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Central bank policy under significant balance-of-payment shocks and structural shifts[☆]

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Abstract

In this paper, we analyze a number of monetary and FX policy alternatives using the model of a small open oil-exporting economy hit by severe balance-of-payment shocks, such as those that simultaneously affected the Russian economy in 2014–2015. For our purposes, we modify Romer's (2013) IS-MP general equilibrium model by adding a structure similar to the Russian economy (tradables and oil vs. non-tradables). In the model, we consider an optimal policy mix that includes a floating exchange rate, FX liquidity provision by a central bank and temporary tightening of monetary policy. The flexible exchange rate works as a shock absorber, helping restore aggregate demand and domestic production. If inflation expectations are not anchored, contractionary monetary policy helps to stabilize them. Financial stability risks are addressed by lending FX liquidity to the banking sector.

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1. Introduction

Over the past 2 to 2.5 years, the Russian economy has experienced several balance of payment shocks. These are related to the onset of the Fed monetary policy normalization, geopolitical tension followed by the sanctions which led

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to capital outflow, as well as the decline in oil prices and increased volatility. This drastically different external environment has brought about substantial changes in the Russian economy that have been dubbed “new reality”. There are still heated discussions underway regarding the most appropriate macroeconomic policy that would enable the economy to adapt to the situation and to put it on the path of sustainable growth under the new conditions, as soon as possible.

The range of policy measures being proposed is quite broad, while theoretical justification for many of them is not quite clear. To narrow this gap in policy discussions, this paper attempts to deal with the issue from the standpoint of standard macroeconomic theory. We demonstrate how standard basic macroeconomic models should be adapted and used to find the most appropriate macroeconomic policy for Russia. This paper addresses both monetary and fiscal policies and relies upon basic macroeconomic models.

The first part defines the macroeconomic variables describing the long-run equilibrium in the model: potential GDP, the long-run real interest rate, and a central bank’s inflation target. It also defines indicators that reflect the structure of the economy (tradable goods and commodities vs. non-tradable goods) and the variables responsible for structural shifts in the economy in the aftermath of changes in oil prices (the real exchange rate). In our description of a small open economy we follow the textbook by Vegh (2013).

In the second part of the paper, we look into the short-run equilibrium in the goods and money markets (IS-MP model), following Romer (2013), measuring the equilibrium real interest rate and the equilibrium GDP output, the values of which may differ in the short run and in the long run. In parallel, we analyze the foreign exchange market and define the equilibrium real and nominal foreign exchange rates, putting the balance of payments in equilibrium. To close the model, we define inflation and inflation expectations and introduce a tight link between inflation and aggregate output. The model is helpful in explaining correlation between inflation and aggregate demand. Finally, we describe the core elements of the government budget and present the concept of a long-run (equilibrium) budget deficit and national debt.

With the modelling tool now at our disposal, in Part 3 we analyze how the Russian economy reacted to the 2014 balance of payment shocks and explore the most appropriate monetary policy response to the oil shock, taking into account the projected medium-term fiscal policy.

1. Theoretical description of the economy

1.1. Long-run equilibrium and the structure of the economy

1.1.1. Economic equilibrium

Put in the simplest way, an economy is the material balance between production and demand (desired spending). In equilibrium, physical production must equal the consumption of the goods produced, i.e., GDP produced (plus imports) must be equal to the desired spending. The main types of spending in an open economy are household and government consumption, business in-

vestment and exports. That is, the material balance of the economy can be expressed as:

$$Y + Im = C + I + G + Ex, \quad (1)$$

where Y is the real GDP produced, Im is physical imports, C is household consumption, I is investment in physical capital (and reserves), G is government consumption, and Ex is exports.

An economy can achieve equilibrium between desired production and demand by changing the prices of goods, wages, price of the physical capital, the price of money or debt (interest rate) and the foreign exchange rate. Therefore, when hereinafter describing economic equilibrium, we will always do so in terms of price indicators. If the economy is not exposed to any shocks, it will forever remain in the long-run equilibrium once this state of equilibrium has been achieved. Accordingly, price indicators will have well-defined, constant values under the conditions of long-run equilibrium. We will further define these indicators and will refer to them as long-run equilibrium levels.

Regarding goods prices, we will refer to the equilibrium inflation rate (price change) $\bar{\pi}$, which, where a central bank targets inflation, is defined as its inflation target (4% p.a. in Russia). As we intend to show in what follows, price inflation correlates with wage inflation. The price of borrowing consists of interest income in real terms (lost return) and compensation for inflation. The formula for the nominal risk-free interest rate is:

$$i \stackrel{\text{def}}{=} r + \pi^e, \quad (2)$$

where i is the nominal interest rate, r is the real interest rate, and π^e is inflation expectations (or inflation).

In order to define the *equilibrium nominal interest rate*, we need to define the equilibrium inflation rate $\bar{\pi}$ (defined above) and the long-run equilibrium real interest rate r_{natural} . The equilibrium real interest rate is subject to the three arbitrage-free conditions.¹

Let us proceed to define potential GDP, a key concept for long-run economic equilibrium. Assume that the economy has certain labor resources \bar{L} and the stock of capital K at its disposal. The value added that can be produced by fully employing those labor resources (some natural unemployment might

¹ We assume the real interest rate in long-run equilibrium to be a fixed value because our goal is to study fluctuations in an economy in response to shocks, rather than the factors of long-run equilibrium. The first of these conditions requires equal returns on investments in financial assets and physical capital. In other words, in equilibrium, investors should see no difference between buying a financial asset which pays interest r_{natural} (in natural terms or less an inflation rate) or invest in the acquisition of a plant that would generate a certain profit (also deflated for price change). It is through this ratio that the interest rate, as a component of the financial system, is linked to returns on physical capital. The second condition sets an “intertemporal arbitrage,” i.e. with the equilibrium interest rate, households should see no difference between spending their extra income on current or future consumption (savings). The third arbitrage-free condition requires that returns on investments in domestic and foreign financial assets should be equalized to ensure alignment with movements in the real foreign exchange rate and risk premiums. This condition is dictated by the uncovered interest rate parity. Taken together, the above conditions determine the long-run equilibrium real interest rate in the general equilibrium.

exist) given the normal capital utilization is called *potential GDP*. This definition, however, disregards that the desired level of demand should adjust to the production volume determined by potential GDP. This adjustment occurs through price changes. But the resulting equilibrium inflation rate might not be in line with, or could even contradict, the desired central bank-determined equilibrium inflation rate when labor resources are fully employed. Therefore, the intrinsic feature of potential GDP is that the rate of inflation is aligned with the central bank's target when output is at its potential level and firms have no incentives to accelerate or slow down the growth of prices for the goods they produce (there is no extra inflationary pressure on the economy, or inflation is stable).

We will now proceed to describe the structure of the economy in the model to investigate the role of the real exchange rate.

1.1.2. Structure of the economy

A real economy has a complex structure capable of changing, e.g., impacted by oil shocks. Structural changes in the economy have major implications for monetary policy. Understanding the nature of structural transformations is a key prerequisite for the analysis of the monetary policy in the aftermath of a dramatic fall in oil prices.

Let us assume that there are three types of goods produced by the economy.

1. *Non-tradable goods (services)*. Non-tradable goods are goods that cannot be exported or imported. Specifically, economic activities such as construction, retail, domestic services, and utility services belong to the non-tradable sector of the economy. A building cannot be exported, nor can we use central heating without actually being in the country, building or place where that service is provided. A key quality of non-tradable goods, central to the arguments below, is that their consumption is always equal to their production (because these goods cannot be exported, all surplus must be consumed domestically).

That is,

$$C^N + G^N = Y^N, \quad (3)$$

where C^N is household consumption of non-tradable goods (quantity or volume), G^N is government consumption (procurement) of non-tradable goods, and Y^N is the physical production in the non-tradable sector.

2. *Tradable goods*. Tradable goods are goods which compete with imports, i.e., those that can be exported or imported. Thus, their production does not necessarily equal their consumption. If there is a deficit of tradable goods, they can be imported; if there is a surplus, they can be exported. The material balance for tradable goods can be expressed in the following formula:

$$C^T + G^T + I(r) + Ex = Y^T + Im = Y^T - (NX - p_{oil} \times \bar{X} - Ex), \quad (4)$$

where C^T is household consumption of tradable goods (quantity or volume), G^T is government consumption (procurement) of tradable goods, $I(r)$ is investment in capital (which depends on the level of the real interest rate r and as-

sumed to be tradable goods²), Ex is the physical exports of tradable goods, Y^T is the physical production of tradable goods, Im is imports of tradable goods, p_{oil} is the global oil price (in terms of tradable goods), \bar{X} is the volume of oil exports (tons), and NX is net exports, i.e., $NX = Ex + p_{oil} \times \bar{X} - Im$.

We further assume that the global price for a unit of tradable goods is equal to one US dollar. Therefore, physical values (consumption or production levels) in terms of tradable goods would be equivalent to their value in US dollars.

3. *Tradable commodities.* These tradable goods form a separate category for two reasons. First, the labor costs for producing these goods are very low (only 1 million people are employed in Russia's mining and minerals sector). Second, the physical production of these goods is a fixed value in the short run. In particular, physical oil exports are determined by the diameter of the oil pipeline or by the number of available railcars. These are the reasons why in the literature export proceeds from these goods are commonly called rent or endowments and are modeled as a sort of gift to the economy. We assume that all commodities produced (extracted) are sold in the global market and that the proceeds are allocated to buy tradable and non-tradable goods. The fact that commodities are, in reality, partly consumed domestically, rather than exported, does not run contrary to the logic of the model.³

Assume that producing Y^N of non-tradable goods requires L^N units of labor (the number of people employed in the non-tradable sector), while producing Y^T of tradable goods requires L^T units of labor (the number of people employed in the tradable sector). Then, the quantity of all labor resources in the economy equals

$$L^N + L^T + U = \bar{L}, \quad (5)$$

where U is the number of the unemployed in the economy.

Then, assume that the increase in production of a given good requires more people employed in that sector (the capital used is assumed to be fixed because we are considering a short period of time). It means that an additional workforce should be recruited from the unemployed or pulled out from other sectors. Consequently, after a certain point, any additional increase in production in one sector would lead to lower production in other sectors.

This dependence can be expressed graphically. It is called the *production possibilities frontier*, see Fig. 1. This includes all production levels of tradable and non-tradable goods attainable by the economy. The economy can choose any point on the curve, thus determining its production structure, i.e., the ratio between the production of tradable and non-tradable goods.

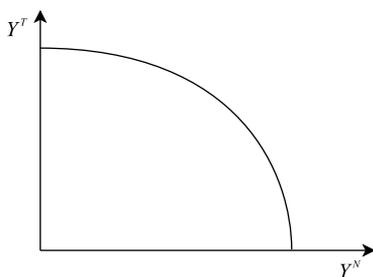


Fig. 1. Production possibilities frontier.

² This assumption is based on the following factors: first, that the tradable sector is more capital-intensive than the services sector; second, in a sector open to global trade, maintaining competitive performance requires adoption of imported technology, i.e. “tradability” of investments; third, physical capital must not be consumed if there is shortage of non-tradable goods.

³ Since raw materials are consumed by an open market economy at the same price as by the global market, we assume that such consumption is partially reflected in imported goods.

What factors can affect the choice between producing tradable and non-tradable goods? This issue is explored in the section that follows.

1.2. Structural transformation of the economy following changes in oil prices and the role of the real foreign exchange rate

1.2.1. The real foreign exchange rate and its role in the economy

In this section we show that the production structure is chosen based on the *real foreign exchange rate*.

Because there are two types of goods for consumption in the economy, i.e., tradable and non-tradable, the need arises to compare them. This is exactly what the real foreign exchange rate does. It is defined as the *relative price of non-tradable goods in terms of tradable goods*. We will designate it as p . For example, if tradable goods are television sets and non-tradable goods are hairdresser's services, then p is the price of one haircut in terms of television sets (a number of television sets per one haircut); when p is rising, the national currency is said to be strengthening.

Assume that individuals own a certain physical stock W of some tradable goods (petrodollars) in each period in time and wish to use that stock to consume tradable and non-tradable goods. Obviously, tradable goods C^T will be exchanged for non-tradable goods one for one, while for non-tradable goods, the proportion will be the value of the real foreign exchange rate (or the relative price of the non-tradable goods in terms of tradable goods):

$$C^T + C^N \times p = W. \quad (6)$$

Assume that the amount of resources available to an individual for the consumption of tradable goods is increasing (e.g., W is doubled due to a rising oil price) enabling the individual to buy twice as many tradable and non-tradable goods. How can this affect the real foreign exchange rate? At first glance, this will have no implications whatsoever, as consumption will double for both types of goods. However, this answer is not correct. We should remember that the important characteristic of non-tradable goods is that their deficit cannot be compensated through imports, with all additional production having to take place domestically. This means that if the consumption of C^N is growing, the production Y^N should be increased as well.

To make this happen, more labor (L^N) is needed to produce tradable goods at the expense of non-tradable goods. For the non-tradable sector to attract extra workforce from the tradable sector in an open economy, workers must be offered higher wages. By definition, rising wages in the non-tradable sector, relative to the tradable sector, will be translated into price growth and reflect a strengthened real foreign exchange rate.

For example, a higher petrodollar income W leads to the growth of p (strengthened real foreign exchange rate). This strengthening has a twofold impact on the economy.

1. It encourages labor to move from the tradable sector to the non-tradable sector, i.e., to move down along the curve in Fig. 1.

2. Demand for non-tradable goods shifts towards tradable goods, lessening the production bias towards non-tradable goods. This is shown in (6) above (the exact inference is given in the textbook by Vegh, 2013).

It should be noted that when the petrodollar income is falling, production moves in the reverse direction (which actually happened in 2014).

Thus, *the real foreign exchange rate plays an important distributional and stabilizing role in the economy.*

1.2.2. *Production capacity of the economy following changes in the foreign exchange rate*

Our understanding of potential GDP becomes more complex once the structure of the economy is taken into consideration. *Structural changes in the economy are usually accompanied by increased costs (cost-push shocks) and losses in potential output (supply shocks).* There are two types of costs (losses) that occur at the time of structural economic adjustment accompanied by changes in relative prices.

1. *Costs generated by the old economic structure in response to changes in the real foreign exchange rate (cost-push shocks).* As an example, a weaker real foreign exchange rate makes imported components and raw materials, used for production, more costly. In the short run, while the economy has yet to switch to another production structure, the use of imported components affects production costs, leading to price growth. Those costs accelerate structural adjustment but also make it impossible to maintain the current output at constant prices (or inflation rate). See on that Clarida et al. (2001).

2. *Costs associated with changes in the economic structure.* These costs depend on how easy it is to “dismantle” production facilities in some industries (the degree of labor market liberalization, the extent of government support for industries) and “move” them to others (the ease of running a business, market entry barriers). These costs may have a long-term effect on potential GDP (see Davis and Haltiwanger, 2001; Harberger, 1998).

Hereinafter we will use these results to find the appropriate policy response by the Bank of Russia in the aftermath of the oil shock.

The next chapter analyses aggregate demand and inflation.

2. Equilibrium model, inflation and economic policy

Let us turn to the demand side to analyze what determines the equilibrium real interest rates and what determines the output in the short run in the case of external shocks.

2.1. *Equilibrium in the goods and money markets (IS-MP model), equilibrium output and the equilibrium real interest rate*

2.1.1. *Equilibrium in the goods market: the Investment-Savings (IS) line*

The model below determines the equilibrium real interest rate and output based on the advanced versions of the IS-LM model, introduced by John Hicks in 1937 (see Romer, 2013).

Below is the material balance condition for the economy:

$$B_t = B_{t-1}(1 + r^f) + Y^T + p \times Y^N + p_{oil} \times \bar{X} - C^T - G^T - I(r) - p(C^N + G^N), \quad (7)$$

where B_t and B_{t-1} are net foreign assets (if $B_t < 0$, then net foreign liabilities) in terms of tradable goods, while r^f is the real interest rate in the global capital market. All of the other variables have been defined above.

The equality between current and financial accounts of the balance of payments means that increasing net foreign assets in the economy (with B_{t-1} being positive), or a capital outflow, is equal to the sum of the returns on assets $B_{t-1} \times r^f$ and a positive trade balance NX :

$$B_t - B_{t-1} \stackrel{\text{def}}{=} -FA = CA \stackrel{\text{def}}{=} B_{t-1} \times r^f + NX, \quad (8)$$

where FA is the financial account of the balance of payments and CA is the current account of the balance of payments.

Based on the above, we can arrive at an equivalent expression for (1), adjusted for the heterogeneous economic structure:

$$Y^T + p \times Y^N + p_{oil} \times \bar{X} = C^T + G^T + I(r) + p(C^N + G^N) + NX. \quad (9)$$

To find the total output of the economy (total value added), we sum up the output of the three goods in terms of tradable goods (or US dollars⁴):

$$Y = Y^T + p \times Y^N + p_{oil} \times \bar{X}. \quad (10)$$

It should be noted that in dynamics for comparability purposes, all relative prices should be fixed at the reference period level.

As a result, we obtain the familiar equation for production output and its consumption:

$$Y = C^T + G^T + I(r) + p(C^N + G^N) + NX. \quad (11)$$

For the purposes of our further discussion, we aggregate the demand for tradable and non-tradable goods:

$$C = C^N \times p + C^T. \quad (12)$$

$$G = G^N \times p + G^T. \quad (13)$$

$$NX = Ex + p_{oil} \times \bar{X} - Im. \quad (14)$$

⁴ The choice of the unit of measurement is irrelevant for GDP, since all prices remain constant (at the reference period levels) in computing the real GDP within a reporting period (in practice, the procedure is somewhat more complicated because of deflators). Without loss of generality, the real foreign exchange rate can even be assumed to equal 1 for the base period. However, expressing GDP in terms of tradable goods (e.g. exported goods for the manufacturing industry) is more preferable for our objectives, as we must explore the equilibrium in the foreign exchange market wherein payments are made against trade flows.

Accordingly, the overall equilibrium of demand and output for the economy will be as in (1):

$$Y = C + I(r) + G + NX. \quad (15)$$

This is the equation for the IS-MP model, namely, the *IS (Investment-Savings) equation*, which links the real interest rate with the output in the economy.

This equation fixes a set of equilibrium points in the goods market for various real interest rates. The lower the real interest rate, the higher the physical investment and demand as well as the equilibrium output.

2.1.2. Equilibrium in the money market: the Monetary Policy (MP) line

The modern versions of the IS-LM model (see Romer, 2013) rely on the assumption that central banks control interest rates, while the money supply in the economy is determined endogenously by demand for money at a given interest rate. The interest rate (the price of money in the money market) is controlled by the central bank, e.g., in the form of the following monetary policy rule:

$$r = r_{natural} + \alpha(Y - \bar{Y}) + \beta(\pi^e - \bar{\pi}), \quad (16)$$

where r is the real interest rate, $r_{natural}$ is the equilibrium real interest rate, and $\alpha > 0$ and $\beta > 0$ are parameters for the monetary policy rule.

The equilibrium real interest rate $r_{natural}$ is independent of the central bank's policy and is determined by "real" factors such as returns on physical capital or the degree to which the economy is open to capital flows, the risk premium, and the age structure.

In this way, the central bank adjusts the money market rates to its inflation and output targets with respect of the real interest rates. At the same time, the model implies that the central bank exercises tight control over the transmission of money market rates ("short rates") into rates on loans provided to businesses and households ("long rates"). However, this is not the case in real life, to the dismay of monetary policy makers. For the purposes of understanding the general logic of the central bank's actions, such complications in transmission are not critical (rather, they will be reflected in how strongly short rates will react to shocks, i.e., how great the $\alpha > 0$ and $\beta > 0$ multipliers have to be).

It should be noted that Russian textbooks more often use earlier versions of this model (LM instead of MP), which simulate equilibrium in the money market expressly through the equality between money supply and demand. In their model, the central bank targets the money supply and its growth in line with the growing demand for money, following GDP movement and interest rates.

$$\frac{M}{P} = L(r + \pi^e; Y), \quad (17)$$

where M is the money aggregate (M1 in this model), P is the price level, L is the money demand function, which depends on the nominal interest rate (2) and

on real income. The interest rates in the model are determined endogenously. As shown in Romer (2013), these two expressions are equivalent.

Note that in some versions of the model, the rule (16) includes foreign exchange rate stabilization indicators. In this case, the rule is expressed as follows:

$$r = r_{\text{natural}} + \alpha(Y - \bar{Y}) + \beta(\pi^e - \bar{\pi}) + \gamma(E - \bar{E}), \quad (18)$$

where E is the nominal foreign exchange rate (RUB for a US dollar) and \bar{E} is the *fundamental foreign exchange rate determined by the equilibrium balance of payments*. In certain cases, the policy rule may also aim at smoothing the foreign exchange rate:

$$r = r_{\text{natural}} + \alpha(Y - \bar{Y}) + \beta(\pi^e - \bar{\pi}) + \gamma(E_t - E_{t-1}). \quad (19)$$

Monetary policy in emerging markets is often based on rules expressed in (18) or (19). Such modifications to the monetary policy rule do not affect the conclusions from the model given below. On the other hand, the central bank's response to a shock in the foreign exchange market will be stronger than that in the standard model of the central bank's policy reaction function.

We would like to emphasize that in all versions of a central bank's policy rule (or equilibrium in the money market), the real interest rate will be equal to the *long-run equilibrium real interest rate* if inflation expectations—which determine future inflation—are aligned with the central bank's target and the output is at its potential level (the exchange rate is consistent with the fundamental equilibrium and/or is stable) and if there are no shocks in the foreign exchange market.

As we revisit the issue of the standard monetary policy rule, dictated by (16), it is worth noting that it includes expected, rather than actual, inflation rates. The reasons behind this are two. First, targeting expected inflation is contingent upon the specifics of the monetary policy transmission mechanism (monetary policy lags). Second, if the central bank has credibility as an inflation targeter, inflation expectations will be anchored, i.e., will correspond to the central bank's target. In this case, the central bank can afford to ignore temporary inflation deviations from target and should react only if the dynamics of inflation trigger a change in inflation expectations.

The Russian central bank has yet to gain experience in anchoring inflation expectations, which is why the rule depends on changes in the actual inflation rate, rather than on a central bank target. Frequent inflation shocks (including those of relative prices) are reflected in changes in both the inflation rate and inflation expectations. Therefore, the Russian central bank's response function can be expressed through the following formula:

$$r = r_{\text{natural}} + \alpha(Y - \bar{Y}) + \beta(\pi - \bar{\pi}). \quad (20)$$

Unlike (18) and (19), we have left out the foreign exchange rate in (20). As noted above, this presentation of the model keeps the mathematics simple and its conclusions intact. Strictly speaking, the foreign exchange rate has implications

for inflation and inflation expectations, and therefore the influence of significant exchange rate shocks is implicitly taken into account in (20).

Equations (15) and (20) provide a description of the economic system in terms of the real interest rate and output, for a fixed inflation rate. The IS-MP model uses (15) as the *IS* line with fixed values for the other variables, and it uses (20) to describe the monetary policy rule as the *MP* line: see Fig. 2.

If inflation expectations are anchored (i.e., remain constant in the event of any non-monetary shock), there is a univocal correspondence between the nominal and real rates. If they are unanchored (as is the case with Russia), changes in inflation expectations will lead to a shift in the *MP* line (the central bank's response to an increasing inflation rate and inflation expectations).

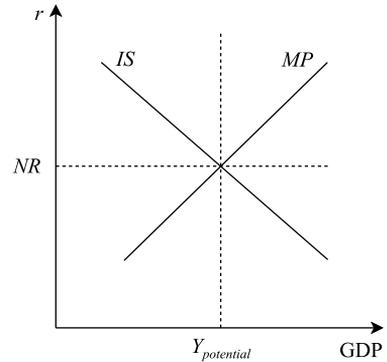


Fig. 2. An equilibrium in the IS-MP model.

2.2. Equilibrium in the foreign exchange market

We have discussed how changes in the real foreign exchange rate can affect changes in the structure and production capacity of the economy, but we have yet to see in detail how the real foreign exchange rate reaches an equilibrium point. Equilibrium in the foreign exchange market is defined as equality of demand for the currency and its supply (in US dollars). In addition:

Demand for foreign exchange $\stackrel{\text{def}}{=} \text{payments for imported goods} +$
 $+ \text{demand for foreign asset acquisitions or foreign liability repayments} +$
 $+ \text{the central bank's foreign exchange purchases}$

Supply of foreign exchange $\stackrel{\text{def}}{=} \text{conversion of export revenues} +$
 $+ \text{supply of foreign exchange by non-residents buying}$
 $\text{domestic assets or providing foreign credit} +$
 $+ \text{foreign exchange sales by the central bank.}$

Thus, the equilibrium in the foreign exchange market is expressed as follows: $NX(p, Y, Y^f) = CO(\Delta)$, where $NX(p, Y, Y^f)$ is net exports and $CO(\Delta)$ is the net demand for foreign financial assets (outflow of capital minus inflow of capital), including changes in the central bank's forex reserves. All variables in the model are expressed in units of tradable goods but in reality are usually measured in USD. The formula is as follows:

$$NX(p, Y, Y^f) = Ex(p, Y^f) + p_{oil} \times \bar{X} - Im(p, Y), \quad (21)$$

where NX is net exports, which depend on the real foreign exchange rate p , the economy's revenues Y , and the rest of the world's Y^f , Ex is non-commodity exports in terms of tradable goods, which depend on the real foreign exchange

rate and revenues of the rest of the world, $p_{oil} \times \bar{X}$ is commodity exports, and $Im(p, Y)$ is imports.

$$CO = CO(\Delta), \quad (22)$$

where CO is the net capital outflow (outflow minus inflow), defined as a differential in real interest rates $\Delta = r - r^f - risk_premium$.

Capital outflow is negatively related to the real interest rate (allowing for carry trade), but is not entirely resilient in terms of the interest rate differential.

For the sake of simplicity, we further assume that net capital outflow is not elastic to the actual foreign exchange rate, but is elastic to foreign exchange rate expectations. For purposes of the arguments below, assume the change in the central bank's forex reserves is already factored in capital outflow (i.e., we are considering a standard presentation of the balance of payments).

Equilibrium in the foreign exchange market is usually defined in terms of the nominal foreign exchange rate, while our model is built for the real foreign exchange rate. In this context, *we will find a link between the nominal and real foreign exchange rates*. We use the definition of the real foreign exchange rate as the relative price of tradable and non-tradable goods and assume that the global price of tradable goods is equal to \$1. Finally, we arrive at the following ratio:

$$p = RER = \frac{P^N}{P^T} = \frac{P^N}{E \times P^{Tf}} = \frac{P^N}{E \times 1}, \quad (23)$$

where E is the nominal foreign exchange rate (national currency units per foreign currency units), P^N is the price of non-tradable goods in rubles, P^T is the price of tradable goods in rubles, P^{Tf} —the price of tradable goods in USD.

The Appendix shows that prices of non-tradable goods P^N are not directly dependent on changes in the nominal foreign exchange rate. Their fluctuations depend on the nature of changes in the nominal exchange rate: real or monetary. Assume that following a change in the nominal exchange rate that occurred due to external factors (decreasing oil prices and respective changes in the real exchange rate), prices for non-tradable goods do not change greatly over a short period (up to one year) or that $\Delta P^N \sim \varepsilon \Delta E$, where ε is a small number. If the change in the nominal exchange rate is monetary in nature (i.e., reflects the differences in monetary inflation between countries), then, in the long run, $\Delta P^N = \Delta E$.

This theoretical conclusion has been verified in practice. Indeed, in the second half of 2014 and first half of 2015, the ruble lost approximately 50% of its value against the US dollar (that is, the USD gained 100% against the ruble), while the prices for services (in the non-tradable sector) increased by only 10% over the year, i.e., the rise of importables' prices is ten times less in ruble terms. This means that, in the short run, with a floating foreign exchange rate, there is an almost direct link between the nominal and real foreign exchange rates⁵. In other

⁵ As noted in a great number of studies on developed and emerging economies. See e.g. Burstein et al. (2005).

words, the adjustment of the real foreign exchange rate required for a new equilibrium in the balance of payments is achieved through the respective changes in the nominal foreign exchange rate.

Equations (21) and (22) can be expressed graphically (Fig. 3).

Now that we have found the equilibrium foreign exchange rate, we turn to the last element of our model — inflation and its relation to aggregate demand and output.

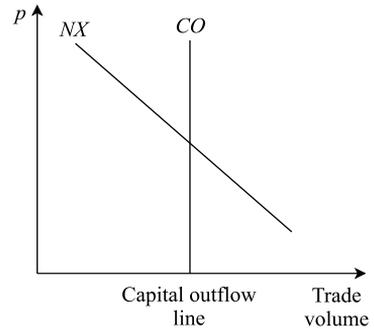


Fig. 3. An equilibrium in FX-market.

2.3. Inflation, inflation expectations, and the relationship between inflation and GDP movements

According to a broad definition, *inflation* is a change in a general price level. It is defined by the following formula (a geometric mean of the prices in the economy):

$$P = (P^N)^\alpha (P^T)^{(1-\alpha)} = (P^N)^\alpha (E)^{(1-\alpha)}, \quad (24)$$

whereby we relied on the above assumption that the price of tradable goods equals 1, then $P^T = E \times P^{Tf} = E \times 1 = E$.

This formula demonstrates that a lower nominal foreign exchange rate leads to changes in prices, i.e., to inflation. This change in the nominal foreign exchange rate transmitted to the price level is one of the manifestations of rising costs (cost-push shocks) noted above.

This change in the price level in which *certain prices change relative to other prices* should be distinguished from the other change that *equally affects all prices for goods*. Indeed, if we raised the prices for all goods by 100% (e.g., by increasing money supply by 100% and replacing all price tags overnight), we would find that the general price level has also changed by 100%. This is why inflation, in its broad sense, should be differentiated from *monetary inflation (true inflation from the central banks' point of view), understood as equally proportionate change in all prices*. To simulate this type of price movement, we turn to the following example.

Assume that output has reached a point at which increasing the production of both tradable and non-tradable goods would require that unemployment U be reduced with fixed labor resources available in the economy as $L^N + L^T + U = \bar{L}$, to a point below a certain level \bar{U} , which we will call the natural unemployment level (or NAIRU).

Assume the following rate of changes in nominal wages (which in the case of non-zero production in the tradable and non-tradable sectors should be the same in both sectors, otherwise labor resources will move to one of the sectors):

$$w = \psi \pi^e + \gamma(\bar{U} - U) = \psi \pi^e + \gamma(Y - \bar{Y}), \quad (25)$$

where w is the rate of increase in nominal wages. Inflation expectations can be determined in a number of ways in this case. We assume that inflation expecta-

tions are not anchored at the targeted inflation rate but depend on past inflation $\pi^e = \pi_{-1}$, $0 < \psi < 1$ and ψ is close to 1.

Thus, wages are indexed according to the expected inflation rate, preventing a decrease in real wages while taking into consideration the deficit of labor resources in the labor market (labor utilization). The higher expected inflation is, the higher the indexing rate is.

Producers in the tradable and non-tradable sectors incorporate their labor costs into their prices in total. Therefore, the inflation rate equals:

$$\pi = \psi\pi^e + \gamma(Y - \bar{Y}) + \text{cost_push_shocks}. \quad (26)$$

This formula reflects both definitions of inflation. The narrow definition (trend inflation) corresponds to the first two terms; the broad (changes in relative prices) corresponds to the third one.

This means that for purely monetary inflation, prices change proportionately for tradable and non-tradable goods. Consequently, the real foreign exchange rate will remain unchanged (see (23)) at the level defined by the equilibrium balance of payments, whereas the nominal foreign exchange rate will fall (\bar{E} is rising). Thus, in the long run, a monetary change in the nominal exchange rate corresponds to the inflation rate in the economy.

Equation (26) is also called *the aggregate supply (AS) curve*. For a fixed inflation rate, we can determine the equilibrium levels of the real interest rate and output based on the IS-MP model. A set of such equilibrium points for various inflation levels will determine the aggregate demand (AD) line in the inflation-output coordinates. The AD line is obtained as follows: with a higher inflation rate, the central bank will keep rates higher, causing a shift of the MP line and a decrease in output (in other words, higher inflation reduces the real money supply, leading to increased interest rates as a means to reduce the demand for money). This new equilibrium point (higher inflation and lower aggregate demand and output) helps draw the aggregate demand line (Fig. 4).

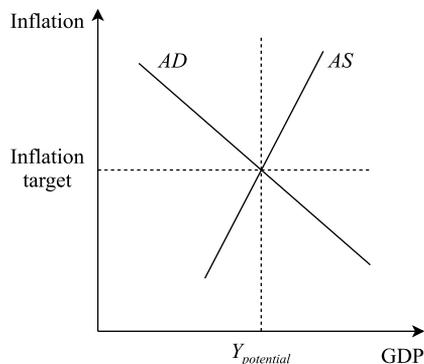


Fig. 4. An equilibrium in the AD-AS model.

We intentionally present these standard charts in terms of the inflation rate rather than the price level because falling prices in response to a certain shock is a less realistic assumption than just slowing inflation.

The rigidity of the inflation rate under cyclical fluctuations of GDP determines the slope of the AS curve. For Russia, due to its labor market specifics, the AS curve may be steeper than that in other countries (see Gimpelson and Kapeliushnikov, 2013).

Thus, we have all the prerequisites for a full description of economic equilibrium: IS-MP-AS model + equilibrium at the foreign exchange market. We will now look at the fiscal policy in more detail.

2.4. Fiscal policy

We assume that government budget revenues consist of two components.

1. Deductions from oil sales. To keep things simple, we assume that all oil revenues go to the state.

2. Value added tax in the non-tradables sector.

Thus, budget revenues are equal to

$$T = p_{oil} \times \bar{X} + \tau(Y - p_{oil} \times \bar{X}), \quad (27)$$

where τ is the VAT rate. This form of taxes is represented in terms of tradable goods.

Government spending in terms of tradable goods consists of the costs of buying tradable (imported equipment purchases) and non-tradable goods (wages in the civil service sector).

$$G = G^T + p \times G^N. \quad (28)$$

The state covers the entire imbalance between costs and revenues through loans for which the interest rate depends on the global interest rate and risk premium:

$$r_{gov} = r^f + risk_premium. \quad (29)$$

Changes in the national debt relative to GDP in terms of tradable goods are expressed as follows:

$$\frac{Debt_t}{Y} = \frac{Debt_{t-1}}{Y} (1 + r_{gov}) + \frac{(G - T)}{Y}, \quad (30)$$

where $Debt_t$ is the national debt in the period t (if $Debt_t < 0$, then the government retains assets in the reserve fund).

Formulas (26) to (30) are insufficient for describing fiscal policy. We need to make additional assumptions about a national debt “ceiling” (relative to the size of the economy). We assume that, in the long run, there is a certain amount of government debt as a percentage of GDP, which the financial markets are willing to finance at acceptable interest rates. That is, if the amount of national debt is kept below that level, the risk of a debt crisis will remain low. Consequently, it follows from (30) that the initial budget surplus (as a percentage of GDP, $T - G > 0$) should be maintained at or above the level of the total amount of interest payments on the maximum amount of debt: $\frac{(T - G)}{\bar{Y}} \geq \frac{Debt \times r_{gov}}{\bar{Y}}$.

In the short run, for the purposes of a countercyclical policy, the budget deficit may deviate from this formula, but not for long. For example, in the event of a drop in oil prices (which is expected to be temporary), a temporary decrease of budget revenues (T) will occur. For the economy to ignore the drop in demand resulting from government spending cuts, budgetary spending will continue at the same level or even increase. National debt will

also rise temporarily (or the “safety cushion” will be used). Recovered oil prices allow budget spending to be cut by allocating initial surpluses to pay off the national debt.

If oil prices remain low for a long time, there will be no choice but to cut government budget spending. Otherwise, as follows from (30), if the revenues T decline, national debt will accumulate very fast. The fact that the government has a “safety cushion” in the form of the Reserve Fund in this situation means that there is an opportunity to pursue a softer fiscal policy than in a situation where the government is already in debt before the shock.

Before we continue to the next chapter, we should define the long-run economic equilibrium: an economy is in a state of *long-run equilibrium* when its output equals potential output, and inflation and inflation expectations are in line with the central bank’s target, the real interest rate equals the long-run equilibrium real interest rate, the real foreign exchange rate redresses the balance of payments (which corresponds to the outflow of capital under the long-run equilibrium interest rate and equilibrium sovereign risk premium), and the national debt is stable.

Short-run economic equilibrium under external shocks is described in terms of the IS-MP-AS model plus the model for determining the foreign exchange rate.

3. Alternative monetary policy under balance of payment shocks

Now we will examine potential monetary policies in a situation similar to the balance of payment shocks that occurred in Russia in recent years. As an example of this type of shock, we consider the following:

- (a) decline in global oil prices;
- (b) increased risk premiums (due to a tighter monetary policy pursued by the US Federal Reserve, rising geopolitical risks, and falling oil prices) and, consequently, increased capital outflow (in the form of increased demand for foreign assets);
- (c) peaking foreign debt payments by Russian companies (the outflow of capital in the form of reduced liabilities to non-residents).

The foreign exchange market was the first to fall under the influence of those shocks — see Fig. 5.

The oil price shock led the net exports line to shift to the left (falling foreign exchange supply) and the capital outflow line to shift to the right. Demand for foreign exchange rose due to the inability of refinancing foreign debt in the face of financial sanctions imposed. This effect could have been aggravated by the rising expectations for lower foreign exchange rates and the desire to “stock up” some foreign exchange ahead of peaking foreign debt payments. As a result, a foreign exchange deficit occurred in the foreign exchange market, equal to the distance between E_0 and E_1 .

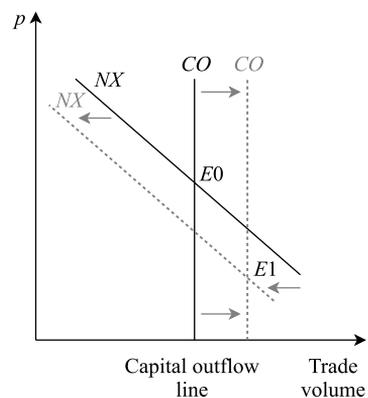


Fig. 5. FX-market response to balance of payment's shocks.

Now we will consider central bank policy options and their impact on the economy and inflation:

(a) *maintaining the foreign exchange rate at the same level or gradual devaluation* through an unsterilized sale of foreign exchange from the foreign exchange reserves;

(b) *sterilized interventions* to support the foreign exchange rate;

(c) utilization of *foreign exchange refinancing tools* to address the temporary stress in the foreign exchange market associated with the peak of foreign debt payments reached at the end of 2014;

(d) *transition to a floating foreign exchange rate*, enabling a quick adjustment of the rate to the new equilibrium under lower oil prices;

(i) *a temporary increase in interest rates* to prevent inflation expectations from growing.

Undoubtedly, the best policy in reality is likely to represent a combination of the following separate measures.

We will consider these options in sequence.

3.1. Maintaining the foreign exchange rate at the same level or gradual devaluation

Maintaining the foreign exchange rate at the same level or gradual devaluation through an *unsterilized* sale of foreign exchange from the foreign exchange reserves under a long-term reduction in oil prices means that the central bank should move the capital outflow line (as noted above, the change in the central bank's assets is taken into consideration) to the left, from $E1$ to $E2$ in Fig. 6 in which the foreign exchange rate will remain the same as before the shock.

The complexity of analyzing the central bank's policy is that we must consider all measures taken by the bank in their entirety. Therefore, it is important that the sale of reserves is unsterilized, i.e., by selling foreign exchange on the market, the central bank will remove ruble liquidity. This means, based on (17), that money market rates should rise.⁶ As a result, the central bank will actually cease using the rate as a policy tool (in this case, the interest rate is said to be determined endogenously), and the key equation for the model (16), will cease to be true. The IS-MP model will turn into IS-LM, and the line describing equilibrium at the money market will move towards the top left corner (Fig. 7).

This shift corresponds to the shift of the AD line towards the bottom left (rather than a movement along the AD line because the inflation rate remains the same for each level of interest rate; Fig. 8).

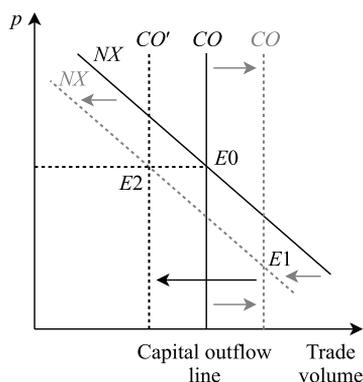


Fig. 6. FX-market imbalance under fixed exchange rate arrangement after the shocks.

⁶ An example of an unsterilized or partly sterilized intervention in interest rates is the rise of interest rates in Kazakhstan's money market in certain months in 2014 and 2015.

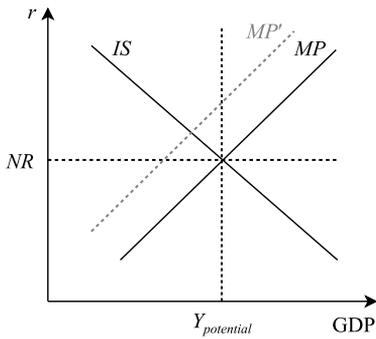


Fig. 7. An endogenous reaction of interest rates under fixed exchange rates.

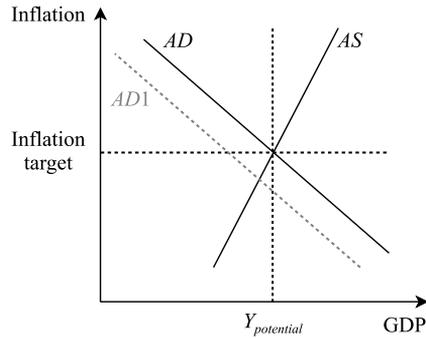


Fig. 8. Output and inflation under fixed exchange rates and balance of payment shocks.

Note that a decrease in oil prices due to fewer resources available for spending on consumption leads to lower aggregate demand and output in the economy (and indeed slightly shifts the net exports line back towards the top, as it depends on GDP—(21)). This occurs through the consumption of non-tradable goods, which usually accompanies the consumption of imports (in the calculation of real GDP, oil prices are fixed at the reference period level and do not directly affect aggregate demand).

Another reason behind lower aggregate demand is lower government consumption. If the budget does not cut spending, lower oil prices will lead to a budget deficit and rapid accumulation of national debt. The structure-related fall in oil prices leaves no choice but to gradually cut budget spending.

On the whole, these two reasons push the *AD* line further than *AD1*. In reality, the shift in Russia was very slight in 2015 due to the countercyclical fiscal policy that utilized the Reserve Fund.

Thus, if the central bank carries out unsterilized interventions, a rising real interest rate in the IS-MP-AS model will lead to contraction of aggregate demand in the economy.

In the end, the economy will face a recession and decelerating inflation. The price to pay for maintaining a constant foreign exchange rate is the significant contraction of liquidity and reduced production.

Other disadvantages of this policy are as follows.

1. The rates will remain high for a long time, until oil prices recover and foreign exchange revenues begin to infiltrate into the foreign exchange market. As long as oil prices remain low, any attempts to reduce real interest rates will lead to an outflow of capital and create pressure on the foreign exchange rate. This means a protracted negative effect of limited borrowing opportunities (high real rates) on the production of goods and services.

2. The structural transformation of the economy will be blocked by the fixed foreign exchange rate (constant relative prices), because export-oriented sectors gain no competitive advantage from a cheaper national currency, while the costs of imported goods and services remain high. Imports will slowly decrease as revenues fall (due to the recession); however, the demand for domestic products will also decrease. Importantly, no import substitution will occur, as the prices for imports will not change.

On the whole, this type of policy will simultaneously trigger deflation and growth in unemployment (reduction of labor utilization) in the economy. A cyclical recession will begin in the economy as inflation falls below the central bank's target. This deflation is a painful way to lower relative prices (reduce the foreign exchange rate, see (23)), which will bring the economy back to equilibrium in the long run.

3.2. Sterilized interventions to support the foreign exchange rate

If the central bank uses the interest rate as a policy tool, then the ruble liquidity should be reinjected into the banking system. Interest rates will not change in the economy; no shifts of the MP or AD line will occur as shown in Figs. 7 and 8.

In the foreign exchange market, the central bank will have to sell foreign exchange in the amount of $E1-E2$ (Fig. 6) in every period.

Considering that the central bank's foreign exchange reserves are limited, this policy will fail in the event of a protracted deficit in the foreign exchange market, which occurs when oil prices remain low over long periods of time. Nor would fixing the foreign exchange rate encourage a reduction in the speculative pressure on it (outflow of capital) due to the expectations of an imminent depletion of reserves. As a result of this policy, the foreign exchange rate will not allow the economy to adapt to external conditions, and while this policy is in effect, the economy will retain a frozen structure of consumption and production in line with high oil prices. In the end, this policy will lead to a quick depletion of reserves.

3.3. Utilization of foreign exchange refinancing tools to address excessive stress in the foreign exchange market

We have shown above that, in the event of a protracted foreign exchange deficit, maintaining the foreign exchange rate at a constant level will lead to either depletion of foreign exchange reserves or a protracted tightening of monetary policy.

If the foreign exchange deficit is temporary, the central bank can maintain the exchange rate of the national currency through sterilized sales of foreign exchange or through lending foreign exchange liquidity from the foreign exchange reserves (ruble liquidity will meanwhile remain unchanged). There are at least two theoretical arguments in favor of this policy.

1. To the extent to which the shift in foreign exchange demand on the foreign exchange market (CO shift to the right in Fig. 6) is caused by a temporary peak in foreign debt payments, stabilizing the foreign exchange rate (reverse shift of CO) may achieve the goal of securing financial stability. Even a temporary change in the foreign exchange rate may have an adverse impact on the balances of banks and non-financial entities with large foreign exchange liabilities. The aspiration to hedge losses against foreign exchange rate fluctuations will result in an attempt to "stock up" on foreign exchange, which will shift the capital outflow line further to the right.

2. Time lags in the reaction of trade flows to changes in the foreign exchange rate will hinder the quick adjustment of the foreign exchange market to the temporary decrease in foreign exchange supply. This will result in the need for a greater adjustment of the foreign exchange rate and a more volatile equilibrium rate. As soon as the payment peak has passed, a reverse adjustment of the foreign exchange demand and supply flows and a reverse change in the foreign exchange rate will be

required. To avoid this, the central bank can lend foreign exchange to the market, thereby evening out the fluctuations of the foreign exchange rate. When the payment peak has passed, the gradual repayment of foreign exchange to the central bank will no longer be able to create this type of pressure on the market.

In reality, between 2014 and 2015, the Russian central bank partly relieved the pressure on the foreign exchange rate associated with the debt payment peak, both through direct foreign exchange sales and through providing foreign exchange liquidity (capital outflow line shift to the left). The use of currency swap transactions proved to be an effective way of stabilizing the foreign exchange market under the circumstances.

3.4. Transition to a floating foreign exchange rate with anchored inflation expectations

A floating foreign exchange rate under conditions of falling oil prices partly offsets reduced oil export revenues through growth in alternative exports and reduction in imports such that net exports decrease slower than they would under a fixed rate (or even grow). The side effect is weaker expectations of FX depreciation and a respective decrease in the capital outflow. In the end, a state of equilibrium in the foreign exchange market can be achieved at E_2 in Fig. 9. In this case, we assume that capital outflow will remain at the same level as before the oil shock, i.e., we ignore the debt payment peaks that the central bank can even out with the help of foreign exchange refinancing.

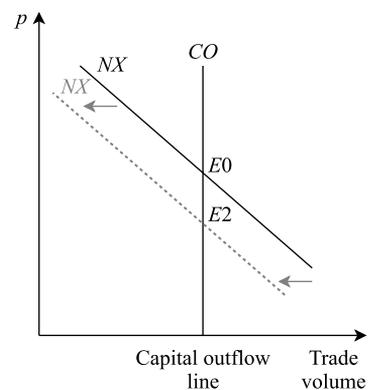


Fig. 9. FX-market under floating exchange rate arrangement.

As follows from the components of the AD model (see (15) and (16)), a lower real foreign exchange rate (decline of p from E_0 to E_2 in Fig. 9) will have the following implications.

1. Equation (21) (net exports) means that equilibrium is being restored in the foreign exchange market and, most importantly, aggregate demand is rising (because net exports are part of aggregate demand). As a result, the negative shift of the AD line to AD_1 in Fig. 8 due to decreased oil revenues is offset by a reverse movement towards the old equilibrium point.

2. The main reason for this reverse movement in demand is the substitution effect (including that expressed by (3) to (6)). Excess employment, which has been seen in the non-tradable sector under the effect of high oil revenues (AD shift to AD_1), is moving to the tradable sector (due to a weaker real foreign exchange rate), which has gained a competitive advantage following the weaker ruble (stronger foreign demand for domestic goods and import substitution). Domestic demand, in contrast, is moving to relatively cheaper non-tradable goods, which helps maintain their output.

3. As noted above, changes in relative prices are associated with cost increases in the economy (cost-push shocks): AS shifts to the top left. This is the observable rise in inflation caused by cost-push shocks against the backdrop of a declin-

ing foreign exchange rate (see (24) for the direct consequences for price movements of such a decline).

4. Changes in relative prices will trigger a structural transformation of the economy, possibly causing losses in potential output (supply shocks), which can either be temporary or permanent depending on how easily the structural transformation of the economy unfolds. This means that a temporary or permanent shift of the vertical line of potential output to the left is taking place.

In the end, an adjustment in the real foreign exchange rate will lead to the interim equilibrium in the economy at the $E1$ point (Fig. 10).

If inflation expectations are anchored, the observable rise in the actual inflation rate caused by higher costs against the backdrop of a declining foreign exchange rate will be of temporary nature. Economic agents will realize that this is a one-time change in prices and not an acceleration of inflation (within the meaning of a long and steady process). Therefore, following an abrupt shift to the top left, the $AS1$ curve will quite soon move back to the bottom right. While in Fig. 10 the inflation rate increase is accompanied by a certain tightening of monetary policy (upward movement along the AD line), with anchored expectations, as noted above, central banks will respond not to the deviation of the actual inflation rate from the target (20) but to the deviation of inflation expectations from the target (16). This is why, in reality, given anchored inflation expectations, the impact of a tighter policy is either not felt at all or this tightening is very short-lived.⁷ As a result, the economy will return to the old equilibrium point but with a lower foreign exchange rate, a new economic structure, a lower consumption of imports, and with higher production of tradable goods.

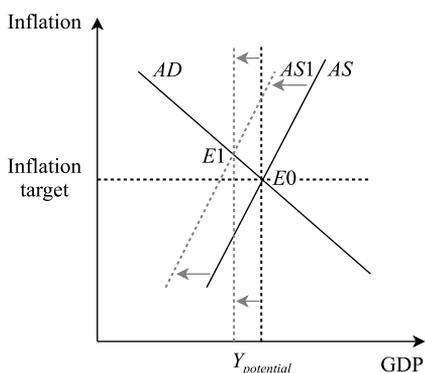


Fig. 10. A short-run equilibrium under floating exchange rates and anchored inflation expectations.

3.5. Transition to a floating foreign exchange rate and a temporary increase in interest rates

Countries that recently switched to inflation targeting have relatively high inflation and unanchored expectations. In such a way, a higher actual inflation rate is interpreted by economic agents not as a change in relative prices, which has no long-term impact on inflation, but as a change in the monetary (trend) inflation rate, or the overall price level. The undesirable effects of this are manifest first in that the AS shift to $AS1$ in Fig. 10 is no longer temporary, as is the case with anchored expectations. The AS line can remain at $AS1$ for a long time (e.g., because

⁷ If the model uses (16) of the rate's response to inflation expectations rather than to the actual inflation rate as described in (20), the rate will remain the same. An example of a minimal response of a central bank to a rising inflation rate under deteriorating trade conditions is the policy pursued by the Central Bank of Chile between 2015 and 2016.

the mechanism for indexing wages according to the inflation rate is quite common). Second, following a one-time change in the foreign exchange rate, inflation expectations can grow higher than the actual inflation rate, which amplifies (according to (25) and (26)) the shift of the *AS* line to the top left. A high inflation rate ignored by the central bank will translate into a higher risk premium, thereby increasing the outflow of capital and dollarization of deposits, thus compromising positive structural shifts in the economy. This higher capital outflow through a further decrease in the foreign exchange rate translates into extra growth in the inflation rate and a shift of the *AS* costs line to the top left. In the end, the interim equilibrium of the economy is reached at the *E2* point (Fig. 11).⁸

In this equilibrium, the inflation rate is much higher than the central bank’s target, while the production capacity of the economy is not fully utilized. This is called stagflation. The economy could have produced more but for the costs it generates.

Therefore, the central bank has to use its tools to bring the inflation rate back to the target and restore demand to align with potential GDP level.

*In response to increased inflation expectations, the central bank will need to temporarily increase the real interest rate, which, in the IS-MP-AS model, corresponds to a shift of the *AD* curve to the bottom left when the equilibrium point of the economy shifts to *E3* (Fig. 12a).*

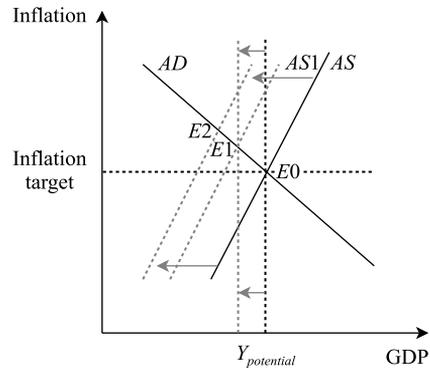


Fig. 11. A short-run equilibrium under floating exchange rates and unanchored inflation expectations.

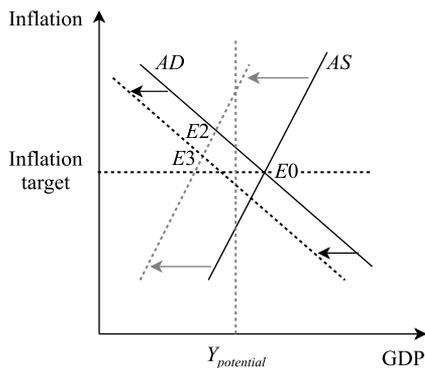


Fig. 12a. Output and inflation response to tight monetary policy under unanchored inflation expectations

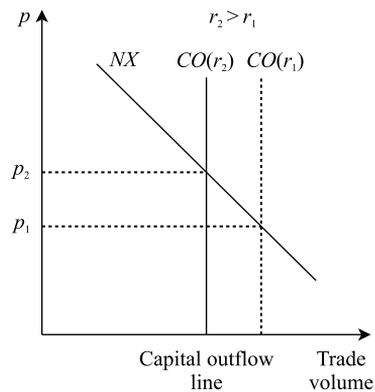


Fig. 12b. FX-market equilibrium under tight monetary policy.

⁸ The shift to *E2* is accompanied by an increase in the real interest rate (*AS* movement along the *AD* line): this is the central bank’s response to accelerated inflation and inflation expectations. However, due to the increase in the latter, this tightened policy proves to be insufficient for inflation expectations to begin to decrease (the reverse movement of the *AS* line).

Following an increase in the real interest rate (AD shift to the bottom left), the following adjustments occur in the economy:

(a) the equilibrium point in the economy shifts to $E3$, where the inflation rate is lower than at $E2$ and closer to the central bank's target;

(b) the foreign exchange market stabilizes faster than during the transition to a floating rate without increasing interest rates, and consequently, expectations of a falling ruble and actual inflation are reduced. See Fig. 12b, where the outflow of capital declines and the foreign exchange rate $p_2 > p_1$ rises, following an increase in the interest rate:

(c) lower dollarization (higher demand for rubles) makes the central bank's policy more effective, enabling to drag down inflation with lower GDP losses. That is, we see the slope of the AD line change in Fig. 12a;

(d) the main effect of the increase in the real interest rate is quickly reduced inflation expectations. This reduction is based first on stabilization of the foreign exchange market and second, on a certain reduction in aggregate demand, which relieves some of the inflation pressure. As a result, the AS line begins a reverse shift to the bottom right;

(e) this policy can be accompanied by a slight additional decline in output. The faster inflation expectations are stabilized, the lower this negative effect will be. The inevitability of extra drops in output under balance of payment shocks is the price to pay for unanchored inflation expectations.

As the inflation expectations decrease (equilibrium shift from $E3$ to $E4$ in Fig. 13 due to lowering AS), the central bank begins to push down interest rates.

This leads to higher output and lower inflation. The initial structural shocks, i.e., those related to costs (the cost-push shocks that pumped up inflation in Fig. 10 by moving AS to the top left) and potential GDP (potential GDP shift to the left), which accompany the structural transformation of the economy, will completely lose their strength over time.

Therefore, over time, the economy will return to the initial equilibrium (or close to it) but with a different (lower) foreign exchange rate and a new economic structure (higher production and exports of tradable goods and lower imports).

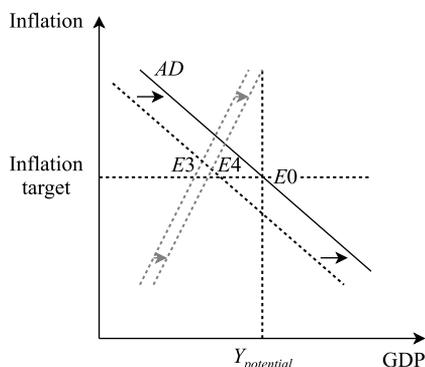


Fig. 13. From a short-run equilibrium to the long-run one under tight monetary policy.

3.6. Fiscal policy during an oil shock

In describing the equations that represent the public sector in the model above, we wrote that the fiscal policy responses to temporary and long-term declines in oil prices will vary. Now, we will examine a simple graphical presentation of a model for ruble-denominated budget revenues and expenditures based on oil prices: see Fig. 14. Generally, budget revenues and expenditures are positively correlated with oil prices. However, the budget expenditures line is steeper, reflecting their higher stickiness after the adverse shocks. This higher tolerance of expenditures is ex-

plained by the requirement that fiscal policy should be countercyclical and by the traditional inertia in implementing spending cuts due to political and administrative circumstances (time costs of approving policy changes). The slope of the budget revenues line may change, particularly in response to changes in the foreign exchange rate (the revenues line becomes steeper when the ruble is declining).

As shown in Fig. 14, lower oil prices form a budget deficit in the amount of AB . When an external shock is known to be temporary, the best policy would be to “even out” the consequences of that shock. This is achieved either through spending the Reserve Fund or increasing the national debt. This policy dampens excessively volatile movements in aggregate demand and employment within the economy.

Whenever an external shock is permanent, market players choose not to wait for oil prices to return to the former higher level. In that case, budget deficits in the amount of AB would lead to (according to (30)) a quick depletion of the Reserve Fund and subsequent accumulation of the national debt, casting doubts among investors on the solvency of the state. This pushes the risk premium and the interest rate up and increases the budget deficit (due to more expensive debt). It also accelerates debt accumulation: the budget expenditures line shifts to the bottom right in Fig. 14. A rising deficit against the backdrop of a growing national debt aggravates the expectations of default or monetization of the government’s obligations. This results in higher inflation expectations, a more intensive outflow of capital, and pressure on the foreign exchange rate. The AS line in Fig. 13 shifts to the top left; the foreign exchange rate becomes lower (partly changing the slope of the budget revenues line in favor of a lower deficit in Fig. 14 but at the cost of a higher inflation rate). The central bank reacts to this fiscal policy by raising the interest rates, thereby creating more problems with national debt servicing. In the end, the economy finds itself trapped in an unwinding spiral: budget deficit → inflation and lower ruble rate → rising real interest rates → budget deficit.

To avoid this scenario, during a long-term reduction in oil prices, budget expenditures should reach a new equilibrium at lower costs. The equilibrium of the budget must be achieved at point B in Fig. 15 by shifting the expenditure line to the top left from the previous equilibrium point E .

The transition of the budget equilibrium from E to B (of expenditures from A to B) may take place at a varying rate. The most appropriate rate of expenditure cuts is a tradeoff between a countercyclical policy and investor confidence. On the one hand, the budget implements a counter-

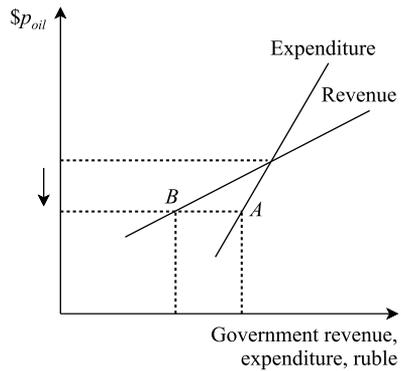


Fig. 14. Government budget deficits and oil prices.

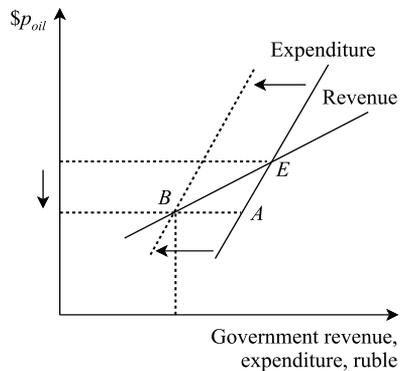


Fig. 15. Government spending corresponding to a new long-run oil-prices.

cyclical policy in the amount of AB (as long as A is further than B , the budget expenses will exceed their equilibrium). In this way, the budget supports the aggregate demand after a decline in oil prices, thereby ensuring a smooth structural transformation of the economy. This support may be reduced in the future, which may coincide with the central bank's transition to a cut in interest rates once inflation expectations have stabilized (Fig. 13).

On the other hand, the later the fiscal policy finds a new equilibrium, the less tolerant investors will be of the budget deficit. They will claim higher risk premiums, as reflected in the interest rates on debt; it will lead to an increase in interest expenses of the budget; and to an accelerated accumulation of debt. The risk arises that the economy will be pushed into the above-mentioned unwinding spiral.

On the whole, expenses should be brought into a new equilibrium at a right moment. The fiscal and monetary policies should be consistent with each other.

It should be noted that spending reserve funds leads to provision of liquidity via budgetary channels. The central bank sterilizes respective liquidity as part of its policy of controlling rates in the money market. This may be accompanied by a reduction in the structural liquidity deficit and a transition to its structural surplus. This transition may result in changes to the transmission mechanism, i.e., correlations between the rates in the money market and rates in the economy. Within the model, it means a change in the position of the monetary policy response curve. These changes are incorporated in interest rates.

4. Conclusions: The role of the monetary and fiscal policies during balance of payment shocks

The implications of various central bank policy options are compared in the Table. Thus, with anchored inflation expectations, a floating foreign exchange rate is the best absorber for balance of payments shocks. With unanchored expectations, the policy of a floating foreign exchange rate provides for a less sustainable trend of aggregate production and inflation rates, but allows the economic structure to adapt quickly to the new oil prices, ultimately reducing aggregate demand by a smaller amount than if the foreign exchange rate is fixed. A simultaneous temporary tightening of monetary policy solves the problem of high inflation expectations. This is especially important when threats to financial stability arise. In that case, a rise in interest rates helps stabilize both the foreign exchange market (by decreasing the net capital outflow through both lower dollarization and higher capital inflows) and inflation.

On the whole, an appropriate monetary policy response during balance-of-payment shocks allows the economy to adapt quickly to the new external conditions. The floating rate serves as the basic adaptive mechanism and mitigates the negative impact of external shocks on output, limiting the economic recession as much as possible only to its structural component. In this situation, a finely tuned monetary policy enables rapid stabilization of inflation expectations to avoid stagflation, which in itself is an additional risk for the economy. Nevertheless, we need to remember that monetary policy cannot spell the economy from a full-fledged recession. An economic recession during a balance-of-payment shock is structural in nature and stems from the impetus of a new economic structure adapted to external shocks. In the new equilibrium, demand is lower, and its structure changes as external demand for Russian products decreases.

Table

Equilibrium of the key economic variables under different monetary policy options.

	Foreign exchange rate	GDP	GDP structure	Inflation rate	Real interest rate
Constant foreign exchange rate with unsterilized interventions	Unchanged	Significant demand contraction due to higher interest rates	Unchanged	Below central bank's target	Significant long-term increase
Constant foreign exchange rate due to sterilized interventions, with long-lasting foreign exchange deficit	Unchanged if the reserves are sufficient to finance the foreign exchange deficit	Unchanged	Unchanged	Unchanged	Unchanged
Constant foreign exchange rate due to sterilized interventions, with temporary foreign exchange deficit	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Floating foreign exchange rate with anchored inflation expectations	Adjusted to the new equilibrium, central bank's reserves intact	Slight decrease due to higher costs, but the effect is offset later as structural transformation of the economy proceeds	Changes in favor of tradable goods, supports aggregate demand	Temporarily grows due to cost-push shocks	Unchanged
Floating foreign exchange rate with unanchored expectations	Adjusted to the new equilibrium faster (with an overshoot, due to higher rates), central bank's reserves are intact	Reduced temporarily, both due to higher costs and higher interest rates	Changes in favor of tradable goods, supports aggregate demand	Temporarily grows due to cost-push shocks and side effects	Temporarily grows

Note. Limitations of use or the inability to achieve the goals of the central bank's monetary policy are marked bold.

Nonetheless, these negative effects on aggregate demand can be made somewhat milder through fiscal policy measures. In the new long-run equilibrium, budget expenses should be cut back to adapt to the new conditions. The new equilibrium budget expenses should correspond to the new equilibrium budget revenues. However, this reduction may be stretched over time. The capacity of the budget needed to implement this policy depends on the accumulated reserves and national debt, on the economy's total debt burden and on investors trust in the government's policy. If the level of investor trust is high and the national debt and debt burden in the economy are low, the government is capable to increase the budget deficit, smoothing the transition to a new equilibrium. However, it should be remembered that a large budget deficit undermines market trust in the government's policy and may bring about market volatility. It may also adversely affect econom-

ic growth through the expectations of economic agents who, while realizing that the budget deficit cannot last forever, will be concerned about potential new taxes or other restrictions on their business, as well as higher macroeconomic instability. Therefore, the trajectory of government spending—which, on the one hand, evens out the most significant costs of the adjustment period and, on the other hand, provides financial markets and businesses with a clear understanding of how long it will take for the budget to consolidate—is the main challenge for fiscal policy on the road to the new equilibrium. At the same time, coordination between the monetary and fiscal policies is essential.

Structural reforms also play an important role during structural shocks. They are supposed to help adjust the economy to the new equilibrium but also to improve the quality of that equilibrium by increasing the flexibility and adjustability of the economy and improving its structure.

To conclude, this paper shows how standard economic models, slightly modified, can be used to describe the balance-of-payment shocks the Russian economy has faced over the past few years, as well as the monetary policy options to be used in response. It is certainly impossible to describe, in a simple model, all the specifics of the Russian situation and the factors to be considered in decision making. Specifically, the important aspects beyond the scope of this paper include monetary policy transmission channels, the liquidity situation in the banking sector, the transition from a structural liquidity deficit to a structural liquidity surplus, the structure of the financial system, the development of individual financial markets, and financial stability risks. We took the liberty to ignore those factors to simplify the presentation without changing the key qualitative conclusions. Nevertheless, these are important matters that should become subject of further research.

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Appendix

Model solution

First, we will list the exogenous variables for the model and the long-run equilibrium levels.

- *Exogenous variables:*
 - r^f —foreign interest rate
 - Y^f —foreign income (demand for domestic products)
 - p_{oil} —oil price in terms of tradable goods (USD)
 - \bar{X} —fixed physical oil exports
 - \bar{L} —amount of workforce
- *Long-run equilibrium levels:*
 - \bar{Y} —potential GDP
 - \bar{U} —natural unemployment level
 - $r_{natural}$ —equilibrium real interest rate
 - $\bar{\pi}$ —CB target inflation rate
 - $\frac{\overline{Debt} \times r_{gov}}{\bar{Y}}$ —equilibrium initial national budget surplus
 - $\frac{\overline{Debt}}{\bar{Y}}$ —equilibrium national debt to GDP.

The IS-MP-AS model consists of *four* equations:

- *dependence of investment in fixed capital on the interest rate*

$$I = I(r); \tag{AI}$$

- *IS line*

$$Y = C + I(r) + G + NX, \tag{AII}$$

where Y is the physical GDP produced, $I(r)$ is capital investments, C is household consumption, G is government consumption, and NX is net exports;

- *MP line*

$$r = r_{natural} + \alpha(Y - \bar{Y}) + \beta(\pi - \bar{\pi}); \tag{AIII}$$

- *AS line*

$$\pi = \psi\pi^e + \gamma(Y - \bar{Y}) + cost_push_shocks, 0 < \psi < 1. \tag{AIV}$$

These are four equations with respect to four unknowns, Y , r , π , and I , with other model variables assumed to be fixed. Note that the variables in the (AI)–(AIV) system actually change over time. Thus, the model includes inflation expectations, which should be defined in terms of dynamics: inflation π is also a *change* in the price levels, which reflects a price change. In reality, each variable in the model (AI)–(AIV) is related to the current time period, i.e., is written with a subscript t , e.g., $Y \stackrel{\text{def}}{=} Y_t$.

We will now describe economic equilibrium in more detail. The economy consists of a goods market (also used for investments), a labor market, a foreign exchange market, a money market, and a financial assets market (bonds market). To find an equilibrium in these five markets, according to Walras' law, it will suffice to analyze equilibria in the first four of them.

We begin with the goods market and the labor market. We will describe labor supply and demand and then goods supply and demand.

Assume that the production of non-tradable goods is characterized by a certain production function depending only on labor (assuming that the majority of non-tradable industries produce labor-intensive services):

$$Y^N = F(L^N), \quad (\text{A1})$$

whereas labor and capital are used in the production of added value of tradable goods:

$$Y^T = H(L^T; K_{-1}), \quad (\text{A2})$$

where change in capital is described by the following equation:

$$K = K_{-1}(1 - \delta) + I. \quad (\text{A3})$$

The demand for investment is negatively correlated with the real interest rate (user cost of capital) and with the investment costs in terms of consumer goods (equivalent to Tobin's marginal q).

$$I = I(r; Q). \quad (\text{A4})$$

We previously ignored the price of capital goods in terms of consumer goods, assuming for the sake of simplicity that $Q = 1$. In this elaborated version of the model, the divergence occurring between the interest rate set by the central bank and the returns on physical capital will have an effect on the price of capital goods.

Here, we will add a definition of GDP in terms of production:

$$Y \stackrel{\text{def}}{=} Y^T + p_0 \times Y^N + p_{oil_0} \times \bar{X}. \quad (\text{A5})$$

Firms' demand for labor will be determined based on production volumes, i.e., (A1) and (A2).

Labor supply from households is positively correlated with real wages (assumed to be the same in the tradable and non-tradable sectors): $L^N + L^T = \theta(w - \pi) + L_{02}^S$, where w is the growth rate in nominal wages, π is the inflation rate, and $L_0^S = \bar{L} - \bar{U}$ is the labor supply at constant real wages (when output equals potential output).

This equation can be expressed differently, as the wages required to secure a certain level of employment (and output), as a standard Phillips curve:

$$w = \psi\pi^e + \gamma(Y - \bar{Y}) = \psi\pi^e + \vartheta(\bar{U} - U), \quad (\text{A6})$$

where w is the rate of increase in nominal wages, π^e is the inflation expectations, which are defined below, and U is the number of the unemployed, $\vartheta > 0$, $0 < \psi < 1$.

Producers in the tradable and non-tradable sectors incorporate their total labor costs into their prices. Thus, we arrive at the following equation:

$$\pi = \psi\pi^e + \gamma(Y - \bar{Y}) + \text{cost_push_shocks}. \quad (\text{A7})$$

The sum of all labor resources in the economy equals

$$L^N + L^T + U = \bar{L}. \quad (\text{A8})$$

Now, we will expound all of the conditions for material balance (equality between demand and fixed production).

The aggregate demand in the economy:

$$Y = C + I + G + NX. \quad (\text{A9})$$

Demand for goods is assumed to depend on current income:

$$C = C_0 + \mu Y. \quad (\text{A10})$$

The total consumption:

$$C \stackrel{\text{def}}{=} C^N \times p_0 + C^T. \quad (\text{A11})$$

Material balance for non-tradable goods:

$$C^N + C^T = Y^N. \quad (\text{A12})$$

and for tradable goods:

$$C^T + G^T + I + NX = Y^T. \quad (\text{A13})$$

Assume the following function with respect to the demand for tradable goods (see Vegh (2013) for its exact derivation from the solution to the problem of optimizing a consumer's utility):

$$\frac{C^T}{C^N} = f(p), \quad (\text{A14})$$

where p is the current relative price of non-tradable goods in terms of tradable goods.

Total public consumption

$$G \stackrel{\text{def}}{=} G^N \times p_0 + G^T. \quad (\text{A15})$$

It follows from equations 1 to 15 that knowing the values of p , NX , G^T , G^N , r , and π^e , we can determine the following 15 variables: Y , π , w , I , Q , Y^N , Y^T , L^N , L^T , U , K , C^N , C^T , C , and G . The number of equations equals the number of unknowns, i.e., the equation system has a single solution.

Our objective now is to determine p , NX , G^T , G^N , r , and π^e . We will begin by determining relative prices p and net exports NX .

The interest rate is inferred from the condition

$$r = r_{natural} + \alpha(Y - \bar{Y}) + \beta(\pi - \bar{\pi}). \quad (A16)$$

Equilibrium in the foreign exchange market is fixed as an equality between the demand for a currency and the supply of that currency:

$$CO = CO(\Delta) = NX(p, Y, Y^f) = Ex(p, Y^f) + p_{oil} \times \bar{X} - Im(p, Y), \quad (A17)$$

where NX is net exports, which depend on the real foreign exchange rate p , the economy's revenues Y , and the rest of the world Y^f , Ex is non-commodity exports in terms of tradable goods (USD), which depend on the real foreign exchange rate and revenues for the rest of the world, $p_{oil} \times \bar{X}$ is commodity exports in USD, $Im(p, Y)$ is imports, and CO is net demand for foreign financial assets (capital outflow minus inflow), determined as a differential between real interest rates $\Delta = r - r^f - risk_premium$.

Equation (A17) provides us with real foreign exchange rate p , while net exports NX are derived from equation (A18):

$$NX(p, Y, Y^f) = Ex(p, Y^f) + p_{oil} \times \bar{X} - Im(p, Y). \quad (A18)$$

We determine the nominal foreign exchange rate based on the ratio:

$$p = RER = \frac{P^N}{P^T} = \frac{P^N}{E \times P^{Tf}} = \frac{P^N}{E \times 1}. \quad (A19)$$

P^N is calculated drawing on an expression equivalent to (7) (AS line) for the fixed P_{t-1}^N level: $\log(P_t^N) = \log(P_{t-1}^N) + \psi\pi^e + \gamma(Y - \bar{Y})$. Then, with P^N known, (19) yields the level for nominal foreign exchange rate E .

Now, we need to write down the equations for the public sector. Budget revenues are conditional upon proceeds from oil exports and taxing the non-commodity sector:

$$T = p_{oil} \times \bar{X} + \tau(Y - p_{oil} \times \bar{X}), \quad (A20)$$

where τ is the VAT rate. Note that this form of tax is represented in terms of tradable goods. We assume that government spending on non-tradable and tradable goods relate as:

$$\frac{G^T}{G^N} = \varphi(p). \quad (A21)$$

That is, a relative appreciation in tradable goods (against a lower foreign exchange rate and decrease in p) leads to a decrease in demand for them.

We will also assume that the government determines the total amount of government spending (budget deficit) based on the requirement to maintain a constant level of national debt from a long-term perspective (e.g., over a 3-year horizon). That is, beginning from the third year, the following ratio should always be true: $\frac{(T-G)}{\bar{Y}} = \frac{Debt \times r_{gov}}{\bar{Y}}$, where the interest rate on the debt is correlated with global rates and risk premiums and positively correlated with the debt level.

$$r_{gov} = r^f + risk_premium; \quad (A22)$$

$$risk_premium = \rho \left(\frac{Debt_t}{Y} \right). \quad (A23)$$

This means that in the coming three years, the government has the opportunity to increase or reduce the national debt (accumulate reserves).

$$\frac{Debt_t}{Y} = \frac{Debt_{t-1}}{Y} (1 + r_{gov}) + \frac{(G - T)}{Y}. \quad (A24)$$

We will also assume that the government has independently chosen the best trajectory for the coming three years, i.e., we have the following variables fixed:

$$\frac{Debt_t}{Y_t}, \frac{Debt_{t+1}}{Y_{t+1}}, \frac{Debt_{t+2}}{Y_{t+2}}, \frac{Debt_{t+3}}{Y_{t+3}}.$$

In all future periods, the debt should remain the same. With the debt levels known, we can use (A24) to calculate the absolute amount of government spending in each year (which will depend on Y ; the lower the Y value, the lower the deficit the government can opt for to satisfy the current level of national debt). In the end, we calculate G^T and G^N .

To describe the model dynamics, we need to draw a distinction between the price level and its changes (inflation). As the price level, we have:

$$P = (P^N)^\alpha (P^T)^{(1-\alpha)} = (P^N)^\alpha (E)^{(1-\alpha)}. \quad (A25)$$

By taking the difference between the logarithms, we obtain this expression for inflation:

$$\pi_t = \log(P_t) - \log(P_{t-1}) = \alpha \pi_t^N + (1 - \alpha) \Delta E, \quad (A26)$$

where π_t^N is inflation rate for non-tradable goods, and ΔE is the change in the nominal foreign exchange rate (RUB per USD) expressed as a percentage. $(1 - \alpha) \Delta E$ reflects the so-called exchange rate pass-through effect. By comparing (A26) to (A7) (AS line), we can understand one of the interpretations of the *cost_push_shocks* in (A7): it is the direct effect of the exchange rate pass-through to prices.

Based on (A7) and (A26), we can obtain an expression for changes in the prices for non-tradable goods: $\log(P_t^N) = \log(P_{t-1}^N) + \psi \pi^e + \gamma(Y - \bar{Y})$, and the cost-push shocks: $cost_push_shocks = -(1 - \alpha) \Delta p$, where Δp is the change in the real foreign exchange rate expressed as a percentage (growth means strengthening).

Only when $\pi_t^N = \Delta E$, we can speak about the monetary inflation represented by the two summands in (A7).

By using the definition of the real foreign exchange rate (A19) in logarithms, we obtain the following for changes in the nominal foreign exchange rate:

$$\Delta E = \pi_t - \alpha \Delta p_t, \quad (A27)$$

where Δp_t is the change in the real foreign exchange rate, expressed as a percentage.

Thus, with a constant real foreign exchange rate, the nominal foreign exchange rate decreases in accordance with the inflation rate.

To fully define the model, we need to fix an initial price level $\log(P_{t-1})$, real foreign exchange rate p_0 , and capital reserve K_{-1} ($Q_0 = 1$). Then, we need to determine how inflation expectations are shaped. For example, expected inflation may depend on past inflation or, in the event of anchored expectations, may be constant: $\pi^e = g(\pi_{-1})$.

Expectations can also be defined as rational if we assume they are equal to the mathematical expectations of future inflation, conditioned upon all information available at the moment (in the model): $\pi^e = M(\pi_{+1} | \Omega_t)$.

We define the nominal interest rate as

$$i \stackrel{\text{def}}{=} r + \pi^e, \quad (\text{A28})$$

where i is the nominal interest rate, r is the real interest rate, and π^e is the inflation expectation (or inflation).

Finally, we introduce the nominal money supply into the model, as follows:

$$\frac{M}{P} = L(r + \pi^e; Y), \quad (\text{A29})$$

where M is the money aggregate (in case of this model, M_0), P is the price level, and L is a function of money demand depending on the nominal interest rates and real income.

Regarding the model dynamics, we should also impose certain limitations on the speed of accumulating net foreign assets, determined as follows: $B_t = B_{t-1}(1 + r^f) + Y^T + p \times Y^N + p_{oil} \times \bar{X} - C^T - G^T - I(r) - p(C^N + G^N)$, where B_t and B_{t-1} are net foreign assets in the economy (if $B_t < 0$, then net foreign liabilities) in terms of tradable goods (USD), and r^f is the real interest rate in the global capital market. All other variables are defined above.

In particular, B_t should not decrease (no debt should be accumulated) at a speed exceeding the interest rate, r^f . Otherwise, the so-called pyramid scheme will occur.