Pokydko Anastasiia
Master student, NaUKMA

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).

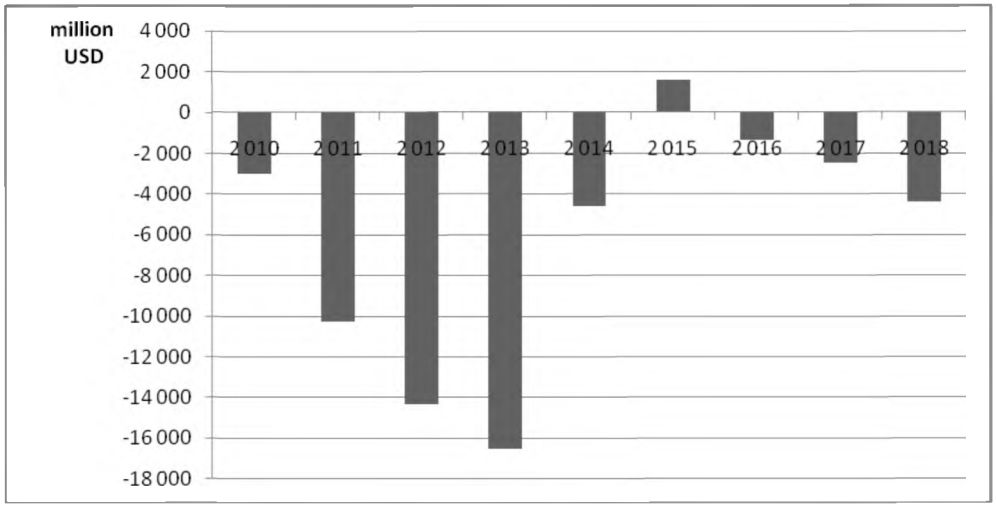

Figure 1. Current account balance of Ukraine from 2010 to 2018 (million USD)

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.

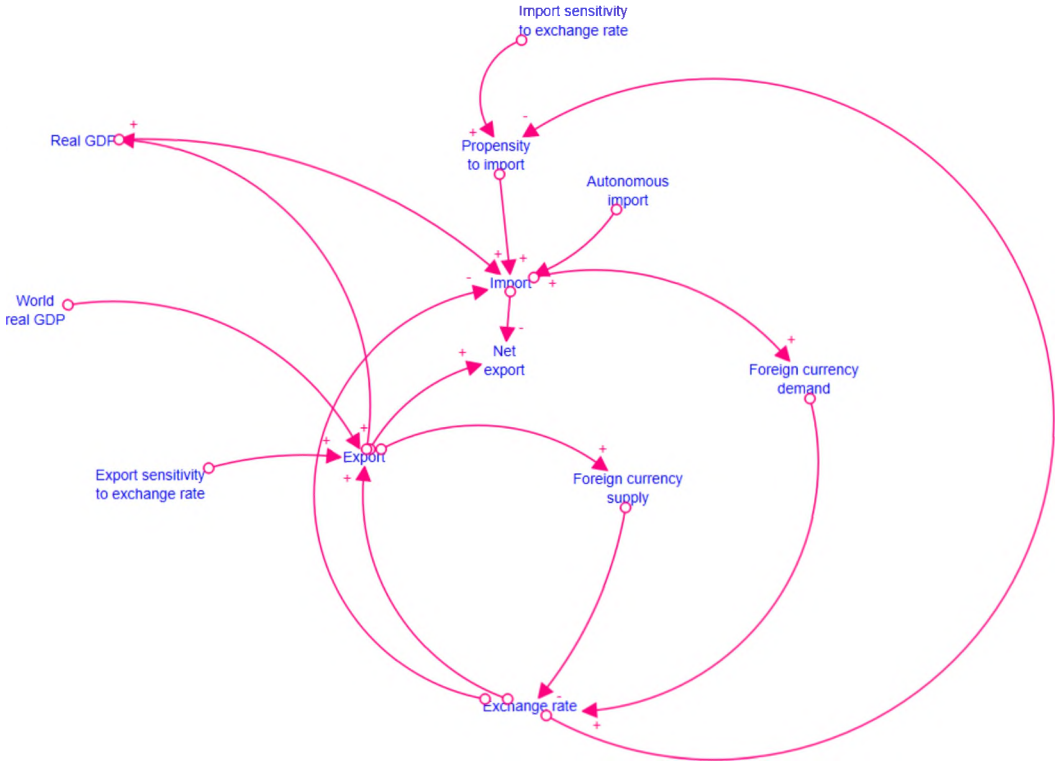

Figure 2.Causal loop diagram of the external sector of Ukraine

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.

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Protsyshak Lesia
Teacher of Physics of the highest category of
Lviv Academic Gymnasium at the National University "Lviv Polytechnic"

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