



## MODELING THE MACROECONOMIC TRANSMISSION ENVIRONMENT: PUBLIC SECTOR IMPACT USING THE MONEY AND FINANCIAL MARKET MODEL

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### ABSTRACT

**Goal:** The systemic macroeconomic environment is represented by economic and mathematical models that describe basic conditions for transmissions. Transmission mechanisms are formed not only by monetary policy instruments but also by other macroeconomic tools and factors that launch self-organizing processes, in particular, cyclicity and economic growth. **Methods:** To define such transmissions, the authors used the main macroeconomic models and functions that describe the institutional sectors of the economy; consumption and investment functions; arguments and functions underlying the balance of payments; and identity of national accounts. **Results:** An example of non-monetary transmissions is the influence of the public sector using the model of monetary and financial markets. The proposed methodological approach can be an economic and mathematical basis for developing software systems focused on forecasting economic dynamics, predicting monetary and financial crises, and managing the development of the national economy.

**Keywords:** Macroeconomics; Systemic macroeconomic environment; Transmission mechanism; Innovations; Economic and mathematical modeling; Macroeconomic forecasting.



MODELAR O AMBIENTE DE TRANSMISSÃO MACROECONÓMICA: O IMPACTO  
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## RESUMO

**Objetivo:** O ambiente macroeconômico sistêmico é representado por modelos econômicos e matemáticos que descrevem as condições básicas para as transmissões. Os mecanismos de transmissão são formados não apenas por instrumentos de política monetária, mas também por outras ferramentas e fatores macroeconômicos que desencadeiam processos auto-organizados, em particular, ciclicidade e crescimento econômico. **Métodos:** Para definir tais transmissões, os autores utilizaram os principais modelos e funções macroeconômicas que descrevem os setores institucionais da economia; funções de consumo e investimento; argumentos e funções subjacentes ao balanço de pagamentos; e identidade das contas nacionais. **Resultados:** Um exemplo de transmissão não monetária é a influência do setor público usando o modelo de mercados monetários e financeiros. A abordagem metodológica proposta pode ser uma base econômica e matemática para o desenvolvimento de sistemas de software focados em prever dinâmicas econômicas, prever crises monetárias e financeiras e gerenciar o desenvolvimento da economia nacional.

**Palavras-chave:** Macroeconomia; Ambiente macroeconômico sistêmico; Mecanismo de transmissão; Inovações; Modelação econômica e matemática; Previsão macroeconômica.

## 1 INTRODUCTION

The economic and mathematical modeling of responses of the economic system to various factors opens up new opportunities for improving the management of the national economy and its innovative development through indirect influence on the macroeconomic system (Savina et al., 2020; Tsenina et al., 2022).

These opportunities emerge throughout a systematic study of the macroeconomic environment as a self-sufficient agent of influence on the self-organization of the economy due to the identification of new types of transmissions (i.e. mechanisms for the transmission of economic signals). If we find a connection between transmissions and innovative processes, the study of the systemic macroeconomic environment becomes more relevant for considering self-organization in the field of innovative development (Veselovsky et al., 2019).

Modeling transmission mechanisms will contribute to the creation of an advanced system for managing the development of the national economy based on information technologies (Dokholyan et al., 2022; Drobyshevskii et al., 2008). The use of these models as part of information systems will reduce the negative impact of subjective factors and increase the efficiency of achieving sustainable development goals on an innovative basis.

### ***Literature overview***

Macroeconomic transmissions are understudied in scientific literature. This is caused by the fact that, according to traditional ideas, transmission mechanisms are regarded not as an immanent property of the systemic macroeconomic environment in general, but as its small fragment, i.e. the transmission mechanism of the influence of monetary policy instruments (Ivanchenko, 2006; Moiseev, 2002). The reason for the spread of such a fragmented approach was the long-term neglect of the systemic macroeconomic environment (the environment in which all possible transmissions occur) as an independent phenomenon.

J. Keynes (2021) was the initiator of studying transmissions in the macroeconomic environment in his fundamental work. His theoretical concept defines transmissions as the transmission mechanism of monetary policy.

The post-Keynesian tradition preserved the monetary content of transmissions determined by the theoretical context of the scientific discussion between Keynes and representatives of the classical economic school (his opponents) (Bean et al., 2002). However, the concept of transmission mechanism did not exist in the classical analysis since the impact of monetary policy on the national economy was studied by checking the relationship between changes in the money supply and the gross product, based on the fact that the economy is a black box (Boivin & Giannoni, 2002).

The quantitative theory defines lags, i.e. periods during which prices and wages remain rigid (unchanged and insensitive to any changes in the money supply). Such periods are called short-term (Havraneka & Rusnak, 2013). Lags are very important for economic forecasting but are often neglected in real politics, especially for predicting monetary and financial crises (Krusec, 2010). Since one complete transmission can last from several months to several years, its inner links might be left unnoticed. Accordingly, the level of output (Boykova, 2022), prices, and wages does not depend on changes in the money supply in the short term but matters in the long term (the policy of the central bank and the banking system) (Karmanov et al., 2017). This effect is called the classical dichotomy (dual nature) (Kuttner & Mosser, 2002).

Keynes became the first scholar to study transmission mechanisms and introduce the concept of effective demand, i.e. a well-balanced demand of households and demand (investment) of companies. Intermediate and final consumption should be in a certain ratio, i.e. balanced. Unbalanced demand negatively affects the economy either by artificially created overproduction (underconsumption) or by eating up its

resources.

Demand is a function of disposable income, while investment is a function of interest rate. When considering the category of effective demand, one should proceed from the available income of households, interest rate, and investment (including savings), i.e. examine the market of money and finance (Barilenko et al., 2022; Kishan & Opiela, 2006). According to Keynes, the economy is in equilibrium under such an interest rate that equates the savings of households and the investments of companies. Therefore, the household income (employment), interest rate, and money supply ensured by the central bank will play an important role (Leonteva, 2013).

Keynes focused on the role of money in this process, the policy of the central bank and transmission mechanisms to transfer the influence of its instruments to macroeconomic indicators that condition demand. This is one of the key theses of his concept.

Today Keynes' followers practically repeat his definition of transmission mechanism as a mutually agreed system of indicators (variables), through which the money supply affects activities in the national economy (Aleem, 2010; Elbourne, 2008). This viewpoint consists in determining the channels of influence on the economy by means of monetary policy instruments (Moiseev, 2002). The method developed on its basis is often used by analysts who refer to such theses as transmission mechanism channels (Angeloni et al., 2002), shocks (Romer & Romer, 2004), structures (Boivin et al., 2008), and steps of transferring a monetary impact (Gelain et al., 2013).

However, this method does not answer several questions regarding the emergence of transmissions not only due to the use of monetary and financial instruments but also due to factors generated by economic systems in the form of cyclicity and changes in the direction of capital flows. These shortcomings become obvious when preparing and using macroeconomic forecasts. Traditional forecasts practically cannot predict the so-called sudden stops in capital flows (Borio & Zhu, 2012).

An exception is B. Bernanke's studies (Bernanke & Gertler, 1995). The scholar pushed the limits of the traditional theory and practical methods, namely, he considered the impact of coordinated fiscal and monetary policy on transmission in order to maintain capital flows, and promote anti-crisis measures by increasing liquidity pressure on the economy (the policy of quantitative easing Q1-Q3) and the financial sector during major threats to the US economy.

Another exception to this rule was the following studies (Dedola & Lippi, 2005; Elbourne & de Haan, 2006) which present models of monetary and financial crises for

emerging markets (Frolova et al., 2018). These are the first- (FGM) and second-generation (SGM) models that consider the influence of fixed exchange rates and spontaneous crises on the formation of transmission mechanisms. These studies do not formally deal with the topic of transmissions but are located in its framework.

One of the main reasons for invalid macroeconomic forecasts, which hinders their use for predicting monetary and financial crises, is the use of traditional economic and mathematical methods that do not consider the general economic dynamics caused by sharp changes in the direction of capital flows, as well as monetary and financial resources that stay behind unexpected crises (Altunbas et al., 2010; Shubtsova et al., 2020). The second reason is that transmission mechanisms are studied outside the related systemic innovation processes, whose impact on transmission mechanisms is not sufficiently considered. The third reason is the impact of the systemic macroeconomic environment (namely its maturity) on transmission mechanisms. There is also the problem of traditional approaches that do not meet modern challenges in transmission modeling. Overcoming this inertia requires developing the foundations for modeling the systemic macroeconomic environment.

The study aims at substantiating approaches to the economic and mathematical modeling of the systemic macroeconomic environment in order to form the basic conditions for macroeconomic transmissions.

The research objectives are as follows: 1. to analyze the scientific literature on the research topic; 2. to determine the basic conditions for transmission formed by the systemic macroeconomic environment; 3. to create a model of the systemic macroeconomic environment as an intermediate link transmitting the influence of the state and the central bank on the economy.

## 2 METHODS

To solve the above-mentioned tasks, we used the following general scientific methods: a) theoretical: the analysis of scientific sources on the research topic; b) mathematical modeling.

The study was conducted in three stages between August and September 2022.

At the first stage, we considered scientific and analytical works on the research topic. The analysis of publications on the outlined issues allows considering scientific approaches to the functioning of transmission mechanisms.

At the second stage, mathematical modeling was carried out to compile a

mathematical model of the systemic macroeconomic environment as an intermediate link transmitting the influence of the state and the central bank on the economy, as well as a transmission model caused by the influence of the government institutional sector.

The following provisions became the methodological basis of this study.

Firstly, there is a model of financial flows, which is the basis of the System of National Accounts. In the System of National Accounts, the main macroeconomic indicator is gross domestic product (GDP) as the sum of final consumption over a certain period. This international standard includes the main models and functions that describe the basic conditions for launching transmission mechanisms.

According to the System of National Accounts, the national economic system consists of four subsystems (stable institutional sectors of the economy): "households", "companies" (financial and non-financial corporations), "government" (general state administration), and "foreign sources".

Secondly, we determined the following relationships while studying the economic mechanisms of these sectors:

- Structural proportions of institutional sectors of the economy;
- Arguments and their functions that affect the consumption of each institutional sector.

### 3 RESULTS

The structural proportions of institutional sectors within the national economy are approaching the Golden ratio (Veselovsky et al., 2019). Thus, the consumption of three institutional sectors in terms of (1) is approximately 30%. If this proportion is violated, it causes crises, which can be regarded as an adaptive reaction of the economic system aimed at restoring the balance (the initial proportion). The relationship of institutional sectors is described through the national accounting identity:

$$Y = C + I + G + NE \quad (1)$$

where Y is the total income of all institutional sectors of the economy for a certain period of time (GDP), most often a year;

C is the consumption of the household institutional sector, which is a function of disposable income ( $Y - T$ ), i.e. its income (Y) minus taxes (T); all taxes and tariffs in the economy are included in the price of final products and are paid by households as final consumers:

$$C = C(Y - T) \quad (2_1)$$

The Keynesian theoretical basis for the study of household consumption (2\_1) was supplemented by the theory of consumer behavior developed by M. Friedman, F. Modigliani, and A. Ando. Accordingly, the current real expenditures of households ( $C_t$ ) are determined by their real available income ( $YP_t$ ) and real wealth ( $W_t$ ). The equation (2\_1) of private consumption dependence in relation to welfare is as follows:

$$C_t = C_0 + \beta YP_t + \delta W_t + \varepsilon_t \quad (2_2)$$

where  $C_0$  is autonomous consumption;

$\beta$  is a propensity to consume due to income;

$\delta$  is a propensity to consume due to savings;

$\varepsilon_t$  is consumption shocks (an increase in consumption with a decrease in disposable income or a decrease in consumption with an increase in disposable income).

The coefficients  $\beta$  and  $\delta$  are related in the following dependence  $0 < (\beta + \delta) < 1$ . They follow from the Keynesian distribution of household income ( $Y$ ) into current consumption ( $C$ ) and deferred consumption ( $S$ ), i.e. savings.

If  $Y = C + S$  and  $Y$  is a unit, we get  $1 = MPC + MPS$ , where MPC is an extreme propensity to consume ( $dC/dY$ ) and MPS is an extreme propensity to save ( $dS/dY$ ). Subsequently, MPC and MPS are  $\beta$  and  $\delta$  proportions in the formula (2\_2), respectively. This was the exact subject of discussion between Friedman and Keynes. The former argued that the Keynesian extreme propensity to consume and save in the national economy is not equal to the maximum but rather to the average propensity. Thus, one should consider not propensity but proportions ( $\beta$  and  $\delta$ ), as shown in (2\_2) in contrast to (7).

Wealth is expressed by two variables: the ratio of stock market capitalization to GDP and aggregate real estate prices.

$I$  is investments of companies dependent on disposable income ( $Y - T$ ) and interest rate ( $r$ ):

$$I = I(Y - T) \quad (3)$$

$$I = I(r) \quad (4)$$

Only enterprises can invest using their own disposable income ( $Y - T$ ) and capital. This is essential for understanding the reasons for the reorientation of financial flows from small companies to large ones and the oligarchization of the economy in case of an increase in the interest rate (interest expenses) to critical values and the dominance of disposable income ( $Y - T$ ).

In formula (1),  $G$  is the consumption of the general state administration sector. It is only one of the four institutional sectors, not the entire economy. Its consumption depends on the state budget and parliamentary decisions on the state budget.

The consumption of the foreign sources sector (net exports ( $NE$ )); exports minus imports) is a function of the exchange rate ( $e$ ):

$$NE = Ne(e) \quad (5)$$

In the foreign sources sector, it is necessary to pay attention to the dependence between the consumption of products and the capacity of markets, which makes them dependent not only on the exchange rate but also on the disposable income ( $Y - T$ ) of their consumers:

$$NE = Ne (Y - T) \quad (6)$$

Formula (1) sets the structure of aggregate demand. The amount of demand cannot exceed the amount of income. Not all subsystems of the national economy can consume more than the value of GDP, i.e. the amount of income in the economy ( $Y$ ). If any subsystem (institutional sector) increases consumption, there will be another subsystem that will be forced to reduce consumption, i.e. the so-called crowding out effect.

In the absence of innovation processes, a decrease violating macroeconomic proportions causes crisis phenomena, as a result of which the balance between institutional sectors will be restored, but at a lower level of GDP ( $Y$ ).

In the systemic macroeconomic environment, each subsystem of the national economy consumes at the level of disposable income ( $Y - T$ ). Autonomous consumption ( $C_0$ ), which we consider the minimum possible consumption of an open economic system or its subsystem, does not depend on the available income but is carried out at its expense. Moreover, if there is no disposable income, autonomous consumption still exists. Keeping this in mind, the entire national economy (equation



(1) can be represented by a consumption function:

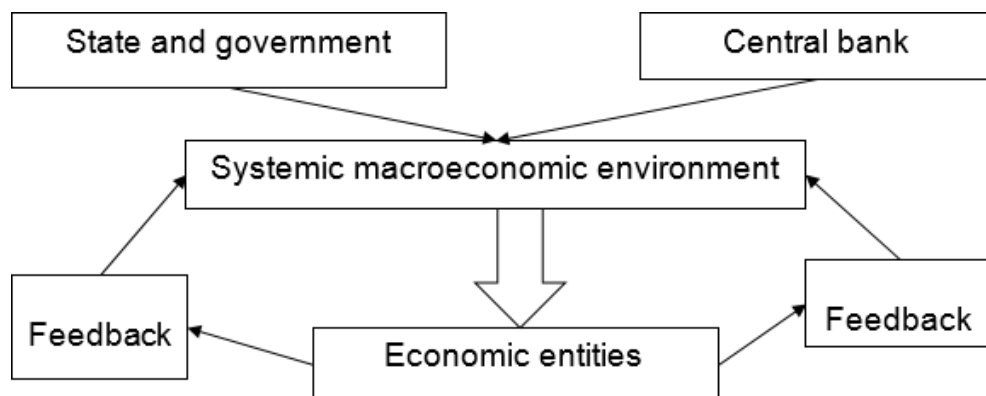
$$C = C_0 + C' (Y - T) \quad (7)$$

where  $C$  is the consumption of all four institutional sectors of the economy (1), GDP;  $(Y - T)$  is disposable income (income  $Y$  minus taxes  $T$ );

$C_0$  is autonomous consumption, i.e. the minimum required consumption of any institutional sector;

$C'$  is an extreme propensity to consume, an indicator of how much consumption will change if income ( $Y$ ) changes by one unit.

The variables in formulas (1-7) given in an aggregate form reflect the necessary (basic) macroeconomic conditions for the formation of transmission mechanisms as functional interdependencies in the systemic macroeconomic environment of the national economic system (Figure 1).



**Figure 1.** The systemic macroeconomic environment as an intermediate link transmitting the impact of the state and the central bank on the economy

The identification of the arguments and variable functions given in formulas (1-7) allows determining basic conditions for the flow of transmissions.

In addition to macroeconomic policy instruments (belonging to the state and the central bank), which purposefully form transmission mechanisms, the systemic macroeconomic environment also causes transmissions but in the mode of spontaneous self-organization.

One such interaction channel connects the "household" (people) and "government" sectors. It is defined by formula (2\_1). Consumption depends on disposable income  $(Y - T)$ . Taxes  $(T)$ , which reduce the available income of households, ensure the income

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of the general state administration sector. In formula (1), the consumption of the government ( $G$ ) depends on this flow. The optimal amount of taxes is 30% of GDP.

The second channel combines the households and companies sectors through savings ( $S$ ). The income that households have after all deductions is distributed to current and deferred consumption (savings). The latter become the main financial resource for investments.

In addition to monetary influence, there are other factors that form transmissions. All of them become obvious when we manage to determine the main conditions for their occurrence, i.e. to formalize the systemic macroeconomic environment.

Let us consider a model of transmission caused by the influence of the government sector. Figures 2-4 show the IS-LM model for a small closed national economy in the short term.

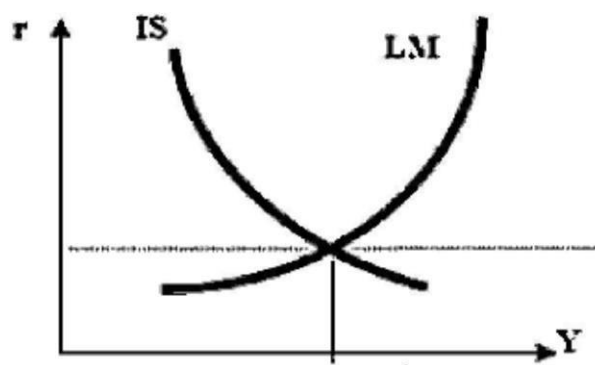


Figure 2. The IS-LM model, or Hicks-Hansen model

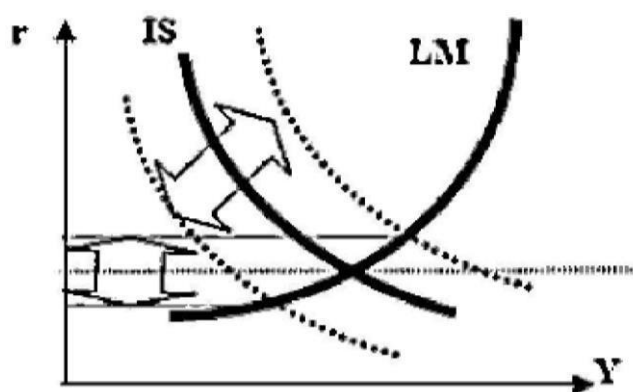


Figure 3. The impact of budgetary and financial policy

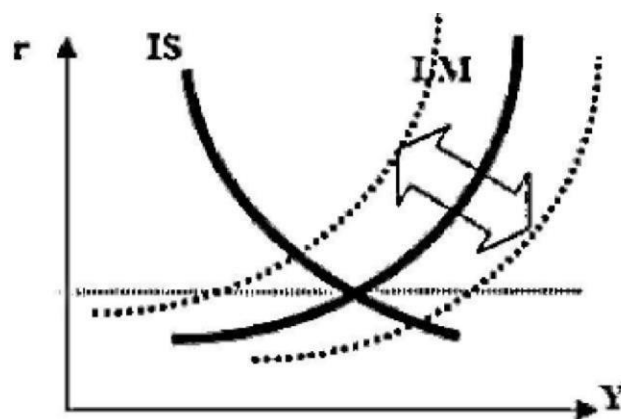


Figure 4. The impact of monetary and credit policy

The Hicks-Hansen model of the money market (Figure 2) assumes that investment (I) and savings (S) are equal and balanced by the market interest rate (r). Then formula (1) for a closed economy is as follows:

$$Y = C + I + G \quad (8)$$

To determine the transmission caused by the influence of the government sector, we assume that there is no change in prices (P), i.e.  $P = \text{const}$ .

If  $G_{t+1} = G_t + \Delta G$ , then  $(C + I + G) \uparrow$  will increase by  $(\Delta G)$ . An increase in aggregate demand for goods and services will form demand for money, which is shown by the IS curve in Figure 2-4. The IS curve in Figure 3 begins to shift to the right and up, resulting in an increase in the interest rate (r) and income (Y). Since the interest rate and income are arguments of the functions (2\_1), (2\_2), (3), and (4), both household consumption (C) and company investment (I) will change.

Figure 4 demonstrates the emergence of transmission due to the influence of monetary policy traditionally considered by post-Keynesian scholars.

#### 4 DISCUSSION

According to Keynes and his followers, the structure of monetary transmission mechanisms is a set of channels through which impulses are transmitted from monetary policy instruments to parties of economic relations. These often include (Angeloni et al., 2002) an interest rate channel, exchange rate channel, credit channel, price channel, cash flow channel, and household welfare channel.

The interest rate channel is considered the main one (Boivin et al., 2008). The

actions of the central bank lead to changes in real interest rates. This changes investment and consumer demand. New interest rates also affect other indicators, including output and employment (Krusec, 2010).

In addition, changes in interest rates affect the profitability and prices of various assets (securities, real estate, gold, etc.), forming an asset value channel that influences economic agents by changing the amount of their savings.

The amount of accumulated wealth determines the consumer and production decisions of economic agents. An asset is the amount of money reserves at the disposal of companies and people, whose real value changes according to the policy of the central bank. In this case, the cash channel is activated.

The exchange rate channel is most often associated with a fixed exchange rate, when its change causes changes in the basic economic conditions, including the competitiveness of domestic goods in the domestic and foreign markets, the cost of borrowing in foreign currency, the level of debt burden, as well as the cost of imported resources and components.

The credit channel is dependent on monetary policy.

Sometimes inflation expectations are seen as a separate channel of monetary transmission (Degtev et al., 2022). The current policy of the central bank gives companies and people an idea of what it is doing and intends to do in the future. Accordingly, expectations are formed regarding the actions of the central bank, which affects macroeconomic indicators. Companies and people make their economic decisions with due regard to these expectations (Aleem, 2010; Dudin et al., 2020).

However, limiting transmission mechanisms to monetary factors would oversimplify the phenomenon. The relevant studies (Boivin & Giannoni, 2002; Leonteva, 2013) show that such mechanisms are an immanent property of the systemic macroeconomic environment. They relate to the above-mentioned channels but the list is not exhaustive. For a more complete definition of transmissions, we need to analyze the macroeconomic environment in which they are formed and the basic conditions for their emergence (Elbourne, 2008).

Transmissions can happen without any instrumental impact on the economy generated by economic cycles (Boivin & Giannoni, 2002), monetary and financial crises (Borio & Zhu, 2012), systemic innovation processes (Elbourne, 2008), and adaptive reactions of the economy to evolutionary processes.

Many scientific results demonstrate that the total number of transmissions in the economic system can exceed tens and hundreds. Each of them forms relatively stable

chains of the transmission mechanism that do not change under certain conditions (Romer & Romer, 2004). The basic conditions are those that require adaptive responses of institutional sectors of the economy and economic agents. The transmissions that are not related to policy instruments arise mainly during changes in basic conditions as an adaptive reaction of the economy to such changes and are an important part of the self-organizing processes of economic development.

If we determine the basic conditions, it expands the possibilities of qualitative and quantitative analysis of transmission factors for their further systematization and modeling.

The transmission mechanisms of reactions in the economic system can also cause side effects, i.e. the acceleration or deceleration of innovations. They can be positive or negative in relation to various spheres of economic activity. As a result, they are purposefully used. Given that the action of transmissions can go beyond national economic boundaries, it is possible to use them as tools of a forceful economic impact or as tools to protect against such. Therefore, forecasting the reactions of economic systems based on transmissions will be relevant as long as they develop.

## 5 CONCLUSION

Modeling the responses of an economic system in the form of transmission mechanisms (impact generation and transmission) requires determining the basic conditions for their emergence. Transmissions in the national economy arise in the systemic macroeconomic environment, which plays the role of a transmission link between various instruments of macroeconomic policy and parties to economic relations, in particular institutional sectors of the national economy.

The systemic macroeconomic environment can autonomously generate transmissions with due regard to the new conditions caused by crises, economic booms, sudden shortages of capital, etc. Such transmissions are an adaptive response of the economic system to any changes and their natural result.

In the short term, transmissions can be artificially launched by state and monetary policy instruments. These transmissions can be used as anti-crisis policies and compensation for negative factors. They signal an evolving economic system. They form new combinations of development factors determined by the constraints of the relevant basic conditions.

Under certain conditions, transmissions are permanent, which allows one to model

them and develop decision-making software/hardware to optimize the country's economic development. The creation of such models will lay a theoretical basis for solving scientific and practical issues of macroeconomic management, in particular for managing economic dynamics and forecasting socio-economic, monetary, and financial crises.

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