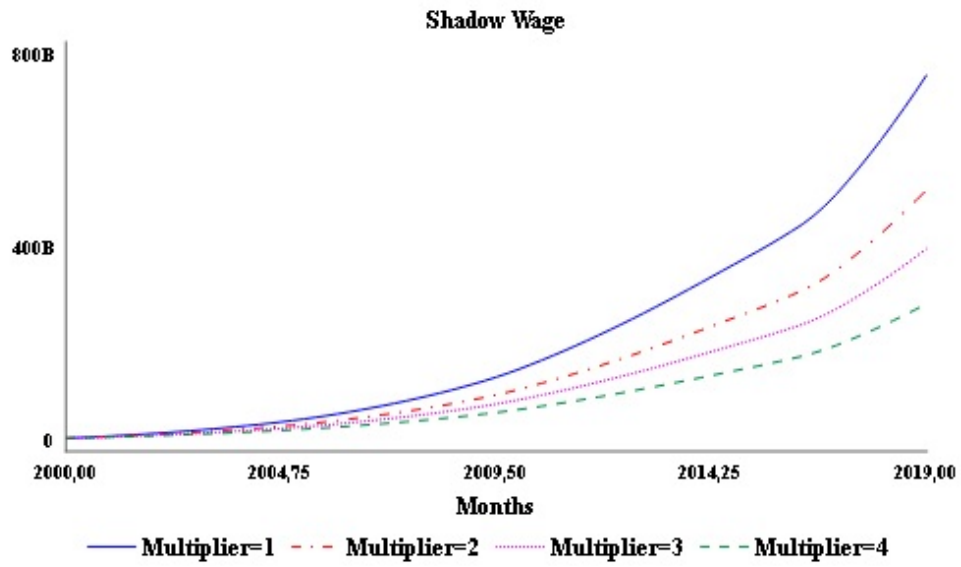

Figure 3. The scenarios of shadow wage formation based on the share of "white" salary

Source: created by the author in Stella Architect Software

Taking into consideration the threats connected with the rise of the shadow economy, the new effective legislation should be created to provide effective regulation of the salary payments and enforcing the entrepreneurs to pay their employees the worthy salaries, and the new policy also should be directed to decrease the amount of cash in the economy.

References

1. Monetary and Financial Statistics (2016), National Bank of Ukraine, URL https://old.bank.gov.ua/doccatalog/document?id=31841872
2. Novik, A. (2019), "The use of imitation modeling for the research of migration flows", Ekonomika ta derzhava, vol. 4, pp. 119–122. DOI: 10.32702/2306-6806.2019.4.119
3. Schneider, Friedrich, Buehn, Andreas (2016), Estimating the Size of the Shadow Economy: Methods, Problems and Open Questions, Discussion Paper Series, No. 9820, 39 p.
4. Schneider, F. and A. Buehn (2013), Shadow Economies in Highly Developed OECDCountries: What are the Driving Forces?, University of Linz, Linz, Austria, June 2013.
5. Vinnychuk, Igor & Ziukov, Serhii (2013), Shadow economy in Ukraine: modelling and analysis, Business Systems & Economics, 3, p. 141-152.
6. Williams, C.C. and P. Rodgers (2013), The role of informal economies in the post-Soviet world: The end of transition?, Routledge Publishing Company, London.
7. Лук'яненко, І., Віт, Д. (2017). Системний аналіз формування державної політики в умовах макроекономічної дестабілізації.
8. Abakumova, J., Primierova, O. (2018). Globalization, growth and inequality: testing causality and asymmetries. Ekonomicko-manazerske spektrum, 12(2), 83-95.
9. Lukianenko I. Evidence of asymmetries and nonlinearity of Unemployment and labour force participation rate in Ukraine // Prague Economic Papers. – 26(5). – 2017. – P. 578–601.

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ELECTRIC VEHICLES POPULARITY IN NORWAY

It is an interesting question of why little Norway which has enough oil resources has a supportive policy to EV. Oil production has not changed in recent years, but resource scarcity in the future may lead to problems with the supply of gasoline to the market. The Norwegian government is also worried about the amount of carbon dioxide emissions into the air. So, it formulated a policy to increase electric cars in the country to 50,000 EV from 1990. Thus, electric vehicles became more economical for residents than ordinary cars because of tax and convenience purposes, but conventional cars did not disappear from the market.

All internal energy will be obtained through the use of hydroelectric power stations, so the decision to use electric vehicles was made by the government in 1990. Country's extensive charging infrastructure was funded by the government, but manufacturers began to finance such projects themselves in order to increase the inflow of business investment [1].

According to a study by A. Gärling and Thøgersen "Typically, market penetration starts with a small segment consisting of customers with particular characteristics, needs, or wants" [2]. Government involvement in the structure of the automobile market is due to the influence on consumer decisions. Consumers have been influenced by financial instruments and the convenience of using different types of cars.

The state has set itself a goal of increasing the number of electric cars not through a ban but through the use of green taxes. VAT had been canceled from the purchase of EV since 2001, and bus lanes had been permitted to use since 2005. However, the VAT tax was reset in 2015, but the desired amount of EVs for cars (50,000) was reached earlier than expected [3].

Therefore, the use of the system dynamics method will help to understand the impact of government policy on the market structure and what the structure of the Norwegian car market will be in the next 10 years (Figure 1).

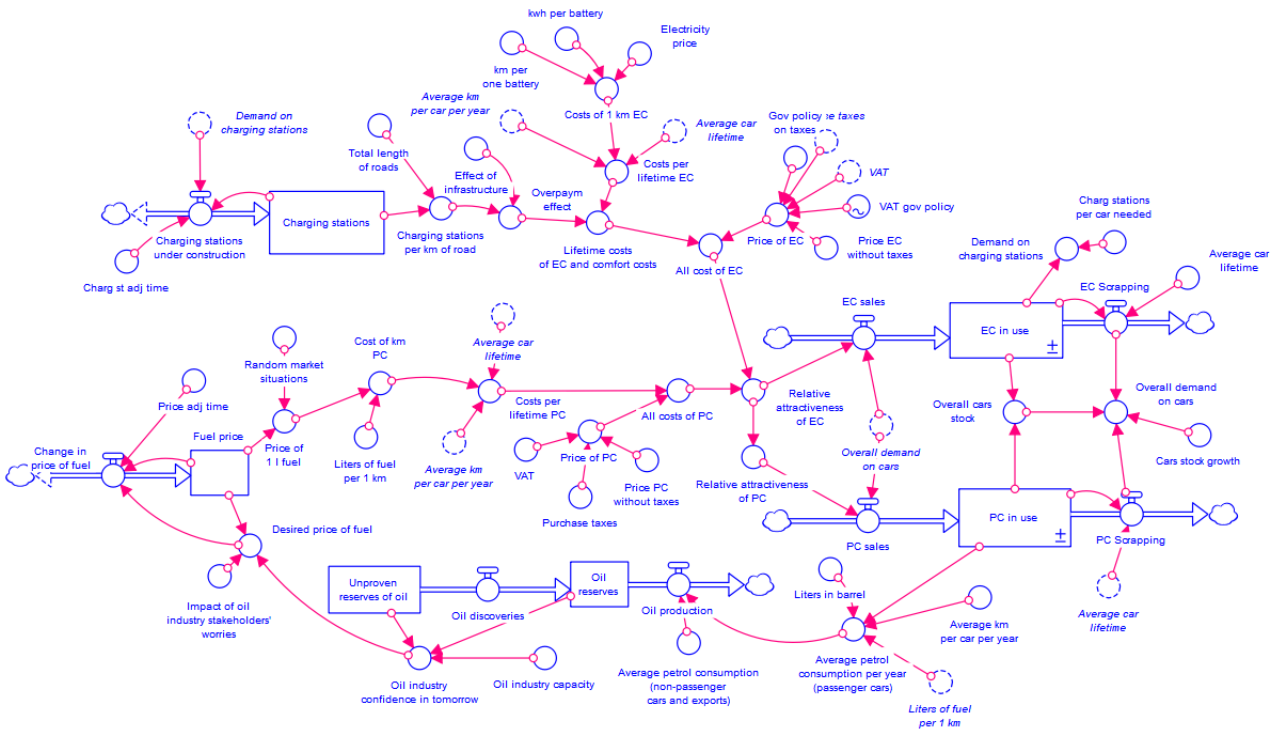

Figure 1. The dynamic model of popularity electric vehicles in Norway

There are two major causal loops in this system. The first one is a reinforcing loop about electric vehicles where the better EV infrastructure is, the smaller the comfort index becomes, the higher are the electric vehicles sales. As a result, a higher demand for the electric vehicles infrastructure in the country.

Then, the result of the balancing loop in this system: the more petrol cars used in Norway, the less oil reserve, which is a cause for higher petrol prices. As a consequence, the less is the attractiveness for petrol cars.

Comparing the data created by the model and the real data on the number of vehicles from Norway can help to understand how adequately the model explains the real process (Figure 2).

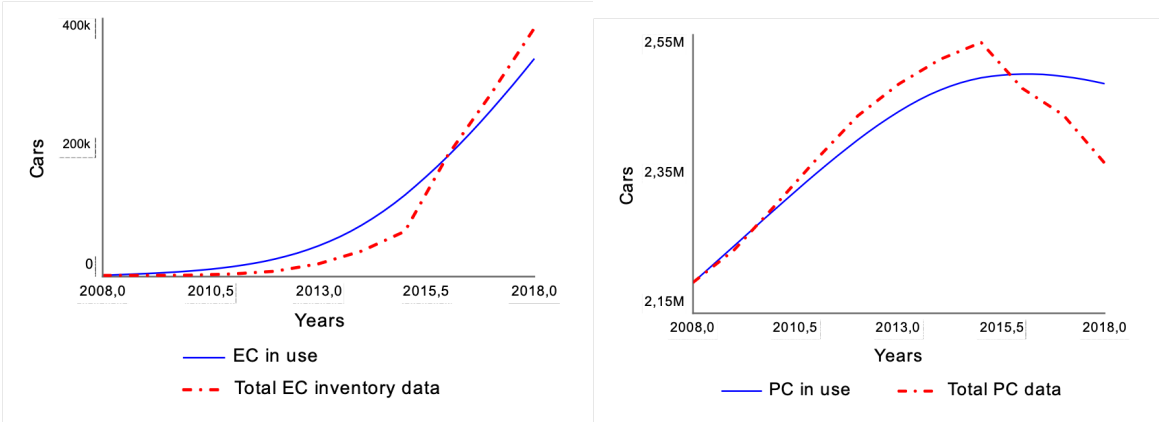

Figure 2. Comparison of model and historical data of the electric and petrol cars in use in Norway

Analyzing the graphs, the behavior of the indicators has changed over time, as a result of the influence of government policy and the coefficient of the comfort of use of cars. All statistics were taken from the official website of Statistics Norway. The simulated data are close to real, showing that the model reflects real-world mechanisms. The structure, parameter confirmation, and dimensional consistency tests were done to prove the model confidence in results.

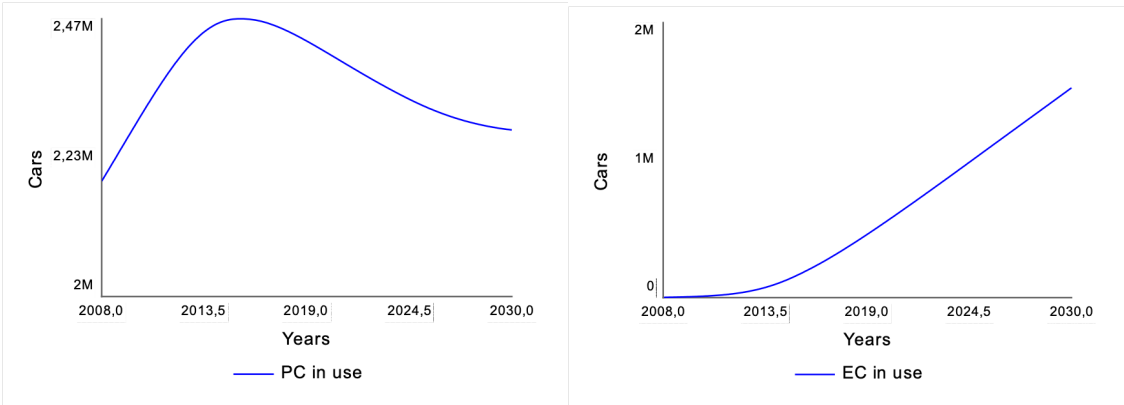

Figure 3. The forecasting for electric and petrol cars in Norway for next 10 year

The developed forecast (Figure 3) shows that in the future the number of electric cars in Norway will increase, but the number of cars on petrol will not be much reduced. The reason for this is the willingness of buyers to pay extra for the convenience of the petrol cars (it has more mileage without the additional use of fuel, faster time for refueling). However, the state-sponsored electronics change program has worked, as the government has achieved its target and created demand for the use of electric vehicles for everyday use in the city.

References:

1. David Nikel (2019). Electric Cars: Why Little Norway Leads The World In EV Usage – Access mode: https://www.forbes.com/sites/davidnikel/2019/06/18/electric-cars-why-little-norway-leads-the-world-in-ev-usage/#70246bb213e3
2. Gärling, A. and Thøgersen, J. 2001. Marketing of electric vehicles. Business Strategy and the Environment, 10: 53–65.
3. Zeniewski, Peter. "Electric vehicle policy in Norway." Climate Change (2017). – Access mode: https://www.climatexchange.org.uk/media/2086/eu_case_studies_norway_transport.pdf
4. Official site of the Statistics Serves of Norway – Access mode: https://ofv.no/bilsalget/bilsalget-i-desember-og-hele-2008
5. Прімєрова, О., Дадашова, П. (2015). Вивчення економіки методами системної динаміки в Національному університеті"Києво-Могилянська академія".

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MODELLING OF FISCAL TRANSMISSION CHANNELS USING SYSTEM DYNAMICS METHOD

In the process of fiscal transmission, impulses from the State fiscal service of Ukraine are transmitted through dedicated channels to the real economy and facilitate the stimulation or slowdown of business activity of business entities, which leads to a change in macroeconomic indicators and revenues in budgets of all levels, and therefore affects the level of economic development in country.

Each of the taxes is transformed into a channel of fiscal transmission in the process of determining its main components: the taxpayer, the object of taxation, the tax rate, as well as tax benefits, restrictions and payment frequency [3].

The problem of tax system is an insufficient amount of tax earnings to the budget. The amount of tax earnings is increasing last years, but Ukraine still has the deficit of the state budget. This is due to the fact that Ukraine has a large share of the shadow economy as we have high tax rates compared to other countries. That is why, state budget doesn't have enough revenues and it becomes the main problem of economy. To solve this situation, it is necessary to use mechanism of the fiscal transmission.

Considering the main hypothesis in the model, it may be accented that:

taxes ↓→ available income ↑→ aggregate demand↑→ consumption↑→ production volume↑→ unemployment rate↓→ state budget revenues↑→ ;

taxes ↑→ available income ↓→ aggregate demand↓→ consumption↓→ production volume↓→ unemployment rate↑→ state budget revenues ↓→ [3].

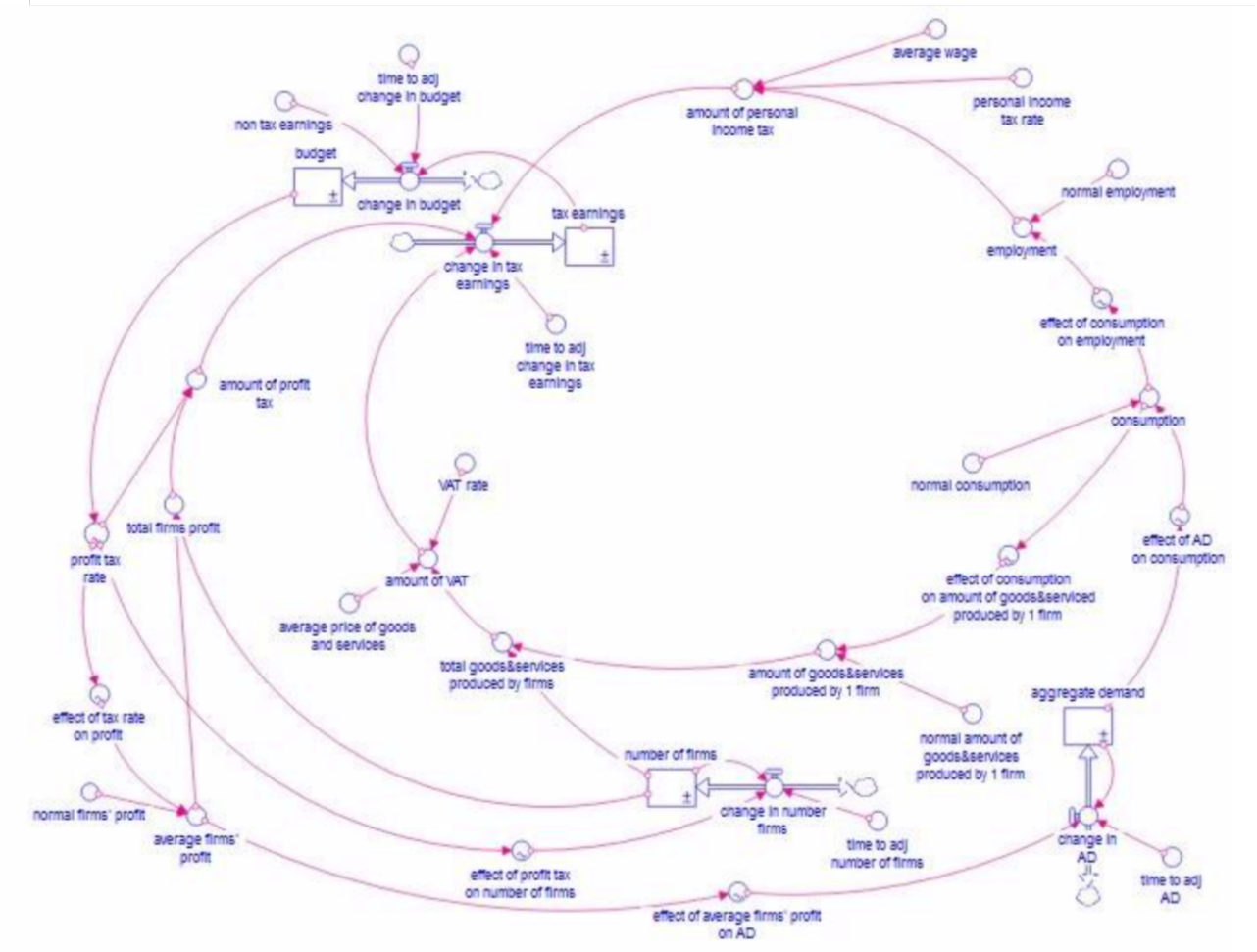

Figure 1. Fiscal transmission channels model

Following the trend of historical data of the tax earnings, we can see that simulating the model shows that the model and historical data almost coincide and they have the similar tendency of curve. During the period from 2011 to 2014, the curve is slowly increasing. This variable is growing more sharply from 2014 to 2018. During the period from 2014 to 2018, it was needed more revenues in the state budget for reforming different spheres of the economy and military defense funding.

Using this type of modeling, we can get an idea of the real processes and analyze their behavior that we want to explore. However, various tests are also required to verify and draw conclusions the model's results. Therefore, it was conducted analyzing the effects and sensitivity test. Effects help us to consider what effects model has between the indicators. One of the effects is the more tax earnings, the more budget revenues. It is logical and corresponds to real life as the most part of budget revenues consists of tax earnings. Applying the sensitivity test of the different variables, it was shown that the time to adj number of firms has the greatest impact on tax earnings.

Having considered the limitations of impact of taxes on economic indicators, simplifications were used for building this model. These simplifications concern the types of taxes as it was chosen only those taxes that occupy most of the tax earnings in the revenues of state budget. This model has only 3 types of taxes are profit tax,

personal income tax and value added tax. But there are other types of taxes such as excise tax and duty tax. For further improve the model, it can be added these 2 types of taxes for better problem research and representation of results of the model.

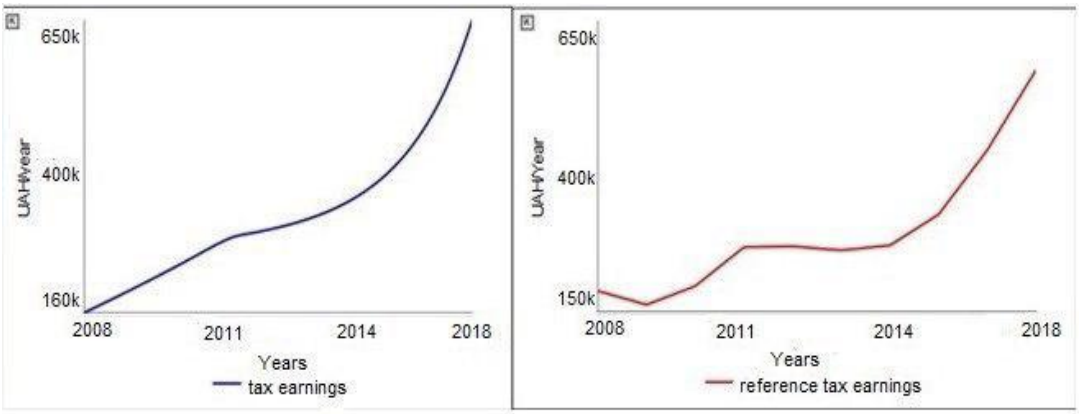

Figure 2. Comparison of model and historical data of the tax earnings

Another way to improve the model is adding the other factors that are affected by taxes. These factors can be budget expenditures, state debt (external and internal debt) and budget deficit. Budget expenditures show how budget revenues are spent and used. Budget expenditures also are spent for covering the debt. Tax earnings increase throughout the entire period, but Ukraine still has a budget deficit. So, to improve this model it can be added the deficit of the budget. But it has some problems to do it because budget deficit measures in negative numbers and it can influence on all model.

References

1. Wheat, D. I. (2007). The Feedback Method: A System Dynamics Approach to Teaching Macroeconomics. PhD thesis, University of Bergen.

2. Official site of the State Statistics Service of Ukraine [Electronic source] – Access mode: http://www.ukrstat.gov.ua/

3. Panchenko N., Shen H. Influence of fiscal transmission channels on macroeconomic indicators. Матеріали Міжнародної науково-практичної конференції студентів, аспірантів і молодих вчених «Національні та світові фінансово-економічні системи в умовах сучасних викликів» 30 січня 2019 р. Київ. НаУКМА.

4. Алімпієв Є.В. Податковий канал фінансово-монетарної трансмісії в економіці України. Економічний часопис – XXI. 2013. №5-6(2). С. 24-26.

5. Лук'яненко, І., Віт, Д. та ін. (2017). Системний аналіз формування державної політики в умовах макроекономічної дестабілізації.

6. Abakumova, J., Primierova, O. (2018). Economic Growth, Globalisation and Income Inequality: The Case of Ukraine. Economics, 10, 11th.

7. Лук’яненко І.Г. Напрями реформування бюджетно-податкової системи в Україні // Економіка,Фінанси, Право, Київ, 2004.- № 6.- С.26-32.

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SYSTEM DYNAMIC MODEL OF UKRAINE'S EXTERNAL SECTOR

Ukraine is considered an open economy as it is engaged in international trade and is a participant in the global financial markets. In order to explore the economic relations of our country with the rest of the world, it is necessary to analyze Ukraine's balance of payments. Balance of payments is a statistical report that systematically reflects economic transactions between residents and non-residents over a period of time. Its main elements are a current account that includes material assets (goods and services) and a financial account that reflects nonmaterial assets (investments, loans and bonds).This research focuses on current account analysis.

The persistence of the country's current account is an important indicator of macroeconomic stability. Therefore, research into the causes of current account deficits and assessing its normal level is necessary for effective public policy. In particular, according to economic theory, the exchange rate is the main factor that influences on the current account. In order to confirm this, consider the dynamics of the current account balance of Ukraine from 2010 to 2018 (Figure 1).

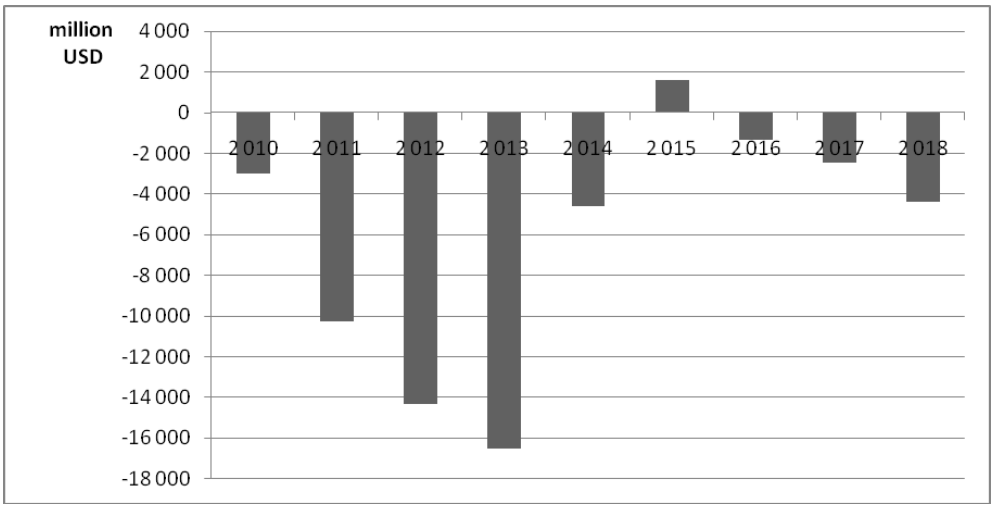

Figure 1. Current account balance of Ukraine from 2010 to 2018 (million USD)

As the graph shows, the current account deficit has been steadily widening from 2010 to 2013. This can be explained by the fact that during this period the exchange rate was fixed, ie the National Bank of Ukraine artificially maintained the hryvnia at one level. Low hryvnia exchange rate contributed to increase in imports and reduced competitiveness of Ukrainian exports. In 2014, Ukraine switched to a flexible exchange rate regime. After that, the hryvnia was heavily devalued; therefore, imports became very expensive. These changes were reflected in the current account surplus in 2015. Since 2016, the current account deficit is widening again, but not very significantly.

System dynamics were used to model the external sector of Ukraine. This type of simulation helps to illustrate the interconnections of elements of the external sector of the economy and to determine the response of model variables to certain changes, such as how the hryvnia appreciation affects Ukrainian exports.

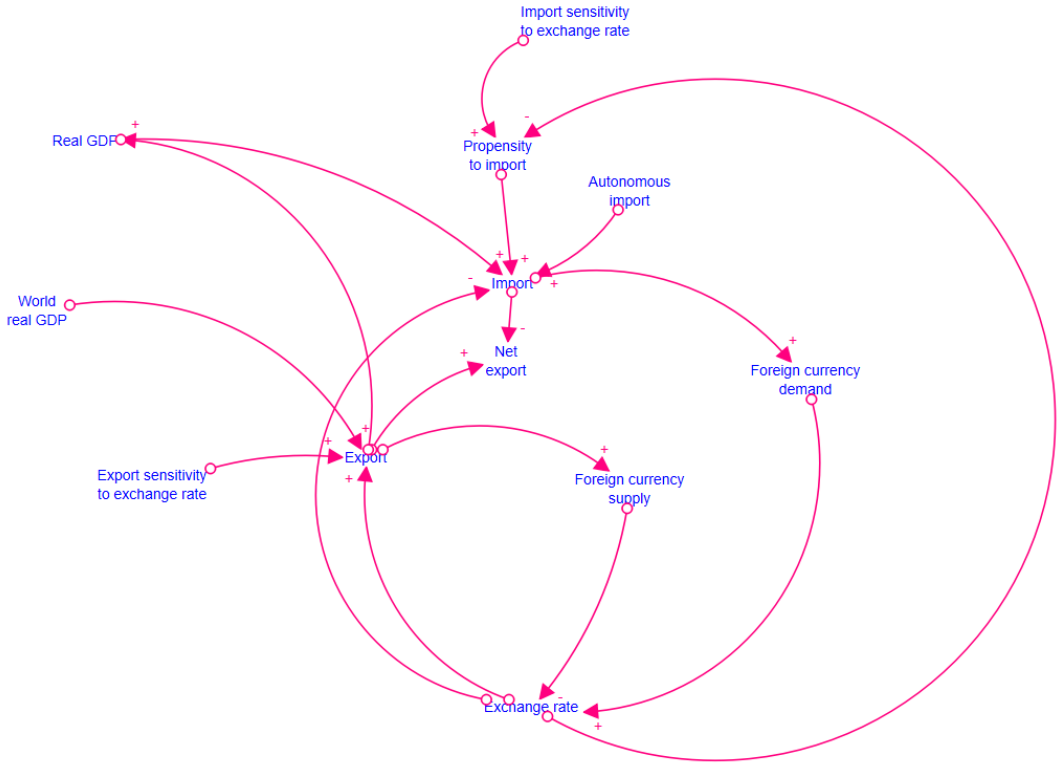

Figure 2.Causal loop diagram of the external sector of Ukraine

The constructed causal loop diagram (Graph 2) shows the logic of interconnections in the external sector of Ukraine, in particular, explains the mutual influence of the exchange rate and exports, imports. In the beginning, it is important to note that the model assumes that the exchange rate regime is flexible. Then it is necessary to define logical assumptions for all the variables included in the diagram. The first hypothesis is that real GDP has a positive effect on imports and exports. For example, if a country's GDP grows, then it has more income to buy more imported goods. In terms of exports, the real world GDP is important: if world GDP grows, then other countries can buy more, and accordingly, more Ukrainian goods can be sold abroad. The diagram shows imports are also influenced by autonomous import, for example, it reflects the need for some goods or services that cannot be produced in our country. In addition, imports are influenced by the propensity to import, which in turn depends on the import sensitivity to changes in the exchange rate. If the coefficient of sensitivity increases, then the response of imports to changes in the exchange rate will also increase. The same logic is for the coefficient of export`s sensitivity. According to economic theory, imports increase the demand for foreign currency, and exports increase its supply. Then the demand and supply of foreign currency affect the exchange rate of the national currency: the increase in demand for foreign currency depreciates the hryvnia, and the increase in the supply of foreign

currency, on the contrary, strengthens the hryvnia. In the next step of the system, the exchange rate has a positive effect on exports and negatively on imports. As the hryvnia exchange rate increases, exports increase as Ukrainian goods become cheaper compared to foreign ones. For import goods, this is the reverse, if the hryvnia becomes cheaper, then it becomes more expensive to buy foreign goods. The last variable is the difference between export and import, that is, in this model; it reflects the current account balance.

A system dynamic model is useful for exploring the relationships between the variables of the external sector of the Ukrainian economy. In order to continue this research, the model should be improved. In particular, it is necessary to add variables related to the financial account of the balance of payments (FDI and portfolio investments). In addition, variables reflecting state policy (discount rate, foreign exchange intervention) and world conditions (world CPI, world interest rate) should be added.

References

1. Official site of the National bank of Ukraine: https://bank.gov.ua/statistic.
2. Yamaguchi K (2007). Balance of Payments and Foreign Exchange Dynamics: SD Macroeconomic Modeling. Proceedings of the 25th International conference of The System Dynamics Society.
3. Пазізіна К. Платіжний баланс і макроекономічна стабільність у перехідній економіці: порівняльні аспекти. // Журнал Європейської економіки. Том 3(№2), 2004.– 32 с.
4. Лук'яненко, І., Віт, Д. (2017). Системний аналіз формування державної політики в умовах макроекономічної дестабілізації.
5. Фарина О. І. Концептуальніпідходи до побудови макромоделі економікиУкраїни методами системної динаміки / О. І. Фарина, П. А. Дадашова. – К.: НаУКМА, 2015.
6. Abakumova, J., Primierova, O. (2018). Economic Growth, Globalisation and Income Inequality: The Case of Ukraine. Economics, 10, 11th.

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A VIRTUAL EXPERIMENT IN PHYSICS LESSON BY THE SYSTEM DYNAMICS APPROACH

Formulation of the problem. The modern stage of development of the system of physics learning experiment characterize by the wide introduction of in-formation and communication technologies and means of virtu-al reality. Making of the modern learning methodical complexes which provides integration of real and virtual learning experi-ment is appropriate. Digital information kit is an essential com-ponent of this complex. It is a set of electronic learning means that together represent a model of learning process and designed for practical using by teachers and students [1, p. 123].

Presentation of the main material. Consider the following distance and time problem: Jennifer and Jamin were on opposite ends of the country, a distance of 3200

miles. At the same time both started driving toward one another. Jennifer drove at a constant speed of 62 miles per hour. Jamin drove at a constant speed of 53 miles per hour. How many hours elapsed before the two met one another? And how far had each one traveled? The answer to this problem is shown in the graph. Visual presentation of the solution with the help of the created model encourages children to analyze the material studied and to apply the acquired practical skills in everyday life.

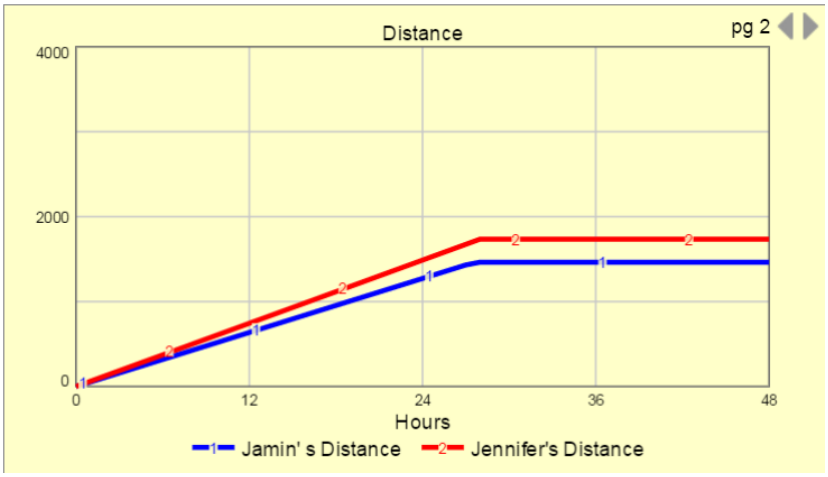

Figure 1. Dynamics of Distance

Figure 2 will find us with children consuming the reality of their pets. So we can compare the real speeds of cats or dogs living at home. This method of using system dynamics is suitable for the interest of 7th grade children in studying physics at school through short-term projects.

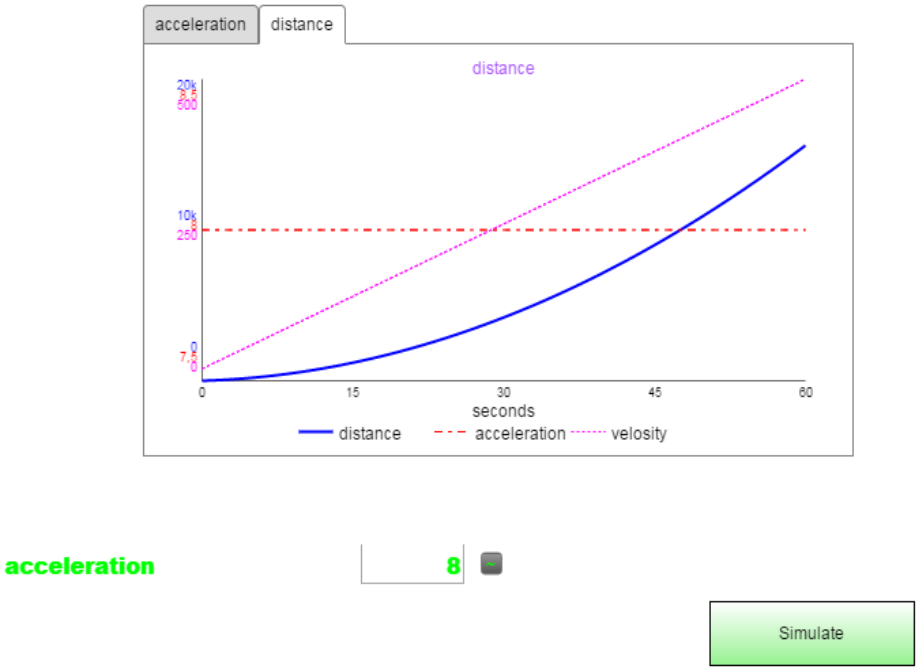

Figure 2. Dynamics of Distance, Velosity and Accelaration

If you like Xtreme sports, bungee jumping is the game for you. The sport is exciting. The pace is fast. And the risk is real! But maybe you don't have a bungee jumping facility nearby. Or maybe you don't have a strong desire to test the bungee cord with your life. If that's the case, virtual bungee jumping is what you want. And you can get it right here. Your challenge in the first round of experiments is to choose the best bungee cord for your weight. When you jump with the "best" cord, you will almost (but not quite) touch the pavement below the platform. Too few strands in your bungee cord will send you crashing into the pavement and too many will give you a short ride. In the second round of experiments, you can do bungee jumping on a variety of planets. You'll have complete control over the apparatus. You'll truly be able to boldly go where no person has gone before! You have two options for exploring the structure of this model. First, you can take a guided tour, in which you can walk thought, the essential structure of the virtual bungee, which is an idealized spring-mass system. Just hit the spacebar to walk through the key relationships that govern a simple harmonic oscillator (Figure 3).

Or, if you'd like, you can look at the model that was used for the second round of simulations. It is on your choice. In either case, when you're all done, you can click the home button to return to the main screen.

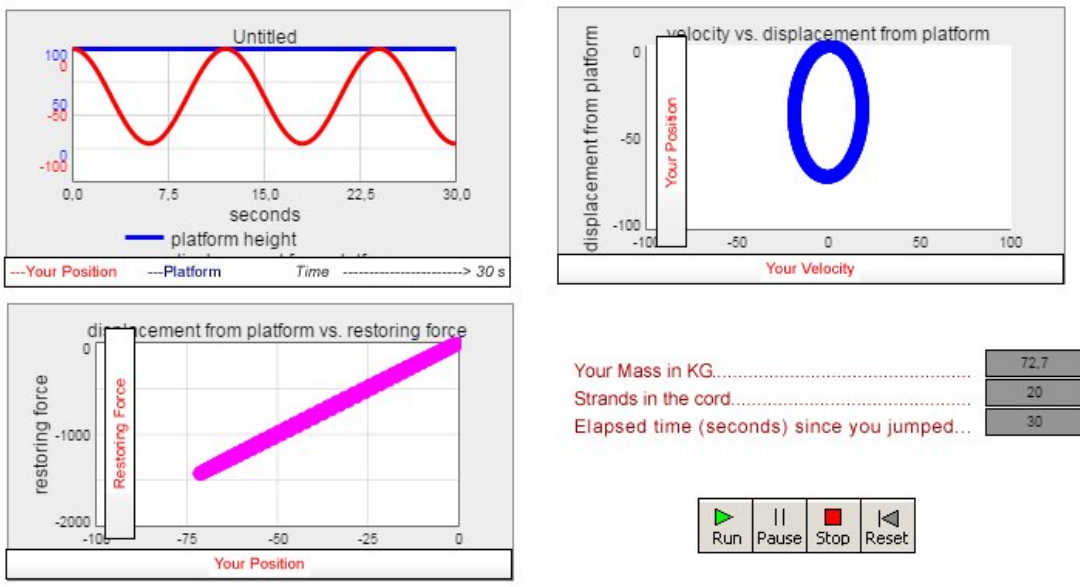

Figure 3. Harmonic oscillations

Conclusion. Experience in the introduction of system dynamics to the teaching of physics has shown that it not only eliminates the use of other methods and forms of training, but also facilitates their skillful combination.

The use of such an approach to teaching physics in the modern school is the implementation of an active approach to learning, focused on the development of cognitive and creative abilities of students enshrined in the Concept of physical education. I am convinced that the future of the Ukrainian school is to transform it into a circle of comprehensive and harmonious personality.

References

1. V. Salnyk Virtual and the Real in the Educational Physical Experiment of the Senior School: Theoretical Foundations: [monograph]. - Kirovograd, 2015, 324 p.
2. 2. Computer Science. Computer Engineering. Computer Technology: Textbook for Students of Higher Educational Institutions / Ed. O. I. Pushkar – K., 2002, 246 p.
3. Karshiev, X. (2016). Electronic means and methods of teaching to increase the efficiency of the educational process. *Young Scientist*. – №14. – P. 539–542.
4. Poiasok, T. B. (2010). Elektronni zasoby navchannia: pedahohichnyi aspekt Pedahohichnyi protses: teoriia I praktyka. – N2. – S. 164–169.
5. Chernylevskyi, D. V. (2002). Dydaktycheskye tekhnolohyy v vysshei shkol. :ucheb. Posobye dlia vuzov. – M.: Yunyty-Dana. – 437s.
6. Fisher, Diana M. «Lessons in Mathematics a dynamic approach».
7. Прімєрова, О., Дадашова, П. (2015). Вивчення економіки методами системної динаміки в Національному університеті"Києво-Могилянська академія».
8. Лук'яненко, І., Віт, Д. (2017). Системний аналіз формування державної політики в умовах макроекономічної дестабілізації.

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SYSTEM DYNAMIC MODEL OF BACKWARD–LOOKING MONETARY POLICY DECISIONS

In developed countries, the primary objective of monetary policy is to achieve and maintain price stability in the country. Stabilization policy means how policymakers should use their tools to influence the behavior of inflation and output. Stabilization policy often begin from an assumption that their goal should be to keep inflation low and stable and to minimize departures of output.

The goals of stabilization policy should be models that give accurate statements about how the policy should be conducted, so here we consider a model where private behavior is backward- looking.

In our model, economy is described by two equations, one characterizing aggregate demand and the other characterizing aggregate supply. The first equation is the representation of the traditional curve IS. The second equation is the representation of Phillips curve. The following two equation describe the behavior of the two driving processes- shocks to the IS curve and to the flexible- price level of output. Also we assume that ε_t^{IS} and ε_t^{Y} are independent white- noise process. The final equation suggests that there may be a constant gap between the Walrasian and flexible- price levels of output.

The model is described by such system of equations:

$$y_t = -\beta r_{t-1} + u_t^{IS}, \beta > 0 \quad (1)$$

$$\pi_t = \pi_{t-1} + \alpha(y_{t-1} - y_{t-1}^n), \alpha > 0 \quad (2)$$

$$u_t^{IS} = \rho_{IS} u_{t-1}^{IS} + \varepsilon_t^{IS}, -1 < \rho_{IS} < 1 \quad (3)$$

$$y_t^n = \rho_Y y_{t-1}^n - \varepsilon_t^Y, 0 < \rho_Y < 1 \quad (4)$$

$$y_t^* - y_t^n = \Delta, \qquad \Delta \geq 0 \quad (5)$$

where y_t^n is the economy's flexible- price level and y_t^* is Walrasian levels of output.

After observing u_t^{IS} and y_t^n, the central bank chooses r_t. So central bank minimizes $E[(y-y^*)^2]+\lambda E[\pi^2]$, where λ is a positive parameter that shows the relative weight bank puts on inflation and where the most desired level of inflation is normalized to zero.

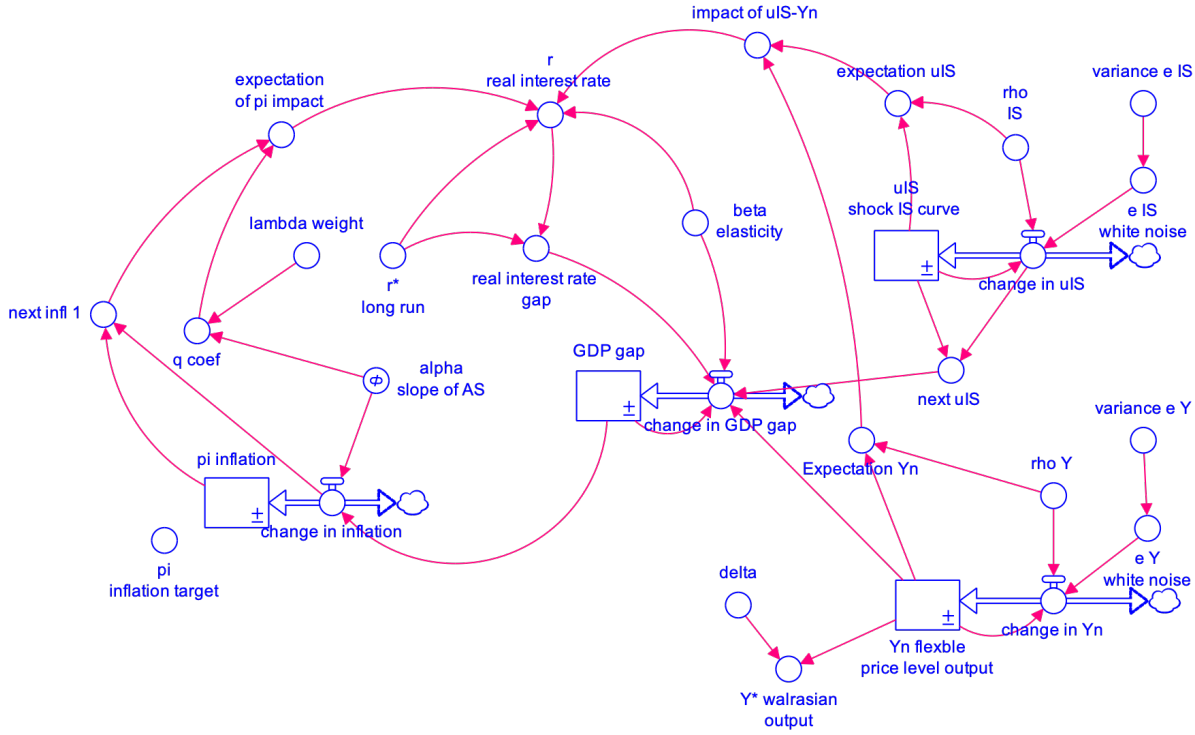

Figure 1. Backward - Looking model with System Dynamics

If λ approaches zero: the central bank doesn't care about inflation and pay more attention to bring departure of output gap to natural level. Then it follows that inflation is random walk.

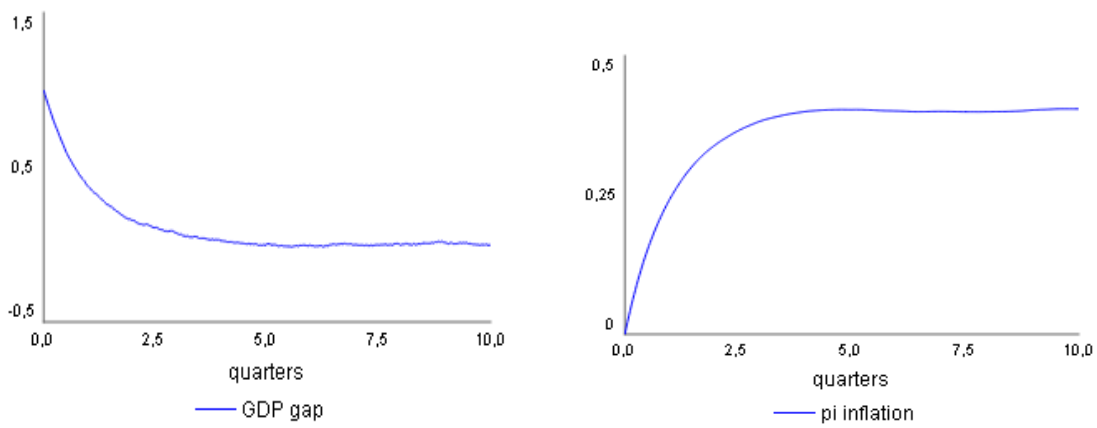

Figure 2. The choice of Central Bank $\lambda = 0$

If λ approaches infinity, this corresponds to a policy of returning inflation back to zero as soon as possible after shock. As λ approaches infinity, the variance of output does not approach infinity: even if the central bank cares only about inflation, it wants to keep output close to its natural level to prevent huge changes in inflation.

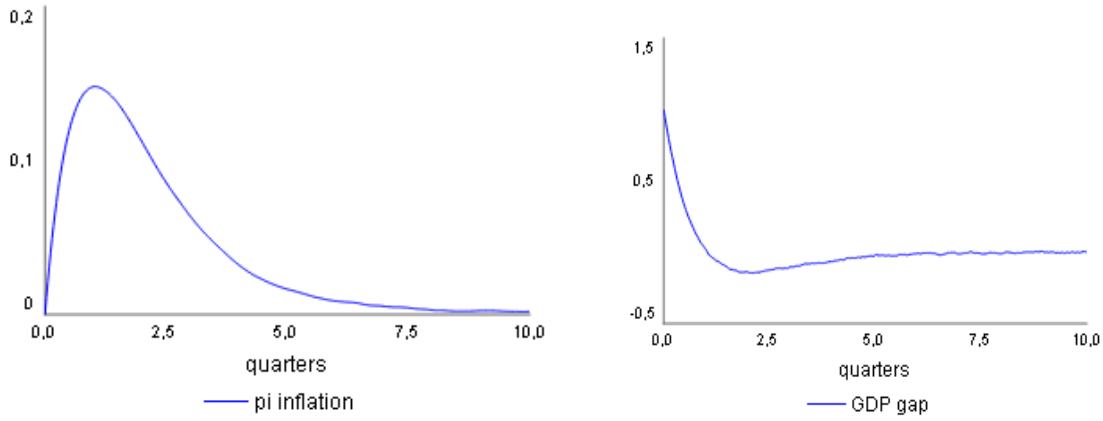

Figure 3. The choice of Central Bank $\lambda = 200$

If λ rises: the central bank pays more attention to stabilizing inflation, it induces departures of output from its natural rate to return inflation to its optimal level after a departure.

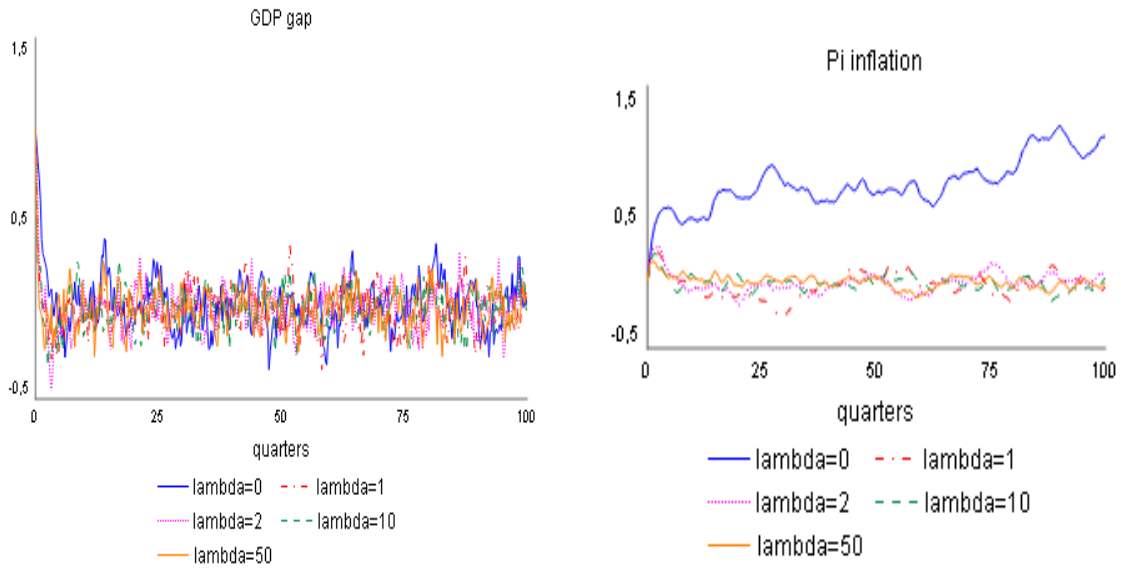

Figure 4. The choice of Central Bank $0 \leq \lambda \leq 50$

The central bank cares about inflation, it should react aggressively to changes in both output and inflation to keep inflation under control; responding to one but not the other is inefficient.

At present time, the issue of monetary policy is very relevant because of its impact on the economic system of Ukraine. Monetary policy itself, as an integral part of the economic policy of the state, has a decisive influence on the course of

economic processes in a market economy. Solving these problems and further implementing the NBU with effective and adequate monetary policy conditions will be important prerequisites for ensuring the socio-economic development of Ukraine. Therefore, we will continue to explore the peculiarities of monetary policy, in particular, using the system dynamics method.

References

1. Romer, D., (2012). Advanced macroeconomics. University of California, Berkeley.
2. Sterman, J.D. (2000). Business Dynamics: System Thinking and Modeling for a Complex World. New York, Irwin. McGraw- Hill. 982 p.
3. Wheat, D. I. (2007). The Feedback Method: A System Dynamics Approach to Teaching Macroeconomics. PhD thesis, University of Bergen.
4. Official site of the National Bank of Ukraine – Access mode: https://www.bank.gov.ua/.
5. Прімєрова О.К., Янчук В.О. (2017) Особливості монетарної політики в Україні на сучасному етапі.
6. Лук'яненко, І., Віт, т.,та ін. (2017). Системний аналіз формування державної політики в умовах макроекономічної дестабілізації.

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MODELLING WAGES AND PRICE BY USING SYSTEM DYNAMICS

Wages as an indicator is not only an indicator that determines the overall standard of living of employees. From this status and forms of realization, the shares in GDP largely depend on the possibilities of economic development in general. In a modern market mechanism, wages are becoming an increasingly important factor in the reproduction of social production. This indicator acts as one of the main regulators of the labor market. However, the analysis and assessment of the impact of wages on the labor market and, above all, the employment in Ukraine is not given due attention, which leads to negative consequences - accelerated growth of unemployment, the destruction of motives and incentives to work, etc.

The dynamics of real wages in the country characterize the dynamics of the real standard of living of the living wage population. Real wage indices make it possible to relate it to other economic indicators, such as employment, income and consumption, and production. The wage calculation is usually related to the total number of hours worked and the average wage in the country:

*Average Wage * Total Hours*

The average wage is a drain in our model because the initial nominal hourly wage is the average wage that changes all the time.

The average wage increase is calculated by multiplying the average wage by delaying the rate of wage growth:

*Average Wage * Delayed Wage Growth Rate*,

where *Delayed Wage Growth Rate = DELAY1 (Indicated Wage Growth Rate; Wage Adjustment Delay)*

Consider now the price index, which characterizes the change in the overall price level of goods and services purchased by the population for non-productive consumption. Inflation processes in the country's economy are characterized by the consumer price index, which is the most important indicator and is used to solve many questions of public policy, review the size of household income, analysis and forecast of price processes in the economy, conversion of national accounts to constant prices.

Consumer price index depends on the combination of two information flows: - data on changes in prices obtained through registration of prices and tariffs on the consumer market;

- data on the structure of actual consumer monetary expenditures of households living in urban settlements.

Δ price index is calculated by dividing the difference between the desired price index and the actual price index by the price adjustment time:

$$\frac{(Desired\ Price\ Index - Price\ Index)}{Price\ Adjustment\ Time}$$

Thus, to perform a more accurate analysis of the monthly wage dependence on the dynamics of the consumer price index (in percentage), annual statistical information for the period from 2006 to 2017 was used, and the model was constructed using Stella Architect (Figure 1).

Labor market conditions, supply and demand operate at national and local levels and determine wage rates. When there is a shortage of workers who have the skills, experience and education needed to perform certain tasks, the employer may offer higher pay to those who meet certain requirements. That is, if the demand for a particular type of skilled workforce is higher than the supply, then wages will be higher, and vice versa. Also, wages are affected by the cost of living, according to which the size is adjusted. This approach tends to vary wages depending on changes in the cost of living index after rising or falling overall prices and the consumer price index.

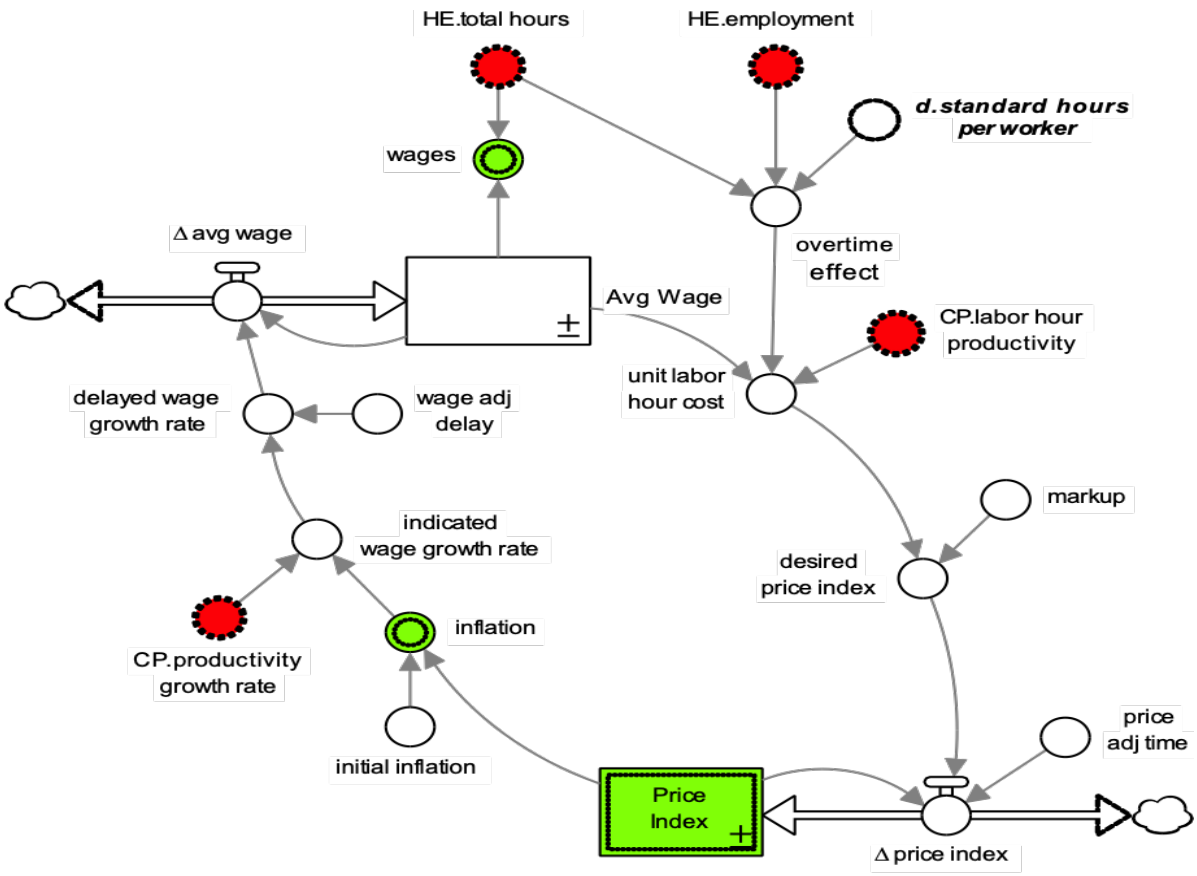

Figure 1. Wages and price index model

Therefore, slow wage growth leads to a link between wages and prices. The analysis reveals that wages and prices tend to move together, complicating efforts to separate cause and effect.

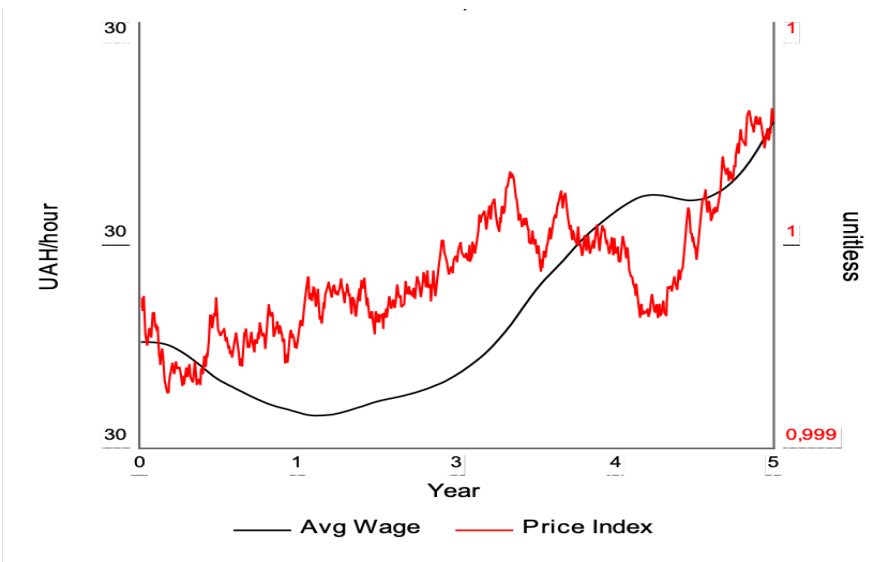

Figure 2. Behavior the average wages and price index

Payment (price) for labor is in the form of monetary compensation, which the employee receives in exchange for his labor for his personal professional characteristics, working conditions. Instead, the cost of labor reflects the cost of human resources used to produce any product or service. Factors such as quality of labor, child labor and labor of migrants, labor productivity, new needs, the rise in prices of various services are most evident in the increase or decrease in real wages as a monetary expression of labor cost and labor cost and productivity.

Having analyzed the situation on the Ukrainian labor market in 2006-2017 years, it is proved that GDP per 1 worker, ie productivity, does not correspond to the size of the average monthly wage, but there is a correlation between them.

Proper stimulation of work in the enterprise, in turn, will lead to increased productivity, which will increase the real product and income. And an increase in GDP per capita means an increase in consumption and, consequently, in the standard of living of the country's population.

References

1. Barlas, Y. (2007) System Dynamics: Systemic Feedback Modeling for Policy Analysis.Knowledge for Sustainable Development. Vol.1, UNESCO, Oxford, pp. 1131 – 1175.
2. Stelmashenko, I., Lukianenko, I., Wheat, I. D. (2015). Learning Economics with Dynamic Modeling. A Norwegian-Ukrainian Collaboration Project. 2
3. Sterman, J. D. (2000). Business Dynamics: Systems Thinking and Modeling for a Complex World. New York, Irwin. McGraw- Hill. 982 p.
4. Shone, R. (2003). An Introduction to Economic Dynamics, Cambridge, New-York, 224 p.
5. Abakumova, J., Primierova, O. (2018). Economic Growth, Globalisation and Income Inequality: The Case of Ukraine. Economics, 10, 11th.

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MODELING THE MECHANISM OF INTEREST RATE FORMATION ON BANK LOAN USING SYSTEM DYNAMICS METHODS

Features of modern development of Ukrainian banks are intensification of banking business, actualization of competition in banking and, at the same time, increase of threats to credit security. Such processes create challenges for banks to maintain financial sustainability and to obtain a market level of profit. Unauthorized pricing decisions for banking products and services may impair the bank's position in the market. As a result, there is a need for the organization and effective management of the bank's pricing policy.

To date, the main characteristic of pricing in commercial banks of Ukraine is the lack of a clear correlation between the consumer value of the banking service and its price. In these circumstances, the bank has the ability to maneuver prices across wide limits, pursuing different pricing policies for different clients, using prices as an important means of attracting customers and promoting services. Pricing is one of the most important aspects of a bank's marketing activities, a management lever that allows it to shape the bank's profit.

First step in modeling the pricing decisions on banking loans is to figure out the main parameters, which affects this kind of decisions. To begin with, the concept of a future model of system dynamics (Figure 1) should be created, distinguishing the main cause and effect relationships of the factors studied. Then, based on the concept, we build a credit-pricing model (Figure 2) with a focus on metrics that can be expressed endogenously.

The key indicator of the model is the interest rate on bank loans in Ukraine (Interest rate on loans). We consider the order of influence of the main macro- and microeconomic factors on the interest rate on the loan, taking as theoretical basis the interest channel of the transmission mechanism of the discount rate. The interest rate channel is the main channel of the monetary policy transmission mechanism through which the central bank influences the money market and the economy. Its action is based on the effect of the discount rate on changes in market interest rates at which economic entities place and raise funds, and through them - on decisions on consumption, savings and investment, and therefore on the level of aggregate demand, economic activity, inflation and price stability.

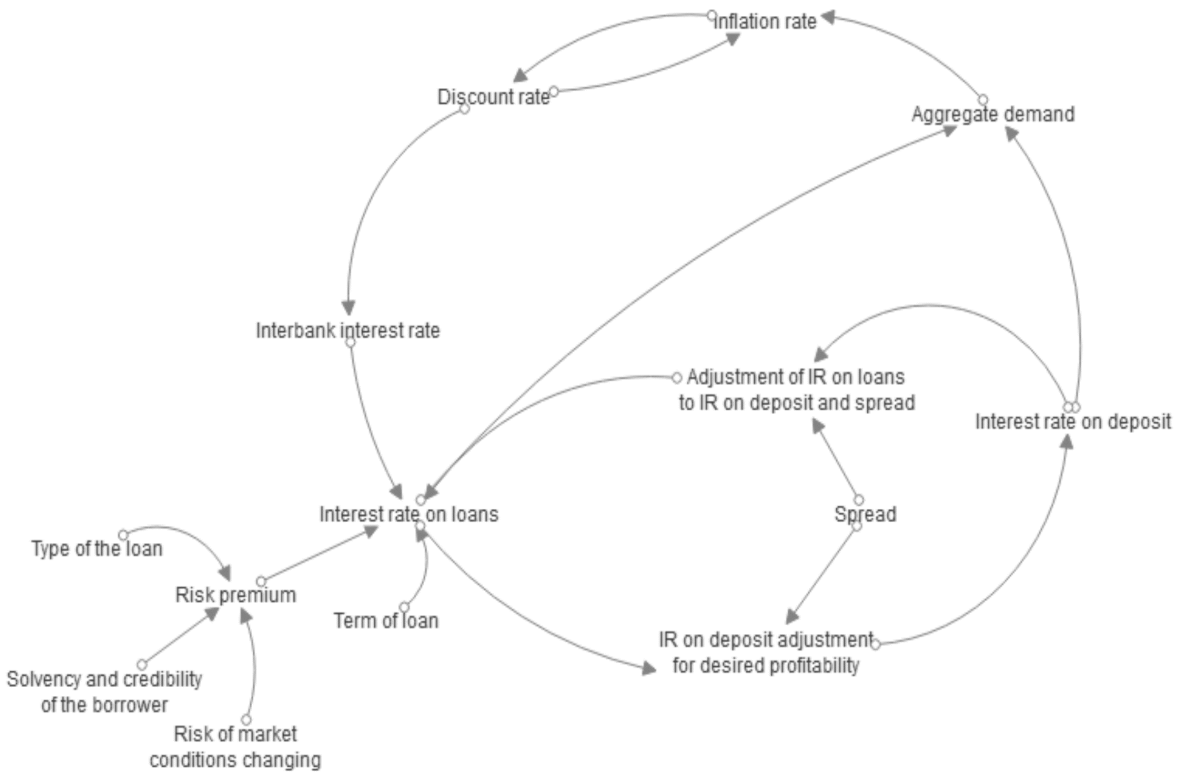

Figure 1. Concept of the model of interest rate formation for banking loan

Figure 1 shows us the change in aggregate demand affects the inflation rate in the country, which is reflected by the change in the interest rate (depending on the current policy of the NBU). The interest rate directly affects the price of credit resources in the banking market (interbank interest rates), which in turn changes the

interest rate on loans. However, the interest rate on the loans also depends on the risk premium, which collects information about the riskiness of individual loans, including such basic characteristics as the type of loan, the borrower's creditworthiness and the risk of market conditions changing. Interest rates on loans and deposits have a reciprocal effect. The interest rate on loans affects the interest rate on deposits through adjustments to the desired level of profitability. In fact, the volatility of interest rates on loans and deposits mainly depends on changes in interbank rates (macro-levels), followed by weighing the desired level of profitability on active and passive operations of a commercial bank.

After the conceptualization phase, we proceed to build a model of system dynamics, identifying the major exogenous and endogenous factors, estimating the latter through equations. The constructed model of the mechanism of the interest rate formation for banking loan is shown in Figure 2. This model can be considered simplified, the discount rate is expressed by an exogenous variable (actual NBU data for the period 2005-2019 are used to reflect the behavior of the discount rate time series).

Figure 2 shows that the discount rate affects the interbank rate with some adjustment, and due to this, it reflects the change in interbank rate on an annual basis.

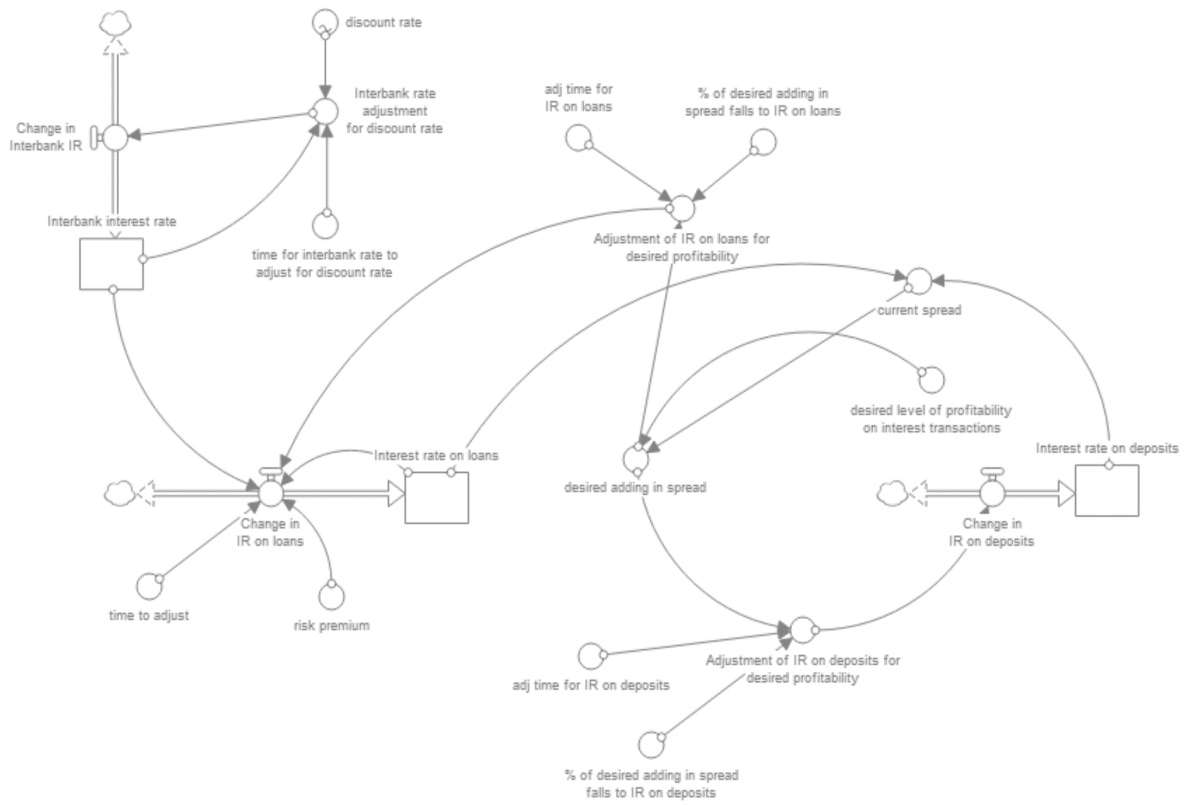

Figure 2. Simplified model of mechanism of interest rate formation on banking loans

The interbank interest rate, together with the risk premium, is already the basis for the interest rate on loans. Such impact also comes with a time to adjust. At the

same time, the bank determines the allowance for this rate (adjustment of IR on loans for desired profitability), which depends on the level of the margin to maintain the profitability of banking (desired adding in spread in the model). The model yield adjustment is as follows: there is a desirable margin level that the bank wants to obtain from the desired spread of interest and a current spread, calculated as a loan rate minus the interest rate on deposits. Then we calculate the desired margin addition (desired adding in spread). This indicator influences the change in interest rates on loans and deposits, divided into two parts in a certain ratio: depending on the competitive market conditions, some of the preferred rate falls on the adjustment of the deposit rate, and the other part on the adjustment of the loan rate.

To conclude with, the built model of system dynamics allows reflecting in a simplified form the mechanism of pricing for loans of commercial banks. In addition, the developed model allows not only reproducing the historical development of the studied indicator; it can serve as a basis for revealing the power of the influence of individual means of regulation on the behavior of the system.

References

1. Wheat, D. I. (2007). The Feedback Method: A System Dynamics Approach to Teaching Macroeconomics. PhD thesis, University of Bergen.
2. Mishkin F. Financial Markets and Institutions (8th Edition) / F. Mishkin, S.Eakins. – Boston: Pearson Prentice Hall, 2011. – 704 c. – (Pearson).
3. Watson C. Banking Operations / C. Watson. – Edinburg: Chartered Institute of Bankers in Scotland, 2008. – 233 c.
4. Banks' Reports of Demand and Credit Standards since 2008: Results from Norges Bank's Survey of Bank Lending [Electronic resourse] / K. Lindquist, M. Olav, M. Riiser, H. Solheim. – STAFF MEMO. – 2016. – #16. – P. 1-22.
5. Farina O. I. Conceptual approaches to the construction of macromodels of Ukrainian economy by system dynamics methods / O. I. Farina, P. A. Dadashova. - K.: NaUKMA, 2015.
6. Прімєрова О. К. Особливості монетарної політики в Україні на сучасному етапі // Ефективна економіка: електронне наук. фахове вид. - 2017. - №. 10/
7. Лук'яненко, І., Віт, Д. (2017). Системний аналіз формування державної політики в умовах макроекономічної дестабілізації.

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SYSTEM DYNAMICS MODELING OF MIGRANT REMITTANCES' INFLUENCE ON THE ECONOMIC GROWTH

The continuous flow of migrants from third countries, developing countries, and countries that are involved in various conflicts like political, social, and economic, is of particular relevance. That leads to the inevitable long-term imprints on the economy of different states. IZA World of Labor represents a global perspective. They estimated that a 10% increase in emigration rate leads to a 4% growth of wages in the country of origin on average. In addition, according to the WTO statistics over the last 30 years, the number of free trade agreements worldwide

has only grown annually, increasing from 7 in 1991 to 260 in 2019. It means that economics become more open to people. Therefore, a more detailed study of migration phenomenon may help to analyze such a new vector of influence for the economic growth of small open economies and improve relations between countries.

The last decade represents several scientists that researched this topic from different sides like economic, political, social and historical. However, the basis for it is Everett Lee and his work The Migration Theory (1966). There is a differentiation between the push (threats) and pull (opportunities) factors. As a migration process is the result of the interaction of them, Lee suggests that the final decision to move depends on the balance of positive and negative factors in the place of origin and destination. The balance in favor of the relocation should be sufficient to overcome the natural inertia and intermediate obstacles. As for intervening difficulties, Lee understands ethnic barriers and personal reasons. Push factors are those, which motivate people to leave their place of origin to the outside areas. For instance, poor economic activity, lack of job opportunities, conflict, drought, famine or political intolerance. Pull factors are attractive forces in the area of destination which are found in metropolitan areas. They are also known as place utility, which is the desirability of a place that attracts people. Good economic opportunities, more jobs, and the promise of a better life often pull people into new locations.

Another theory is the new economy of labor migration. Migration can affect economic growth from different directions, but especially the remittances sent by immigrants to their countries of origin, they bring in extra capital, which is what households need.

Private migrant remittances are international transfers and the flow of resources to households coming from other countries and mainly related to temporary or permanent migration. They can be done through official channels - through banks, international money transfer systems, post offices, and informally - by transferring cash and other tangible assets from one household to another.

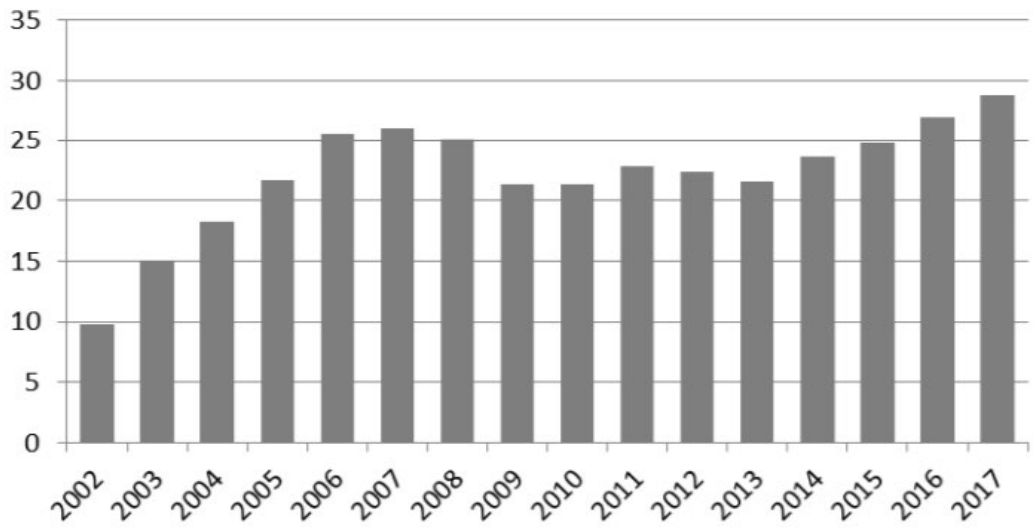

Figure 1. Annual Money Flows to Mexico, Billion USD USA, 1981-2017

Source: MPI data from the World Bank's Prospectus Group

For example, Mexico is one of the largest recipients of remittances from citizens who work outside the country, so remittances are critical to the Mexican economy and its development. In general, since the late 1990s, money transfers have been an important source of income for many Mexicans. In 1996-2007, remittances increased from $ 4.2 billion to $ 26.1 billion. As shown in Figure 1, over the last ten years, there has been a trend towards increased remittances of Mexican migrants. Even 2017, although accompanied by a slight decrease in the number of immigrants, funds still tend to increase. In 2017 these remittances accounted for about 3% of the country's GDP.

As we can see, migration remittances occupy not a small part of GDP and significantly affect the economic development of the country. The connection between the labor market and economic growth is represented in Figure 2.

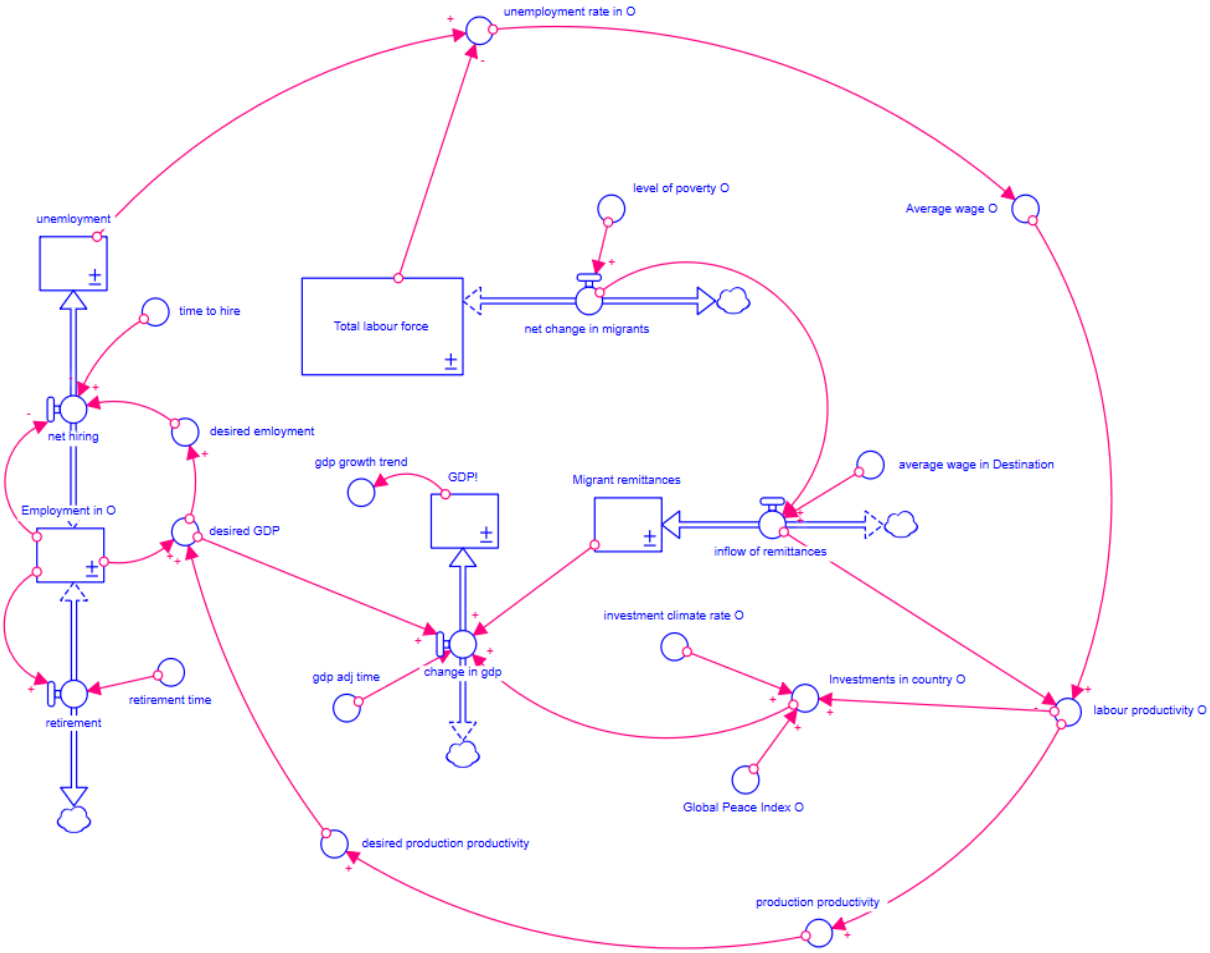

Figure 2. The simplified view of the migrant remittance influence model

The main goal of the recreation of those capital flows is to investigate the importance of them for small open economies like Ukraine and to understand their influence on economic growth factors like GDP. There are a few hypotheses confirming or refuting of which this research will be dedicated:

- Migrant remittances from destination country positively influence GDP;

- The outflow of the potential workforce creates a lack of qualified workers in the labor market. This has direct pressure on businesses forcing them to increase wages in the origin-country to attract “young blood”;
- The larger is inflow of remittances influence the lower is labor productivity.

To be sure, that the results are valid and efficient this model will be tested for consistency, experimental and practice checks to be done as well.

The idea of further development is to add more factors that could influence the labor market that will need separation to other branches or forming a supplementary model for the country of destination. That will help to see how this interaction between both economics stimulates an increase in potential economic growth and which other advantages they could receive from it.

Migration has been a historically positive phenomenon as migrants bring new ideas and high motivation. They contribute to the economy of their host countries and even more to the economies of their countries of origin by sending money transfers to their families. Therefore, regulating migration paths can reduce fluctuations in irregular migration, stabilize capital and investment flows, economic linkages between countries, and improve competition in the labor market, which in turn will contribute to the overall economic growth of the country.

References

1. Asia Center (n.d.). Trends by Status (cumulative) - Free Trade Agreements. [online] Aric.adb.org. Available at: https://aric.adb.org/fta-trends-by-status.
2. Elsner, B. (n.d.). Does emigration increase the wages of non-emigrants in sending countries?. [online] IZA World of Labor. Available at: https://wol.iza.org/articles/does-emigration-increase-wages-of-non-emigrants-in-sending-countries/long.
3. Lee, E. S. (1966). A Theory of Migration. Demography, 3 (1), 47-57.
4. M. Nicholson, t. (2017). The Facts on Immigration Today: 2017 Edition - Center for American Progress. [online] Center for American Progress. Available at: https://www.americanprogress.org/issues/immigration/reports/2017/04/20/430736/facts-immigration-today-2017-edition/.
5. Abakumova Ju., Primierova O. Economic growth, globalization and income inequality: the case of Ukraine // Proceedings of 18th International Scientific Conference Globalization and Its Socio-Economic Consequences (10th – 11th October 2018). Part VI. – Inequality in Society, P. 2445-2452.
6. Clemens, M., Huang, C., Graham, J. and Gough, K. (2018). Migration Is What You Make It: Seven Policy Decisions that Turned Challenges into Opportunities. [online] Cgdev.org. Available at: https://www.cgdev.org/sites/default/files/migration-what-you-make-it-seven-policy-decisions-turned-challenges-opportunities.pdf.
7. Novik A. (2018) Modeling Of Migration Flows As A Regulator Of Economic Growth // Proceedings of the 1st Research Conference "Conference System Dynamics Modeling for Public and Corporate Finance: Background and Opportunities", p. 39-41
8. Ortega P. Remittance Flows from the U.S. to Mexico at the State Level: Drivers and Trends (2018) [online] / P. Ortega, M. Orozco // Remittence Industry Observation. Available at: https://www.thedialogue.org/wp-content/uploads/2018/12/Mexico_Final_ Blog.pdf.
9. Abakumova, J., Primierova, O. (2018). Globalization, growth and inequality: testing causality and asymmetries. Ekonomicko-manazerske spektrum, 12(2), 83-95.

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SYSTEM DYNAMIC MODELLING OF INFLATION

Inflation is a socio-economic phenomenon, generated by the disproportion of production in various spheres of market economy. At the same time, inflation is one of the most acute problems of the current economic development of almost all countries of the world, especially in Ukraine. One of the goals of the National Bank of Ukraine is low and stable inflation. As prices rise, they start to affect the general cost of living for the public and the central bank takes the necessary measures to keep inflation within permissible limits.

In order to reduce the negative impact of inflation on the economy of Ukraine, and consequently on the quality of people's lives, it is necessary to know the inflation processes, factors that generate them, and to be able to prevent them. That is why we investigated the inflation model of Ukraine. The purpose of the project was to make the inflation model relevant to the Ukrainian economy.

Our task was to investigate the SFD of the New Keynesian Monetary Policy Model especially inflation part and apply it for Ukrainian data, identify and analyze the causes of inflation in Ukraine, understand the behavior of the inflation of Ukraine and compare it to the output variable of the model.

Model Structure. Since inflation accumulates over time and it takes time to see the change in inflation, we consider inflation as a stock. We know that stocks can change only through the flows. In our model, we have netflow Δ inflation that calculates difference between indicated and current inflation per adjustment time. This difference we called the gap between indicated and current inflation.

From the New Keynesian Phillips curve: Inflation in the current time depends on its value in the previous period, the central bank's target value in the next period, and the output gap in the current period.

The inflation equation is expressed as:

$$inflation_t = a1 * inflation_{t-1} + (1 - a1) * inflationtarget_{t+1} + \\ + b1 * outputgap_t \quad (1)$$

This equation defines *indicated inflation* that adjusts over time in our model. Variables indicated inflation, inflation and Δ inflation creates negative feedback loop. Negative feedback loops act to bring the state of the system in line with a goal or desired state (Sterman, 2000). Our case brings inflation to indicated inflation. Indicated inflation is influenced by 4 exogenous factors such as *inflation target, output gap, parameters a1* and *b1*.

Central bank's inflation target is goal for inflation that a central bank publicly announces and commits to achieve over the medium term (2-3 years). The output gap is the difference between actual GDP and potential GDP. In our model output gap measured in terms of its percentage deviation from the potential GDP. We can show it as a formula:

$$100 * (GDP - Potential\_GDP * Normal\_Capacity\_Utilization) / (Potential\_GDP * Normal\_Capacity\_Utilization),$$

where normal capacity utilization is assumed to be 100 per cent of potential GDP.

The parameter a1 ($0<a1<1$) reflects the credibility of the central bank's monetary policy makers. If the Central Bank commits to an inflation target, is capable of reaching that target, and has demonstrated its capability well enough for its commitment to be credible, a1 will be close to zero, ideally zero from the perspective of policy makers. If a1=0, indicated inflation equals the central bank's inflation target plus the effect of the output gap. If a1=1, the Central Bank's target has no effect on inflationary expectations, and indicated inflation equals current inflation plus the output gap effect. The parameter b1 ($b1>0$) reflects the unitless output gap effect on inflation.

When indicated inflation is determined, the inflation adjusts towards that value over time. Adjustment time is speed with which inflation adjusts to indicated inflation. After one adjustment time, 63% of the initial gap is corrected. After two adjustment times, the state of the system is moved 86% of the way to the indicated value. After three adjustment times, the adjustment is 95% complete. Technically, the gap is never fully corrected; there is always some small fraction of the gap remaining at any finite time. However, for all practical purposes adjustment is complete after three to four adjustment times have passed when goal is constant value. But we have more complex process because indicated inflation is not a constant; it changes with the output gap and with prior inflation. Yet the seemingly separate impacts on indicated inflation are actually interrelated and have offsetting effects. An adjustment time constant of 1/3 year was selected because the full adjustment of the gap between inflation and its indicated value would occur in about one year after a change in the output gap.

The one year period for a full adjustment of inflation is suggested by empirical observations at the Bank of England: “The empirical evidence is that on average it takes up to about one year in this and other industrial economies for the response to a monetary policy change to have its peak effect on demand and production, and that it takes up to a further year for these activity changes to have their fullest impact on the inflation rate.” (Bank of England, 1999).

Figure 1 represent the SDF of inflation model:

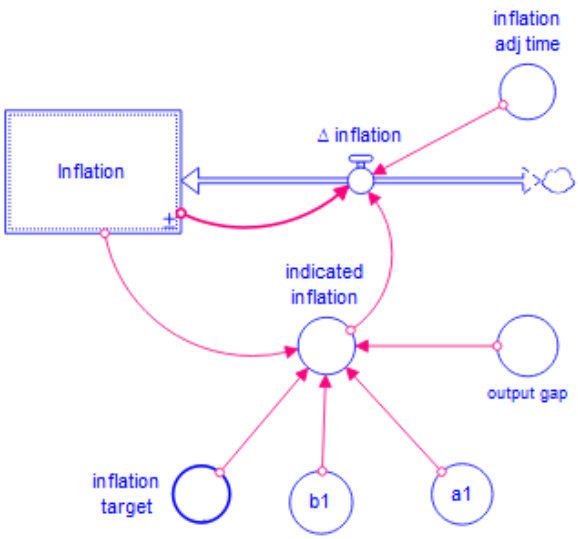

Figure 1. System dynamic model of inflation adjustment process

Historical background. Since the National Bank of Ukraine moved de facto to inflation targeting in 2016 we considered the time horizon for our study from 2016Q4 to 2018Q3. The time units of model are years. All data are quarterly. The data, which are used in this project, are mostly taken from the site of the National Bank of Ukraine – bank.gov.ua. All data don't include temporarily occupied territory of Crimea and the part of the anti-terrorist operation zone.

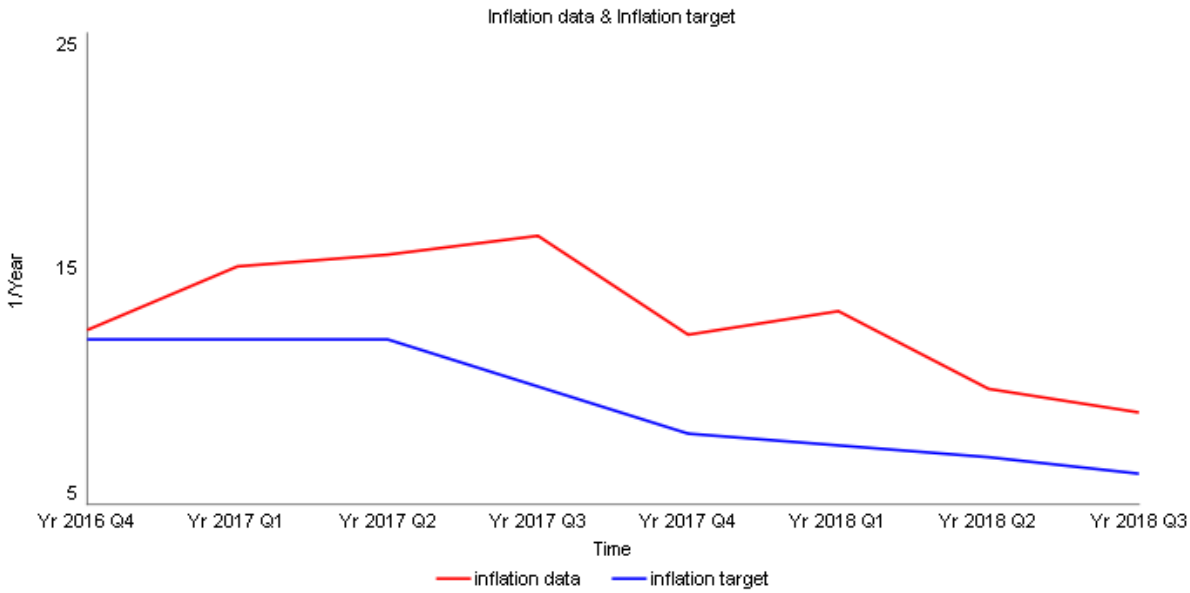

Figure 2. Dynamics of inflation and inflation target in Ukraine

The National Bank implemented the inflation target for 2016 at a level of 12% ±3 because of balanced fiscal and monetary policy. Reductions in inflation also contributed to cheapening grain prices on world commodity markets as a result of a record world harvest this year, slowing down imported inflation in a context of low exchange rate volatility and improving inflation expectations.

Inflation in 2017 was higher than the NBU's forecast, which is primarily due to the following factors: faster growth in raw food prices (large export volumes and a decrease in supply on the back of a decrease of livestock pushed prices for meat and dairy products upwards); higher production costs, and a revival of consumer demand (double the increase of the minimum wage at the beginning of the year); weakening of the hryvnia exchange rate. Starting in 2017Q4, inflation will decrease and approach the targeted level. The reduction of inflation will be conditioned by a rather tight monetary policy, the decay of the impact of a sharp rise in food prices, further slowing down of imported inflation in the context of relatively low exchange rate volatility, and a drop in the growth of raw food prices.

In first quarter of 2018, inflation remained above the targets. The main reason for the high inflation was the continuation of the rapid rise in food prices. This was due to a decrease in production volumes in agricultural products and intensive exports of food.. However, in order to reduce the increase in inflationary pressure, the National Bank has continued the cycle of tighter monetary policy - twice raised the discount rate. In the second-third quarters of 2018, consumer inflation is moderate slowed down. The decrease in inflation was due to the expansion of the supply of domestic and imported food products, as well as the decline in world food prices. However, the fundamental inflationary pressure remained significant, which is the result of a steady expansion of consumer demand, which is supported by high rates of increase in Ukrainian wages (28% more than in the previous year), which far exceeds the growth rate of the economy.

References

1. D. Wheat, M. Oliskevych. The Canonical New Keynesian Monetary Policy Model: A System Dynamics Translation
2. Sterman, J. D. (1984). Appropriate summary statistics for evaluating the historical fit of system dynamics models. Dynamica.
3. NBU Inflation report (October 2016, October 2017, October 2018)
4. Paul G. Fisher, Lavan Mahadeva and John D. Whitley. The output gap and inflation - experience at the Bank of England
5. Richard Clarida, Jordi Galí, and Mark Gertler. The Science of Monetary Policy: A New Keynesian Perspective.
6. Official site of the National Bank of Ukraine [Electronic source] – Access mode: https://www.bank.gov.ua/.
7. Official site of the State Statistics Service of Ukraine [Electronic source] – Access mode: http://www.ukrstat.gov.ua/.
8. Прімєрова О.К., Янчук В.О. (2017) Особливості монетарної політики в Україні на сучасному етапі.
9. Лук'яненко, І., Віт, Д. (2017). Системний аналіз формування державної політики в умовах макроекономічної дестабілізації.

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