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An Educational Model of a Small Open Economy for Monetary Policy Analysis

(with examples from Bank of Russia's practice)

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Abstract

This article presents a diagrammatic model of a small open economy. The dynamics of this graphical model are illustrated using impulse responses from the corresponding formal semi-structural model (Quarterly Projection Model, QPM). [1]

This graphical model reflects the modern understanding of how a fiat monetary economy and the current global financial system operate.[2] It describes the specifics of monetary policy (MP) responses to supply and demand shocks under inflation targeting and the importance of anchoring inflation expectations. It explicitly considers the foreign exchange market (taking into account its potential imperfections) and demonstrates the role of the exchange rate in the transmission of MP. The model helps to link the global financial (credit) cycle to accumulating risks to financial stability, which create constraints on MP ('dilemma, not trilemma') and require the use of additional policy instruments.

In our view, the presented diagrammatic model is a simpler version of the graphical model for analysing monetary policy in a small open economy than that proposed by Basu and Gopinath (2024). Therefore, it is suitable for less experienced readers—undergraduate students. The model not only accounts for the constraints facing monetary policy in a small open developing economy with developed financial markets but also allows for the analysis of extreme cases, like the closure of the financial account of the balance of payments and the associated changes in monetary policy transmission. Consequently, the model can be used to explain the rationale behind the Bank of Russia's monetary policy decisions over the entire inflation targeting period (including from 2022 onward). The authors provide a detailed analysis of the Bank of Russia's decisions from 2022 onward using the model.

Keywords: monetary policy, small open economy, foreign exchange market, inflation targeting, monetary policy dilemma, diagrammatic general equilibrium model, Quarterly Projection Model (QPM), Bank of Russia.

JEL codes: E58, F38, F41, G28.

[1] The program code for the educational formal dynamic semi-structural model was published as an Appendix to the working paper on the Bank of Russia website.

[2] In particular, the model accounts for: the difference between 'money for the economy' (inside money) and 'money for banks' (outside money); the role of commercial banks and financial markets in providing financing for aggregate demand; the long-run neutrality of money; inflation targeting as the ultimate goal of modern MP; targeting the money market interest rate as the operational framework of MP; the channels of transmission of MP through which the regulator can influence inflation; and the impact of financial crises on the ability of commercial banks to create money for the economy.

Contents

Introduction

Modern macroeconomic theory is technically very complicated due to the need to model equilibrium in many markets simultaneously and take into account their joint dynamics. Dynamic Stochastic General Equilibrium (DSGE) models play a major role both in theoretical work and practical applications at central banks. Advances in computational capabilities make it possible to create highly complex models. This focus on technical complexity can reduce the interpretability of modelling results and make changes to macroeconomic indicators in the model less intuitive. In practice, however, central bank decisions are not made mechanically based on models—they are made by people, whose judgment is typically based on simple causal relationships (heuristics). Thus, in practice, a gap exists between what complex DSGE models predict and what is trusted by those responsible for monetary policy decisions. The problem of trust in forecasts from complex macroeconomic models is even more relevant for economic agents unfamiliar with macroeconomics and macroeconomic forecasting—households, businesses, and government officials. The latter is particularly pronounced in developing economies and/or countries that have transitioned to a market economy relatively recently (including Russia).

Thus, regulators face the challenge of explaining the rationale for their actions in more accessible language to a wider audience.

Another issue, characteristic even of developed countries with a deeper tradition of knowledge about the market economy, is the inadequate presentation of modern monetary economics and central banking in undergraduate textbooks.[3] Academics often lead the way in researching current new issues facing central banks, but the reflection of this research in student textbooks in practice often occurs with a significant lag (partly to allow the theories to stand the test of time). In a rapidly changing environment, this threatens to cause textbooks to lag behind current practical issues. Undergraduate macroeconomics course materials (especially those in Russian) do not always contain a modern understanding of how a monetary economy functions, how monetary policy is structured, and what the effects of the global financial system on a small open economy are.

For example, for many years, macroeconomics textbooks have been dominated by the concept of the 'money multiplier'—a money creation mechanism that has been criticised by both practitioners and academic economists. Adherence to this concept leads to a distorted understanding among students of how the modern banking sector operates, and, as a result, of how modern monetary policy functions, as well as the actual limitations of money creation in the economy (not funding, but capital constraints).[4] Another example is the use of the 'trilemma' theory of monetary policy for a small open economy, whereas for modern practice, the 'dilemma' theory is more relevant.[5] Furthermore, textbooks fail to mention macroprudential policy as a condition that allows monetary policy to be independent under the 'dilemma'.[6]

Central banks, being accountable to society, have a goal of ensuring that society (including in its evaluation of central bank policy) relies on an accurate understanding of how the economy and financial markets function. Therefore, central banks are interested in devoting considerable attention to improving economic literacy. This also applies to knowledge about how central banks analyse and model the economy.

In an attempt to contribute to the resolution of the two aforementioned problems, the authors have attempted to develop a visual, educational macroeconomic model, drawing on existing

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[3] See Ihrig and Wolla, (2020); Romer. (2000); Borio and Disyatat, (2015); King, (2024).

[4] Regarding critics from the practical side, see the Bank of England publication (McLeay et al., 2014); regarding critical views from researchers, see Jakab and Kumhof (2015); see also the review of the criticism in Grishchenko (2019). Meanwhile, the concept is included in recent editions of popular undergraduate macroeconomics textbooks, e.g. Mankiw (2022). This same concept is reproduced in many Russian university textbooks (references are intentionally omitted).

[5] Ray (2015); Boyarchenko and Elias (2024).

[6] Basu and Gopinath (2024).

experience in international literature and textbooks. This manual may prove useful to both teachers and students.

The literature describes the logic of central bank monetary policy within the framework of macroeconomic models using visual methodological materials of varying complexity.[7] Among these, the most recent and comprehensive, in terms of the aspects of central bank policy considered, is the graphical version of the Integrated Policy Framework (IPF) model, proposed by the International Monetary Fund (IMF) in Basu and Gopinath (2024). This material has many advantages and few drawbacks for educational purposes; however, in our opinion, it is quite complex for comprehension at the introductory (undergraduate) level.[8]

Other less modern diagram models include:

- The IS-MP model (Romer, 1999; Romer, 2000), which is characterised by the correct modelling of the modern monetary policy compared to the standard IS-LM model[9];

- The C-S model (Carlin and Soskice, 2005), which replaces the IS-LM-AS model, with a graphical model of three equations (IS-PC-MR) and takes into account lags in the reaction of aggregate demand to interest rates and in the reaction of inflation to aggregate demand;

- The BMW model (Bofinger et al., 2005), which develops the model of Romer (2000) and accounts for the credibility of central bank policy. The model also includes a small open economy version with a floating exchange rate;

- A graphical version of interconnected (large) open economies (Corsetti et al., 2007) to replace the Mundell–Fleming model;

- The AS-AD model of a closed economy (Benigno, 2009). This model is consistent with the modern concept of central bank policy. The model emerged as a response to the 2008 crisis and allows for the analysis of the ‘liquidity trap’ (zero lower bound) and the deleveraging process (debt deflation);

- The IS-MP model of a small open economy (Carlin and Soskice, 2010).

In Russia, such publications include the work of Sinyakov and Yudaeva (2016). Compared to that publication, we do not examine the structure of the economy and fiscal policy in detail. Instead, we add a more detailed model of the foreign exchange market (with explicit modelling of currency flows, in particular, the external incoming supply of foreign exchange from global investors), that is, we consider financial flows in the FX exchange market not on a net basis, but on a gross basis. We also model a ‘dilemma, not trilemma’ case and analyse which policy measures can help monetary policy overcome it. The focus of the previous work, written shortly after the Bank of Russia’s transition to inflation targeting, was on an analysis of the advantages of

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[7] This statement doesn’t apply to economic models published in numerous research publications, where the goal is not to describe the tools for educational purposes, but to find an answer to a research question, with the model being merely a research tool to overcome data shortages. This also does not apply to publications describing the modelling apparatus used by central banks. Such descriptions are typically aimed at a more technically experienced reader. See, for example, the section of the Bank of Russia’s website describing its modelling apparatus: http://www.cbr.ru/dkp/system_p/.

[8] In our view, one of the IPF’s advantages is the presence of a rigorous dynamic, micro-based model behind the graphical version of the model. Thus, shifts in the curves and changes in their position over time can be tracked using the equations. Another advantage is the model’s consideration of a wide range of possible shocks and market imperfections, as well as the analysis of the optimal combination of various policy instruments to achieve macroeconomic stabilisation.

One of the downsides is the lack of a more usual representation, at least from the point of view of central banks, of the relationship between the interest rate and aggregate demand (the output gap). Instead, the IMF’s graphical model focuses on the exchange rate, not the interest rate, as an instrument to stabilise aggregate demand. Although the exchange rate depends on the national interest rate through uncovered interest rate parity, this representation, in our view, is not very suitable for educational purposes as it overlooks some other channels through which the interest rate influences aggregate demand—in particular, the interest rate channel of monetary policy.

[9] Despite this, the IS-LM model is still presented in a number of recent editions of popular macroeconomics textbooks, e.g. Mankiw (2022).

an inflation targeting regime versus a fixed exchange rate regime. This work analyses monetary policy decisions in a later period—since 2022.

In preparing the description of a graphical macroeconomic model, we have several goals in mind. First, we would like to present an adapted version of the graphical model to readers who may have difficulty analysing more advanced models, even graphical ones (for example, the diagrammatic IPF model by the authors from the IMF). The IMF graphical model is intended for more experienced readers (at central banks). We are targeting a less experienced and broader audience. Our goal is to describe the modern monetary (fiat) economy and the structure of monetary policy in undergraduate course materials.

Second, our goal is to consider the limitations of monetary policy in a small open, developing economy with developed financial markets. The ability of major central banks to trigger global financial and credit cycles creates a 'dilemma, not a trilemma' for monetary policy in developing countries. Within a graphical model, we will analyse this situation and demonstrate its causes. Such an analysis will help us to understand the tools that can enable monetary policy to overcome this 'dilemma' and allow the central bank to gain control over inflation under a flexible exchange rate and open capital account. Importantly, the original purpose of some of these instruments is to limit the accumulation of risks to financial stability. However, their side effect is greater independence of monetary policy. The Bank of Russia actively applies some of these instruments in practice, for example, macroprudential measures. These issues are addressed in the IMF illustrative model. However, there are three key conceptual differences between our model and the IMF model (excluding substantive differences).

The first difference is that our graphical model is not structural in the sense that it does not follow from a rigorous micro-founded model.[10] Its individual blocks are not derived from solving an optimisation problem under budget constraints. For both the formal and graphical model, we use ready-made behavioural equations from other articles (Gali, 2020; Maggiori, 2022). Due to the lack of rigorous microfoundations, we do not provide a rigorous analysis (justification) of the optimal policy choice or the set of instruments used by the central bank.[11] Our graphical model corresponds to an economic-mathematical model, which, however, is semi-structural—the Quarterly Projection Model (QPM), which we describe in the last section.

The second difference is that our graphical model doesn't explicitly model economic dynamics. We do not accompany the graphical analysis with rigorous mathematical calculations, which would increase the credibility of such an analysis but would greatly complicate it.[12] However, at the end of the article, we supplement the graphical model with a simple dynamic model and demonstrate that the rigorous dynamic model yields the same qualitative conclusions as the simple graphical model.

The third difference is that unlike the IMF model, for ease of visual analysis, we do not add threshold levels for individual macroeconomic variables, beyond which the economy switches to a

[10] The IMF graphical model follows from the model (Basu et al., 2023).

[11] The IMF's work examines the problem of maximising social welfare in conditions where certain imperfections in the financial market lead to the emergence of macroeconomic externalities. These are effects on the economy that cannot be accounted for at the micro level in the decisions of individual agents. For example, an increase in capital inflows into a country by one investor at the micro level strengthens the national currency at the macro level, which may influence the capital inflow decisions of other investors. The presence of such externalities raises the question of the optimal regulatory response that maximizes social welfare. This ultimately reveals which policy instruments are best applied in a given situation—for example, the choice of exchange rate regime (floating or fixed) in the face of a commodity price shock for a small, open economy that exports such commodities.

[12] The authors of the IMF model distinguish three periods in the graphical model: '0' – before the shock, '1' – the short-term period immediately after the shock, '2' – the long-term period after the shock has ended and all variables have been fully adjusted.

different operating mode—crisis or overheating, to the charts.[13] We examine such transitions in separate diagrams. This increases the number of diagrams but improves readability.

The second goal is to describe the changes that have occurred since 2022 and how these changes have affected the rationale behind monetary policy decisions. A typical textbook examines a small open economy. In Russia, significant changes occurred in 2022 that impacted the economy and the transmission of monetary policy. We will demonstrate how our graphical model can help analyse these changes and explain the rationale behind monetary policy decisions made since 2022.

The structure of the description is as follows. First, we will present a standard illustrative model of a small open economy—a model under conditions of a perfect financial market. The exchange rate plays an important stabilising role in the standard model and is an effective channel for the transmission of monetary policy. Therefore, in this section, we will present a modern, albeit simplified, model of foreign exchange market equilibrium. The model can describe both the foreign exchange market under conditions of a perfect financial market (where uncovered interest rate parity holds) and the market under financial and trade sanctions and capital flow restrictions.

In Section 2, we analyse the logic of central bank monetary policy in the case of demand and supply shocks in such a model and discuss why supply shocks under unanchored inflation expectations require unpopular decisions from the central bank—a tight monetary policy.

In Section 3, we will examine the global financial cycle and its impact on small open economies, and analyse how the monetary policy dilemma arises. We will analyse how it changes the ability of monetary policy to stabilise inflation and why additional instruments are needed. In particular, we will examine how instruments that address the issue of financial stability can simultaneously help monetary policy stabilise inflation.

In Section 4, we will consider the shocks the economy faced in 2022–2024 and the rationale behind the central bank's actions in the face of constraints on the external financing market and restrictions on the use of foreign assets.

To illustrate the dynamics of macroeconomic variables, we supplement the graphical version of the model in Section 5 with a semi-structural model ('in gaps')—the QPM—based on the small open economy model (Gali, 2020). The model is used to formally illustrate the logic of the graphical model and the central bank's decisions depending on emerging shocks.

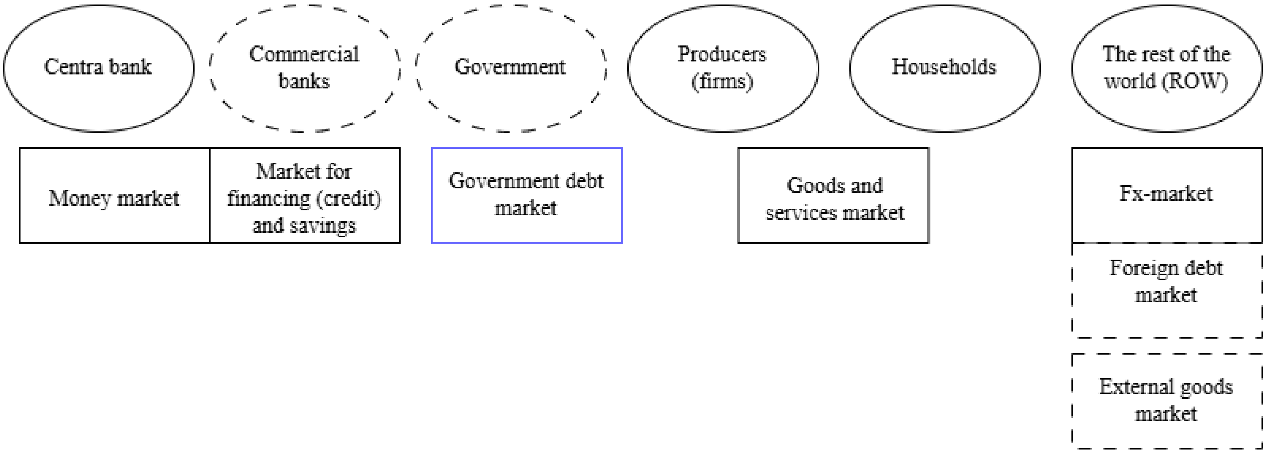
1. Standard model of a small open economy

The economy consists of the non-financial sector (households, corporations, including exporters/importers, government), the financial sector (banks and the central bank), and the export-oriented commodity sector.

The composition of economic agents and markets is presented in Box 1.[14] It helps to understand which participants create aggregate demand and which shape supply in the respective markets.

[13] Such areas are shaded with grey stripes on the IMF charts.
[14] From here on, unless otherwise stated, the figures are drawn by the authors.

Box 1. Markets and their participants



Note: The rectangles indicate the markets being modelled, whose equilibrium will determine the general equilibrium. The ovals indicate the economic agents participating in the markets. The dotted lines are used to highlight markets that are not typically modelled. A blue line marks the market where equilibrium is achieved automatically due to Walras's law.

1.1 Goods market: demand as a function of the real interest rate

We will begin our description of equilibrium in the goods and services markets with the demand side of the market. This section is standard and straightforward, as it is entirely consistent with macroeconomics textbooks.

Aggregate demand (Y^d) for final goods and services produced domestically consists of consumer and investment demand, demand from the public sector, and net exports (exports minus imports):[15]

$$Y^d{}_t = C_t + I_t + G_t + Ex_t - Imp_t = A_t + (Ex_t - Imp_t) \qquad (1)$$

where:

C – household demand for goods and services;

I – gross investment (i.e. investment in the reproduction of capital, the increase of capital, and desired stocks of goods);

G – government consumption;

A (absorption) – the desired demand of the country's residents for goods/services, both produced domestically and imported;

Ex – exports (commodities and other goods);

Imp – imports of goods and services.

Demand in the goods market is driven by the non-financial sector (households and producers). According to the standard approach, consumption (C) and investments (I) are negatively dependent on the real interest rate: consumers prefer to defer consumption when real interest rates exceed their internal discount rate—their intrinsic desire to consume today rather than tomorrow. Companies also reduce investment when the real discount rate for future cash flows from investments rises, reducing the net present value of the investments. A rise in the real interest rate makes the alternative of channelling resources into financial market instruments rather

[15] For simplicity, the time index t has been omitted from the variables in the text when they refer to the same period. Otherwise, the index '-1' or '+1' is added.

than physical capital more attractive. Importantly, these agents base their decisions on the real interest rate. This says nothing about the origin of the interest rate—the interest rate for the private non-financial sector is determined in the money market (which provides funding for the economy).

The real rate is equal to the nominal interest rate adjusted for expected inflation. By definition, the real interest rate r_t is equal to the nominal interest rate minus expected inflation:

$$r_t \stackrel{\text{def}}{=} i_t - \pi^e{}_t.$$

The IS equation for an open economy has the standard form:[16]

$$Y^d{}_t = \mathbb{E}_t[Y^d{}_{t+1}] - \delta^{ir} * (i_t - \pi^e{}_t) - \delta^{rer} * (RER_t - \overline{RER}) + \varepsilon_{dt} \qquad (2),$$

where:

$Y^d{}_{t+1}$ – aggregate demand in the next period;

$\mathbb{E}_t[*]$ – the operator of mathematical expectation at time t;

i_t – nominal interest rate on loans and deposits;

$\pi^e{}_t$ – expected consumer price inflation;

RER_t – real exchange rate.

The exchange rate allows us to take into account the influence of aggregate demand on the foreign trade component $(Exp - Imp)$. $\overline{RER}$ is the level of the real exchange rate in long-run equilibrium; ε_{dt} is an aggregate demand shock. The weaker (lower) the real exchange rate, the higher the external demand and the better the trade balance in real terms, although the coefficient δ^{rer} can also be negative:

$$RER_t = CPI_t / E_t * CPI^f{}_t \qquad (2.1),$$

where:

E – nominal exchange rate (units of national currency for 1 unit of foreign currency);

CPI^f – consumer price index (cost of consumer basket) abroad (assumed to be equal to 1);

CPI – consumer price index in the economy under consideration.

Due to short-term price stickiness, the main driver of changes in the real exchange rate in the short term is assumed to be changes in the nominal exchange rate E.

This relationship between the level of aggregate demand and the real interest rate is described by a line called IS (Figure 1). In the general equilibrium of the economy, the equilibrium real interest rate will correspond to a certain level of aggregate demand and GDP.[17]

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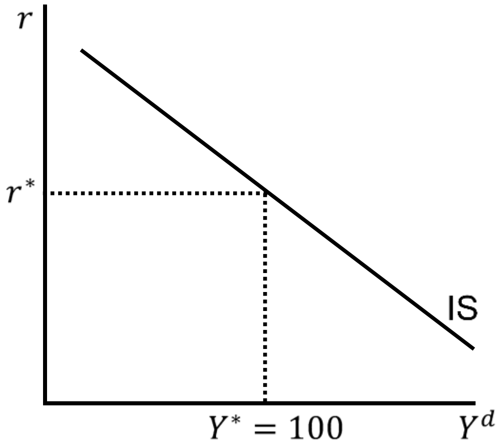
[16] In the formal dynamic semi-structural model from Section 5, this equation is represented in natural logarithms. In our case, for simplicity, it is represented in levels. From here on, capital letters denote levels, and lowercase letters denote their natural logarithms. For example, $y = \ln Y$.

[17] In Figure 1, a value of 100 represents the level of demand consistent with potential GDP (see below).

Figure 1. IS curve

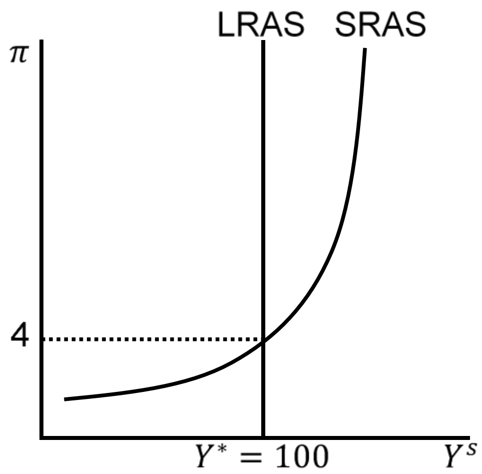


1.2 Aggregate supply

Let us now turn to a description of **the aggregate supply curve**. The non-financial sector produces goods and services using labour and capital and sells domestic (non-tradable) goods and tradable primary goods. It is assumed that tradable primary goods are natural resource rents, meaning they are produced without significant inputs of labour and capital.

The labour market is not explicitly modelled. It is assumed that labour supply grows proportionally to real wages (in micro-based models, this follows, in particular, from the solution of the household sector optimisation problem). This property, as well as the asymmetry of price changes by firms in the economy, yields the Phillips curve, which defines the aggregate supply line. This line describes the relationship between inflation and the level of economic output in the short term (up to two years), the short-run aggregate supply (SRAS) line (Figure 2). This is also known as the Phillips curve. When demand in the economy is low but growing, companies are less inclined to raise prices (for fear of losing market share), even if they need to raise nominal wages to increase output and meet growing demand. When demand is very high and all companies understand this, they are more inclined to pass on nominal wage increases to prices. In general equilibrium this means that real wages remain unchanged and labour supply cannot increase.

Figure 2. The short-run aggregate supply (Phillips curve) and the long-run aggregate supply (LRAS) functions



The overall inflation rate consists of two components:

$$\pi_t = w_1 * \pi_{dt} + w_2 * \pi_{impt} \quad (3),$$

where $w_1 + w_2 = 1$, $w_1 > 0, w_2 > 0$.

The first component is the inflation of non-tradable goods or services (e.g. haircuts) and domestically produced consumer tradable goods (e.g. cars), which is related to business activity and the exchange rate:

$$\pi_{dt} = \alpha\bar{\pi} + (1 - \alpha - \beta^E) * \pi_t{}^e + \beta^{Y\_n}(Y_t - Y^*) + \beta^E * (E_t - E_{t-1}) + \varepsilon_{st}, \quad (3.1),$$

where:

π_{dt} – inflation of prices of goods and services produced domestically (‘d’ denotes domestic);

$\pi_t{}^e$– inflation expectations of agents (companies and households);

$\bar{\pi}$– the central bank’s inflation target;

Y_t – level of output (GDP);

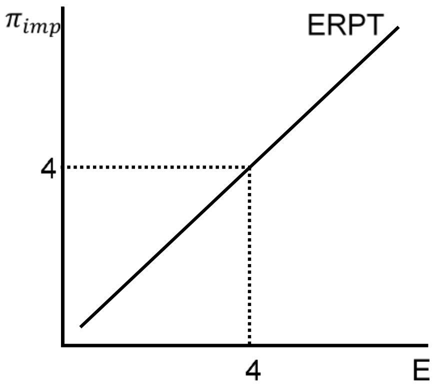
ε_{st}– a supply (cost-push) shock in the production of domestic goods;

Y^*– the equilibrium (potential) level of output.

In equilibrium, the output gap $Y_t - Y^*$ is zero, inflation expectations are consistent with the central bank’s target $\bar{\pi}$, and the nominal exchange rate (as well as other nominal variables) moves one-to-one with the target inflation rate. Therefore, in equilibrium $\pi_{dt} = \bar{\pi}$.

It is also important to identify another component of inflation that is not directly related to domestic demand: the change in the prices of imported goods. Let us assume that foreign inflation is zero. Then, in the absence of various logistics shocks, the prices of imported goods will rise solely due to the exchange rate change. A change in the exchange rate leads to an increase in the prices of imported goods. Graphically, this is represented by the ERPT (Exchange Rate Pass-Through) line (Figure 3), which reflects the pass-through of a given change in the exchange rate (for a given exchange rate at a previous point in time) into an increase in the prices of imported goods.[18]

Figure 3. Import price inflation line (pass-through of exchange rate changes to import prices) for a given exchange rate level at a previous point in time



The formal expression for the change in prices of imported goods is:[19]

$$\pi_{impt} = (1-\beta^E) * \bar{\pi} + \beta^E * (E_t - E_{t-1}) \quad (3.2).$$

Note that overall inflation consists of changes in the prices of domestic non-tradable goods or services and tradable goods, as well as changes in the prices of imported goods. Changes in import prices influence the overall inflation. This pass-through effect is an important source of supply-side inflation shocks. The nominal exchange rate, like any other price in the economy, acts as a stabiliser of supply and demand. Unlike consumer prices, the exchange rate is determined in the financial market and therefore reacts quickly to external financial or commodity shocks. The exchange rate ensures the economy's adjustment to them through aggregate demand and supply reaction to changing prices. However, its impact on inflation is temporary if inflation expectations are anchored to the target of the central bank. As the exchange rate adjusts to the equilibrium level, the rate of its change and, consequently, the pass-through to prices and inflation itself slows down. Over the long term, the nominal exchange rate weakens (depreciates) at a rate corresponding to the difference in inflation rates between the domestic and international markets (for example, for Russia, this is 2% if international or trade-partners' inflation is 2%, and 4% if international inflation is zero).[20] This rate will be passed on to rising import prices (the final inflation rate of import prices in Russia will be 4% in any case).[21]

[18] Changes in import prices depend on changes in the exchange rate. The figure depicts the level of the exchange rate; the exchange rate level at the previous point in time is not shown, as it is fixed (already known), and a change in the nominal exchange rate relative to a *given* level at the previous point is equivalent to a change in the level of E (Figure 3). This is one of the simplifying elements of this model.

[19] It is assumed for simplicity that inflation abroad is zero, otherwise, the formula would have to include another term—'imported foreign inflation'.

[20] As will be seen below, this follows from the assumption of an equilibrium exchange rate based on uncovered interest parity (UIP) and the assumption of equality of real equilibrium interest rates in the small open economy and abroad.

[21] When passing through 2%, another 'autonomous' 2% of imported inflation will be added to this—the growth of import prices in foreign currency (foreign inflation).

An increase in import prices will shift short-run aggregate supply (SRAS) curve leftward and upward, since the same level of the output gap (business activity) will correspond to a higher inflation due to the increase in import prices.

According to standard textbooks, the SRAS curve is nonlinear. This nonlinearity means that, up to a certain output level, an increase in demand leads more to an increase in output than to an increase in prices. After a certain threshold is crossed, further increases in output become very small, even for large increases in wages and prices. This is a situation where even a significant increase in wages (and prices) to boost output fails to lead to any significant increase in labour supply. This property stems from the fact that the volume of productive resources has a limit. For simplicity, this nonlinear relationship between inflation and the output gap is not represented in Equation 3.1, but it is important for graphical representation.

The economy is unable to produce beyond a certain level of output in the long run, irrespective of wage or price growth. Over this horizon, the level of output is independent of the sustained inflation rate (the central bank's target), as shown by the LRAS (Long-Run Aggregate Supply) line in Figure 2.

It is important that in equilibrium demand is equal to supply, that is:

$$Y^d = Y^s.$$

To represent equilibrium in the goods market graphically, these lines must intersect at the same coordinates. To achieve this, we must relate the real interest rate, as the cost of financing expenditures, on the demand side of goods (Figure 1) to the inflation rate on the aggregate supply graph (Figure 2). To do this, we turn to the money market.

1.3 Equilibrium in the money (financing) market

The IS line and aggregate demand are defined for a given interest rate, which requires a description of the equilibrium in the financial market where the interest rate is determined. In a modern economy, economic agents overwhelmingly lend funds, not goods to each other. Although a leasing market does exist, its pricing is tied to the interest rate determined in the financial market. The money market is also important because demand for goods and services cannot exist without sources of financing (payment), that is, independently of equilibrium in the money (financing) market. In practice, demand is realised through payment (a financial transaction) for goods and services. In this regard, a quantitative constraint on financing (money) can lead to a situation where, regardless of the desired demand of households and companies at a given interest rate is, the aggregate demand simply cannot be realised in the form of real transactions without money. In other words, in a monetary economy, it is impossible to consider aggregate demand for goods and services without the availability of financial resources to satisfy such demand. The money market, from a modelling perspective, turns out to be unimportant if there are no quantitative constraints (imperfections) in the provision of money to the economy—such constraints arise during financial crises (Brunnermeier and Reis, 2023). From here on, we will primarily consider the following particular case, which is typical for the economy in normal (non-crisis) periods: the amount of money in the economy automatically (endogenously) adjusts to demand for money at *any given* interest rate. During a crisis, constraints on the money supply to the economy may arise, forcing the interest rate to adjust.

For further consideration, it is important to distinguish between money for the economy and money for banks (liquidity) (Lagos, 2006). We will consider the two money markets in sequence.

1.3.1. Money market for the economy (the market for financing)

Let us start with the monetary market for the economy. Sources of financing for households and businesses include:

- current cash income (cash balances or funds in current bank accounts);

- spending of previously made savings (in the form of deposits in banks), or the sale of financial or non-financial assets (bonds, shares);

- bank loans.

The first two sources are money already existing in the system in the form of cash or deposits, while the third is new money to the system, as banks create money through the process of lending (McLea et al., 2014).

To model the equilibrium in the money market for an economy, it is necessary to determine the demand for and supply of money. Let us start with the demand.

Money is needed both for settlements (payments, purchasing goods and services today) and for transferring value over time—purchasing goods and services tomorrow. The demand for money as savings does not differ from the demand for money as a financial asset (like bonds or stocks). In this regard, time deposits, as a part of money (part of the monetary aggregate M2), combine the function of money and a financial asset for the non-financial sector. In the modern financial system, time deposits are very easily converted into current accounts for making payments (part of the monetary aggregate M1). In banking applications, this requires a couple of clicks. Therefore, the use of money in settlements depends not only on the most liquid part of the money supply (current accounts), but also on the volume of time deposits. The entire money supply, including time deposits (and even bonds on household balance sheets—monetary aggregate L), can be used for settlements—converted almost instantly and without significant costs in a modern economy into a highly liquid form (cash or current/payment accounts).

The traditional approach to determining the economy's demand for money is based on viewing money as a means of settlement and payment that does not earn interest. A key role in the traditional definition of money demand is played by the conceptual distinction between two categories within the structure of financial assets: money and other financial assets. Traditional money demand arises from the private non-financial sector's decision on how to allocate its stock of savings (how to form an asset portfolio) between money and other interest-bearing assets. Economic agents decide how much of their wealth to hold in one form and how much in another.[22] In the traditional approach, money does not earn the same interest as other financial assets (bonds, stocks). Therefore, when economic agents demand money (decide to hold money rather than other financial assets), they forgo additional interest income in favour of the convenience of owning money—making transactions with it (transaction demand). Thus, the well-known form of the money demand function emerges, with a negative dependence on the interest rate spread (the spread is the difference between the yield on other financial instruments and the yield on money):

$$\frac{{M^d}_m}{P} = L_m(i - i_{money}, Y),$$

[22] Thus, modelling the money market for the economy requires also modelling the markets for other financial assets. However, in macroeconomic description in this case, one resorts to Walras's law, according to which the equilibrium (the absence of imbalance) in $N-1$ markets guarantees equilibrium in the Nth market (the market for other financial assets).

where:

$M^d{}_m$ – the demand of the private sector for money;

P – price level;

i – interest rate on financial assets;

i_{money} – interest rate on money;

Y – the level of income in real terms (real GDP).

The traditional approach has long assumed that $i_{money} = 0$, since money is defined as cash or current accounts. In the modern monetary system, cash, for which the interest rate is zero, plays an increasingly smaller role, and in the future, as payment technologies develop, its role in the monetary system will continue to decline. Therefore, without significant loss of generality, we can speak of a cashless economy. Moreover, in the modern monetary system, even current accounts often bear market interest (overnight interest very close to the money market rate), so the rate spread in the demand for money function is zero or near zero, ceasing to be a factor affecting the demand for money. Even if we consider the interest rate spread between current accounts and financial instruments (bonds), this spread is also too small to be a significant factor affecting the demand for money in practice. Does this mean that the demand for money has ceased to be sensitive to changes in interest rates? The argument is that interest rates on money (current accounts, not to mention time deposits) change in tandem with changes in rates on other financial instruments (bond yields), keeping the spread almost unchanged: $i - i_{money} = const$.

For money demand, defined as the desire to hold the cash balances existing at the beginning of the period throughout that period, the answer is affirmative. The demand for cash balances in a modern economy differs little from the demand for other financial assets, which are not considered money for households and businesses but can be converted into means of payment very quickly and at low cost.[23]

To address the problem of determining the interest rate elasticity of money demand in a modern monetary economy, one can consider the transaction demand for money (a flow) in the market for goods and services, rather than the demand for stocks of a particular type of money.

Transactions (spending on goods and services) involving money can be conducted using funds that economic agents already hold, including income received, or that borrowed from a bank (newly created money).

Each economic agent decides how many money transactions they need in a given period of time. Conducting a transaction with the money they already have means that (after the transaction) the agent loses the opportunity to receive the real market interest rate (after deducting the depreciation of money due to inflation). If the agent had not spent the money, they would have received the real market interest rate. Spending borrowed money, however, means the agent will be forced to pay the lender the real interest rate in order to conduct a transaction with money

[23] One might argue that other financial assets cannot guarantee their par value (for example, a bond may momentarily trade on the market at a price below par), whereas current accounts always guarantee their par value. Two points are important here: first, deposits guarantee the preservation of their par value exactly up to the limits of deposit insurance coverage, meaning the par value of money is not predetermined but depends on the bank's financial situation. If a bank goes bankrupt, the money disappears, and maintaining its par value is not guaranteed. Second, this difference may influence the emergence of a yield spread between money and other financial assets (lower yield on money), but this spread is unlikely to adjust in any significant way when interest rates change in the economy. In practice, deposit rates and the yields of other (riskier) instruments tend to change proportionally.

today, not tomorrow. Thus, in the case of demand for money as a flow (money transactions), there is a foregone benefit or an obligation to pay the market interest rate. The higher this foregone benefit or the cost of the obligation, the less inclined the economic agent is to conduct transactions with money and the more inclined they are to save money or to demand less credit.

The higher the real market interest rate (interest rate on loans, interest rate on deposits or other financial instruments), the lower the demand for money transactions ($M^d_{transactions}$):[24]

$$\frac{M^d_{t,transactions}}{P_t} = L_{tr}(r_t, Y_t) \qquad (4).$$

Demand for transactions can also depend on the income level of economic agents. In its meaning, Equation 4 is very similar to the equation for the IS line—Equation 2. Demand for goods and services is precisely a transaction (flow). In a monetary economy, this demand can only be realised through money. Thus, the demand for goods is equal to the demand for money transactions. Therefore, in the flow chart, the goods market and the money market are closely interconnected.

Regarding **the supply of money to the economy**, supply as a flow is determined by banks. In the modern monetary system, banks supply money to the economy by issuing loans (which simultaneously creates a deposit—a current account, i.e. money). Deposits are also created by banks through budgetary or external transactions. The created money is then redistributed throughout the economy as current accounts or deposits of economic agents. What if a bank does not issue a loan to a borrower—that is, it does not create money?

In a modern monetary system, under normal conditions, there are several factors that prevent a bank from creating money: borrowers' risk assessment (lack of a pool of high-quality borrowers), insufficient bank capital (restricted by regulatory standards), and a lack of long-term funding (restricted by regulatory liquidity standards). Under normal circumstances (not during a financial crisis), these factors are non-binding, so banks in a modern monetary system are able to satisfy the entire demand for money for transactions at a given real interest rate. In other words, the supply of money to the economy by banks under normal economic conditions is highly elastic with respect to the interest rate. The supply of money for transactions (M^s) does not necessarily equal the volume of money transactions in the economy. Created money can participate in several transactions—this is determined on the demand side.

Let us define the demand for a nominal amount of money in the economy as a stock:

$$M^d{}_t \equiv \frac{M^d_{t,transactions}}{v} \qquad (5),$$

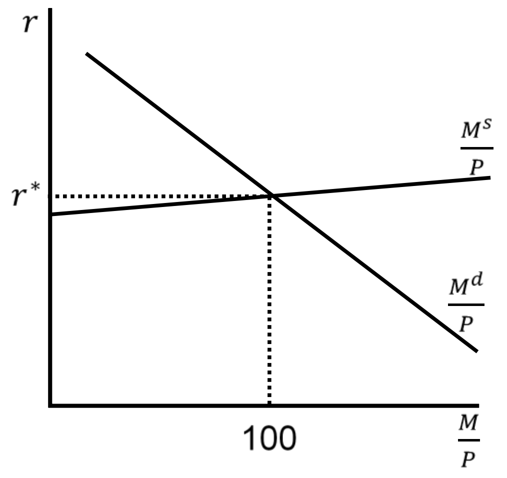
where:

v – a certain velocity of money circulation (the number of transactions in which each unit of money participates), which, generally speaking, is not constant, but for the sake of simplicity we will assume it is constant.

We obtain in equilibrium for the volume of money: $M^S{}_t = M^D{}_t$ (Figure 4).

[24] For simplicity, here and below, it is assumed that the deposit rate is equal to the loan rate, so that the argument of the function includes one real interest rate, rather than the loan and deposit rates separately, which would give rise to two demand functions—for loans and deposits.

Figure 4. Equilibrium in the money market for the economy (demand for and supply of money by banks for transactions)



Let us note again: $\frac{M^d_{t,transactions}}{P_t}$ is analogous to demand in the goods market (the IS line). This is the demand for financing, arising from the desire to conduct transactions in the goods market. That is, $\frac{M^d_{transactions}}{P}$ and IS are equivalent. This demonstrates the connection between demand in the goods markets and demand in the money market for transactions.

Thus, in terms of the supply of money to economic agents, the monetary economy functions as follows: a commercial bank sets interest rates on loans or deposits, and economic agents, based on their need for money (the demand function for money transactions), determine whether they want to make purchases (spend their deposits or attract loans) at such interest rates or not.

How do banks set interest rates? In the modern financial system, it is optimal for banks to set interest rates on loans and deposits that are in some way linked to the interest rate in the banking liquidity market (money for banks), which banks need in order to settle accounts with each other (for more details, see Grant (2011) and the next section).

1.3.2. Money market for banks (liquidity market)

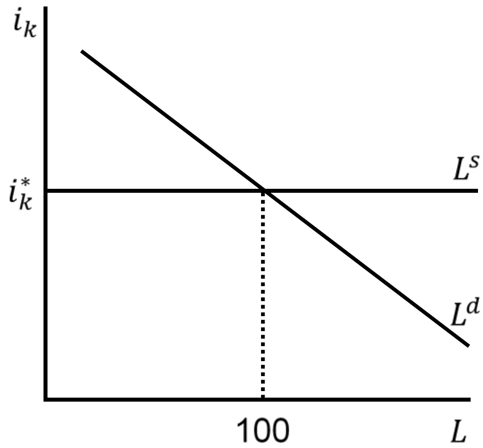
Let us now turn to a description of the money market for banks (in practice, this is what is called the 'money market'). The money market for banks is also called the liquidity market or the bank reserve market. The central bank is a market-maker (monopolist) in the bank liquidity market. In this market, a modern central bank sets the price of money (the key rate in the case of the Bank of Russia), which translates into interest rates on loans and deposits for commercial banks. Unlike the money market for the economy, in the money market for banks, commercial banks represent the demand side (on a net basis for the sector as a whole), and the central bank represents the supply side.[25]

[25] Equilibrium in the market for other financial assets, such as bonds, is achieved automatically (this market is excluded from consideration due to the Walras's law): the central bank is prepared to alter its balance of such assets to ensure a given rate in the money market. In other words, to control interest rates, the central bank can conduct operations in the market for interest-bearing financial assets (bonds and even shares)—influencing supply or demand in these markets to achieve the interest rate desired by the central bank. This

Modern central banks target the price of money (interest rate), rather than the volume of liquidity offered to banks (the central bank adjusts the volume of liquidity supply to demand in order to achieve the money market rate it requires).

Therefore, in a monetary system with a modern central bank, equilibrium in the banking liquidity market is determined by the intersection of a moderately elastic interest rate demand for liquidity (L^d) and a superelastic supply of liquidity by the central bank (L^s) (Figure 5).[26]

Figure 5. Equilibrium in the money market for banks (liquidity market or interbank market)



For a commercial bank, it is optimal (to maximise profits) to set the interest rates on loans (i_c) or deposits (i_d) as a function of the money market rate (i_k). The mechanism for transmitting the short-term money market rate into bank rates on loans and deposits (or rates on financial instruments) is slightly more complex in practice: not only the current money market rate is taken into account, but also expected future money market rates (which the central bank can also influence through monetary policy signals). Loan and deposit rates also incorporate maturity and credit risk premia. For simplicity, we will assume that the rate on long-term bank loans to the economy is equal to the short-term overnight interbank money market rate. As also noted earlier, for simplicity, we will assume that the interest rate on loans to the economy (i_c) is equal to the interest rate on deposits (i_d), and they are equal to the rate of return on financial assets (i). Given these assumptions, the interest rate in the economy on loans and deposits is equal to the key rate: $i = i_k$.

How does the Central Bank determine what the nominal interest rate i_k to set in the money market? Here we come to the key point—the central bank's policy regime and its reaction function. A modern central bank, under an inflation-targeting regime, follows the Taylor rule when setting its key rate; this rule relates the nominal interest rate to the expected inflation rate (assuming the expectations of the central bank and economic agents coincide). This rule, in turn, takes into account the Taylor principle: that the nominal interest rate should be increased by more than one percentage point in response to a one percentage point increase in expected inflation. As a result,

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interest rate control is a fundamental difference from previous monetary policy regimes, when the central bank controlled the volume of liquidity provided to banks. This radically changed the transmission of monetary policy. The supply of money to the economy by banks ceased to be elastic at a given interest rate, since banks needed reserves to support the money created through lending. The volume of reserves was controlled by the central bank. The concept of the money multiplier arose from such quantitative restrictions (Grishchenko et al., 2021; Grishchenko, 2019).

[26] Bindseil (2014).

with a one percentage point increase in inflation expectations, the nominal interest rate will increase by more than one percentage point, or, equivalently, the real interest rate will increase. The Taylor rule, which relates the nominal interest rate to expected inflation, is as follows:[27]

$$i_{kt} = \bar{i_k} + \alpha(\pi^e{}_t - \bar{\pi}) \qquad (6),$$

where:

i_{kt} – key rate (short-term money market rate);

$\pi^e{}_t$ – inflation expectations of economic agents;

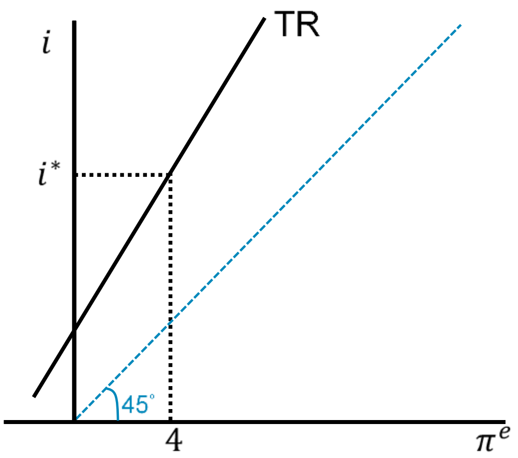
$\bar{\pi}$ – inflation target;

$\bar{i_k}$ –equilibrium interest rate. This condition ($\alpha > 1$) is referred to as the Taylor principle.

A Taylor rule in this form describes strict inflation targeting. If it also includes an output gap (unemployment, NAIRU), such a rule is described as flexible. Flexible rules are used by central banks that adhere to a dual mandate, aiming to stabilise not only inflation at the target but also output (unemployment). The Bank of Russia does not adhere to a dual mandate. Therefore, and given the desire to keep the model simple, Equation 6 only includes the deviation of inflation from the target.

The Taylor rule, incorporating the simplifying assumption $i_{kt} = i_t$, is illustrated in Figure 6.

Figure 6. Monetary policy rule (Taylor rule for the nominal interest rate)



From the Fisher equation, which relates the nominal and real interest rates, it is easy to derive a similar relationship between the real key rate and expected inflation:[28]

$$i_{kt} = r_{kt} + \pi_e \qquad (6.1).$$

Taking into account the simplifying assumption

$$r_{kt} = r$$

and

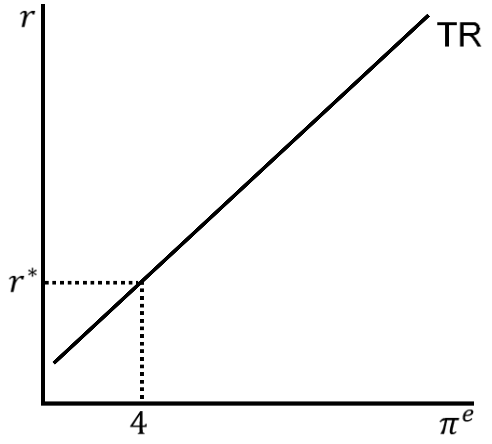
[27] In the formal model of Section 5, this line corresponds to equation 3.
[28] This is Equation 4 of the formal model of Section 5.

$$r_{kt} = r^* + (\alpha - 1)(\pi^e{}_t - \bar{\pi}) \qquad (6.2),$$

where:

r^* – equilibrium (neutral—neither accelerating nor slowing down inflation) real interest rate.

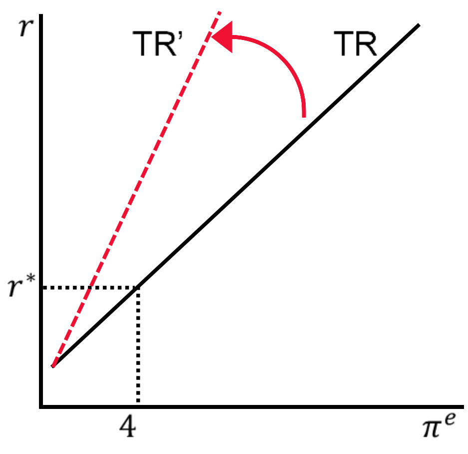
Figure 7. Monetary policy rule (Taylor rule) in terms of the real interest rate



The lines in Figure 6 or 7 represent the central bank reaction function.

In practice, situations may arise where maintaining inflation at target over the long term requires a tighter monetary policy. In this case, the line in Figure 7 will shift upward, as shown in Figure 8.

Figure 8. Shift in the central bank's reaction function under a transition to a monetary policy that is systematically more sensitive to inflation expectations



Thus, by targeting expected inflation, the central bank sets the price of liquidity for banks in the money market. This price for banks is then transmitted into interest rates on loans and deposits offered to the private sector. Based on the demand for money (or the transaction demand for money) at this rate, commercial banks determine the volume of money supply that meets this demand. Ultimately, for any given expected inflation, the nominal and real interest rates in the economy can be determined— rates that ensure equilibrium in both the market for bank liquidity and the money market for the economy as a whole:

$$\pi^e \rightarrow i_k \rightarrow i \rightarrow r.$$

Thus, we have established a connection between expected inflation and the nominal (real) interest rate on loans/deposits.

Discussing the global financial cycle and its implications for the monetary policy of a small open economy, we will consider a situation where a reversal of the global cycle could lead to a crisis, defaults, and capital losses for banks. Then, for a given central bank interest rate, the rates offered by banks to the economy may increase due to restrictions on banks' ability to provide financing to the economy. The TR line will not uniquely determine the supply of financing to the economy. In general, the interest rate on loans (deposits) i is a function of not only the central bank interest rate (and its term structure) i_k, but also of a premium to the key rate (a discount in the case of deposits), which arises from the bank side if they have restrictions. Therefore, the rate of the supply line $\frac{M^s}{P}$ may begin to differ from the rate at the TR line. The line $\frac{M^s}{P}$ may begin to shift for a given rate i_k controlled by the central bank. In the event of a severe financial crisis, the money supply line to the economy $\frac{M^s}{P}$ may even become vertical. However, under normal economic conditions, the supply line will be almost horizontal, and the interest rate will closely follow the key rate.

We linked the real interest rate to expected inflation through the central bank's reaction function. Now we need to link expected and actual inflation.

To link inflation and inflation expectations, we will define the following mechanism for the formation of expected inflation by economic agents.

Following an assumption which is close to practice, inflation expectations are a mixture of adaptive and rational inflation expectations. One part of economic agents thinks that future inflation will be equal to the inflation observed in the current period (or even to the inflation in the previous period):[29]

$$\pi^e{}_t = \alpha * \pi_t + (1-\alpha) * \mathbb{E}_t[\pi_{t+1}] \qquad (7).$$

This mixed mechanism for the formation of inflation expectations is often found in economic models and reflects that a proportion α of agents forms expectations in a 'naive' (adaptive) manner.

This relationship is shown graphically in Figure 9 (for different degrees of inflation expectation anchoring). Despite inflation being located on the Y-axis, the relationship should be read as causal from inflation to inflation expectations.

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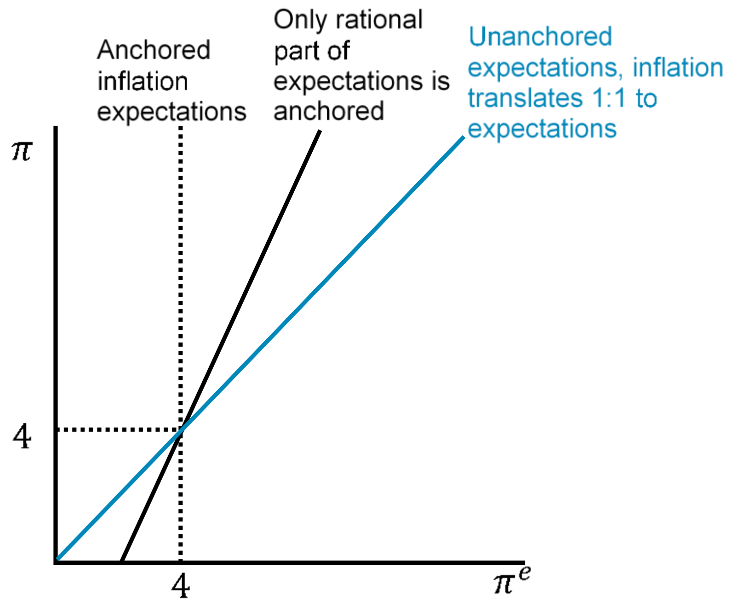
[29] One of the variants of the formal model of Section 5 suggests the same mechanism for the formation of inflationary expectations.

Figure 9. Link between inflation in the current period and inflation expectations of economic agents



The degree to which inflation expectations are anchored will determine the extent to which (temporary) surges in current inflation impact inflation expectations and longer-term inflation. This will then determine the central bank's response through the reaction function. Thus, the model allows one to study real cases and evaluate (similar to the IMF's IPF model) monetary policy recommendations: depending on the degree of anchoring and the stability of inflation expectations (π^e), the central bank will or will not need to respond to temporary surges in inflation.

Overall, we obtain an exact correspondence in the model between current inflation and the real interest rate:

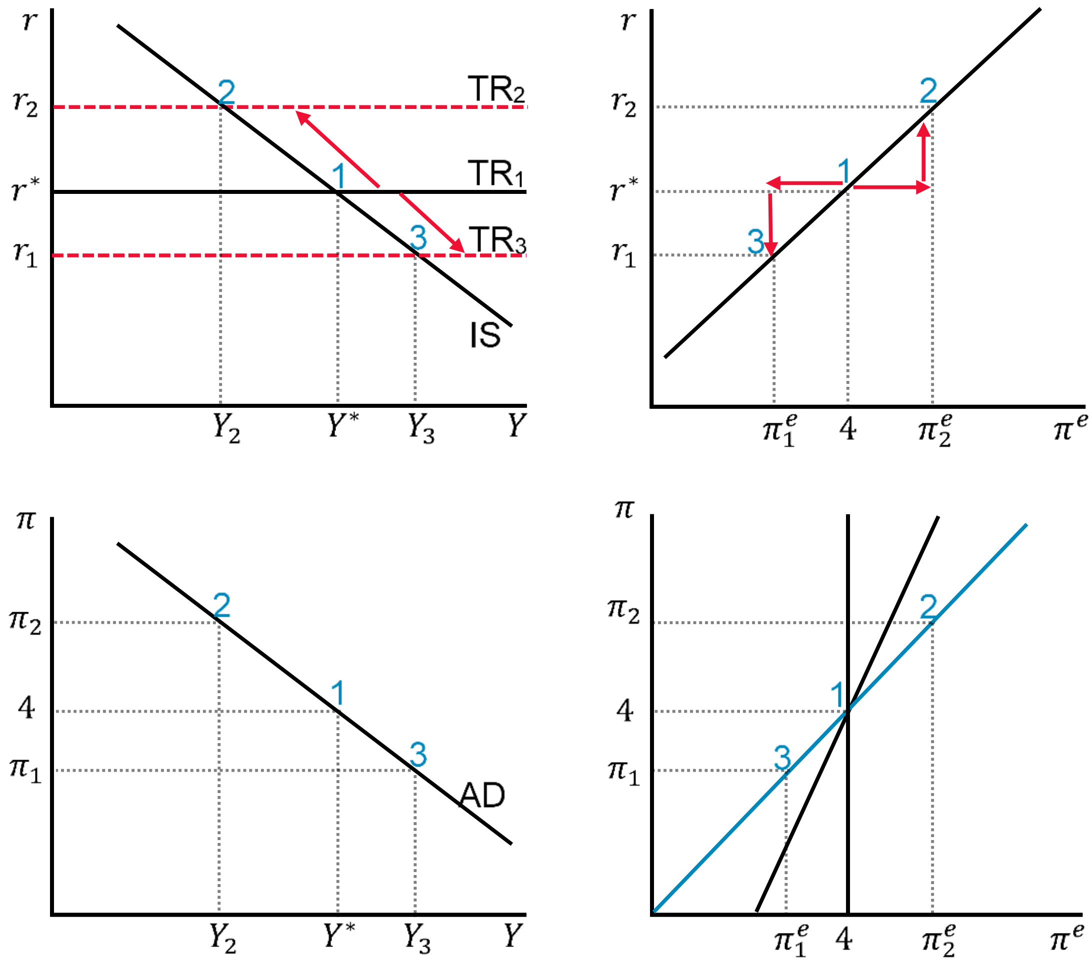
$$\pi \rightarrow \pi^e \rightarrow i_k \rightarrow i \rightarrow r.$$

We have the necessary ingredients to define the aggregate demand line in terms of 'inflation' vs 'quantity demanded' and are ready to describe equilibrium in the goods market.

1.4 Equilibrium in the goods market

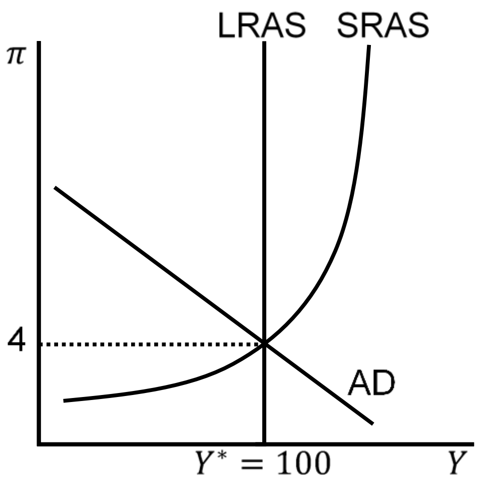
When inflation changes (due to shocks to current inflation), the inflation expectations of economic agents may change if inflation expectations are not anchored to the target, that is, if π^e is not constant. Then, for given rational expectations (or assuming that the rational part of expectations is anchored to the target), we obtain various values of real interest rates according to the central bank's reaction rule, ensuring equilibrium in the money market for the economy, and for given real rates—values of aggregate demand (at which the money market for the economy is also in equilibrium). These values of aggregate demand, at which the financial market is in equilibrium, are called the aggregate demand curve AD (Figure 10).

Figure 10. The aggregate demand line in the coordinates 'inflation' vs 'volume of aggregate demand' and how it is derived



As a result, equilibrium in the goods market (taking into account the simultaneous equilibrium in the money market) will be formed in the coordinates of inflation and output (Figure 11).

Figure 11. Simultaneous equilibrium in the goods and money markets



The equilibrium presented here means that, when inflation is at the target level, output is at its potential level. Importantly, this does not imply that this potential level will remain constant over time, meaning that economic growth is zero. We define equilibrium relative to the long-term trend of the economy.

With the exception of the presentation of the money market and the mechanism for setting interest rates in the economy, the description of aggregate supply and demand is standard. Therefore, we will not outline the full range of situations that could lead to a shift in the corresponding curves (for this, we recommend referring to standard textbooks), but will instead consider only three cases (we invite the reader to draw them).

1. A surge in inflation due to rising costs of imported goods logistics with unanchored inflation expectations.

   This surge in inflation is reflected in inflation expectations due to the unanchored nature of those expectations. It manifests itself as a leftward shift of the Phillips curve. With higher coordinated inflation expectations, producers will raise prices by a greater margin than they will increase output, for the same price increase. Due to rising inflation expectations, the central bank hikes the interest rate, which negatively impacts demand. The Phillips curve shift leads to a reduction in output at the new equilibrium (a leftward movement along the AD line). This is the price paid for stabilising inflation. Weakening demand and rising unemployment will ultimately reduce inflation expectations and return the SRAS line to its original position. As inflation expectations decline, the central bank will reduce the real interest rate to the original equilibrium (a rightward movement along the AD line).

2. An increase in government spending. In this case, for any given real interest rate, demand in the goods market increases, shifting the IS line to the right. Accordingly, the AD line for a given interest rate also shifts to the right. The result is higher inflation (a movement along the SRAS line). To the extent that this is reflected in inflation expectations, the SRAS line also shifts upward and leftward. The economy stabilises with output at potential but higher inflation. If the increase in government spending is temporary, a reverse shift in the AD line will occur, followed by an adjustment in inflation expectations and monetary policy. However, if it is prolonged and inflation expectations rise (a leftward and upward shift in the supply line), then disinflation will require a change in the monetary policy reaction function to shift the demand line back and stabilise inflation at a lower level.

3. Banks increase the interest rate premium offered to borrowers due to tightening regulatory requirements. The money supply curve shifts upward. The same volumes of money supply M^s become available only at a higher rate i_k. This is equivalent to a tightening of monetary policy under normal conditions, an upward shift of the TR curve with the same inflation expectations and inflation. This shift implies a leftward and downward shift of the aggregate demand curve. To offset the inflation impact of such an ‘autonomous’ tightening, the central bank must ease monetary policy.

Having described the equilibrium in the goods market and the money market for the economy, we will now consider another market that is important for a small open economy: the foreign exchange market.

1.5 Small open economy: foreign exchange market and equilibrium exchange rate

The equilibrium exchange rate balances two flows: the outgoing flow (demand for foreign currency) and the incoming flow (supply of foreign currency). The exchange rate is the ratio of the outgoing flow (in domestic currency) to the incoming flow (in foreign currency), that is, units of domestic currency per unit of foreign currency. Accordingly, an appreciation of the exchange rate means a weakening of the domestic currency. Both flows are generated by both residents and non-residents (or 'the rest of the world').

1.5.1. FX currency supply

For analytical purposes, it is convenient to distinguish the flow of external financing from non-residents—the value of foreign currency that the rest of the world brings to the foreign exchange market, wishing to buy assets denominated in the domestic currency (rubles for Russia), and the supply flow as a result of settlements with exporters by non-residents (Borio and Disyatat, 2015).

Formally, the supply of foreign currency is determined by the willingness of non-residents to purchase financial assets in the domestic currency and by the country's foreign currency earnings from exports. Non-residents' willingness to purchase such assets depends on the interest rate differential between the national and foreign currencies, adjusted for the expected change in the exchange rate.

Formally, following Gali (2018) and Maggiori (2022), with some simplifications, the supply of foreign exchange can be defined as:

$$S_t = max\{\frac{1}{H} * \left[i_t - i^f{}_t - \left(e^{expected}{}_t - e_t\right) - rp_t\right],\ 0\} + Export_t \qquad (8).$$

The first term is the value of currency supply (in foreign currency) offered by non-residents as investors. This value is greater the higher the interest rate in the domestic currency i_t, the lower the interest rate in foreign currency $i^f{}_t$, the lower the country risk premium rp_t, and the stronger the logarithm of the expected exchange rate $e^{expected}{}_t(e_t \equiv lnE_t)$ or the weaker the logarithm of the current exchange rate e_t for a given expected exchange rate. The expression in parentheses is the interest rate differential adjusted for the country risk premium and the expected change in the exchange rate (in logarithms—a change in fractions of 100, i.e. analogous to a percentage change). The value of currency supply cannot be below zero, otherwise it will be a demand for currency, which we will describe below. The uncovered interest rate parity (UIP) is described as:

$$i_t = i^f{}_t + \left(e^{expected}{}_t - e_t\right) + rp_t \qquad (8.1).$$

The second term of equation (8) is export revenues denominated in foreign currency (US dollar).

The value H is generally not constant and depends on conditions in the global financial market. The coefficient H plays a key role in determining the degree of imperfection in the foreign exchange market. This coefficient reflects the risk appetite of global investors and, accordingly, the limits on their open investment positions in foreign assets. A low value of H indicates a high willingness to accept risk; a high value of H indicates a low willingness to accept risks.

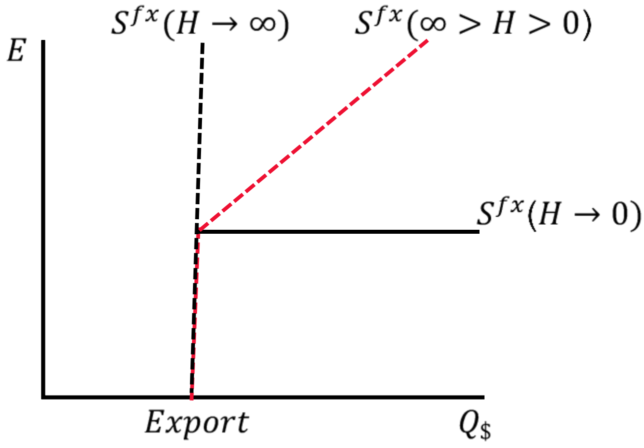
If H is very small, then even the slightest deviations inform the UIP have a significant impact on the currency supply and can make it very large. In this case, the financial market is considered to be perfect.

If H is very large, even significant deviations from the UIP will not induce foreign investors to purchase domestic assets and, consequently, increase the currency supply. The first term will be small even for large deviations from the UIP.

Market participants' expectations of the future exchange rate (depending on the value of H) play a significant role in the dynamics of the current exchange rate. To fully describe the model, it is necessary to formulate these expectations within the model itself. We will not do this in the graphical version, as the model is not dynamic, assuming expectations are predetermined (exogenous) or fixed in the short term. Changes in expectations regarding the future exchange rate will shift the supply line, which we will present below.

Graphically, equilibrium in the foreign exchange market is formed as follows. In Figure 12, the X-axis shows the volume of foreign exchange supply—i.e. external financing.[30] Graphically (for a given expectation of the exchange rate), the currency supply will be described by a broken line (curve).

Figure 12. Currency supply in the foreign exchange market: general case



The volume of external financing (S^{fx}) in the graph is the amount in US dollars that non-residents are willing to spend on domestic financial assets (residents' liabilities). In practice, these are most commonly government bonds (OFZs in Russia's case) or corporate Eurobonds.[31] Added to this is the volume of exports (in foreign currency) of our country, which, by assumption, is weakly sensitive to the exchange rate.[32] Such weak elasticity of exports to the exchange rate is a specific feature of economies that primarily export raw materials.[33] If the exchange rate is stronger than

[30] A similar framework is used by the IMF in the IPF, see https://www.imf.org/en/Topics/IPF-Integrated-Policy-Framework and Basu (2020).

[31] If non-residents acquire Eurobonds, i.e. assets denominated in foreign currency, the question may arise as to how this currency ends up on the foreign exchange market. In this case, the resident company (the Eurobond issuer) that receives the currency finances its imports (for example, of foreign equipment) without resorting to the foreign exchange market and without creating pressure on the exchange rate there through its demand for the foreign currency. This is equivalent to a situation where the Eurobond issuer (importer) would access the foreign exchange market and the non-resident Eurobond investor would sell the currency to it there for rubles.

[32] It is a close approximation to reality for a commodity-exporting economy, like Russia. Exports are denominated in dollars. The bulk of Russian exports are raw materials, the price of which is determined by the global market. A weakening exchange rate does not change the price at which exports are sold, but if production costs are denominated in rubles, it can affect producers' ruble margins (profits). It is important to know the import content of costs. If this content is high (as in exporters integrated into the global value chains (GVCs) or, as in mining, where capital, primarily imported, plays a significant role), a change in the exchange rate has little impact on margins, as both ruble revenue and ruble costs increase.

[33] Another specific feature of commodity-exporting countries is the interpretation of shocks from positive commodity price as predominantly positive aggregate demand shocks rather than negative cost (supply) shocks. Due to the important role of commodity price shocks for such economies, monetary policy analysis begins with an analysis under demand shocks.

the parity rate, foreign investors do not acquire domestic financial assets. Therefore, for a rate that is stronger than a certain level, the volume of foreign currency supply is determined solely by exports. Taken together, this represents the incoming flow of foreign currency into the foreign exchange market. The flow has varying elasticities with respect to the exchange rate.

At the limit, with a very small H (a situation referred to in the literature as FX market shallowness), only a very small deviation of the current exchange rate e_t from the expected exchange rate $e^{expected}{}_t$ is required to generate a large change in supply. This is the situation where interest rate parity holds in the foreign exchange market (Equation 8.1). This situation corresponds to the horizontal part of the currency supply line: at any given exchange rate, foreign investors are willing to provide a very large supply of currency. Even a small deviation from the parity level (for example, due to a shift in demand for currency) triggers an adjustment mechanism through capital inflows/outflows, which brings the exchange rate back to parity. Thus, the currency supply can satisfy demand for the currency within a fairly wide range (until global investors' limits are exhausted), without requiring any exchange rate adjustment.

As H grow for given interest rates the relationship between the volume of external financing and the exchange rate will be as shown in the diagram of Figure 12. Three regimes of foreign exchange market operation are shown there, each with a supply line of one of the three possible shapes. We have plotted all three lines on a single chart for greater clarity of the possible equilibria. The larger the H, the weaker the exchange rate e_t will be relative to the expected one when demand for currency increases.

1.5.2. Demand for currency

Let us now turn to the demand side and define the net demand for financing D^{fx} (net demand for financing) in terms of foreign currency as the sum of:

- demand for currency from importers and residents wishing to deposit their money abroad (to buy foreign assets, having first exchanged rubles for foreign currency);[34]

- purchases by non-residents who previously invested in domestic financial assets (OFZ); and

- net purchases (minus sales) of currency by the central bank at a given exchange rate (and given exchange rate expectations).[35]

This quantity demanded, expressed in terms of the national currency (Q_{rub}), is equal to:

$$Q_{rub_t} = Import_{RUB_t}(E; GDP) + residents\_net\_capital\_outflow_{RUB_t} + net\_CB\_demand_{RUB_t} + D_{nonres_t} \quad (9).$$

Thus, net financing demand describes the demand for foreign exchange associated with foreign trade operations, adjusted for the demand for, or supply of, foreign exchange by residents, non-residents, and central bank operations.

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[34] More precisely, these are net purchases of currency for investment abroad by residents, i.e. purchases minus sales.

[35] The components of residents' and the central bank's demand are taken on a net basis and are not separately added to the foreign exchange supply equation to more clearly distinguish between two entities useful for analytical purposes: the supply of foreign exchange, primarily from non-residents, and the demand for foreign exchange, primarily from residents. Historically, the Russian economy has been characterised by capital outflows, when residents or the Bank of Russia systematically have net demand for foreign exchange.

Non-resident demand is described as follows:

$$D_{nonres_t} = \gamma * B_{t-1},$$

where:

B_{t-1} – the value of previously made investments by non-residents in ruble assets;

$0 \leq \gamma\left(i, i^f, E, E^{expected}, E^{expected}{}_{-1}, H\right) \leq 1$ – the share of non-residents wishing to exit from ruble financial assets each period.

For simplicity, γ is a constant.

Demand for ruble financing (and demand for ruble-denominated imports) grows as the exchange rate strengthens.[36] The preference for saving in foreign currency increases as interest rates in our country fall.

The demand in foreign currency will be expressed as:

$$D^{fx}{}_t = \frac{Q_{rub_t}}{E_t} \equiv Q_\$ \qquad (10).$$

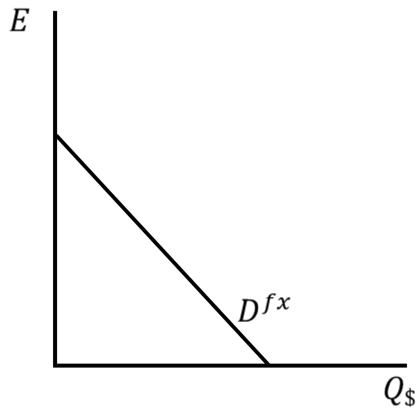
Demand for foreign currency D^{fx} will increase as the exchange rate strengthens (even if the elasticity of demand in ruble terms Q_{rub} is less than one). Import demand and residents' demand for foreign currency rise with a strengthening exchange rate and decrease as the interest rate rises (import demand reacts indirectly, through lower incomes, to an increase in the interest rate).

As a result, we obtain a demand curve for foreign currency with a negative slope. The stronger the exchange rate, the cheaper imports are in terms of the domestic currency and the greater the demand for imports in both physical and monetary terms (in foreign currency). Expectations of an exchange rate adjustment to a weaker (expected) level also increase residents' interest in purchasing foreign currency for a given expected exchange rate and interest rate differential (Figure 13).

Figure 13. Demand for currency in the foreign exchange market

[36] There are two effects of a change in the exchange rate on ruble imports: the effect on physical demand for imports (in units) and the effect on the ruble price of imports. A strengthening exchange rate reduces the ruble price of imports. The overall effect of an appreciation in the exchange rate (E) on the ruble value of imports ($Import_{RUB_t}$) depends on the price elasticity of physical demand for imports ($Import_t$). For goods with sufficiently elastic demand, the increase in physical demand will be greater than the decrease in price, so the ruble value of imports will increase. We will assume a fairly high price elasticity of physical demand for imports.

Imports depend on the real exchange rate; as noted earlier, it is assumed that changes in the nominal exchange rate are the main driver of changes in the real exchange rate, which justifies this replacement with the nominal rate in Equation 9.



1.5.3. Equilibrium exchange rate

In equilibrium, the exchange rate E_t is defined as $\frac{Q_{rub}}{S^{fx}}$, from which we obtain:

$$Q_{rub_t} = E_t * [max\{\frac{1}{H} * [i_t - i^f{}_t - (e^{expected}{}_t - e_t) - rp_t], 0\} + Export_t] \quad (11).$$

From this the definition of the equilibrium rate (depending on the risk appetite of global investors—the phase of the global financial cycle) follows:

$$\begin{cases} E_t = \frac{Export_t}{Q_{rub_t}}, if\ H - \text{is}\ very\ large \\ E_t * \left[max\left\{\frac{1}{H} * [i_t - i^f{}_t - (e^{expected}{}_t - e_t) - rp_t], 0\right\} + Export_t\right] - Q_{rub_t} = 0, \\ \qquad if\ H\ \text{has}\ intermediate\ levels \\ e_t = i^f{}_t + e^{expected}{}_t + rp_t - i_t, \\ \qquad if\ H\ is\ close\ to\ zero \end{cases} \quad (12).$$

If H tends to zero, the exchange rate is determined by UIP. Indeed, $Q_{rub} = E * [\frac{1}{H} * [UIP] + Export]$. If we rewrite it in a different form, we get:

$$E * \frac{1}{H} * [UIP] + E * Export - Q_{rub} = 0.$$

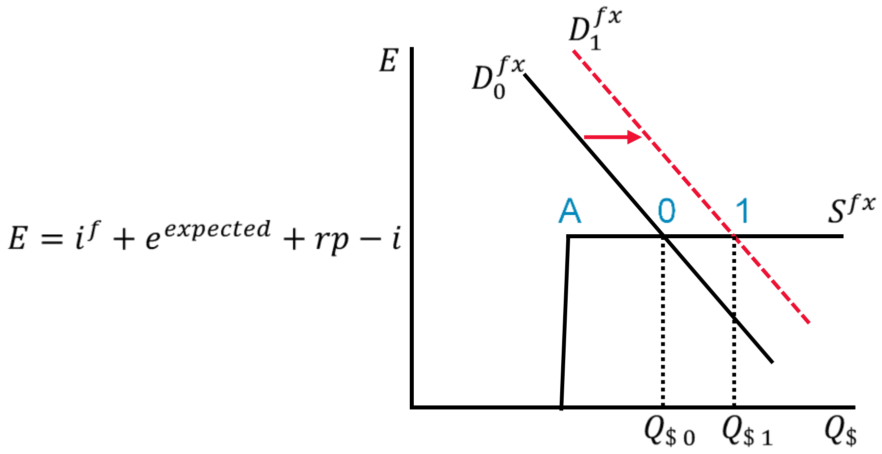
As H approaches zero, this equality can be satisfied only if UIP→0. However, when UIP is satisfied, the indeterminate form 0/0 arises, so the volume of foreign exchange supply by non-residents can be arbitrary. The precise volume is determined by the second term at the exchange rate level at which UIP is satisfied. This is evident from the fact that an exchange rate that satisfies UIP and zeroes the first term in the limit may not lead to a zero value for the second term $E * Export - Q_{rub}$: there may be no balance between the supply and demand for foreign exchange, based on trade flows and residents' preferences regarding demand for foreign assets. In other words, given the absolute elasticity of the supply of external financing with respect to a deviation from interest rate parity, any imbalance in foreign trade adjusted for residents' demand for foreign assets can easily be covered by external borrowing from non-residents at a given exchange rate and interest rate differential. In the case of a foreign trade surplus, adjusted for resident demand, non-residents are willing to absorb the excess foreign exchange without such flows affecting the exchange rate.[37] Therefore, if $H \to 0$ and UIP is satisfied, the indeterminate form 0/0 is resolved so that the supply of foreign exchange by non-residents is equal to the imbalance in foreign exchange demand minus the supply of foreign exchange from exports:

$$-(Export * E - Q_{rub}).$$

As a result, in a perfect financial market, a small open economy can have a foreign trade deficit or surplus, adjusted for residents' preferences for investing in foreign assets. The resulting imbalance, for example, when import demand exceeds export revenues and central bank currency sales, must be financed somehow. Such financing is provided by foreign investors. Otherwise, if foreign investors are unwilling to finance the trade imbalance, the exchange rate must change so that the imbalance disappears.

The three equations graphically represent the following situations. Let us consider a situation where equilibrium is established to the right of point A with very small H (Figure 14). This is the case of perfect financial markets.

Figure 14. Growth in demand for currency in a perfect foreign exchange market (with very small H)



To the right of point A, the supply of currency is perfectly elastic with respect to the exchange rate; this is the case of the basic model, the fulfilment of UIP, that is, the absolute elasticity of the supply flows of currency to changes in the exchange rate.

If there is a shift in net demand for foreign currency (for example, due to increased preferences for consuming imported goods, an increase in the transfer of money abroad by residents, or foreign currency purchases by the central bank), this will not change the exchange rate at all (Figure 14).

Non-residents will provide additional financing immediately as soon as a depreciation trend emerges. Due to the increased demand, an immediate influx of foreign currency from non-residents will arise to exploit the emerging arbitrage opportunity (to capitalise on the violation of

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[37] Indeed, let us assume the UIP exchange rate is 1. Dollar exports are 100. Let us also assume ruble imports are 100, but residents also have an autonomous desire to buy foreign currency (withdraw it to their foreign accounts) equal to 10 units of domestic currency. Then, at a rate of 1, there is a currency shortage equivalent to 10 units on the market. Under other conditions, the exchange rate would weaken, which would reduce the demand for imports in ruble terms to achieve balance and increase the ruble value of exports. However, in a perfect financial market under the UIP condition, 10 units of currency (at a rate of 1) will be provided by foreign investors who agree to invest in financial assets denominated in the national currency. To do this, they must sell their currency on the foreign exchange market. These investors will be motivated by the 10% demand pressure on the exchange rate from residents and by the tendency toward a slight violation of the UIP.

the UIP). Therefore, after point A, the exchange rate strictly adheres to UIP (with or without a risk premium).[38]

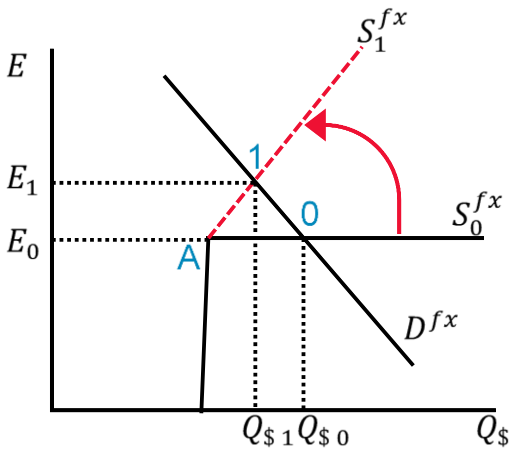
In practice, the line will not be horizontal given an infinitely large volume of external financing. Growing external debt leads to an increase in the risk premium. If the risk premium is positively related to the size of external debt, the permanent accumulation of deficits becomes impossible. An increase in the risk premium will require a depreciation of the exchange rate. This, in turn, will reduce the demand for imports and the trade deficit. In other words, linking the risk premium to the volume of net foreign assets/liabilities will facilitate the search for an equilibrium exchange rate that not only satisfies the UIP but also balances trade flows in the long run. From some point B (to the right of point A), the horizontal line will become upward-sloping.

If the value of H is not sufficiently small, the currency supply curve will be tilted upward. In this situation, international investors are no longer willing to take on the risk of additional lending to residents. They will demand additional compensation for investing in the country's assets in the form of a weaker current exchange rate for any given expected exchange rate. In this case, a violation of UIP is necessary for the currency supply to cover the imbalance.

When the UIP condition is violated, investors demand an additional premium in the form of a weaker exchange rate and, accordingly, a greater deviation of the exchange rate from the given expected exchange rate relative to the UIP. To secure additional financing, non-resident investors are willing to buy domestic assets at a lower price (in terms of foreign currency), expecting the domestic currency to strengthen (by the time they receive investment income, they will be able to buy more of their own currency). When H rises, the supply of foreign currency requires a weaker exchange rate (for a given expected exchange rate) (Figure 15).

[38] There is an objection to this mechanism: a change in net demand for foreign currency, such as an increased preference for imports, can lead not only to a weakening of the exchange rate but also to a change in investors' expectations of the future exchange rate. Therefore, there is no net deviation from interest rate parity, no arbitrage pressure on the exchange rate, and no additional supply of foreign currency. Thus, a change in import demand will translate into a weakening of the exchange rate. In terms of the graphical model, this would mean that the horizontal line shifts upward (due to a change in the expected exchange rate).

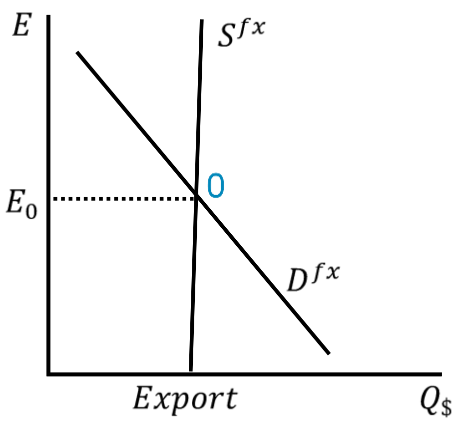
Figure 15. Equilibrium in the foreign exchange market with a larger H



If H becomes very large, that is, if non-residents are unwilling to provide external financing regardless of the magnitude of the exchange rate depreciation, adjustment to equilibrium in the foreign exchange market is ensured through exporters. An increase of H toward infinity requires net demand (Q) to be equal to exports ($Export$), so that equilibrium in the foreign exchange market is achieved at the interest rate set by the central bank (i). That is, instead of the UIP, the exchange rate in the foreign exchange market will be determined by the condition of equilibrium of financial flows (exports, imports, and capital outflows of residents). Exports and imports should be set at a level that balances residents' demand for foreign assets—the desire of residents to hold foreign assets in their investment portfolios.

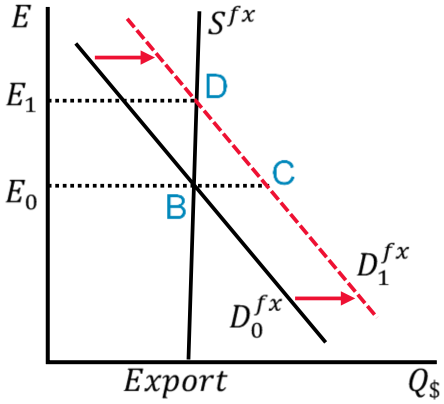
The equilibrium in the foreign exchange market under such specific conditions will be determined on the basis of another diagram (Figure 16).

Figure 16. Equilibrium in the foreign exchange market with strong risk aversion of global investors (very large H)



A shift in demand for foreign currency in such a situation will only lead to a change in the exchange rate to balance net demand without a significant increase in external financing. For example, an increase in demand for imports or a change in residents' preferences for saving in foreign accounts could cause a temporary shortage of foreign currency in the foreign exchange market—segment BC on (Figure 17). Restoring equilibrium will require a reduction in ruble imports through a weakening exchange rate (the transition from point C to point D).

Figure 17. Equilibrium adjustment in the foreign exchange market with a very large H in response to an increase in demand for foreign currency



Depending on the regime in which the international financial market operates (willingness or unwillingness of global invertors to take risks—risk on / risk off) and whether there are restrictions on capital movements, there will be different relationships between the exchange rate and the interest rate.[39]

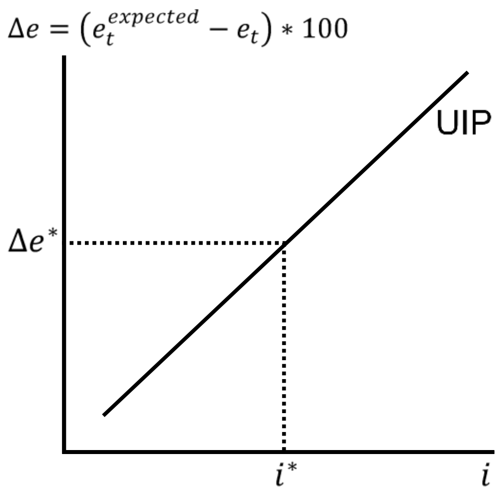
The basic model assumes a perfect capital market, which implies absolute elasticity of capital flows to the interest rate differential. Therefore, any deviation of the exchange rate from interest rate parity due to a trade imbalance is immediately offset by an inflow of foreign exchange. Thus, export and import flows are not important for determining the exchange rate in the basic model. In practice, this elasticity is not infinite (Maggiori, 2021). We will consider this case later.

To further develop the basic model, it is important to graphically link the exchange rate and interest rate. This is necessary to illustrate the operation of the exchange rate channel of monetary policy.

When UIP holds (H is very small), this relationship is illustrated by two graphs shown in Figures 18 and 19.

[39] Developing countries that export raw materials typically have a current account surplus, meaning their imports are less than their exports. If a positive current account balance is present but there are no incoming financial flows from non-residents (non-residents do not purchase OFZs, and local companies do not borrow foreign currency from non-residents), the supply of external financing will be equal to exports. In this situation, the exchange rate will be determined by the ratio of exports to imports and residents' preferences for holding assets abroad. This means that the exchange rate will be determined at the intersection of the net demand line and the vertical export line. Any changes in these flows will shift the net demand line up or down, and, accordingly, the exchange rate will change.

Figure 18. Relationship between the nominal interest rate and the expected change in the exchange rate



In Figure 18, the neutral nominal interest rate (i^*) corresponds to the equilibrium nominal exchange rate depreciation. An increase in the country risk premium leads to an upward shift in the UIP line.

Figure 19. Relationship between the exchange rate level and the expected change in the exchange rate (with fixed exchange rate expectations)

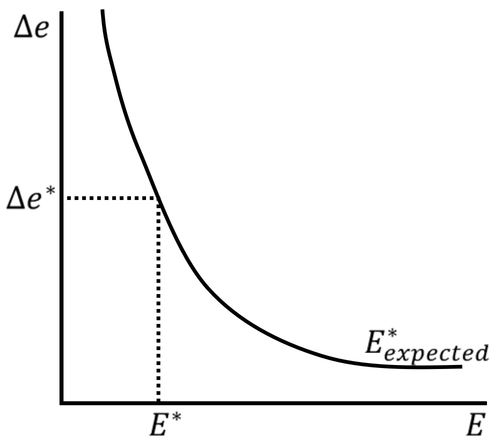


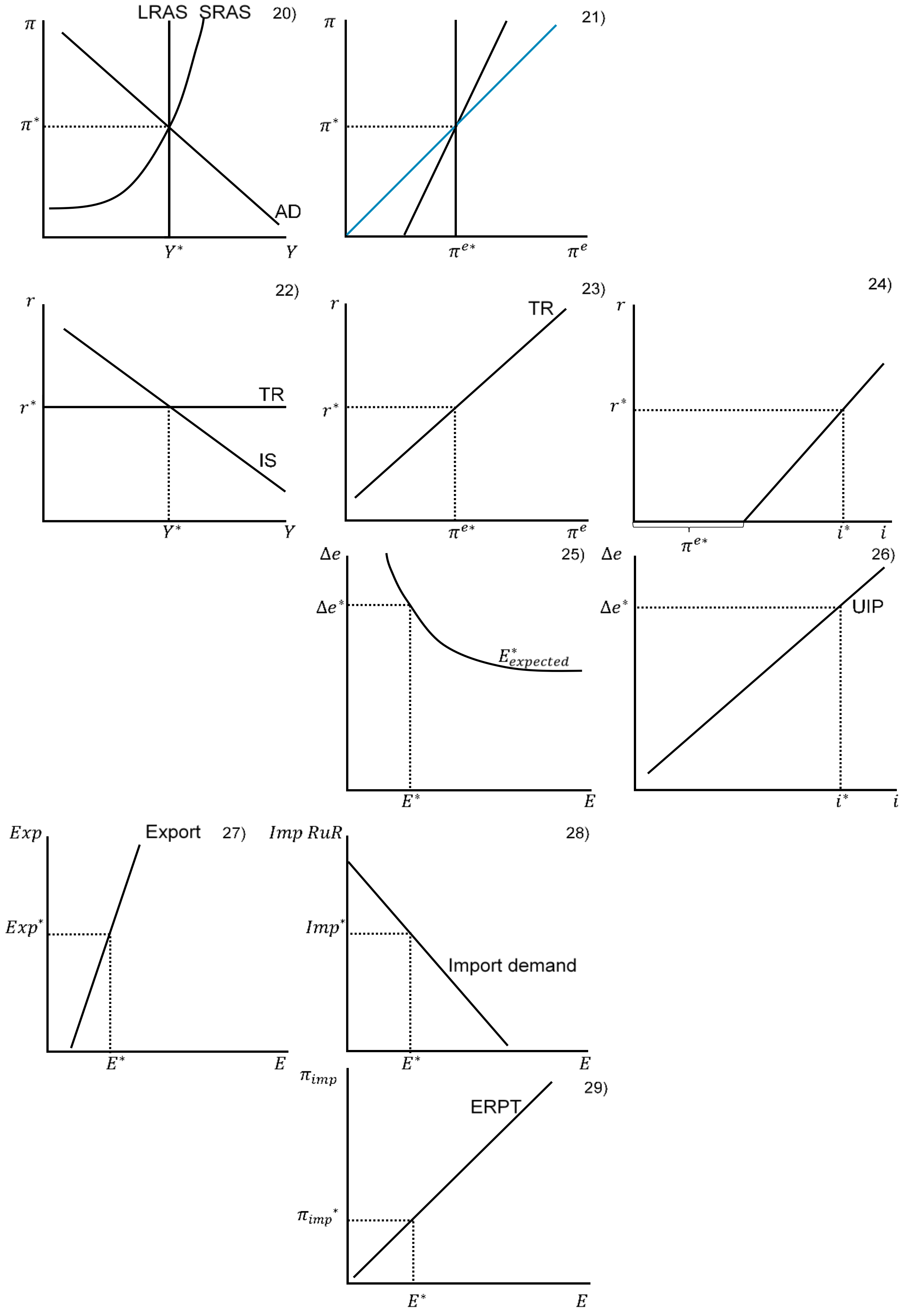
Figure 19 links the exchange rate change with the exchange rate level required for a given expected exchange rate.

Now it is time to formulate the general equilibrium of the graphical model under the conditions of a perfect foreign exchange market.

1.6 General equilibrium model

The basic graphical version of the model of a small open economy under perfect financial markets is presented, with some simplifications, as follows (based on Gali, 2020).

Figures 20–29. General equilibrium model



Where:

SRAS – short-run aggregate supply (Phillips curve, PC);

IS – IS line;

TR – monetary policy reaction function (Taylor rule);

ERPT – exchange rate pass-through to import prices;

UIP – uncovered interest rate parity;

AD – aggregate demand.

The basic version consists of 10 endogenous variables for given values of foreign variables (rest of the world's price level, inflation, interest rate, etc., as well as sovereign risk premium and the value of commodity exports in foreign currency):

$$\pi,\ \pi^e, \pi_{imp},\ Y,\ Exp,\ Imp,\ i,\ r,\ E,\ \Delta e.$$

For any given value of expected inflation (π^e), the Taylor rule (Figure 23) determines the value of the real interest rate (r).

The real interest rate (r) and expected inflation (π^e) together, according to the Fisher equation (Figure 24), determine the nominal interest rate (i) that the central bank must set to achieve the inflation target.

For this nominal interest rate, given expectations of the future exchange rate and the exchange rate value in the previous period, the logarithm of the exchange rate deviation Δe from the expected value is determined. Similarly, from the equilibrium in the foreign exchange market (Figures 25–26) the change in the exchange rate relative to the previous period is determined, which is important for the effect pass-through of the exchange rate on inflation.

The real interest rate allows us to determine the level of aggregate demand in terms of consumption and investment (Figure 22).

The value of the exchange rate (E) helps determine the volume of non-resource exports (Exp) (Figure 27). It is assumed that in the short term, it is the changes in the nominal exchange rate that underlie changes in the real exchange rate.

The interest rate and individual components of demand (such as interest-rate-inelastic raw material exports) determine the size of aggregate demand, including import expenditures. The exchange rate (E) for a given volume of domestic demand helps determine the extent to which this demand will be satisfied by imports (Imp) (Figure 28). This allows us to fully determine GDP (Y) (Figure 20).

Based on the magnitude of the change in the exchange rate from its value in the previous period, import price inflation is determined by the pass-through effect (π_{imp}) (Figure 29).

The level of GDP (Y), inflation expectations and import price inflation for given inflation shocks make it possible to determine general inflation (π) and the position of the supply line in the coordinates under consideration (Figure 20) using the aggregate supply equation (Phillips curve).

Finally, actual inflation, given rational inflation expectations (inflation targets), helps determine inflation expectations (Figure 21). Thus, the system is closed.

Some features necessary for a complete description of the system are left outside of the diagrams (but they are defined in the formal model):

- exchange rate expectations, which depend on the future profile of the interest rate differential and long-term exchange rate expectations (after all shocks have subsided);[40]

- the volume of money supply. Due to the absence of imperfections in the financial sector, we have omitted the corresponding diagrams. They will play an important role in describing the equilibrium in a crisis situation, when commercial banks face constraints in money creation for the economy.

The section demonstrates how 10 diagrams allow us to determine equilibrium in such an economy: the diagrams define 10 equations for determining 10 variables given the expected values of the variables and exogenous parameters (parameters of the global economy). The economy's convergence to equilibrium, if a shock moves the economy out of equilibrium, is described in Appendix 1.

Let us now turn to a description of the types of shocks in the model and the logic of monetary policy.

2. Types of shocks and the logic of monetary policy

The goal of a central bank's monetary policy under inflation targeting is to stabilize inflation at the target. Changes that cause inflation to deviate from equilibrium can occur on the demand or supply side. The sources of such changes (shocks) can be very diverse.[41] They can be internal or external shocks. These can be changes that affect all prices or only a subset of prices—changes in relative prices. In the next section, we will examine external shocks in more detail—shocks in global financial markets and the model economy's adaptation to them.

The model contains important elements for analysing monetary policy decisions. In practice, central banks need to identify:

- the nature of the shock: demand/supply, absolute or relative price shock. For this purpose, the model separately provides for the possibility of shifting the aggregate demand and aggregate supply lines. Shifts in aggregate demand can be neutralised by the central bank without negative consequences for the economy. The same cannot be said about shifts on the cost/supply side (as will be seen below). In the case of supply-side shocks, central banks face a monetary policy trade-off;

- the duration of the shock's impact on the economy: is it a one-time shock or a series of repeated shocks in the same direction. The model allows for successive shifts in the supply and demand lines. The duration of the shock affects actual inflation, and through it, inflation expectations (with unanchored expectations);

- the degree of anchoring of inflation expectations. In the model, the degree of anchoring of inflation expectations (Figure 21) will determine the extent to which temporary inflation spikes

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[40] See formula (6) in (Gali , 2020), shifted one step forward (without taking into account the risk premium for simplicity): $e_{t+1} = \sum_{k=0}^{\infty}(i^f{}_{t+1+k} - i_{t+1+k}) + \lim_{T\to\infty} M[e_T]$, where $M[*]$ is the mathematical expectation operator (unconditional, if long-term exchange rate expectations do not depend on time, the phase of the business cycle and are determined by long-term parameters of the economy).

[41] During the COVID-9 pandemic, most countries initially experienced a negative supply and demand shock (rising costs due to supply chain disruptions and production shutdowns). The resulting effect on inflation was negative. This was followed by a period of increasing government support for economies and accommodative monetary policy. By the end of the pandemic, these stimulus measures had not been rolled back, so the increase in demand due to its return to normal levels was superimposed on the demand growth associated with the government support. This resulted in rising inflation. In 2022, rising energy prices were added, which became a supply shock (Reis, 2023; Arce et al., 2024).

penetrate inflation expectations and longer-term inflation. This determines the shift in the aggregate supply line.

Let us start our analysis with the demand shock—a shift in the AD line to the right due to an increase in budget expenditures financed by bank loans (commercial banks buy government debt (OFZs) issued by the Russian Ministry of Finance on the primary market).[42]

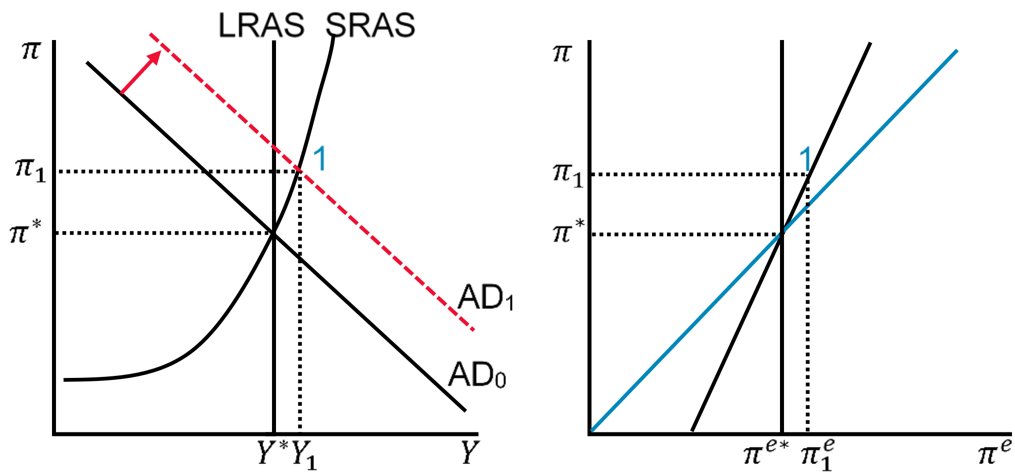
Next, we will consider a supply shock—an increase in the cost of producing goods, accompanied by rising inflation expectations. This implies that the SRAS line moves up and to the left. This sequence of presentation is based on the fact that demand shocks make it easier for central banks to decide whether to tighten or loosen monetary policy. As we will show, this is not the case for supply shocks.

2.1 Stabilising inflation in the face of a demand shock

So, let us assume the economy is in a state of long-run equilibrium, where output equals potential output and inflation equals the central bank's target. Let us assume a demand shock, for example, due to a change in household savings preferences or an increase in government spending, which shifts the demand curve (AD) to the right and upward. This has the following effects (indicated by the corresponding numbers in the figures. Appendix 2 provides a summary illustration).

1. Overheating in the economy is accompanied by rising wages and prices—an increase in inflation (indicated by number 1 in Figure 30). Importantly, even if demand growth is initially concentrated in certain sectors and wages and prices rise in these sectors, this growth quickly spreads throughout the economy (workers in these sectors or suppliers in the industry experience rising incomes, which in turn increases demand, and so on down the line). Thus, a demand shock very often leads to a change in all prices in the economy—inflation.

Figures 30–31. The response of the economy and inflation to a demand shock



If higher real demand is not sufficiently persistent, and economic agents' inflation expectations are anchored (the vertical line in coordinates π and π^e, see Figure 31), such an increase in demand will lead to a shift in the AD line. However, this increase, coupled with higher

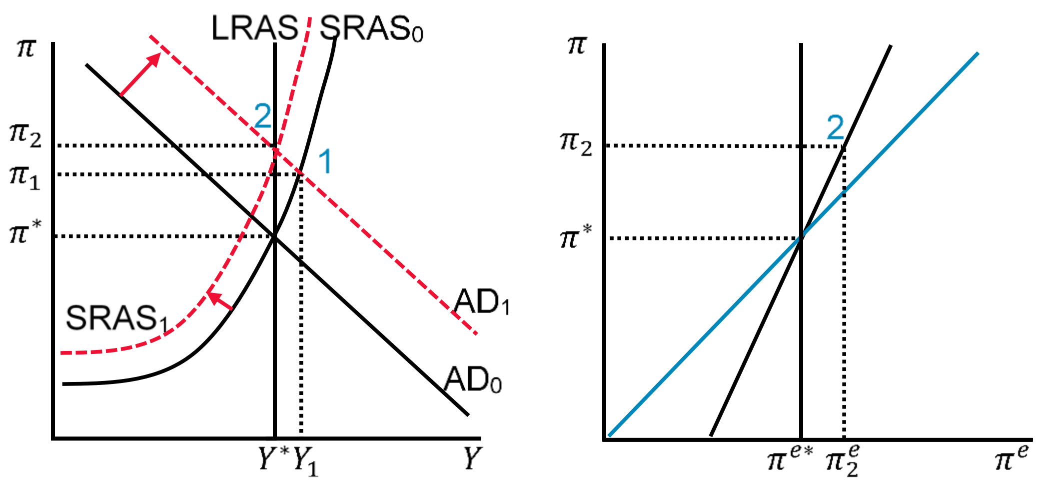
[42] In the basic version of the model, banks are not constrained in their supply of credit at a given interest rate. This financing method is considered to avoid complicating the presentation with crowding-out effects on government spending, and to focus on a pure demand shock. Furthermore, this method of financing government spending is quite common in practice.

wages and actual inflation, will not lead to an increase in inflation expectations. The economy will experience a temporary surge in demand, and in the next period, the economy will return to equilibrium (a reverse leftward shift of the AD line in the next period). The central bank does not need to raise the interest rate in such a situation: inflation expectations have not increased, the SRAS line has not shifted leftward, so normalisation of demand will return the economy to its original equilibrium without intervention by the central bank. It is important to note that even in this case, the very fact that the central bank could intervene makes inflation expectations anchored (insensitive to temporary fluctuations in inflation). This allows for stabilisation without actual tightening of monetary policy.

The central bank's task becomes more complex if inflation expectations are not anchored (so that even a short-term shift in demand with elevated inflation will increase inflation expectations) or if demand growth is persistent enough that a prolonged equilibrium with elevated inflation will lead to the anchoring of expectations. The central bank is required to bring inflation to target over the forecast horizon, which, according to the Phillips curve, is impossible without reducing actual inflation and, consequently, inflation expectations.

2. In response to rising demand and higher inflation, inflation expectations rise (Figure 31). The SRAS curve shifts to the left due to rising inflation expectations.[43] As a result, the economy finds itself in an intermediate equilibrium 2 with higher inflation and the same level of output (Figures 32–33).

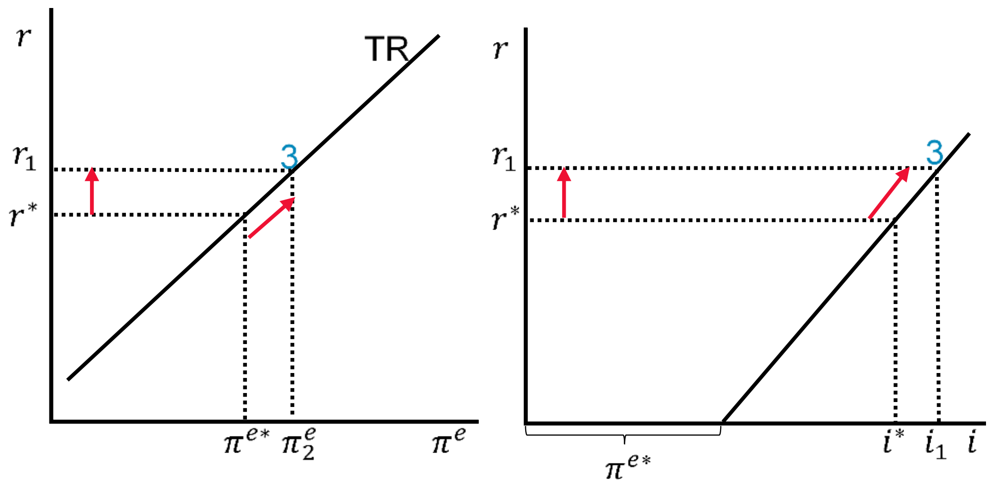
Figures 32–33. Shift in SRAS with rising inflation expectations



3. This situation is, in particular, a consequence of the fact that rising inflation expectations lead the central bank to tighten monetary policy, following the Taylor rule (Figures 34–35). The SRAS line shifts along the AD line, which implies an increase in real interest rates.

[43] For simplicity, the secondary effects of rising inflation on inflation expectations due to such a shift are not considered.

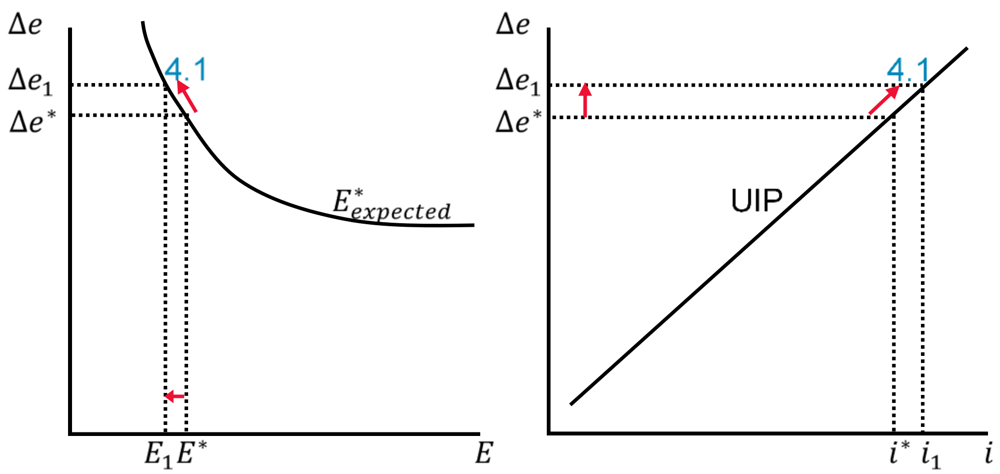
Figures 34–35. Monetary policy reaction to inflation expectation growth



4. Raising the interest rate has two effects.

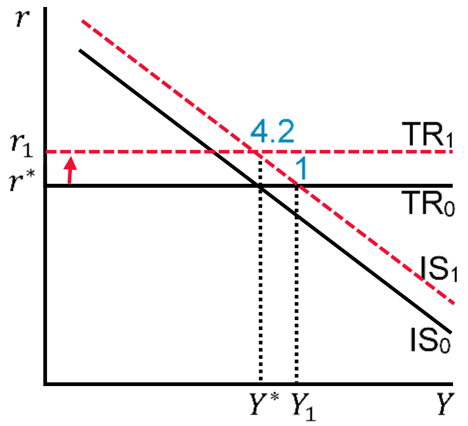
4.1. According to UIP, it leads to capital inflows and exchange rate appreciation (for a given expected exchange rate) (Figures 36–37).

Figures 36–37. Exchange rate response to monetary policy tightening



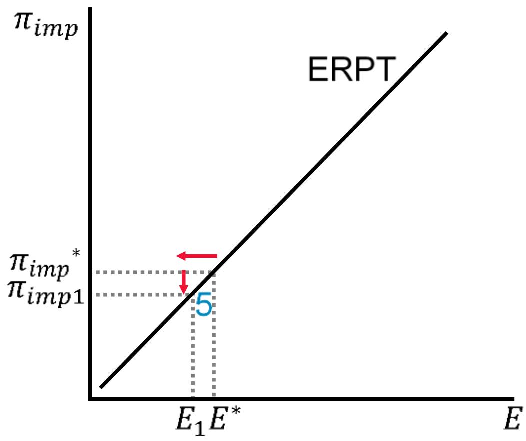
4.2. Aggregate demand decreases: the TR line moves upward along the IS line. The intermediate result is shown in Figure 38.

Figure 38. Aggregate demand response to monetary policy tightening



5. A strengthening exchange rate slows the growth of import prices (Figure 39). This is a direct effect of the exchange rate channel. As a result, the SRAS line shifts to the right.

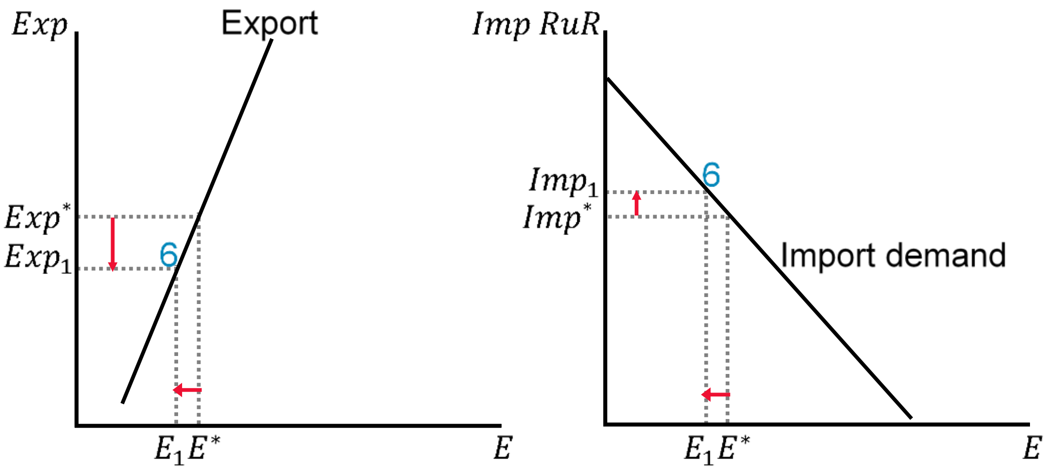
Figure 39. Pass-through effect when monetary policy tightens



6. A strengthening exchange rate also increases demand for imports, shifting spending from domestic to imported goods (Figure 41). This, coupled with the effect of the interest rate channel, weakens the pressure of increased demand on prices. Specifically, demand for non-commodity and exchange rate-elastic exports from non-residents decreases, making our goods more expensive for them (Figure 40).[44] As a result, the IS line, and with it the AD line, shifts back to the left and downward for given interest rates and inflation expectations. This is the indirect effect of the exchange rate channel.

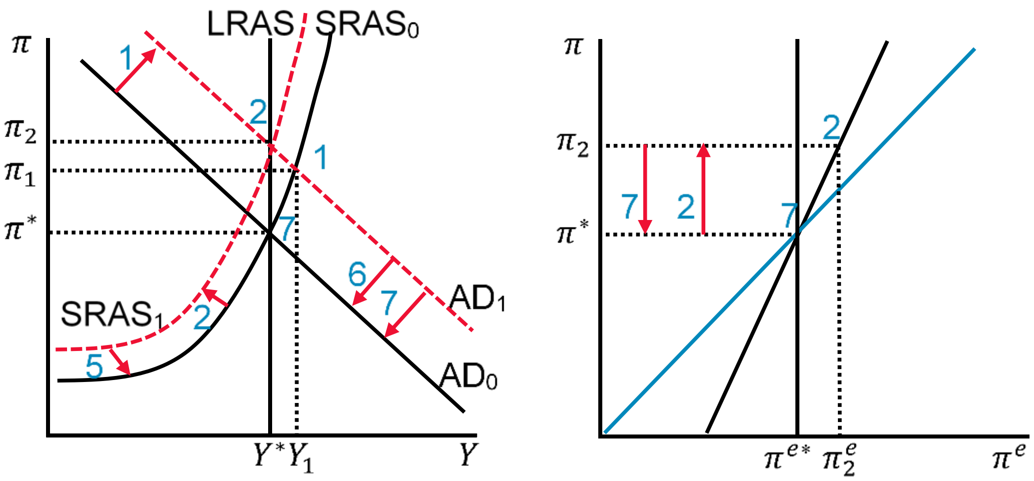
[44] Under certain assumptions regarding the pricing strategy, namely: if our exports are denominated in US dollars, the strengthening of the ruble (with ruble costs) can lead either to the pass-through of predominantly ruble and therefore increased dollar costs into prices, or to a reduction in profit margins.

Figures 40–41. Export and import responses to monetary policy tightening



7. The indirect effect of the exchange rate channel on aggregate demand (the reverse shift of the aggregate demand line) results in aggregate demand returning to its original point given initial inflation, inflation expectations, and the real interest rate (Figures 42–43). Higher interest rates ensure a stronger exchange rate, which displaces part of aggregate demand to the extent that, together with the decrease in demand due to higher rates, it offsets the initial increase in demand.

Figures 42–43. The indirect effect of the exchange rate channel—a downward shift in aggregate demand



If the indirect effect of the exchange rate channel (a reduction in exports) is not strong enough, a reverse shift in AD does not occur (number 7 in Figure 42). In this case, the new equilibrium in such an economy is achieved with higher real interest rates, higher inflation, and higher inflation expectations. If the initial increase in demand, although prolonged, is short-lived, the central bank will subsequently time the normalisation so that monetary policy normalisation occurs simultaneously with the decline in exogenous demand (a reverse downward shift in AD). Ultimately, the central bank will reduce interest rates in the old equilibrium with pre-shock inflation, inflation expectations, and output.

If the higher level of demand is prolonged, then the alignment of previous inflation and inflation expectations with higher real interest rates is only possible if the equilibrium real rate rises.

Such an increase in the neutral rate means that the TR line shifts leftward and upward (Figure 34)—now the previous inflation expectations correspond to a higher central bank rate. This signifies a change in the central bank's reaction function, tightening it. In other words, a permanently higher level of demand in the economy requires a permanently higher real interest rate to maintain inflation at the previous level.

In the new equilibrium, the exchange rate is stronger, imports are higher, and non-resource exports are lower. The increase in the current account deficit is offset by increased external financing, which, however, is not reflected in the exchange rate due to the effect of UIP.

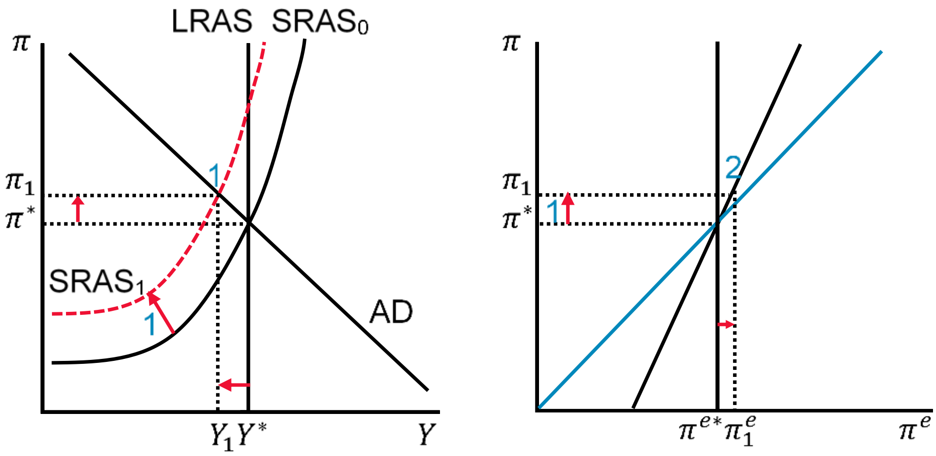
Note that in the case of a demand shock, stabilising inflation does not require reducing demand and output below potential levels. In this regard, disinflation does not impose additional costs in the form of having to lower demand below potential to offset high inflation. The central bank does not face the dilemma of choosing between reducing inflation and avoiding a recession (GDP below potential). The situation is different in the case of a supply shock.

2.2 Stabilising inflation in the face of a supply shock

A cost-push shock occurs, for example, due to rising prices in the production of certain goods. Such a shock typically affects only a subset of goods (during the pandemic, the shock significantly affected goods produced in international value chains). This will have the following effects (indicated by numbers in the diagrams. Appendix 3 provides a summary illustration).

1. The shock results in a leftward shift of the SRAS line. As a result, inflation rises (Figure 44).

Figures 44–45. The economy's response to an inflation-increasing supply shock



The key issue for the central bank is how such a shock affects inflation expectations—the inflation expected by economic agents in the next period. If the shock is temporary and inflation expectations are anchored, there is no point in the central bank tightening monetary policy. This is because inflation has already materialised. If the shock is persistent and inflation remains elevated, there is a risk that expectations will become anchored at a higher level in subsequent periods. If inflation expectations are not anchored, even a temporary supply or cost shock can increase inflation expectations. Therefore, let us assume that rising inflation also increases inflation expectations (Figure 45).

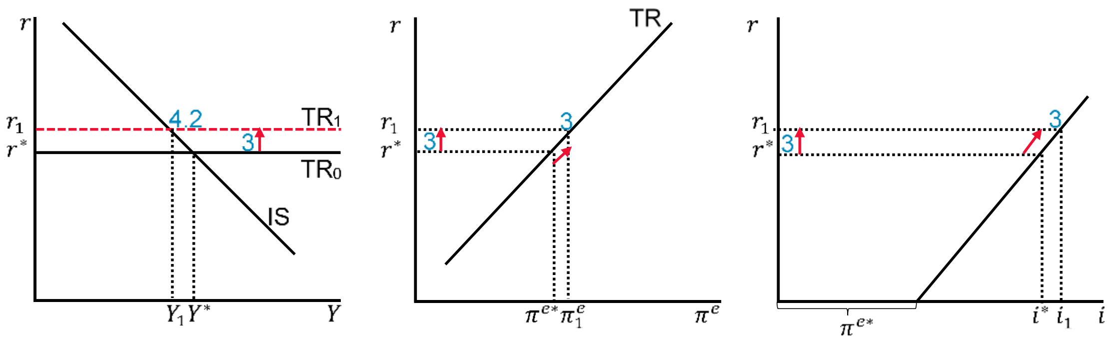
2. In this case, the central bank faces a choice: raising rates would negatively impact aggregate demand (deepening the recession), or not raising rates would fail to bring inflation under

control, meaning it would lose price stability. This problem of choice is known as ‘the monetary policy trade-off’.

The TR line will determine the aggressiveness of the central bank’s response. This determines the extent to which the central bank is unwilling to tolerate elevated inflation expectations. The slope of the AD line will also depend on the slope of the TR line. The AD line can be either vertical, in which case the central bank fully accommodates rising inflation, or horizontal, in which case the central bank is unwilling to tolerate any price increase as a result of the shock and therefore compensates for the effect of a positive cost shock on inflation at the cost of a recession. In the figures, we consider an intermediate scenario: the central bank reacts to rising inflation expectations.

3. Under the inflation targeting regime, in response to rising inflation expectations, the central bank raises nominal interest rates so that real rates also rise (Figures 46–48).

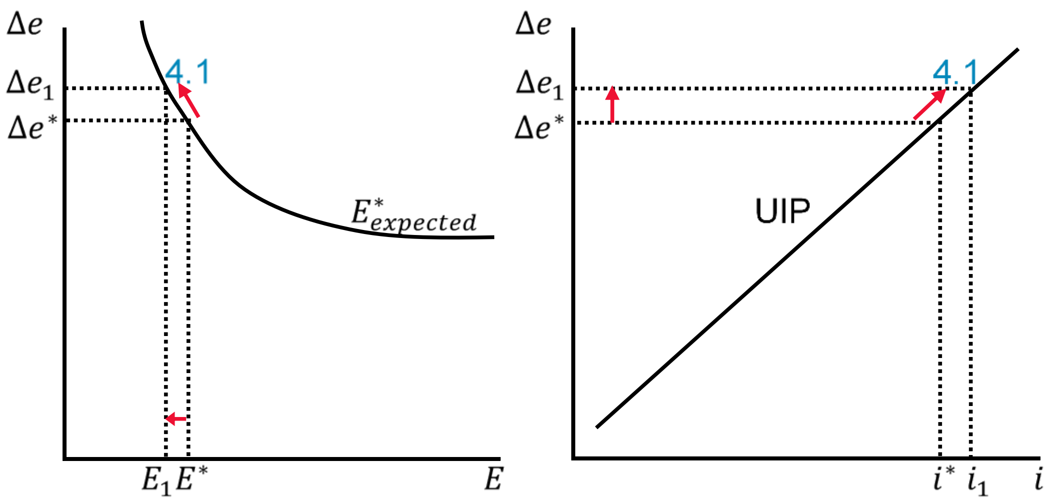
Figures 46–48. Monetary policy response to an increase in inflation expectations under a supply shock



4. Raising the rate has two effects.

4.1. According to UIP, it leads to an inflow of capital and a strengthening of the exchange rate (for a given expected exchange rate), see Figures 49–50.

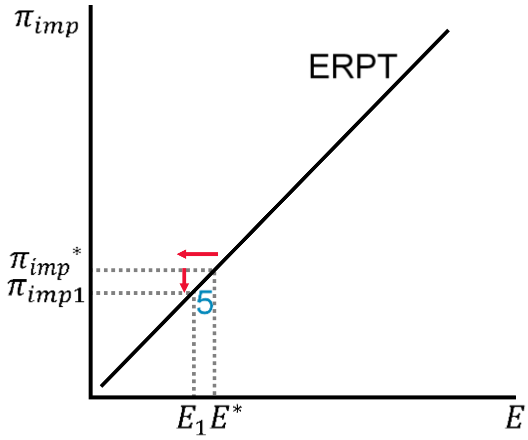
Figures 49–50. Exchange rate response to monetary policy tightening under a supply shock



4.2. Aggregate demand contracts: the TR line moves upward along the IS line. This results in a movement along AD, reducing output and income. This movement along AD is reflected in the initial shift in SRAS (Figure 44). The result is an increase in the negative output gap—a decline in business activity, which has a disinflationary effect.

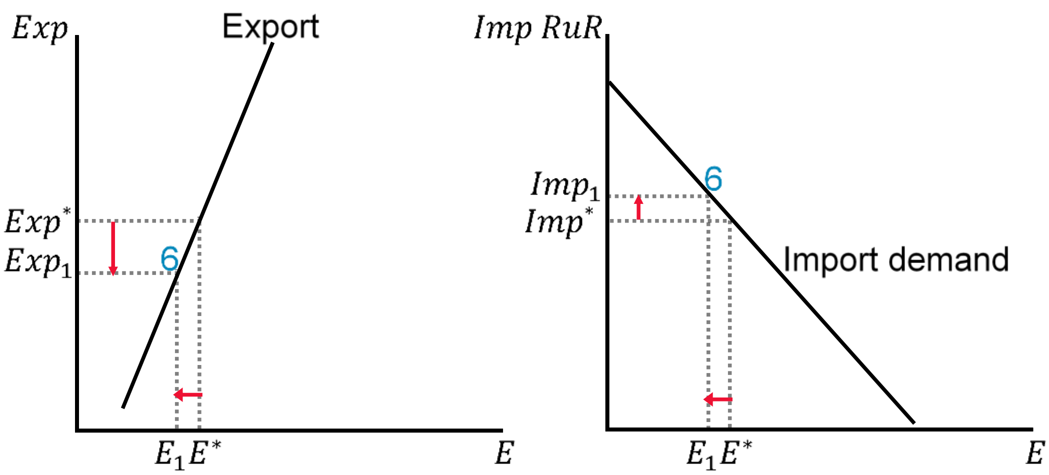
5. Strengthening the exchange rate slows down the growth of import prices—a direct effect of the exchange rate channel (Figure 51).

Figure 51. Pass-through effect of monetary policy tightening under a supply shock



6. A strengthening exchange rate also increases demand for imports. A shift in spending occurs from the consumption of domestic goods to imported ones (Figures 52–53). As a result, the IS curve shifts leftward and downward, given inflation expectations. Consequently, the AD line shifts downward, enhancing the disinflationary effect. Thus, the indirect effect of the exchange rate channel manifests itself.

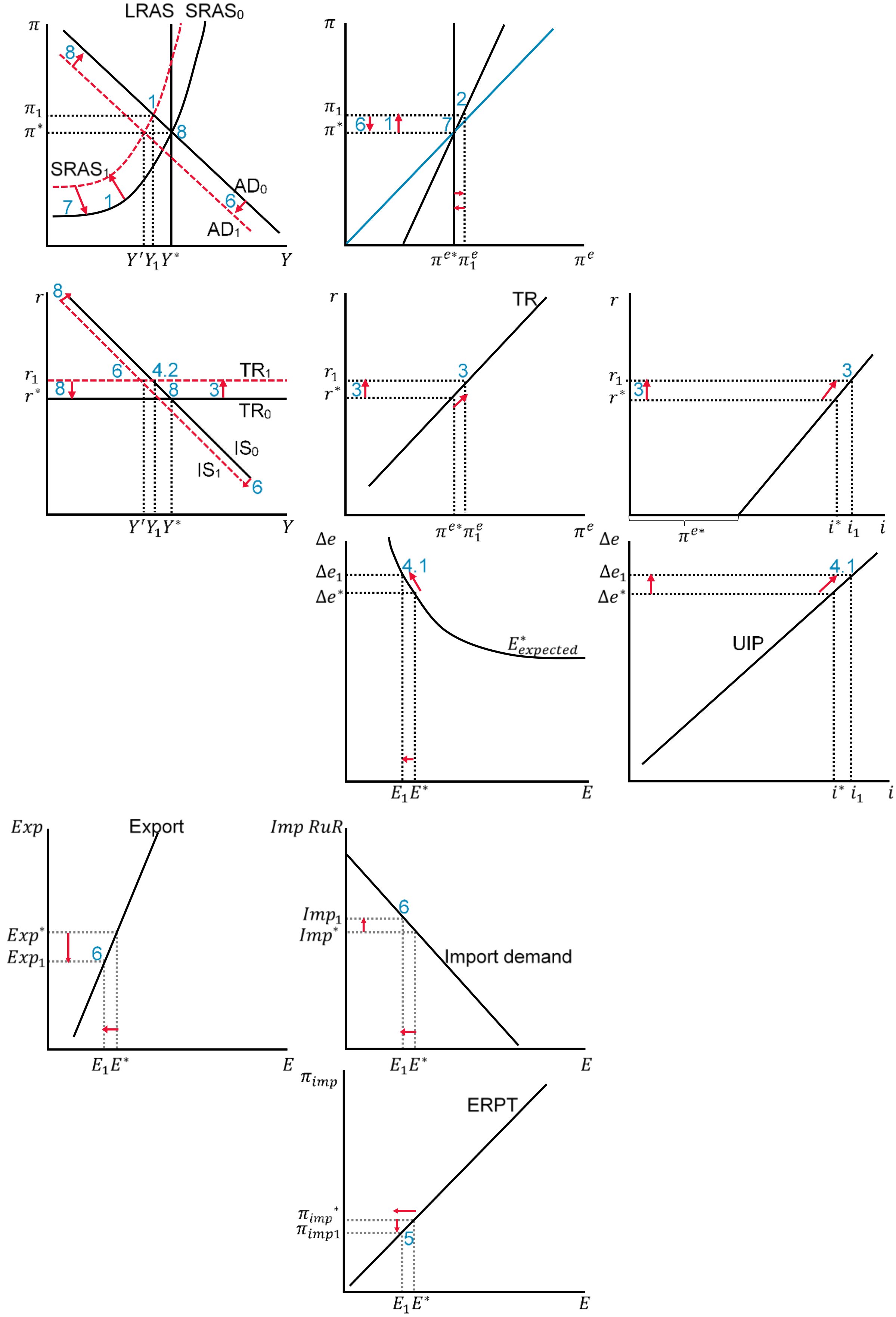
Figures 52–53. Export and import responses to monetary policy tightening under a supply shock



7. The slowdown in import price growth results in a reverse shift in the supply line (SRAS). As a result, inflation reaches the target level of 4%, but a negative output gap opens up in the economy.

8. Against this backdrop, the central bank is adjusting the subsequent trajectory of interest rate normalisation (reduction) so that, as inflation expectations weaken and the SRAS line moves downward due to the recession, inflation is as close as possible to the 4% target. In other words, the normalisation of demand as rates are reduced should offset disinflationary trends due to output being below potential (Figure 54).

Figure 54. General equilibrium model response to a supply shock

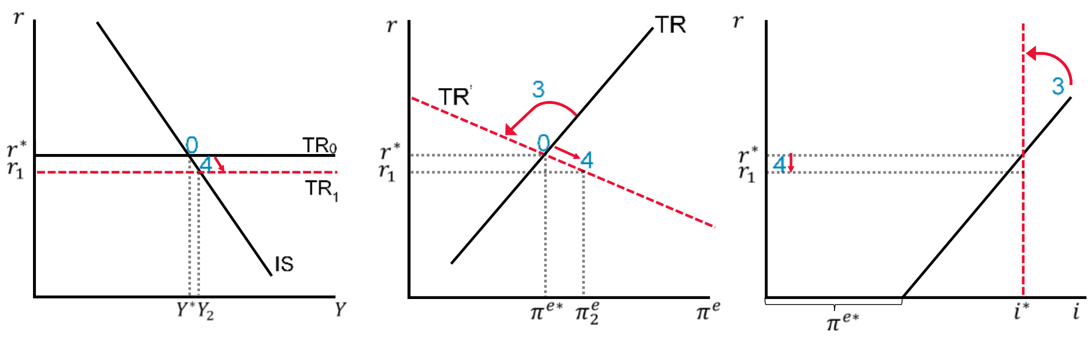


Let us consider what might happen if the central bank is not aggressive enough in Step 3. The mechanism for the subsequent economic dynamics was described by Clarida et al. (1999), and more recently by Bernanke and Blanchard (2023). In this case, an inflationary spiral arises.

Let us assume that, for some reason, the central bank decides not to increase the real interest rate in Step 3 and, despite a surge in inflation and rising inflation expectations, does not change the nominal interest rate (Figure 57) to allow the real rate to rise. This means that the central bank's reaction function changes (Figure 56).

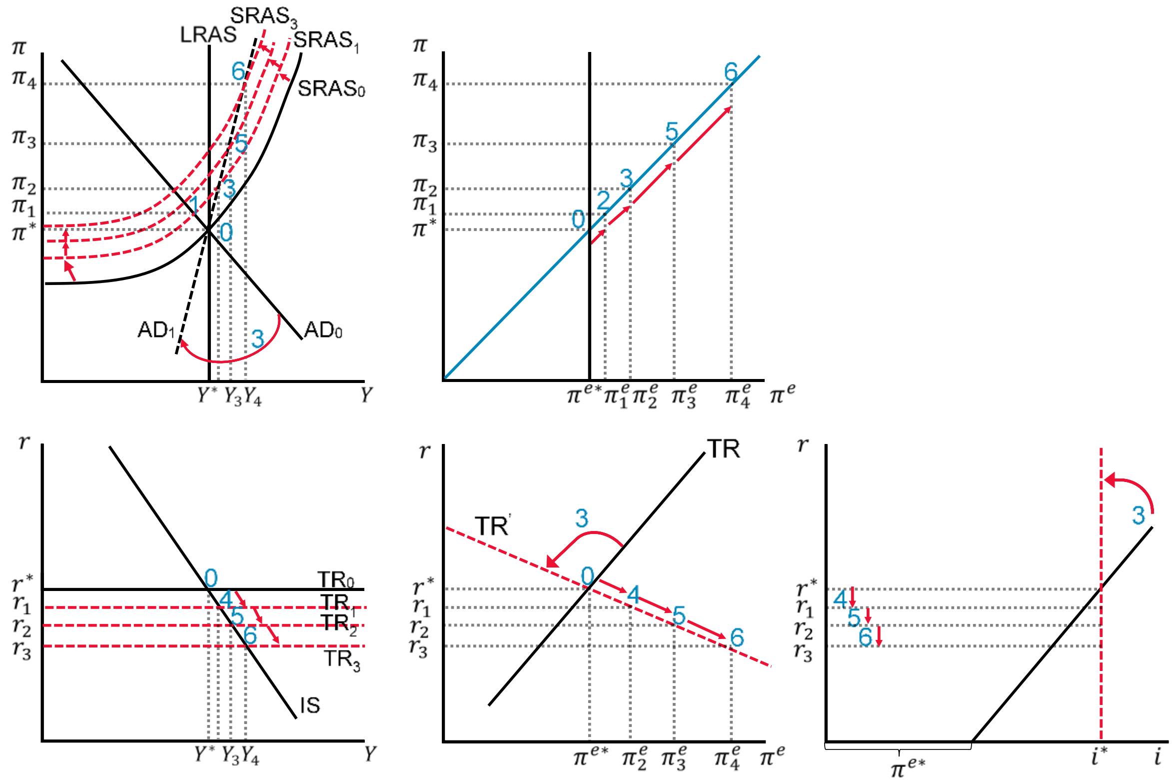
As a result of rising inflation expectations, the real interest rate, for a given (unchanged) nominal interest rate, decreases (Figure 55).

Figures 55–57. Lack of reaction from the central bank to the growth of inflation expectations



This decrease in the real interest rate leads to a change in the slope of the aggregate demand line AD—the slope becomes positive (Figure 58), see a similar change in the position of AD in (Eggertsson and Egiev, 2024, Figure 11). This change in the position of AD further increases the rate of inflation due to overheating in the economy. The cost shock and the increase in inflation expectations are translated into low real interest rates, which provokes an increase in aggregate demand (and the money supply). The increase in inflation, in turn, increases inflation expectations. Thus, an inflationary spiral unfolds in the economy: the SRAS line shifts leftward and upward along the positively sloped AD line. The economy experiences panic demand (significantly exceeding production capacity, which, due to high inflation and the associated uncertainty, may even begin to contract—the long-run equilibrium line may begin to shift leftward, intensifying overheating), which fuels rising prices and inflation expectations as well as a decrease in real interest rates.

Figure 58. Consequences for the economy from the central bank's lack of response to rising inflation expectations



Let us now consider a small open economy in a situation where the central bank faces constraints in pursuing an independent monetary policy, that is, in controlling inflation.

3. The global financial cycle and the 'dilemma, not trilemma'

We start with a description of the monetary policy trilemma.

3.1. The monetary policy trilemma

The monetary policy trilemma is a situation in which the central bank cannot simultaneously pursue:

- a fixed exchange rate;

- free movement of capital (UIP); and

- an independent monetary policy (i.e. the central bank changes the interest rate whenever it deems necessary, based on the dynamics of inflation, in particular).

The central bank can choose only two of the three options. The impossibility of choosing all three is easily illustrated using the UIP (for simplicity, excluding the country risk premium).

$$i_t = i^f{}_t + \left(e^{expected}{}_t - e_t\right)$$

If the central bank fixes the exchange rate and the market believes in the regulator's ability to implement such a policy (which determines market exchange rate expectations), then $e^{expected}{}_t - e_t = 0$. If the central bank maintains an open capital account, then equilibrium in a perfect foreign exchange market (as we demonstrated earlier) is determined by the UIP (the equation above). It follows that $i = i^f$, so the interest rate must be in a certain relationship with the foreign interest rate. Regardless of inflation, the central bank will not be able to deviate from the interest rate set by the external constraint.[45]

If the central bank maintains an open capital account, the UIP condition is satisfied in a perfect market. And if the central bank wants to have an independent monetary policy, it means that i must differ from i^f. It follows from the UIP condition that $e^{expected}{}_t - e_t \neq 0$; it cannot, in general, be zero. Exchange rate changes must bear the burden of ensuring equilibrium in the foreign exchange market if the central bank wants its policy rates to differ from foreign interest rates.

Finally, if the Central Bank wants to conduct an independent monetary policy (i may differ from i^f) and have a fixed exchange rate $e^{expected}{}_t - e_t = 0$, then it must abandon the UIP as a condition for equilibrium in the foreign exchange market. This is possible by introducing restrictions on capital movements, when equilibrium will be determined only by exports, imports, and central bank operations.

Modern central banks, when faced with the trilemma, prefer to pursue an independent monetary policy and maintain an open capital account. The consequence: domestic interest rates may differ from international rates. This means that the central bank is independent in choosing interest rates based on the need to achieve its inflation target. Consequently, to ensure the central bank's freedom of action in controlling inflation, a flexible exchange rate plays a crucial role in aligning a modern small open economy with equilibrium.

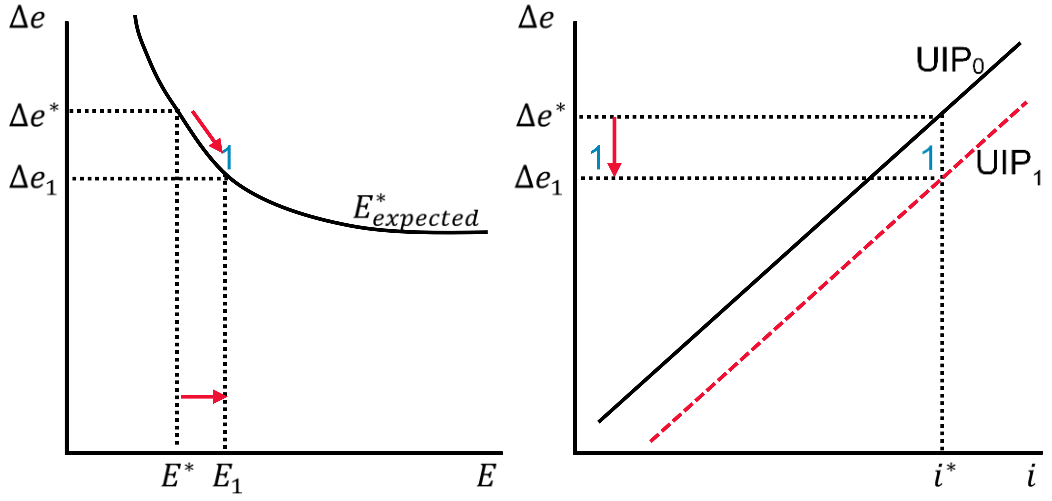
Indeed, let us assume that a foreign central bank raises its interest rate. And let us assume that inflation expectations are anchored at the central bank's target.[46] The diagrams below show the economy's adjustment to such a tightening of external monetary policy. The points below correspond to the numbers in the diagrams:

1. According to the UIP condition, with the domestic rate remaining unchanged, the exchange rate weakens in the current period (Figures 59–60).

[45] In the presence of a country risk premium, there will still be a strong relationship, but with an adjustment for the constant.

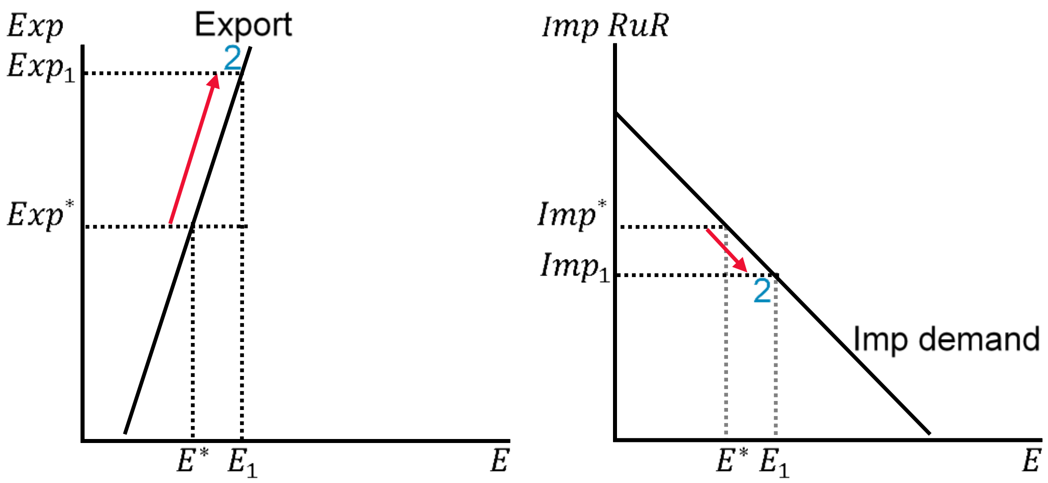
[46] This premise allows us to better highlight the stabilising effect of exchange rate changes and to show that if the central bank does not need to change interest rates, then a change in such rates by a foreign central bank within the trilemma does not necessarily require a replication of the foreign monetary policy by the domestic central bank.

Figures 59–60. Exchange rate change in the trilemma situation with rising foreign interest rates



2. Import prices rise, and demand for imported goods declines due to the weakening of the nominal and, with it, the real exchange rate (the exchange rate reacts faster than domestic inflation) (Figure 62). Non-resource exports increase to some extent due to their reduced cost for foreign buyers (Figure 61). Aggregate demand shifts upward and to the right.

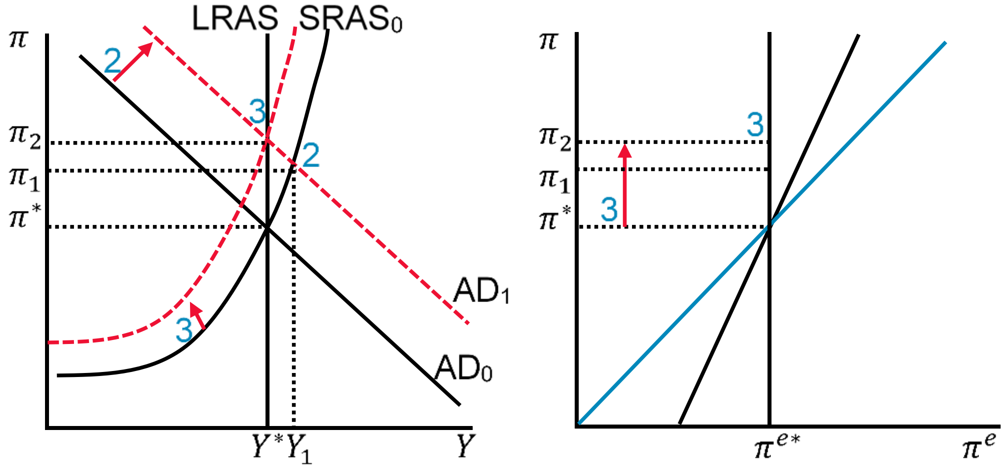
Figures 61–62. Export and import responses under the trilemma



3. Due to the exchange rate pass-through, which acts as a cost-push shock, inflation rises—the SRAS line shifts left and upward (Figure 63).[47] However, with anchored expectations, the rise in inflation does not translate into higher inflation expectations (Figure 64). Economic agents rationally perceive the surge in inflation as temporary while import prices adjust to a new, higher level.

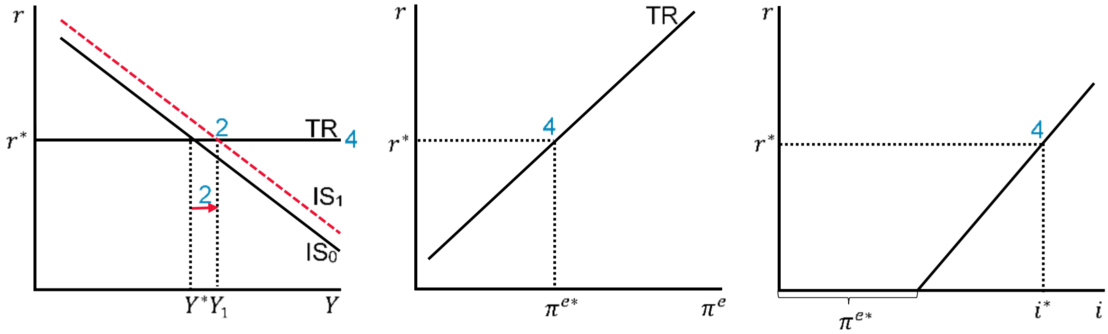
[47] The pass-through effect is not shown in the charts below because it only temporarily affects inflation.

Figures 63–64. The response of the economy under the trilemma



4. The central bank does not need to change the real interest rate due to the unchanged inflation expectations (Figures 65–67).

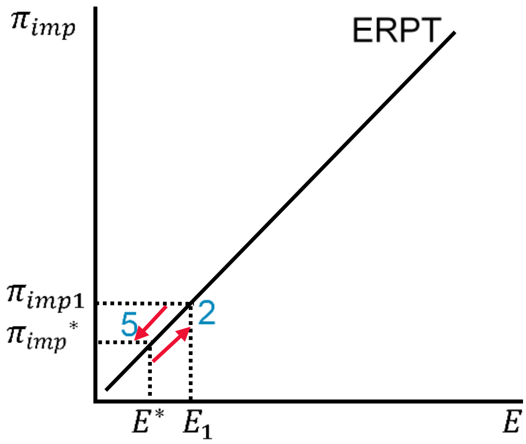
Figures 65–67. Monetary policy response under the trilemma



5. In subsequent periods, the expected exchange rate will correspond to a weaker exchange rate established after the foreign rate increase. Moreover, since the exchange rate will remain unchanged from the previous period (in a strict dynamic model the exchange rate would permanently appreciate in expectations), import price inflation will return to normal levels[48] (Figure 68). At the same time, the SRAS line will shift back down and to the right.

[48] Let us recall that import price inflation depends on the change in the current exchange rate relative to the exchange rate of the previous period, which in the single-period model, for simplicity, is not subtracted from E when designated on the X-axis.

Figure 68. Exchange rate pass-through effect under the trilemma



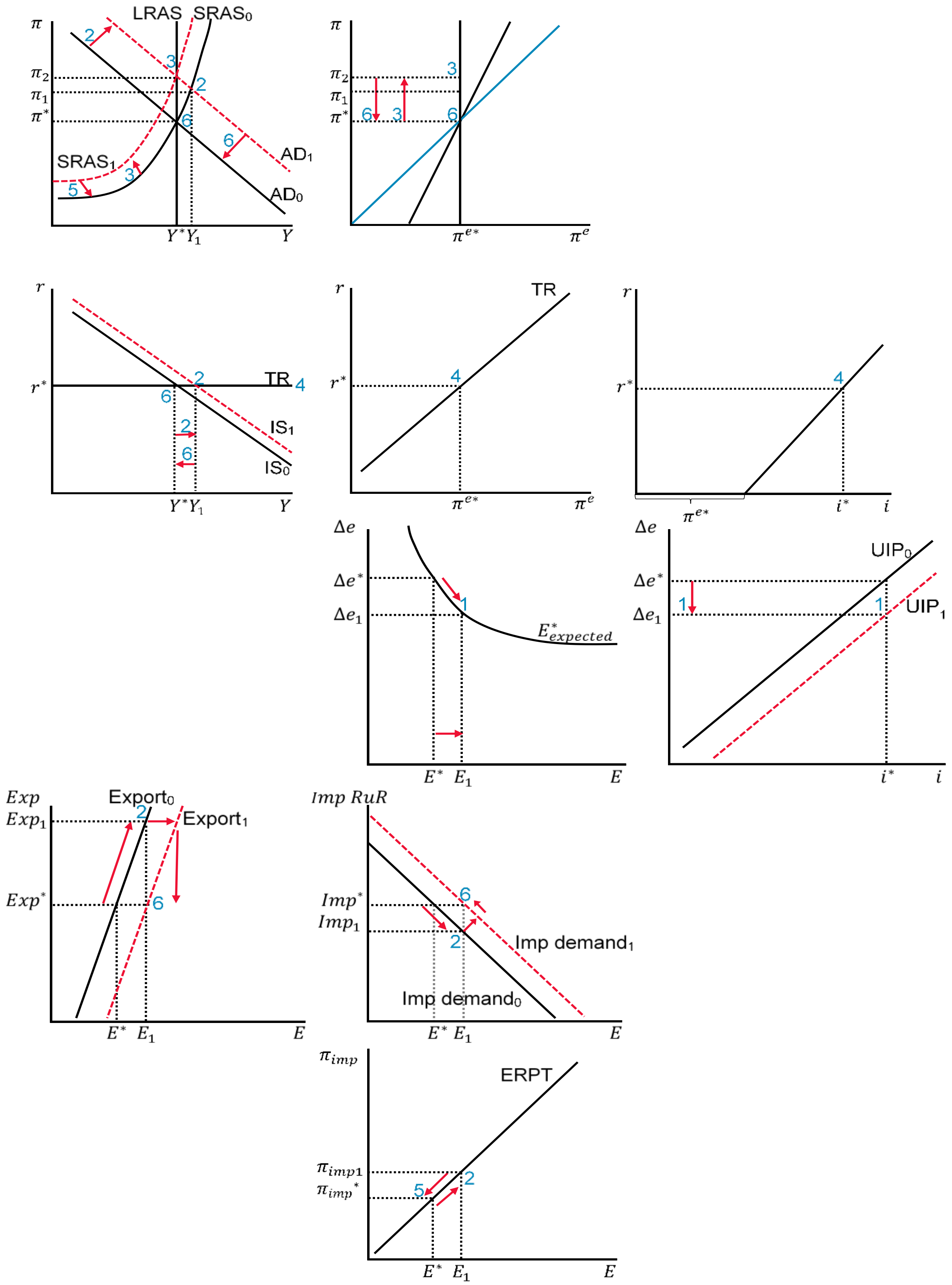
6. The following rise in domestic prices is offset by a weakening of the nominal exchange rate, so that the real exchange rate remains unchanged—the relative price of imports will return to its long-run equilibrium, and with it, the demand for imports (and exports). In these coordinates, where exports and imports depend on the nominal rather than the real exchange rate, the import and export lines will shift (Figure 69). Thus, the real effects of a change in the foreign interest rate will be very short-lived. Importantly, the change in domestic prices will occur exactly as required to keep the real exchange rate unchanged. This is because equilibrium in the economy is formed in terms of real variables. And no changes (shocks) have occurred in real variables. Therefore, a change in the nominal exchange rate will be offset by a change in other nominal variables (prices on the goods market), leaving real variables unchanged. Adjusting the nominal exchange rate to the new equilibrium will bear the entire burden of adjusting the entire economy to a higher level of foreign rates.

Thus, central bank intervention to stabilize inflation (with anchored expectations) is not required in this situation. Inflation will stabilize on its own. The foreign exchange market remains in equilibrium even with unchanged domestic interest rates.[49] In this case, the nominal exchange rate acts as an absorber of such external nominal shocks (the monetary policy of other central banks): when external conditions change, only nominal variables change (adjusting to the new level), leaving real variables at their previous levels. This eliminates the need for the central bank to change interest rates.

The summary diagram is shown in Figure 69, and comments on it are in Appendix 4.

[49] When the foreign interest rate rises, the exchange rate will weaken, overshooting its new equilibrium level. This means expectations of exchange rate appreciation will form. Subsequently, the exchange rate will approach its new equilibrium level at a constant rate (exponentially). This is formally shown in the semi-structural model in the last section.

Figure 69. Monetary policy trilemma in the general equilibrium model



3.2. The Monetary Policy Dilemma

A monetary policy dilemma is a situation in which, despite a flexible exchange rate and an open capital account, a central bank is unable to conduct an independent monetary policy: either it is forced to adjust interest rates whenever a foreign central bank adjusts them or monetary conditions change against the central bank's intentions. In this dilemma, a floating exchange rate ceases to play its stabilising role and, on the contrary, can become a source of accumulating imbalances in the economy due to the specific impact of the global financial cycle on the exchange rate. To avoid this, the central bank is unable to conduct an independent monetary policy and is forced to follow the monetary policy of a major central bank.

Under the trilemma, a depreciation of the real exchange rate led to an improvement in GDP (an increase in demand for domestic goods from residents and non-residents).[50] A depreciation of the nominal exchange rate, while the real exchange rate remained unchanged, had no effect on GDP (we discussed economic adjustment under the trilemma above). Therefore, under the trilemma, the nominal exchange rate could act as an absorber of external shocks—its weakening was reflected only in nominal variables, leaving real variables unchanged in the long run. If the real exchange rate weakened (or a positive output gap arose), it was temporary, until rising prices returned the real exchange rate to its previous equilibrium.

In a dilemma, even the nominal exchange rate can influence GDP. These effects can manifest over a long period of time through the balance-sheet (valuation) channel of financial instability. This mechanism is linked to the global financial cycle, triggered by the monetary policy regime of systemic central banks.

Under the dilemma, regardless of the exchange rate regime (even a floating exchange rate), the central bank must either introduce capital flow controls or follow the global financial cycle: raising or lowering rates in line with leading central banks. If a foreign central bank raises the interest rate, the domestic central bank must raise rates too, to prevent exchange rate depreciation and the materialisation of risks to financial stability, which would result in depreciation and high inflation expectations. Thus, the central bank changes rates in the same direction as its foreign counterpart or monetary conditions change regardless of the rate set by the regulator.

Let us consider the mechanism in more detail. The description is based on (Gourinchas, 2018). The mechanism is associated with the action of the global financial cycle. When the interest rates of central banks with reserve currencies are low, global investors are more willing to invest in emerging markets, among other things, by purchasing assets in the currencies of developing countries or providing them with loans (H in Equation 11 decreases). This leads to an increase in the prices of financial and non-financial assets in such recipient countries and to the expansion of credit to such countries (both from global investors and the domestic banking system). This process affects all countries of the world, as shown in (Rey, 2015) and (Boyarchenko and Elias, 2024). The growth of asset prices on the balance sheets of economic agents eases their credit constraints (in the form of the loan-to-value ratio, LTV, through the growth of the denominator), allowing economic agents to borrow more. At the macro level, this is manifested as a decrease in the country risk premium. This process becomes self-sustaining both in time and space (rising demand and asset prices in some countries attract capital, generating aggregate demand, which positively influences the growth of demand and asset prices in other countries). This is how the global financial (and credit) cycle manifests itself. Lower foreign rates of major central banks result in the expansion of economic activity in the emerging markets, with muted inflation pressure (higher inflation due to demand pressure and lower inflation due to a strengthening exchange rate amid capital inflows). Higher interest rates under the dilemma result in more capital inflow and

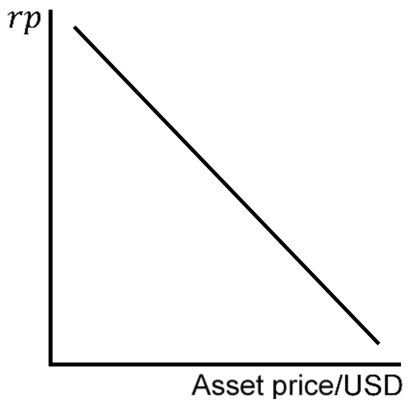
[50] Depending on the type of export price nomination.

more, not less, economic expansion in the domestic economy. Lower interest rates would slow down the capital inflow and expansion of economic activity (but lower domestic rates would stimulate domestic spending and inflation). Thus, the central bank loses its ability to control inflation under the dilemma.

To more formally describe the dilemma, we introduce additional elements to the graphical model. These elements relate to the conditions of external financing, which differ from those in a perfect financial market.

The first element is the assumption that the risk premium for external financing (rp) depends on the dollar value of the collateral assets (previously created assets that are resold on the secondary market—physical capital—machine tools, durable goods, and so on). The stronger the exchange rate, the higher the foreign currency price of the collateral assets, and the lower the ratio of the loan in foreign currency to the value of the collateral in foreign currency (lower Loan to Value, LTV), and the lower the risk premium for such foreign currency lending at the micro level. Thus, changes in the exchange rate can affect the value of collateral assets for non-residents and the risk premium for external financing, and hence, additionally, the volume of capital inflows—the willingness of foreign investors to purchase residents' obligations (Figure 70).

Figure 70. Relationship between the dollar value of collateral assets and the risk premium of external financing in the UIP

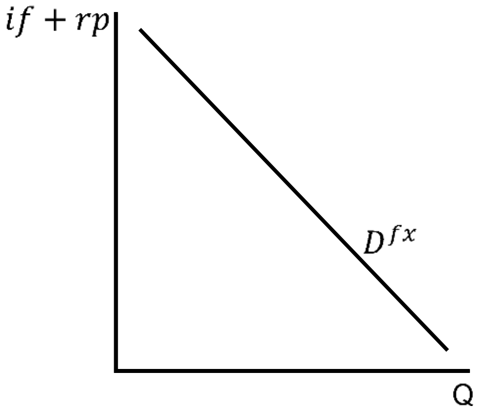


The second element—the reduction in the cost of external financing for residents—changes the structure of residents' demand for external financing. The foreign interest rate, adjusted for the risk premium, may be lower than the domestic interest rate.[51] As a result, residents' demand for domestic financing (loans) decreases, while demand for external financing increases (Figure 71). Overall, the money supply may not change, but its structure (the ratio of deposits in foreign and domestic currencies) does.[52]

[51] Even if strict UIP is observed for global investors, residents may prefer external financing to domestic financing for a number of reasons. In practice, this factor is important when the interest rates on such financing are relatively lower. At the same time, borrowers may (often naively) not account for the fact that a possible weakening of the national currency could offset the entire cost-saving benefits of the cheaper foreign currency loan. Another reason is the narrowness of the domestic financing market (the vertical line money supply in the economy), which obliges companies (especially large ones) to seek financing abroad.

[52] When domestic banks lend at a rate linked to a (lower) foreign rate they typically create liabilities (deposits) in national currency for (corporate) borrowers (less commonly, foreign currency deposits, funding these with foreign currency borrowed reserves from non-residents). But, the bank's assets are pegged to foreign currency and generate income at a lower (foreign) interest rate—the lending rate. As a result, the bank incurs an open foreign exchange position, which in practice violates regulatory requirements. To eliminate this, the bank either attracts foreign currency deposits from residents or, often in practice, enters into an off-balance sheet hedging transaction with non-residents. The bank sells dollars to a global investor under a non-deliverable forward contract. The willingness of global financial intermediaries to enter into such contracts

Figure 71. Relationship between the foreign interest rate, taking into account the risk premium, and the share of foreign sources of financing in the total demand for financing (M^d)



When the foreign interest rate decreases, banks can switch to lending to resident borrowers at a lower foreign rate, thereby easing the monetary conditions imposed by a higher domestic rate. This can result in an increase in the money supply. This is how the monetary policy dilemma manifests itself in the context of easier foreign monetary policy. As a rule, in a business cycle strengthening exchange rate leads to expectations of its weakening. Under the trilemma, these expectations of exchange rate weakening completely offset the borrower's benefits of cheaper borrowing in foreign currency relative to borrowing in the domestic currency. Under the dilemma, lending switches to fx-loans even when the exchange rate has already strengthened significantly. Thus, a strengthening of the exchange rate (which increases the price of collateral assets for non-residents) stimulates an increase in the debt burden of residents in foreign currency.

As a result, in an environment of relatively low foreign interest rates, small open economies accumulate foreign exchange debt. At the same time, their foreign exchange position often becomes unbalanced, meaning there is a currency mismatch on the balance sheets of economic agents (in practice, this is the corporate sector or, less commonly, households)—foreign currency loans are taken out by those who do not have foreign currency earnings.

When central banks with reserve currencies begin a cycle of raising their rates, the global financial cycle reverses. Global financial intermediaries tighten lending conditions (reduce hedging of open foreign exchange positions of domestic banks) and demand a higher risk premium, including in the form of an expected exchange rate appreciation, to continue debt refinancing. A stronger expected exchange rate implies, all else being equal, a weaker current exchange rate. This manifests itself as an increase in the ratio H, leading to a rotation of the external financing supply line (Figure 72). With further increases in H, at some point, financing switches to export revenues, resulting in a 'closing' of the financial market.

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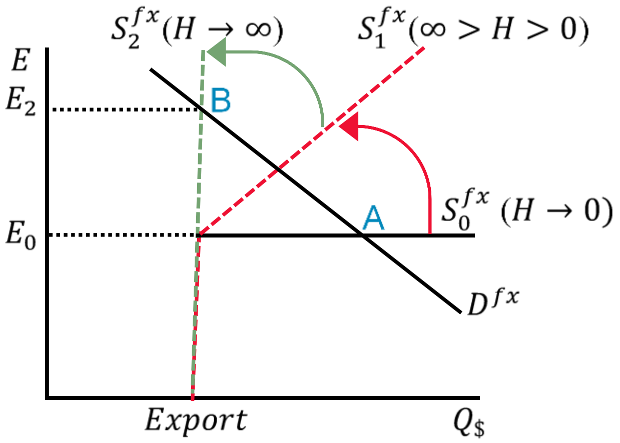
with domestic banks is determined by their risk appetite (determined by the H parameter above). As a result, corporate borrowers are able to increase their debt burden at the cost of their higher exposure to foreign exchange risk. Thus, banks are able to switch to lending to resident borrowers at a lower foreign rate, changing the structure of the money supply or even increasing it.

Figure 72. Equilibrium in the foreign exchange market during an increase in H

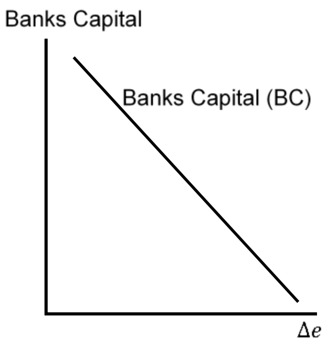


The nominal exchange rate moves from point A to point B, which corresponds to a weakening of the national currency.

The emergence of the dilemma is driven by the fact that nominal exchange rate depreciation (Figure 72) through the balance sheet channel increases the ruble value of borrowers' foreign liabilities, requiring more money (rubles) to service the external debt. This increase in the debt burden triggers defaults by borrowers and then by creditors. This is the mechanism for the development of a financial crisis and the strong negative effects on GDP in the context of the global financial cycle. In the trilemma situation, the depreciation of the nominal exchange rate did not have a negative effect on real GDP through the financial stability channel.

A weakening exchange rate leads to defaults by borrowers who have taken out FX loans from banks. The more borrowers default, the greater the losses and capital impairment for banks (hereinafter referred to as Banks Capital (BC), Figure 73). In the case of secured lending, banks' sell-off of collateral increases the supply of such assets on the market and reduces their price, devaluing the collateral for all banks and thus making them more vulnerable to potential defaults. In other words, there is a correlation between the volume of (linked to) foreign currency loans and the potential capital losses of the banking system, i.e. the dependence of banks' potential capital losses on exchange rate changes.

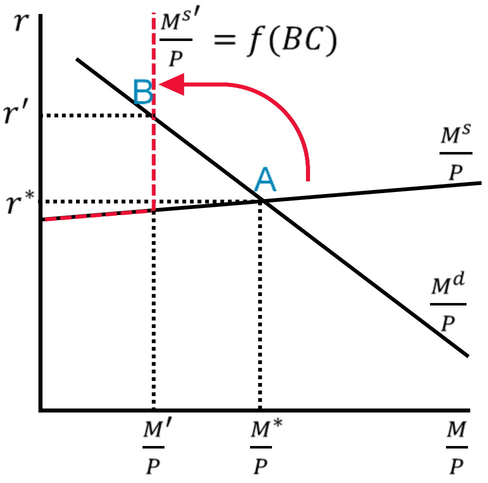
Figure 73. Change in the exchange rate and the capital adequacy of the banking sector in the case of a large share of FX loans in the economy



The basis of this dependence is the accumulation of FX loans by economic agents during periods of low global rates due to the imperfection of the credit cycle (the dependence of capital inflow on the value of collateral assets for non-residents).

A reduction in banks' capital leads to a reduction in the supply of domestic financing (the supply of money to the economy). The money supply line becomes vertical. If banks experience significant losses due to a weakening exchange rate, the money supply to the economy takes on the following form (Figure 74).

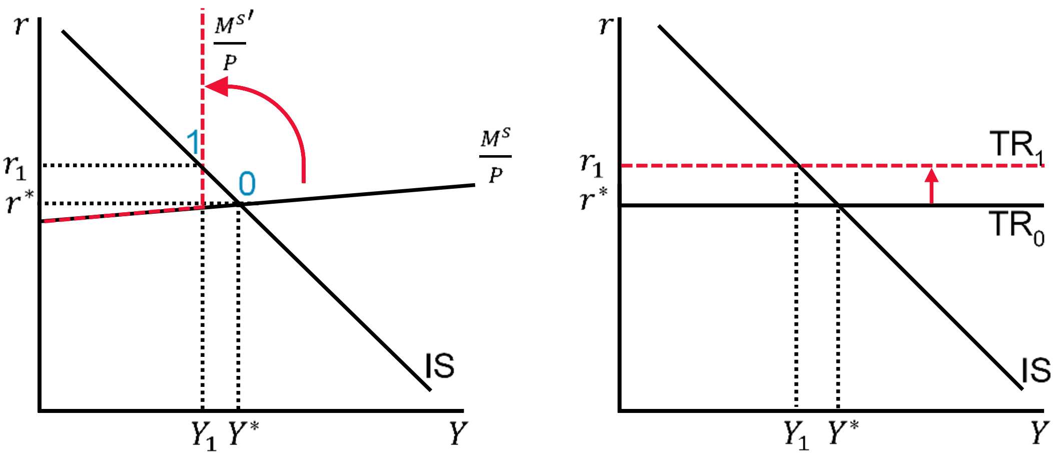
Figure 74. Equilibrium money supply in the case of large bank losses



Despite the central bank's control over money market rates, interest rates for loans rise due to quantitative constraints on banks' supply of money to the economy. Equilibrium shifts from point A to point B (Figure 74). Banks are unable to satisfy economic agents' demand for financing at the rate desired by the central bank.

This restriction of the money supply means a leftward shift of the aggregate demand line AD: any given inflation now corresponds to a lower level of aggregate demand due to higher interest rates in the economy (or, what is equivalent in the graphical model, as if there had been a tightening of monetary policy in the absence of global financial cycle effects, Figure 76).

Figure 75–76. Equilibrium in the goods market in the case of large bank losses

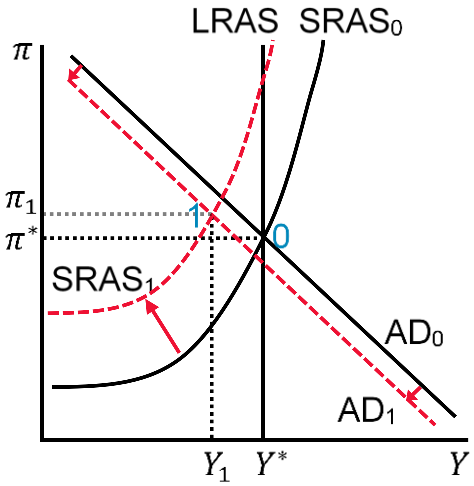


As a result, taking into account the positive effect of the real exchange rate depreciation on exports and aggregate demand, the net effect on GDP is still negative. The negative consequences of banks' capital losses on lending to the economy outweigh the positive effects of the exchange rate depreciation on the trade balance. Problems on the money supply side impede the positive effect on the economy from increased demand for raw material exports and the switch to domestic import substitutes. Consequently, the AD line shifts leftward and downward (with the same inflation, the new equilibrium corresponds to lower GDP, Figure 75). Thus, aggregate demand is affected by increased lending risks in the economy, bank capital losses, and the limited ability of commercial banks to create money for the economy.

The equilibrium (potential) GDP line may also shift due to hysteresis effects from a reduction in demand or 'scars' (long-term scars) of the financial crisis (Ball, 2014; Eggertsson et al., 2019; Cerra et al., 2023).

Importantly, the disinflationary effect of the contraction in aggregate demand may not be sufficient to offset the proinflationary effect of the leftward and upward shift in the SRAS line. Overall, inflation in the short and medium term may increase due to the weakening exchange rate and the 'pass-through' effect. Despite the contraction in demand, the shift in the SRAS line leftward and upward results in a higher inflation rate (figure 77).

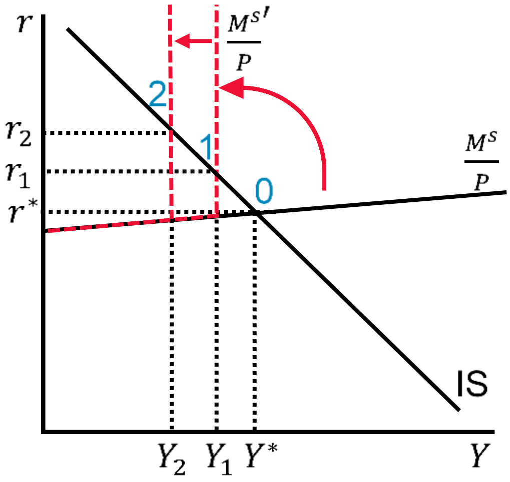
Figure 77. The economy's response to an increase in foreign rates under the dilemma



In the longer term, with anchored expectations, as with the trilemma, the shift in the SRAS line will be a one-time event, and inflation will begin to slow. At some point, the contraction in demand should have a disinflationary effect on prices.

Weaker demand, however, could lead to a decline in borrowers' incomes, further increasing the rate of defaults in the economy. These defaults lead to further losses for banks and further reduce the supply of financing (Figure 78).

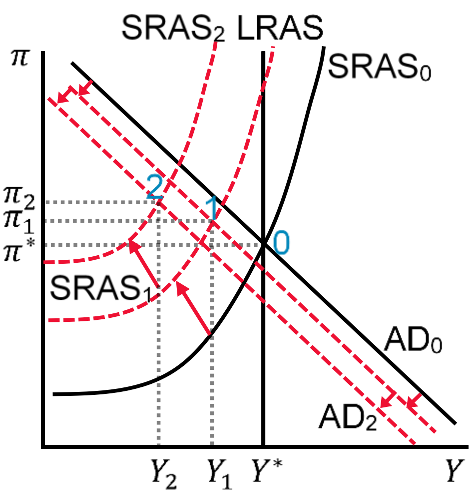
Figure 78. Response of the money supply curve to a reduction in borrowers' income and banks' capital losses



The observed increase in lending rates (even with fixed and unchanged monetary policy rates) reduces the ruble value of collateral assets, further increasing the risk premium for foreign investors. This increase further reduces the supply of external financing, leading to a further weakening of the exchange rate.

As a result, further weakening of the exchange rate and rising import prices will continue to increase inflation and inflation expectations, despite the reduction in demand (Figure 79).

Figure 79. Stagflation under the monetary policy dilemma

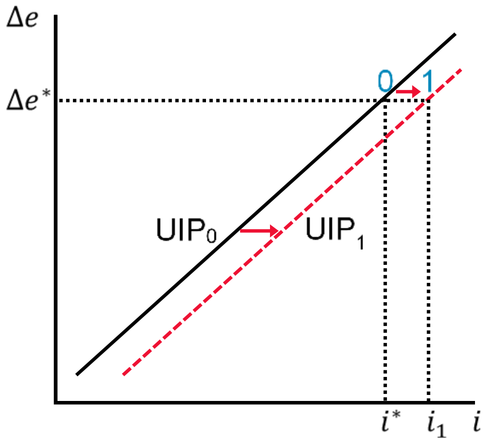


Essentially, the economy is experiencing stagflation—as demand and GDP decline, inflation rises. In this situation, a floating exchange rate does not help stabilise either GDP or inflation. The danger of such price dynamics is that high inflation can de-anchor inflation expectations, even if they were initially anchored on the central bank's target.

How should the central bank act in such a situation? If there are no other tools, the central bank must initially respond to rising foreign interest rates by raising the interest rate to break this vicious cycle. The diagrams below illustrate the case where the central bank follows the foreign monetary policy—thus, the trilemma turns into a dilemma.

1. An increase in the foreign interest rate shifts the UIP[53] (Figure 80).

Figure 80. Exchange rate reaction to monetary policy tightening under the dilemma in response to an increase in the foreign interest rate



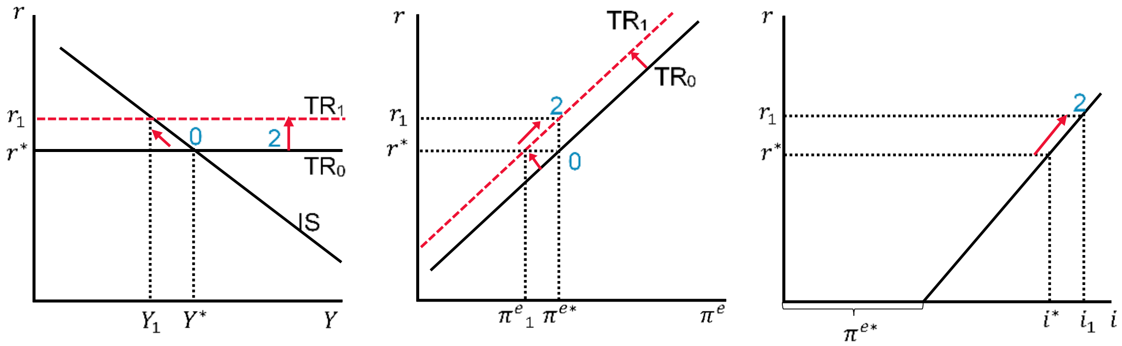
2. An increase in the domestic rate for any given value of inflation expectations in response to a rise in the foreign rate maintains interest rate parity and stabilises the exchange rate (Figure 80).

3. Due to the unchanged exchange rate, the risk premium and the supply of FX financing remain unchanged. As the exchange rate is stabilised, there are no negative effects of the exchange rate on the value of foreign currency collateral, on the domestic currency debt burden, defaults, banks' capital losses, and ultimately GDP. Higher rates reduce the value of collateral assets for non-residents (with the same exchange rate), resulting in a slight increase in the risk premium. This requires an additional compensating increase in the rate (not shown in the figures).

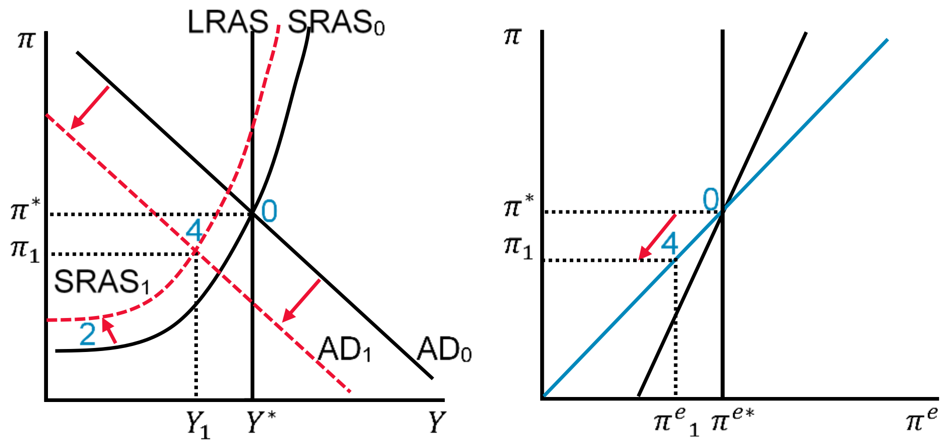
4. Higher interest rates lead to a downward shift in the aggregate demand curve: interest rates rise not in response to rising inflation (Figures 81–82), and with the same inflation, GDP turns out to be lower (Figure 84). However, this leftward shift of the AD curve may actually be smaller than with unchanged (lower) monetary policy rates. By raising rates, the central bank can avoid large losses in GDP and elevated medium-term inflation. Paradoxically, a tight monetary policy is accompanied by smaller losses in GDP than a looser monetary policy in a situation where foreign interest rates rise and the dilemma is in effect.

[53] If not only the foreign rate changes, but also the risk appetite H and willingness of global investors to provide financing for this small, open economy, maintaining the previous equilibrium in the foreign exchange market will require either compensation in the form of a greater exchange rate deviation from the expected level or a higher domestic interest rate. Indeed, from the formula $E * 1/H * [\, i - i^f - rp - lnE_{expected} + lnE] + Exp * E - Q_{rub} = 0$ it follows that, with growth in H, maintaining the first term unchanged will require either a stronger expected exchange rate (a weaker current one) or a higher interest rate i. Thus, if an increase in the foreign rate leads to an increase in H, this will require an additional increase in the domestic rate, which, relative to the UIP situation, is equivalent to a reversal of the UIP line.

Figures 81–83. Monetary policy tightening under the dilemma



Figures 84–85. The economy's response to monetary policy tightening under the dilemma

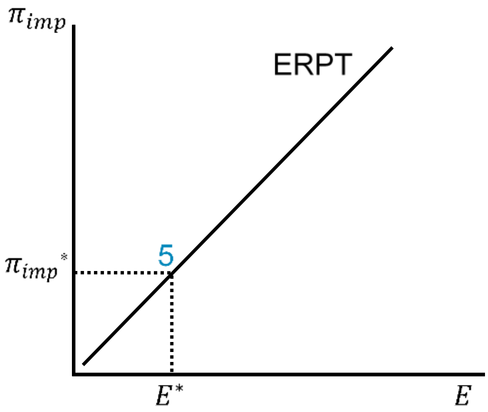


5. Import prices remain stable due to the stable exchange rate (Figure 86). Inflation even slows due to a shift in demand (Figure 85).[54] Stagflation does not occur in the economy.

The economy finds itself in a recession, but the contraction in GDP will be less than in a situation where the central bank had not tried to stabilise the exchange rate and its weakening would have led to the realisation of risks to financial stability.

[54] Figure 84 shows a slight leftward shift in the SRAS line due to rising inflation (devaluation) expectations at the time of the foreign rate hike. This increase in inflation expectations may not occur if market participants are aware of the central bank's new reaction function—there will be a shift in the TR line in Figure 81.

Figure 86. Pass-through effect of monetary policy tightening under the dilemma

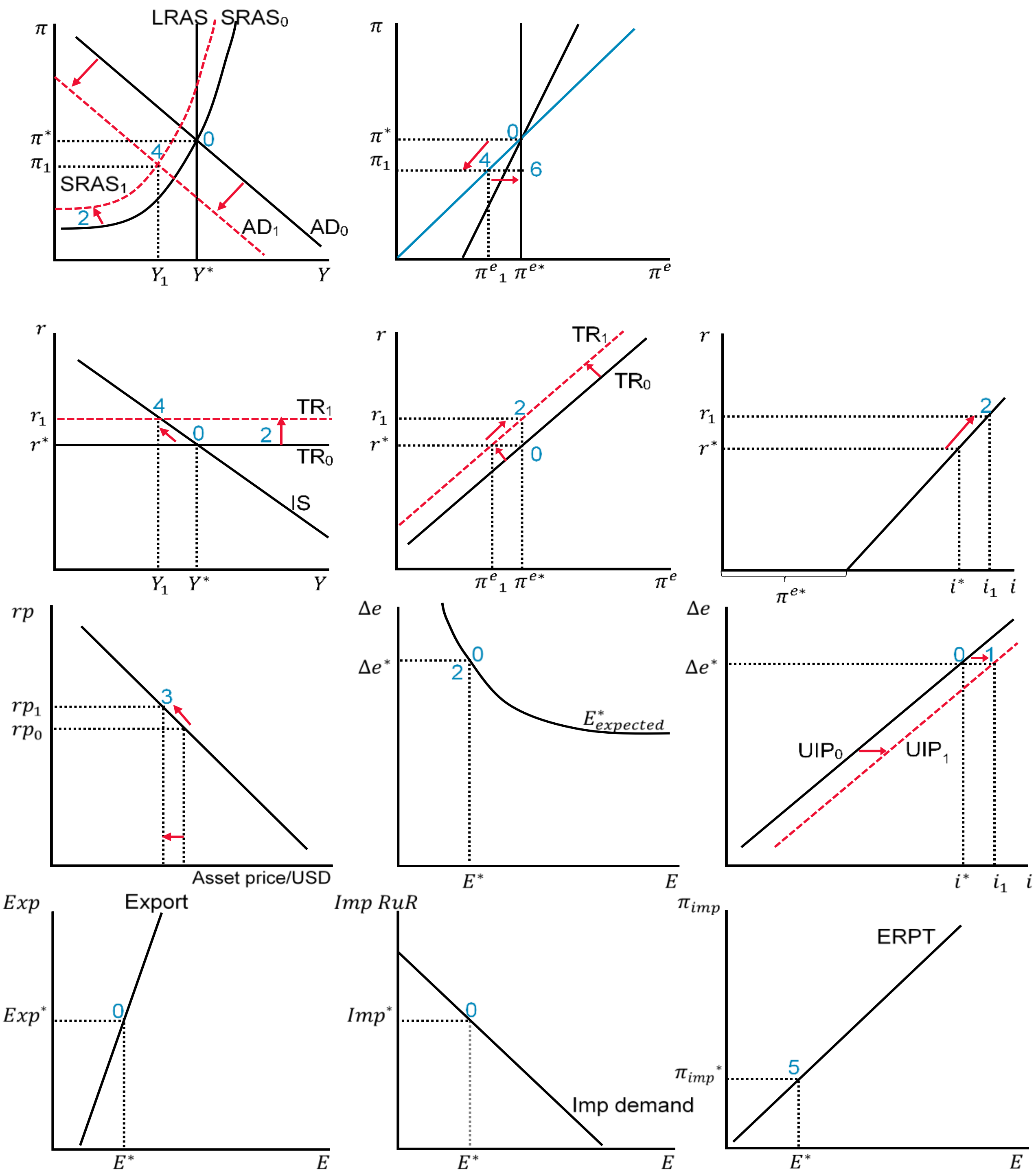


6. With anchored expectations, lower inflation may prove to be a longer-lasting phenomenon: the central bank would like to avoid it, but trying not to follow a foreign central bank will lead to more negative consequences for GDP and price stability (Figure 87).

Overall, by raising interest rates, the central bank achieves better inflation and GDP stabilisation than with unchanged rates and a floating exchange rate. This is the crux of the dilemma: the central bank is forced to adjust interest rates in line with the monetary policy of the systemic central bank, which has decided to tighten monetary policy to achieve its goals. The central bank of a small open economy is forced to do the same, despite a floating exchange rate.

A summary diagram similar to Figure 87 and comments on it are given in Appendix 5.

Figure 87. Monetary policy dilemma in a general equilibrium model

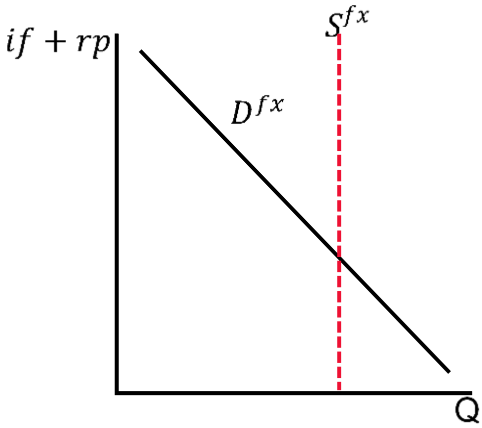


There are two approaches to resolving the dilemma: to avoid monetary tightening in response to monetary tightening by foreign central banks: ex ante or ex post crisis response measures. The literature (Gourinchas, 2018; Basu and Gopinath, 2024) suggests the following tools to ensure that monetary policy can focus on achieving the inflation target.

Firstly, these are instruments that prevent the accumulation of FX debt in the domestic private or public sector during the easy phase of the global financial cycle. Thus, the central bank can conduct ex ante macroprudential policy or introduce capital flow controls so that when the global financial cycle reverses (external rates rise and/or H increase), any given exchange rate depreciation will have less of a negative impact on GDP. During periods of high rates and rising risk premia, investors will perceive the situation as stable and will demand less of a risk premium—meaning that the exchange rate's reaction to changes in the external rate (the leftward shift of the UIP line when external monetary policy tightening is implemented) will decrease.

Suppose the central bank limits the supply of FX loans to a certain level—for example, by introducing capital flow controls (preventing residents from attracting FX financing in excess of a certain amount S^{fx}). Thus, despite the reduction in the cost of external financing during a period of low global rates, it will no longer be possible to increase the volume of such financing above S^{fx} (Figure 88).

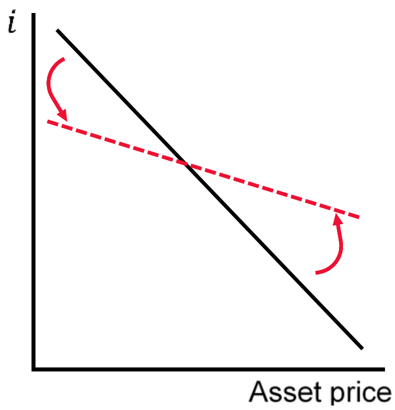
Figure 88. Restriction of the supply of FX loans by the introduction of capital flow controls



Another approach is taxing capital inflows, which increases the cost of external financing for residents. Thus, for a given external rate and risk premium, the demand for FX loans shifts leftward and downward.

Macroprudential policy can also limit the growth of the price of collateral assets when foreign rates decline—reducing the sensitivity of the price of financial assets to interest rates.

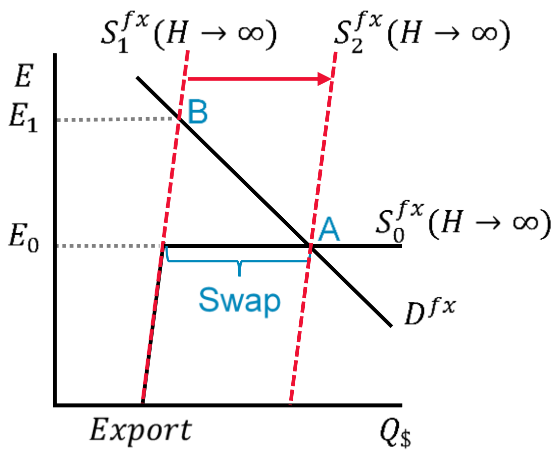
Figure 89. Reducing the sensitivity of financial assets' prices to interest rates



An important tool is increased capital requirements for banks issuing FX loans and, consequently, attracting external financing from abroad. This measure helps reduce the sensitivity of demand for FX loans to foreign interest rates during the tightening phase of foreign monetary policy.

Secondly, if for some reason it was not possible to prevent the accumulation of FX debt, the central bank can use ex post instruments when a foreign central bank has already raised the rate and the financial cycle has reversed. For example, a central bank can impose capital controls or increase the supply of foreign currency through the provision of foreign currency liquidity (FX swaps and repos) from its foreign exchange reserves. Capital controls will reduce demand for foreign currency—the demand line will not shift upward and to the right, while FX liquidity from the central bank will increase the supply of foreign currency, thereby compensating for the turn in the supply line by shifting it to the right (Figure 90).

Figure 90. Provision of foreign exchange liquidity through swap operations between domestic commercial banks and the central bank



As a result, stabilising the exchange rate will prevent the negative spiral of financial instability from unfolding.

Such measures to stabilise the exchange rate in the global financial cycle allow the monetary policy to focus on fulfilling its main task—ensuring price stability.

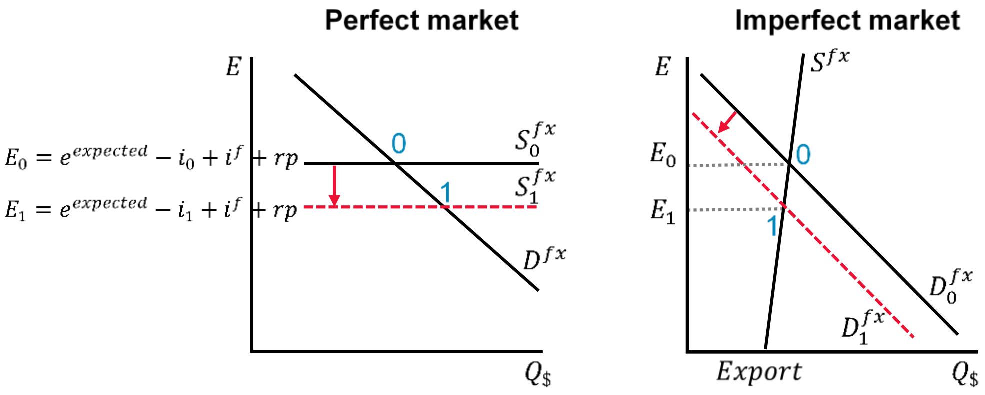
Let us now consider the equilibrium of an economy facing a severe constraint on the supply of external financing from global investors and unable to use its accumulated international reserves to finance imports. This is an economy with a closed financial account.

3.3. Model with imperfections

To describe the model with imperfections in the foreign exchange market, we also use (Maggirori, 2022) with some simplifications.

We have previously shown that if H becomes very large, that is, if non-residents are unwilling to provide external financing regardless of the amount of compensation in the form of exchange rate depreciation, adjustment to equilibrium in the foreign exchange market is ensured by demand Q. An increase in H to infinity requires that net demand (Q) be equal to exports ($Export$), so that equilibrium in the foreign exchange market is achieved at the interest rate set by the central bank (i). Then, instead of UIP, the exchange rate in the foreign exchange market will be determined by the condition of equilibrium of financial flows (exports, imports, and capital outflow of residents), see Equation 12. Demand for imports and residents' demand for foreign currency increase as the exchange rate strengthens and decrease as the interest rate rises (a shift in the demand line for foreign currency). Exports increase as the exchange rate weakens, but with low exchange rate elasticity. The differences in the exchange rate's response to an increase in the interest rate by the central bank are clearly visible in Figures 90a–90b.

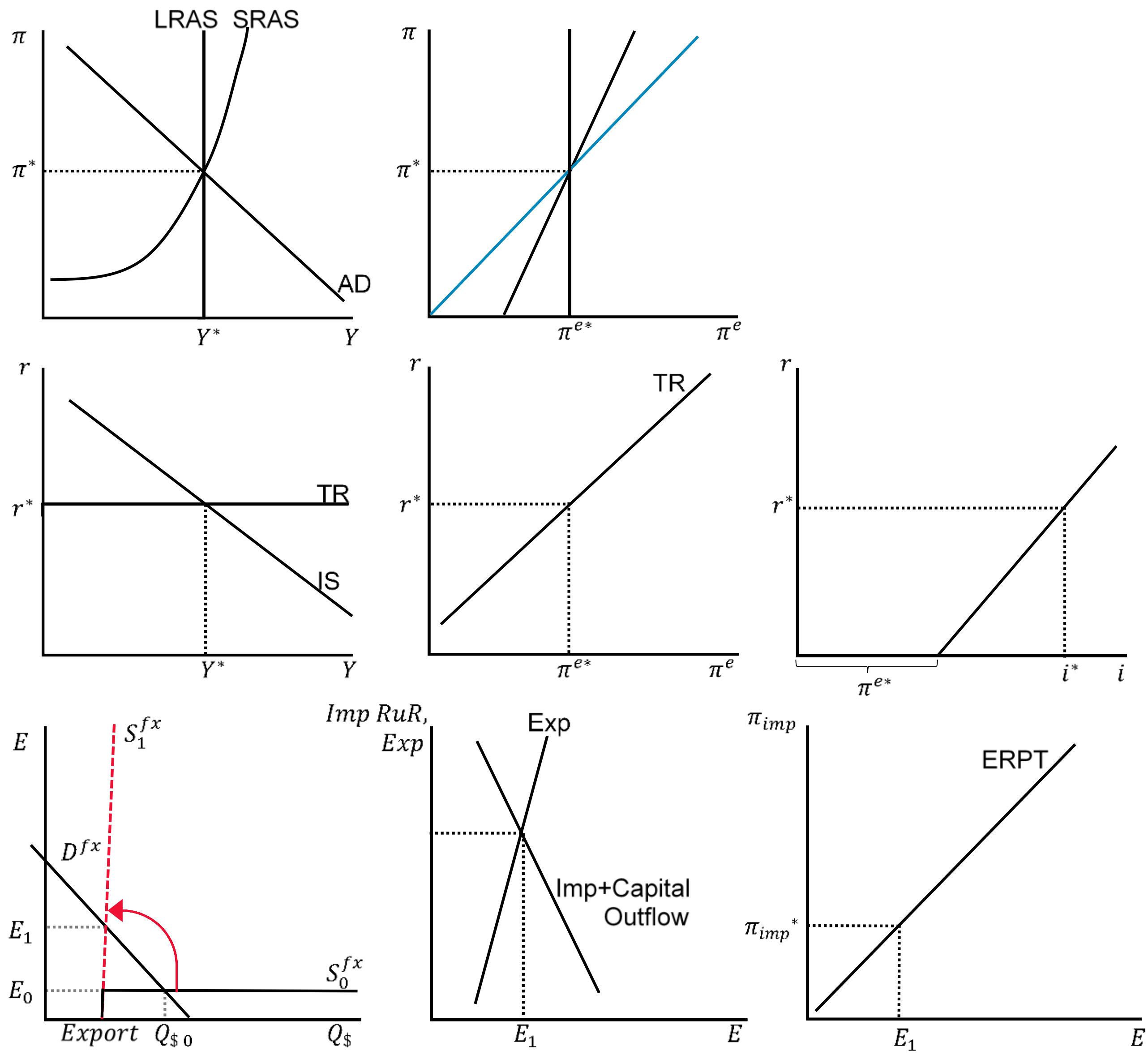
Figures 90a–90b. Equilibrium in a perfect (left) and imperfect (financial autarky) (right) foreign exchange market in response to an increase in the domestic interest rate



In a perfect market, an interest rate hike quickly translates into a strengthening of the exchange rate. In a financially closed economy, however, adjustment occurs through a reduction in imports, resulting in a weaker and more protracted exchange rate response.

As a result, equilibrium in a financially closed economy is described by the aforementioned model (Figure 91).

Figure 91. General equilibrium model with foreign exchange market imperfections

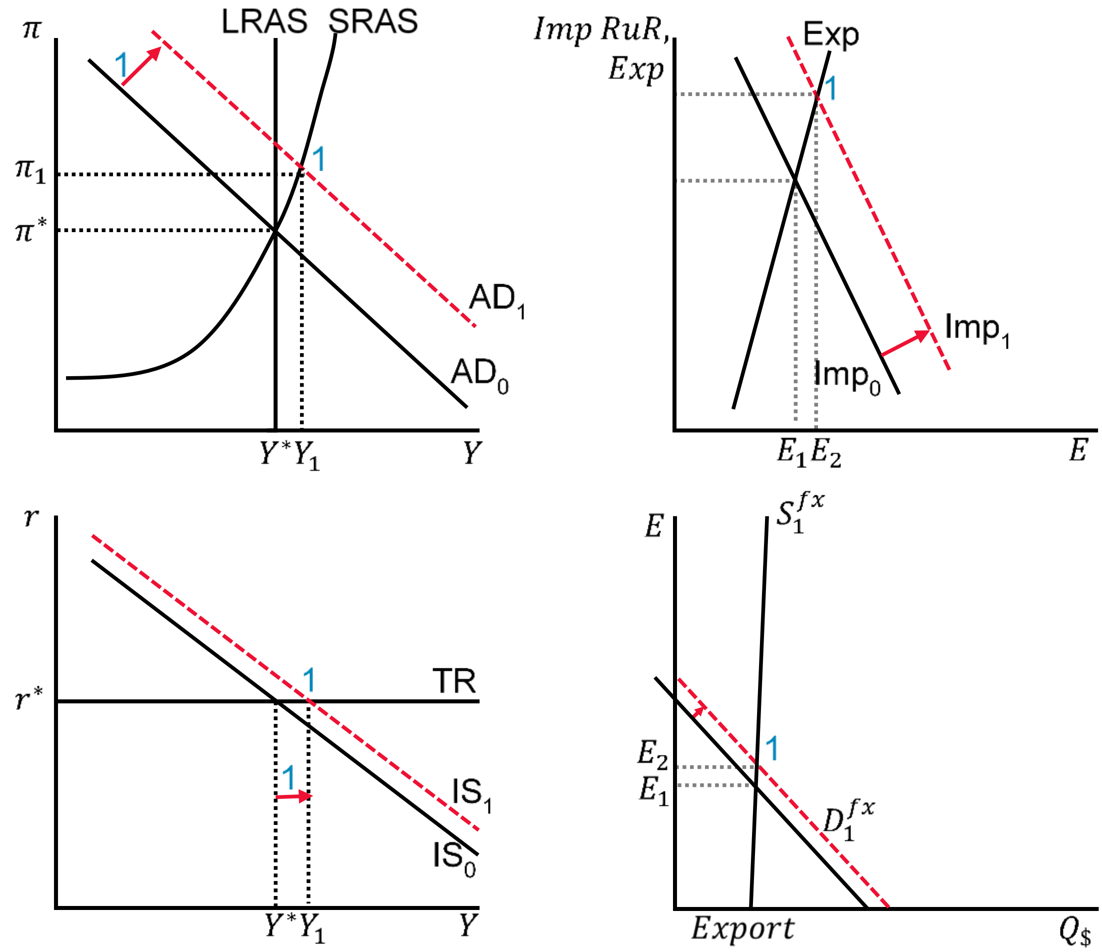


Let us analyse the change in the operation of the exchange rate monetary policy transmission channel in such a situation in the event of a demand shock.

The operation of the currency channel in the context of financial sanctions (restrictions on the foreign exchange market, capital controls).

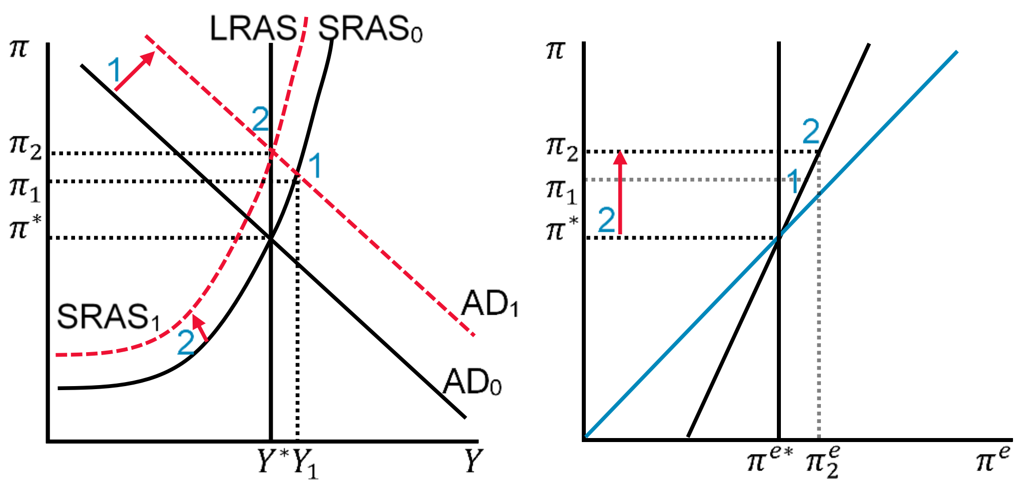
1. Let us assume a demand shock occurs, for example, due to a change in savings preferences or an increase in government spending, which shifts the IS and AD curves upward and to the right (Figures 92, 94). Overheating in the economy is accompanied by rising wages and prices, leading to higher inflation. Furthermore, due to rising incomes, demand for imports increases (a shift in the import line on the foreign exchange market) (Figure 93).

Figures 92–95. The effect of the currency channel under financial sanctions with a demand shock



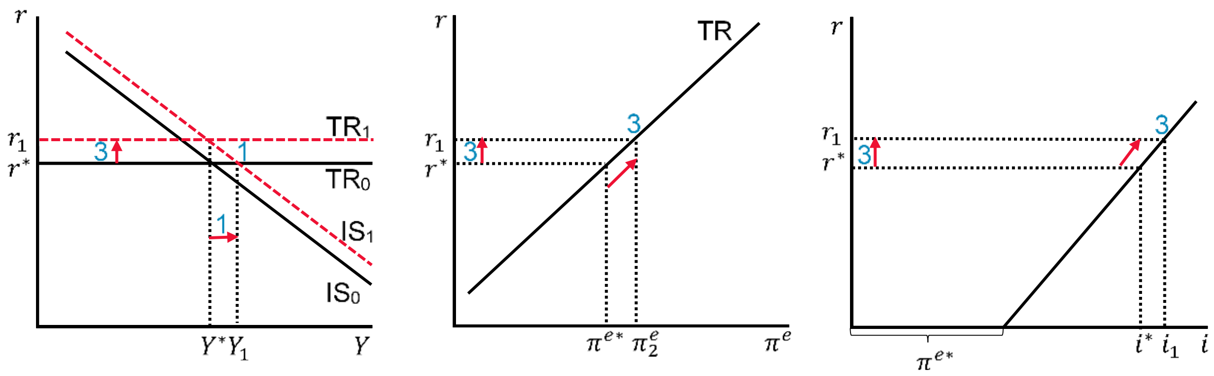
2. If higher real demand is sustained, the persistence of higher inflation translates into elevated inflation expectations, which are essentially the discounted sum of all future output gaps (Figure 97). Consequently, the SRAS line shifts leftward (Figure 96).

Figures 96–97. Inflation and inflation expectations' reaction



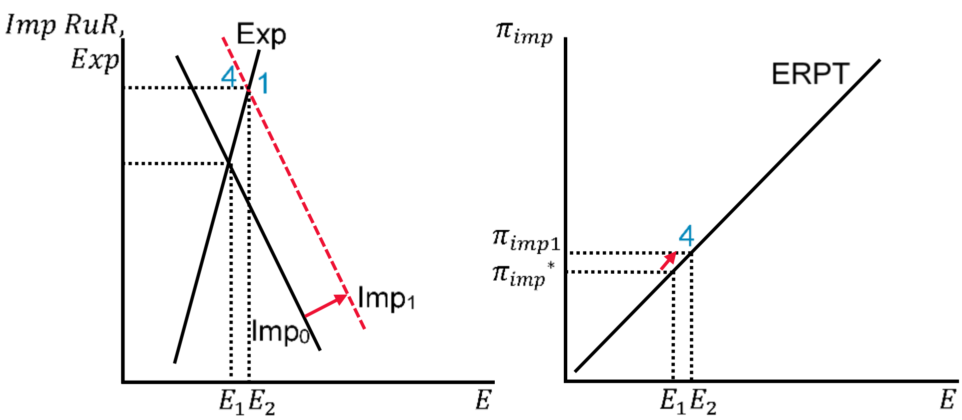
3. The central bank tightens monetary policy following the Taylor rule (Figures 98–100). This manifests itself as a movement along the IS curve (Figure 98).

Figures 98–100. Monetary policy reaction



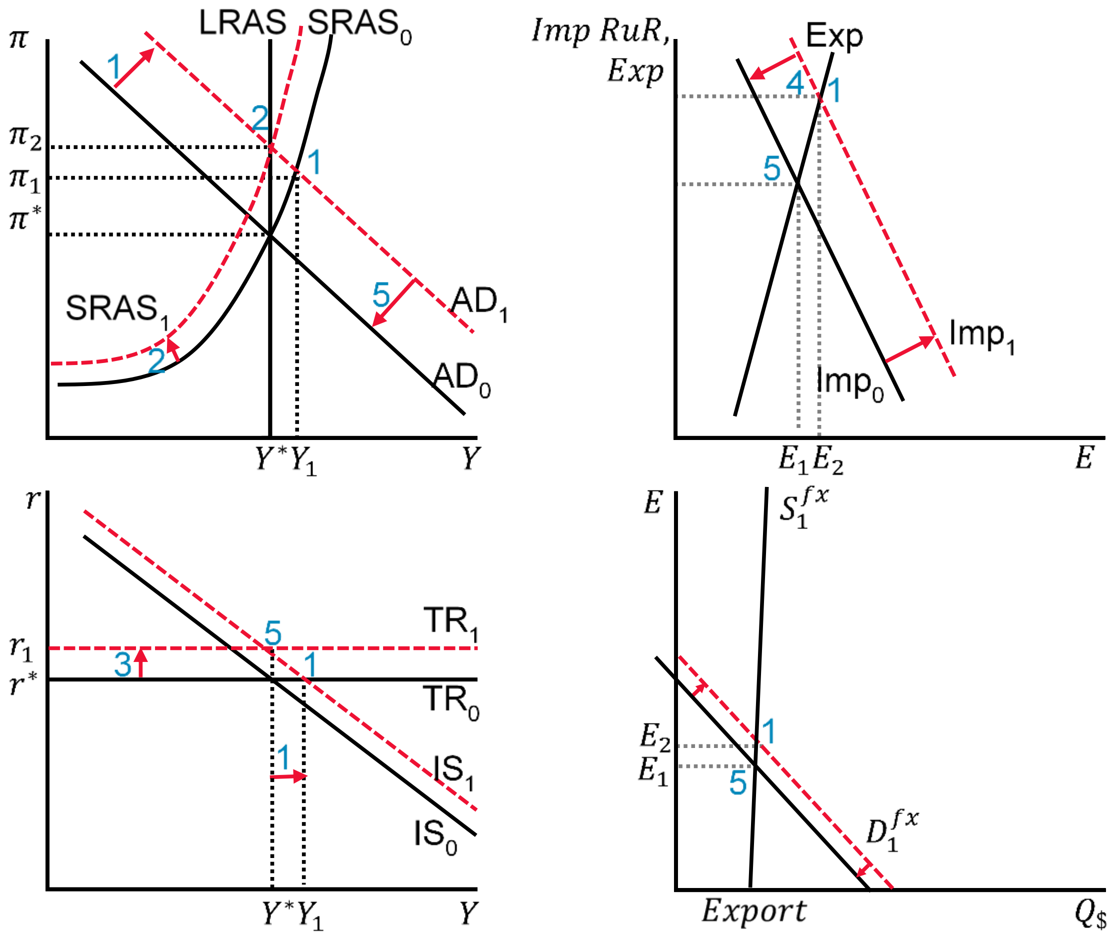
4. A rate hike, unlike under an open financial account, **does not** affect capital inflows. A shift in the import demand line leads to a depreciation of the exchange rate, which is only offset with a lag by a reverse shift in the AD curve and import demand due to tight monetary policy (Figure 101). This further pushes up inflation through rising import prices (Figure 102). An additional shift in the SRAS line occurs.

Figures 101–102. The reaction of export and import



5. If demand remains high for a long time, further tightening of monetary policy will be required to reduce inflation—a change in the monetary policy reaction function (a rotation of the TR line in the coordinates of inflation expectations and the real rate). This will reduce demand for imports, thereby returning the exchange rate to its initial equilibrium (Figure 104). Equilibrium in the foreign exchange market with a tighter monetary policy is established at the previous exchange rate (Figures 103, 105–106).

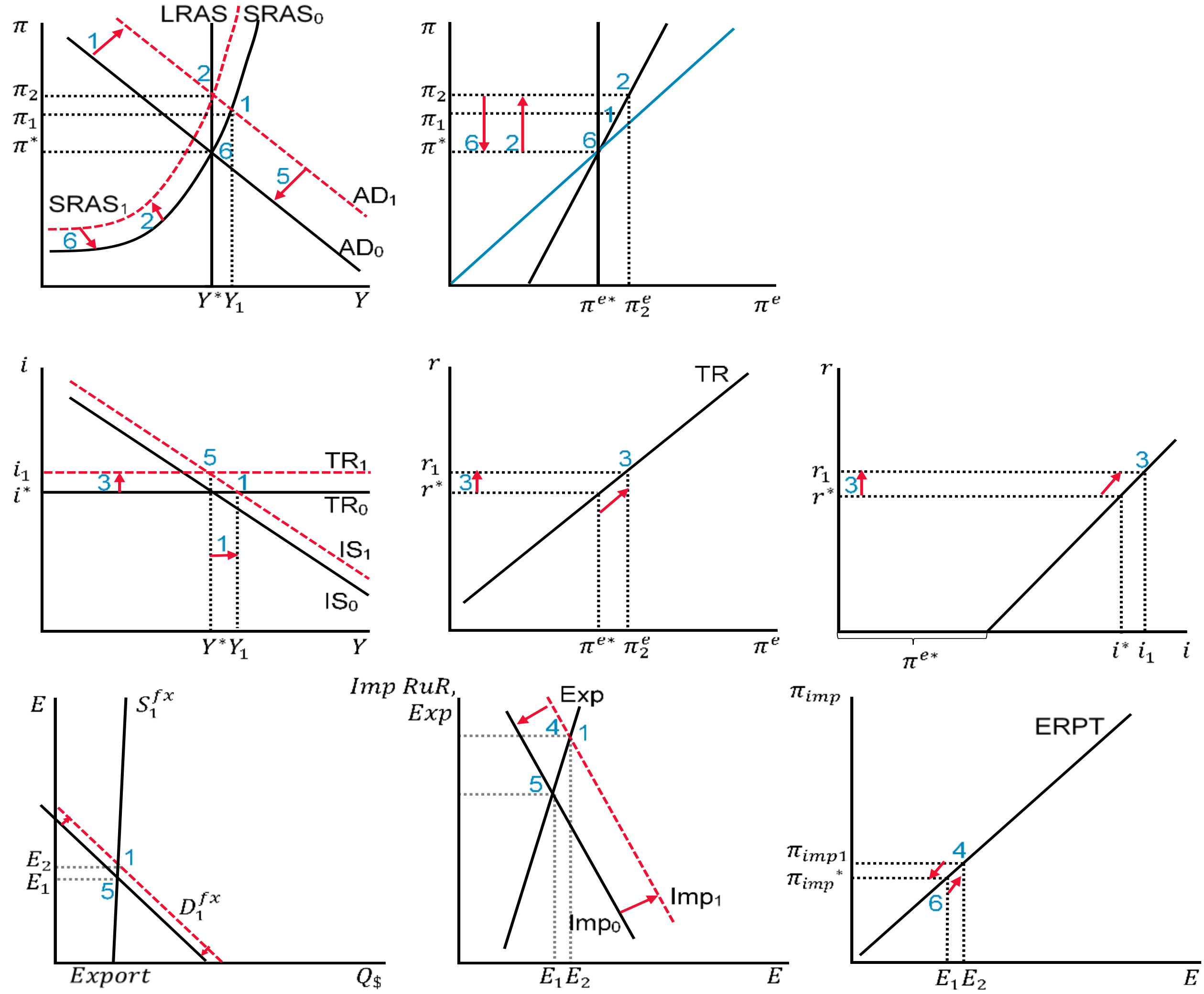
Figures 103–106. Adjustment to equilibrium under persistently elevated demand



6. The result of the slowdown in import price growth is a reverse shift in the SRAS curve (Figure 107).

Overall, the exchange rate's response is slower than in the UIP case. In a foreign exchange market without financial constraints, the exchange rate reacts quickly in line with parity, but trade flows react slowly. This worsens the transmission of monetary policy.

Figure 107. Response of a general equilibrium model with imperfections in the foreign exchange market to a demand shock



A summary diagram with comments is given in Appendix 6.

In the next section, we present a description of the shocks that the economy faced in 2022–2024 and show how these shocks were reflected in the central bank's monetary policy decisions.

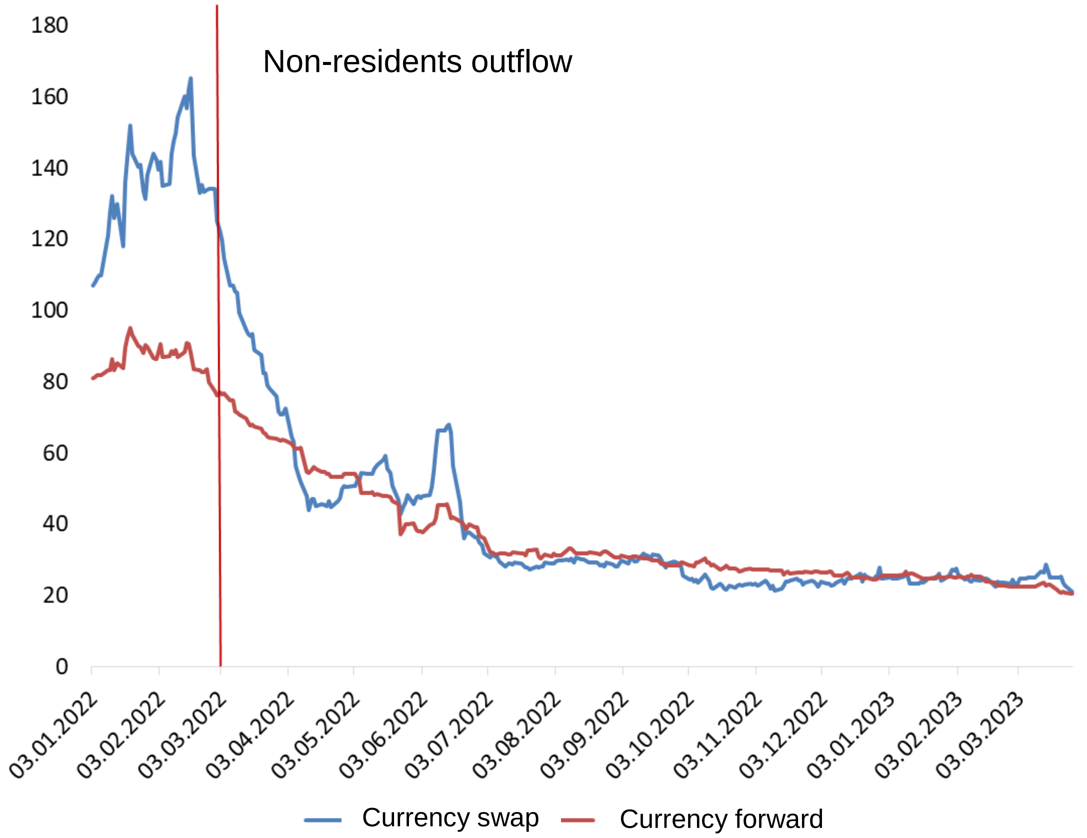
4. Shocks facing the economy in 2022–2024

Let us consider how the model helps analyse the macroeconomic developments in **2022–2024**. The following shocks occurred during this period.

4.1 February – March 2022

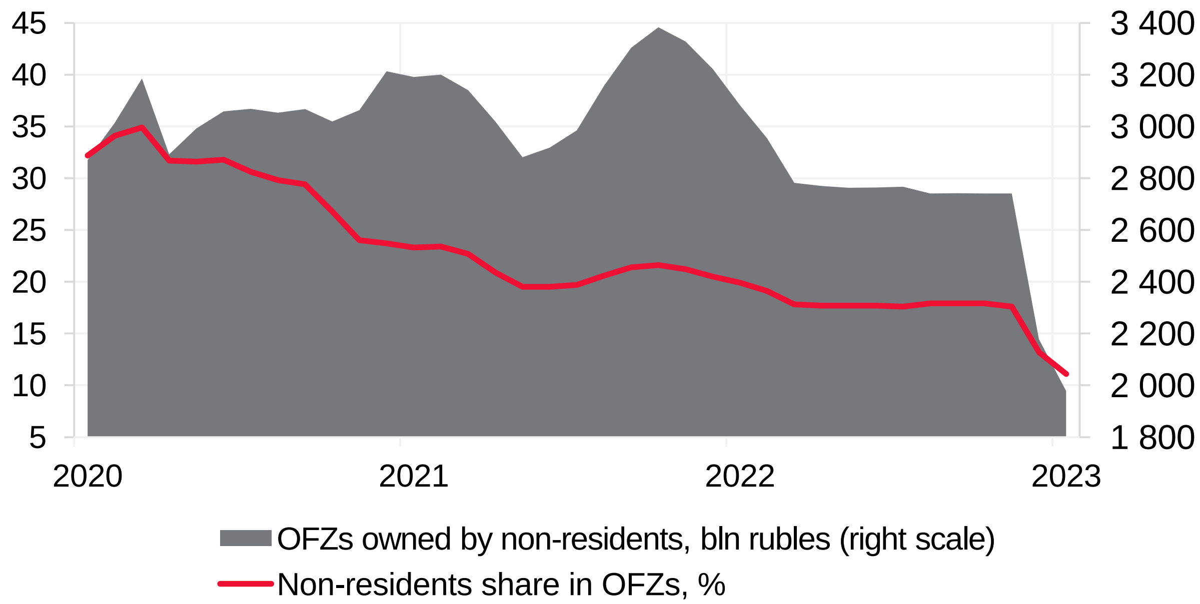
1. Financial sanctions and the freezing of the Bank of Russia's foreign exchange reserves (which could have been used to replace the lost external financing) significantly limited the supply of external financing and the availability of instruments for hedging open foreign exchange positions (Figure 108). Non-resident investors have traditionally played an important role in the government debt (OFZ) market and the Russian Ministry of Finance's primary auctions (Figures 109–110). The contraction in their demand and asset sell-offs have become additional stress factors in the foreign exchange market.

Figure 108. Volumes of open positions in currency swaps and forwards, billion US dollars



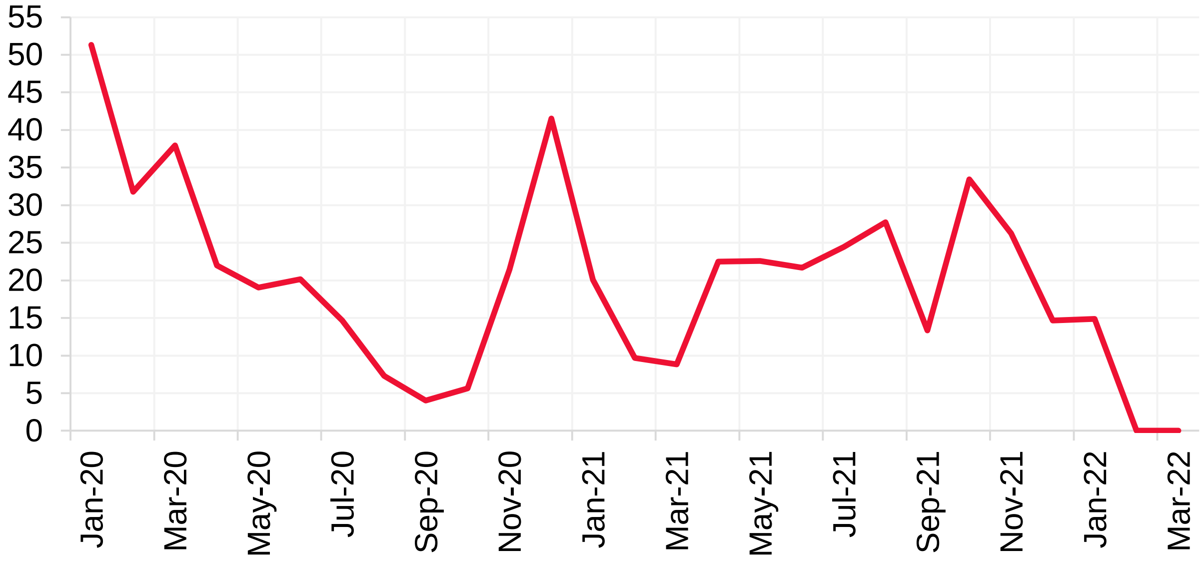
Source: Bank of Russia.

Figure 109. Non-resident investments in OFZs according to NSD, bln rubles



Source: Bank of Russia.

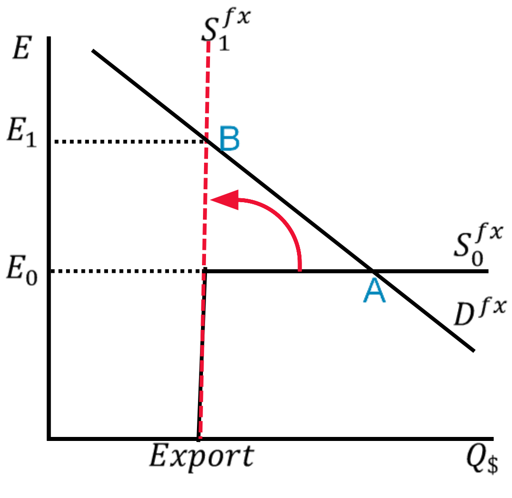
Figure 110. Share of non-resident buyers and foreign subsidiaries at OFZ auctions, %



Source: Bank of Russia.

In the model, these developments mean a closing of the financial market: this is depicted by a leftward turn in the supply of external financing to the point where the supply of foreign exchange is determined solely by exports. As a result of the shock, the exchange rate weakened (weakening from point A to point B, Figure 111).

Figure 111. Adjustment of equilibrium in the foreign exchange market upon closing of the financial market

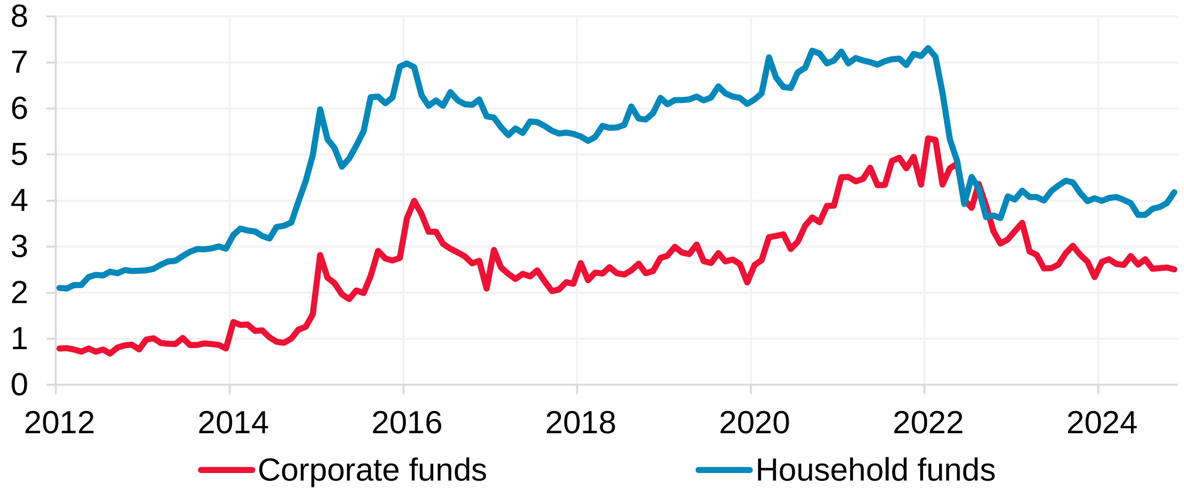


Before the shock, non-residents covered part of the demand for foreign currency, equal to the excess of import demand and capital outflow preferences over export receipts.[55] After the shock, this opportunity disappeared (Figure 111).

[55] From the perspective of balance of payments statistics, there is no contradiction with Russia's current account surplus (exports exceeding imports), as balance of payments statistics record net flows, whereas we model gross flows, which are more informative for economic analysis. Increased non-resident demand for OFZs has no impact on the balance of payments, as the rise in OFZ liabilities to non-residents is offset by an increase in foreign assets (in US dollars) held by residents who sold rubles to non-residents to purchase OFZs. For further details, see Borio and Disyatat (2015). In the absence of non-resident demand

In addition to the supply constraint, there was a surge in demand for foreign currency (Figure 112), shifting the currency demand curve to the right.

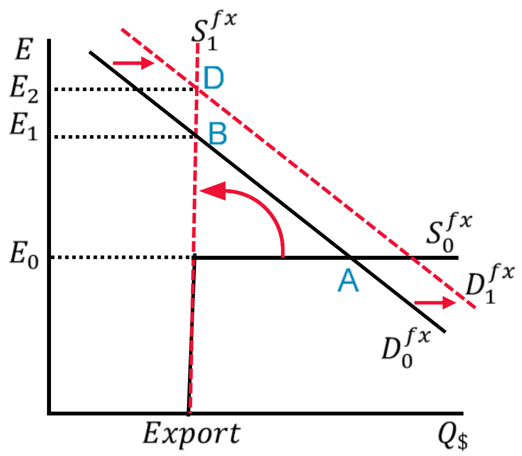
Figure 112. Corporate and household funds with banks in foreign currency and precious metals, trln rubles



Sources: Bank of Russia data and estimates.

2. This served as an additional factor in the weakening of the ruble. Equilibrium in the foreign exchange market in March 2022 shifted from point B to point D (Figure 113).

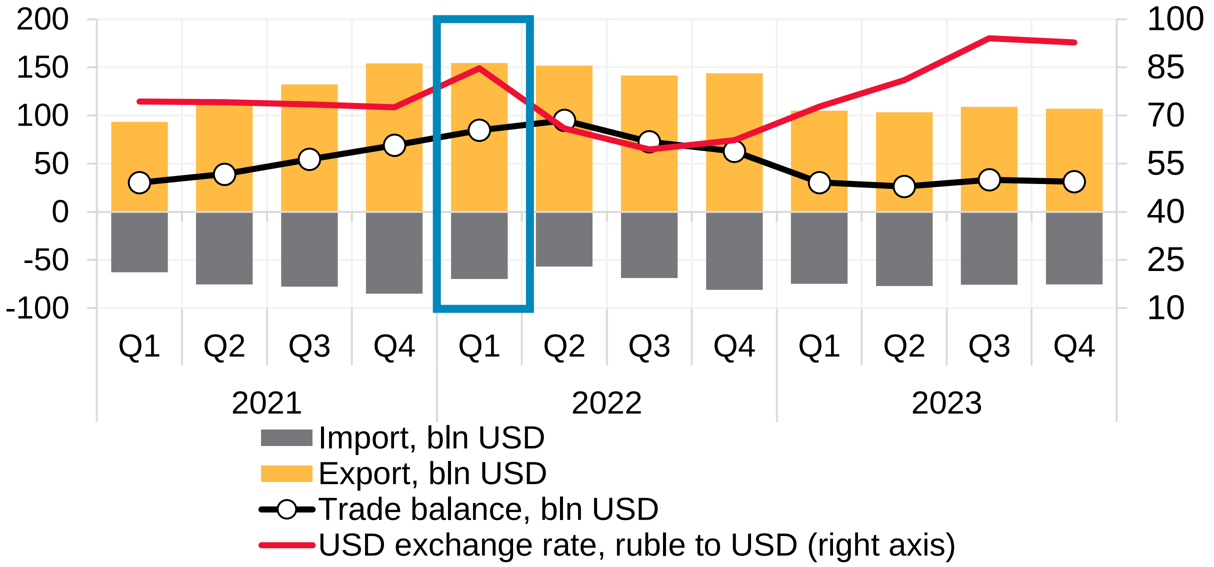
Figure 113. Change in equilibrium in the foreign exchange market in March 2022



The accompanying exchange rate depreciation reduced demand for imports and slightly increased non-resident demand for exports (Figure 114).

for OFZs, the gross inflow into the foreign exchange market would be smaller, and, given export volumes and capital outflow preferences, a foreign currency shortage would emerge. Equilibrium in the foreign exchange market is $Exp + gross\ inflow = (Imp + gross\ outflow + change\ of\ CB's\ reserves)/E$.

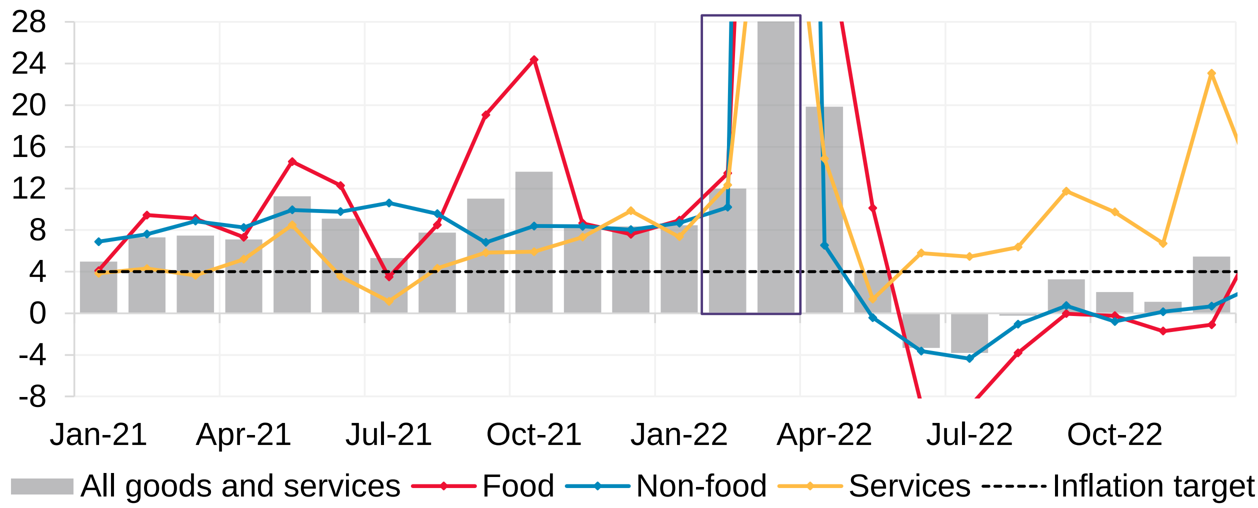
Figure 114. Trade balance of the Russian Federation (left axis) and USD exchange rate (right axis)



Source: Bank of Russia.

3. As a result of the weakening of the exchange rate as well as logistic and payment restrictions, inflation of imported goods accelerated (Figure 115).

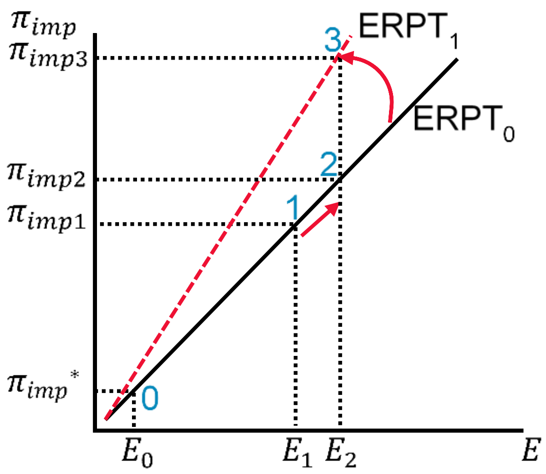
Figure 115. Seasonally adjusted price growth, % MoM SAAR



Sources: Rosstat, Bank of Russia data and estimates.

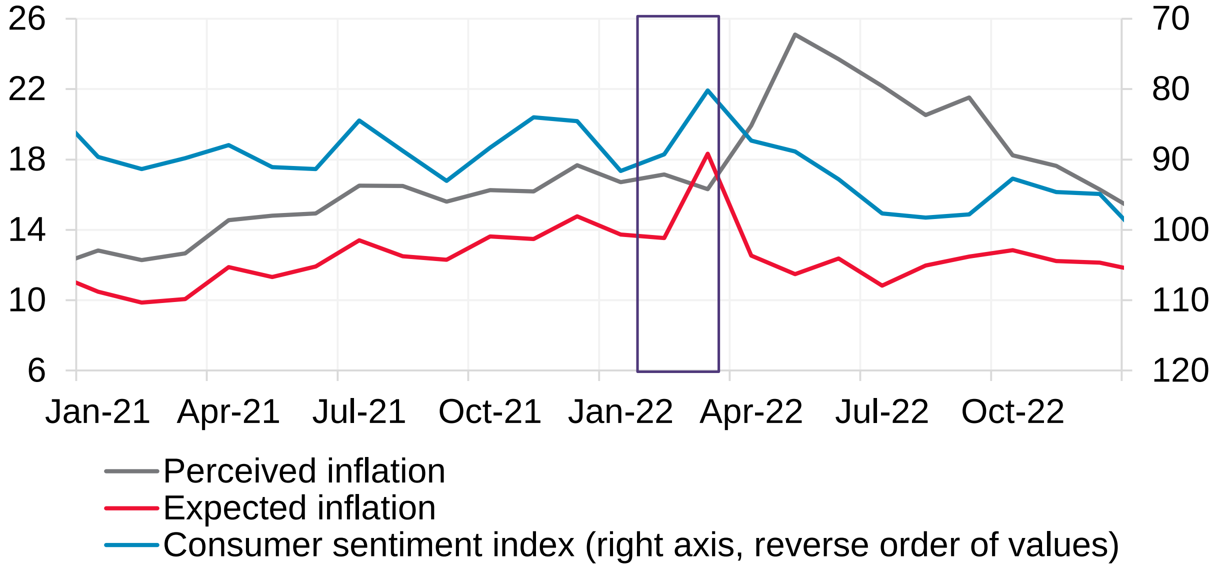
There was an additional inflationary factor through the increased pass-through effect due to economic agents' understanding that the new, weaker exchange rate was not temporary. In other words, the ERPT line steepened (Figure 116).

Figure 116. Increase in the exchange rate pass-through effect when market participants revaluate the long-term exchange rate level



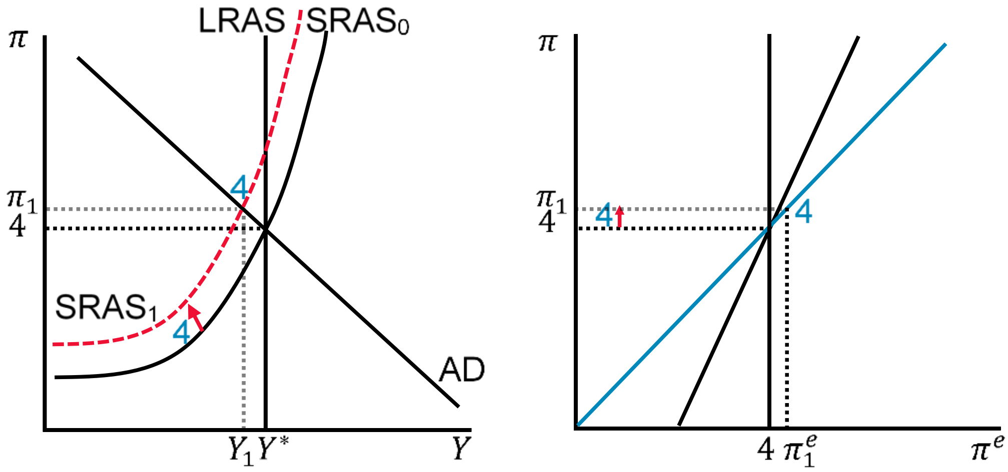
4. Along with this jump in the exchange rate and inflation, inflation expectations also increased (Figure 117–119).

Figure 117. Median estimates of observed and expected inflation by households, % YoY



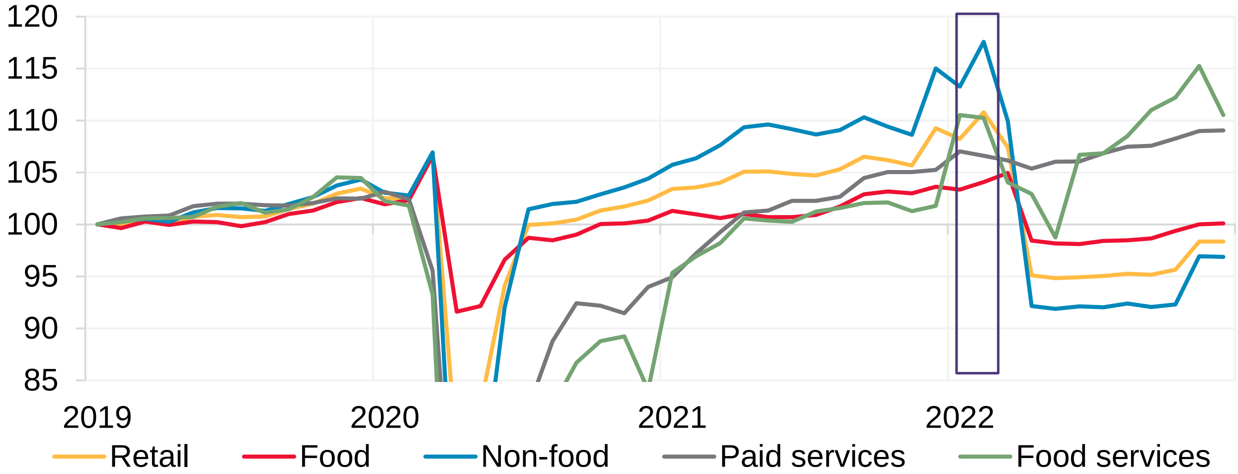
Source: InFOM.

Figures 118–119. Shift in the SRAS line (left) and the effect on inflation expectations (right)



5. At the same time, the propensity to consume (excessive demand) increased sharply. The IS line shifted to the right (Figure 120).

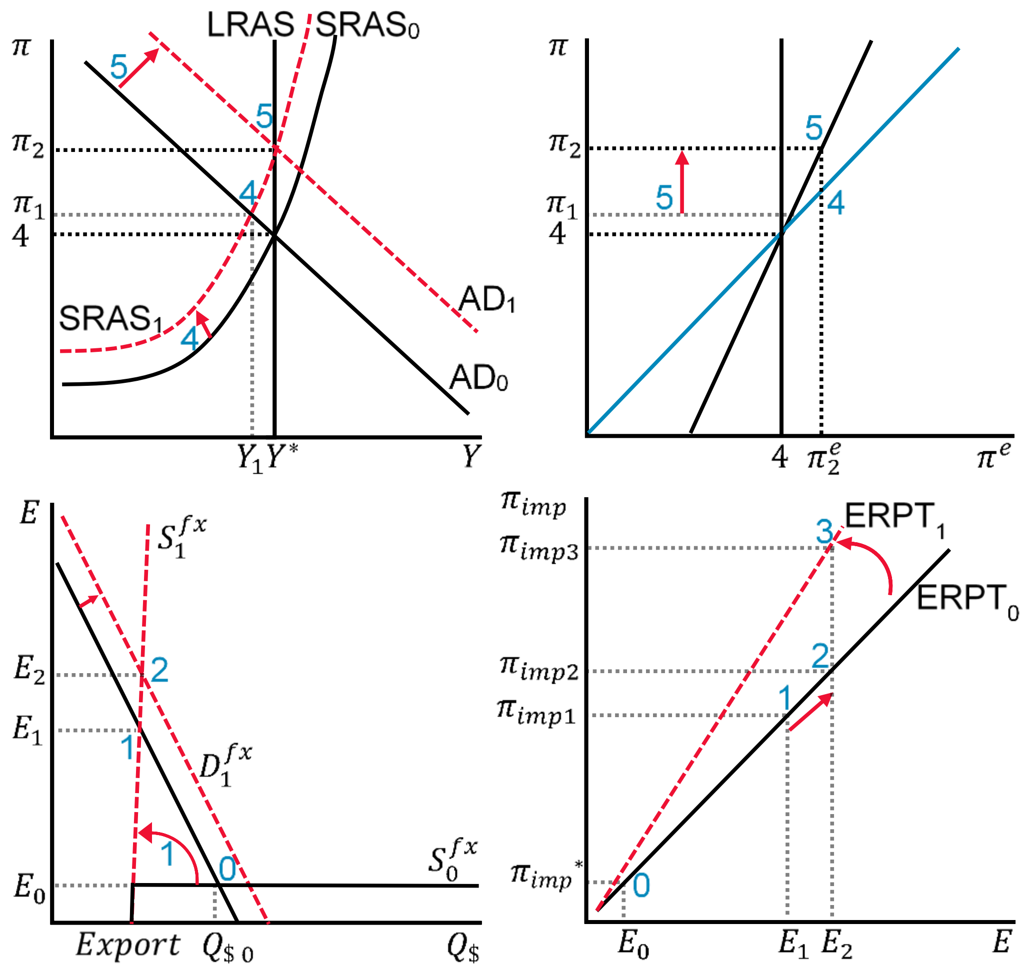
Figure 120. Retail sales, sales of the paid services segment and public food services, index, January 2019 = 100% (seasonally adjusted)



Sources: Rosstat, Bank of Russia estimates.

Thus, both supply-side (rising import prices) and demand-side shocks led to a surge in inflation (Figures 121–124).

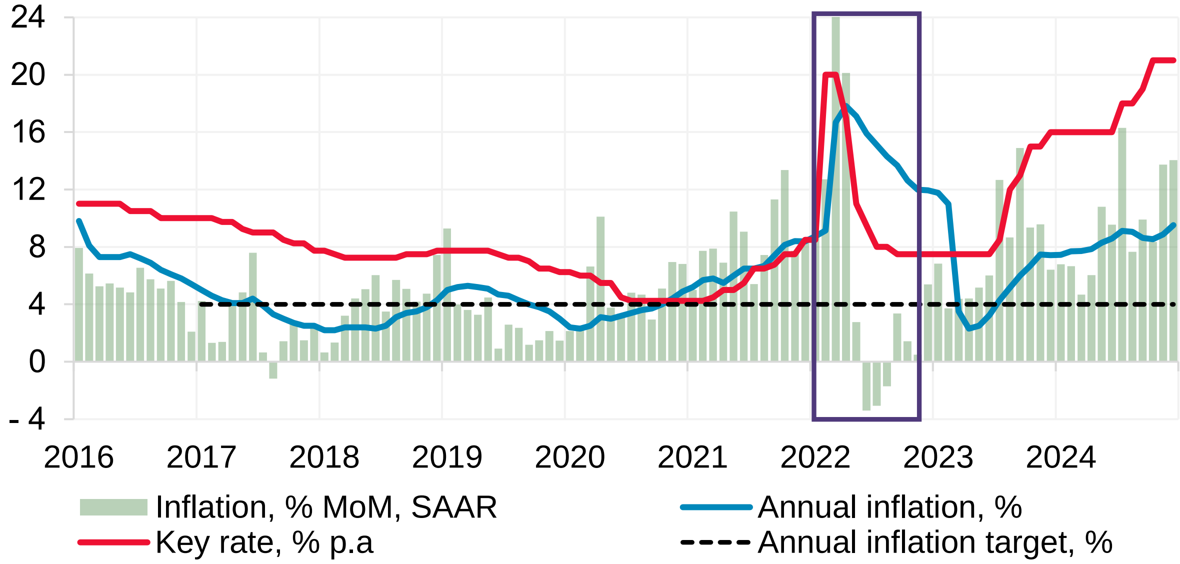
Figures 121–124. Model description of the inflationary consequences of supply and demand shocks



6. The Bank of Russia raised interest rates to ensure price and financial stability (Figure 125). The movement along IS line is shown in Figure 126.[56]

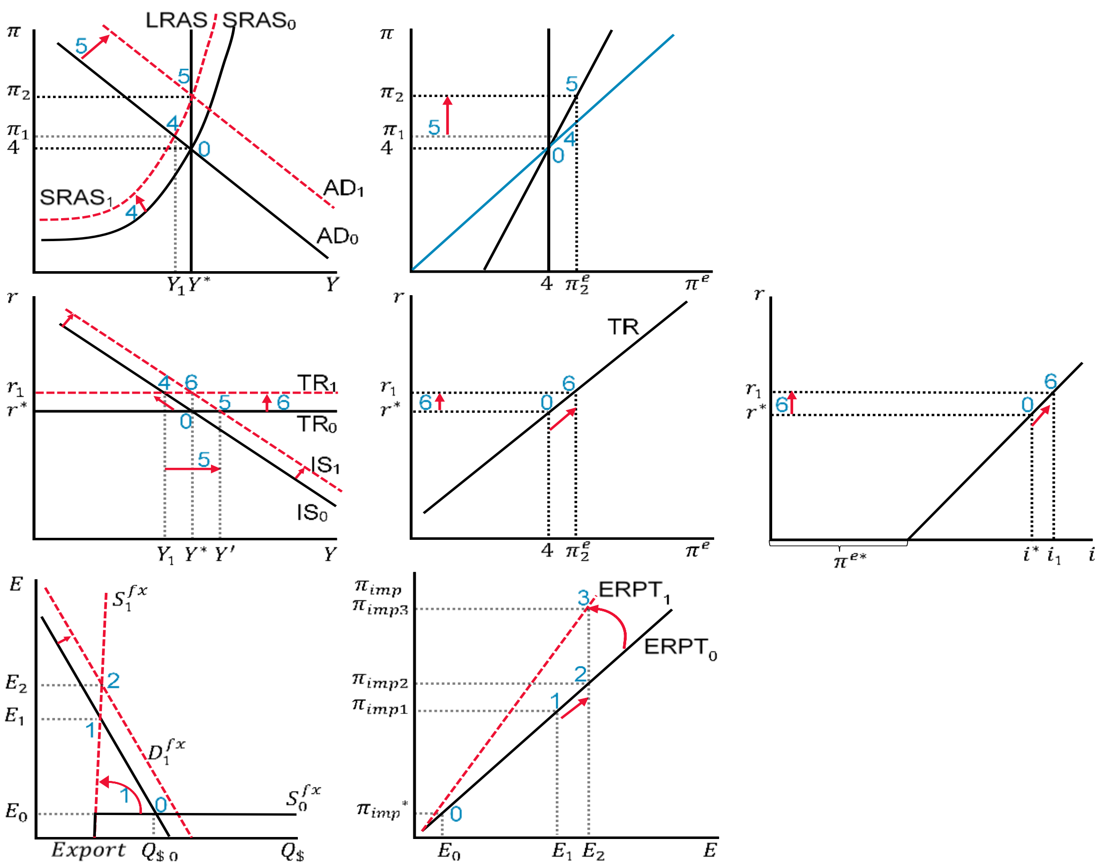
[56] Figure 126 does not depict the change in monetary policy tightness (the upward rotation of the TR line)—a decline in inflation tolerance that likely occurred during this period. Such a shift would have implied a reverse shift in the aggregate demand line, not just a movement along the curve.

Figure 125. Bank of Russia key rate and inflation



Sources: Rosstat, Bank of Russia data and estimates.

Figure 126. Description of the macroeconomic situation and monetary policy decisions in February–March 2022



4.2 Developments in the second to fourth quarters of 2022

After the initial shock, the economy began to function in a mode devoid of global capital inflow. The exchange rate is determined by residents' trade and financial flows.

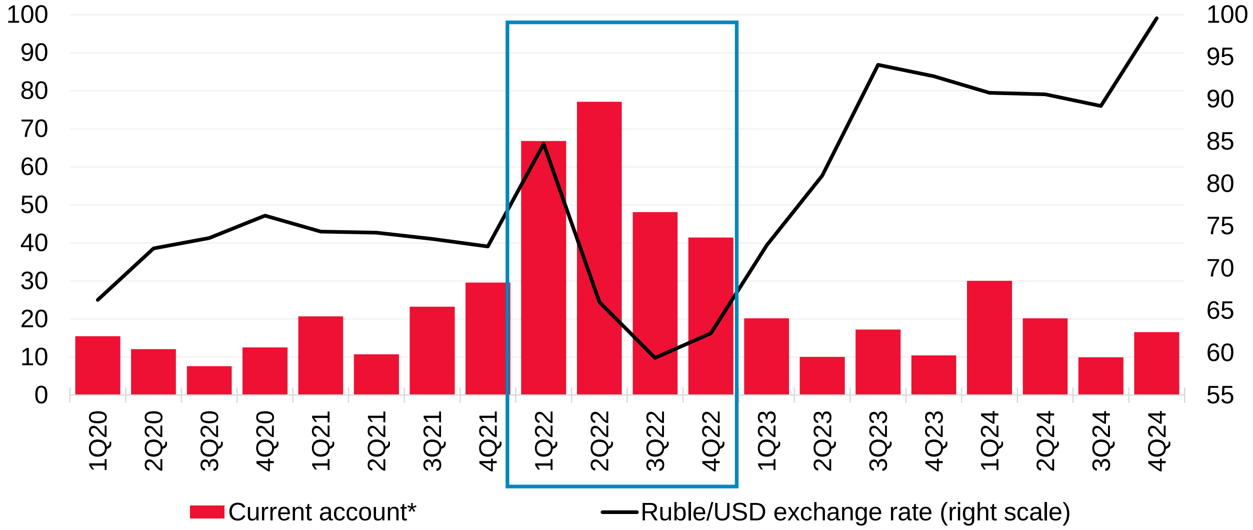
This period was characterised by the following features:

- restrictions on import volumes due to logistics and payment problems;

- rising world prices for key Russian export goods (oil, gas) and growth in export revenues.

As a result, the positive trade balance increased (Figure 127).

Figure 127. Current account (left scale) and Ruble/USD exchange rate (right scale)



** Excluding the Bank of Russia's foreign exchange operations carried out on behalf of the Ministry of Finance under the fiscal rule.*
Sources: Bank of Russia data and estimates.

1. During this period, external restrictions reduced import opportunities (Figure 129). High interest rates lowered residents' propensity to hold savings in foreign currency, and thus the corresponding demand for foreign exchange. This caused the net demand line for foreign currency to shift leftward (Figure 128). At the same time, commodity export volumes reached historical highs (a leftward shift of the export line. The export supply line on the graph has a slight slope—it is not very exchange rate elastic). As a result, the exchange rate appreciated (shown by the arrow in Figure 130).

Figures 128–129. Model description of the exchange rate adjustment to equilibrium in the second to fourth quarters of 2022

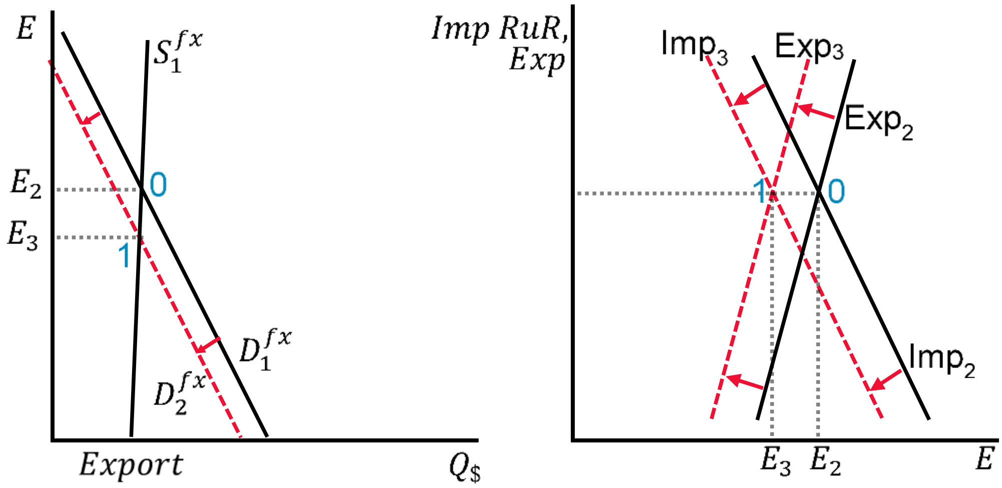
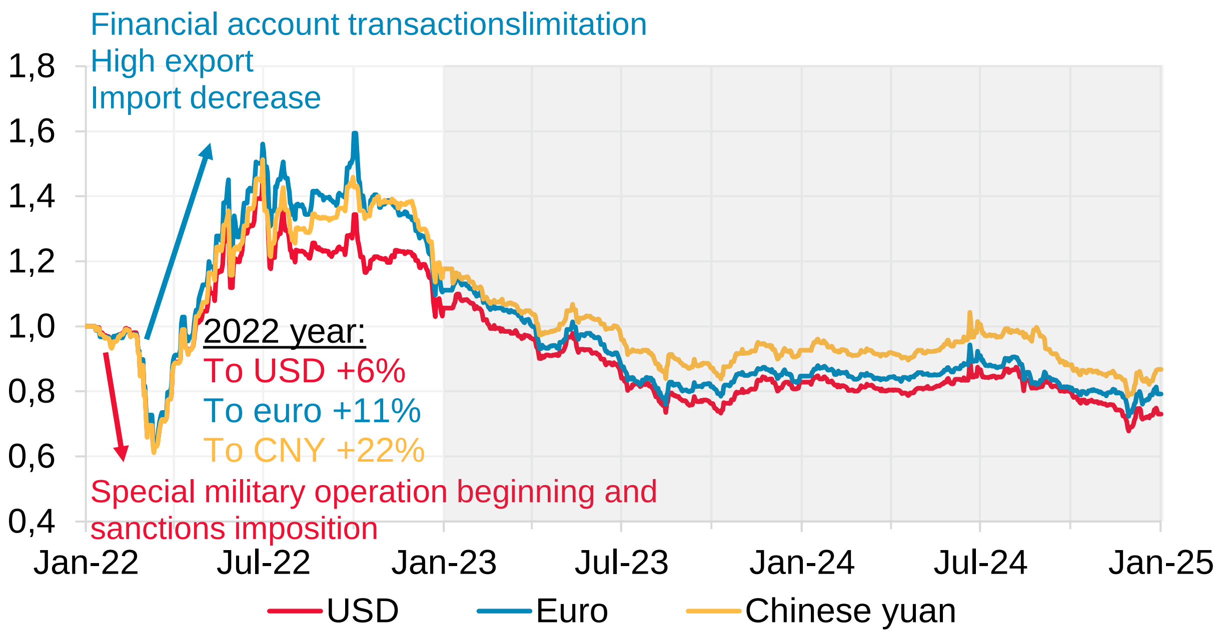


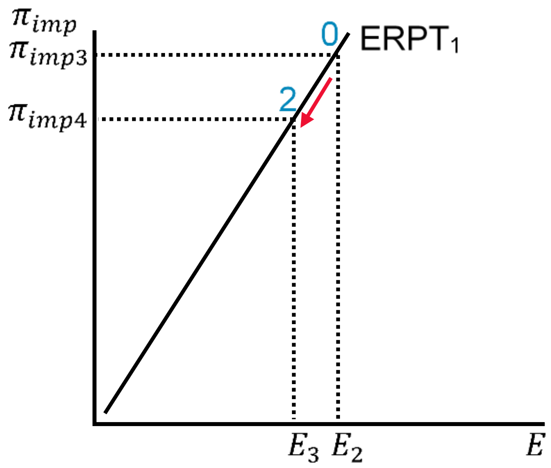
Figure 130. Nominal indexes of ruble exchange rates ('+' strengthening, '-' weakening)



Source: Cbonds.

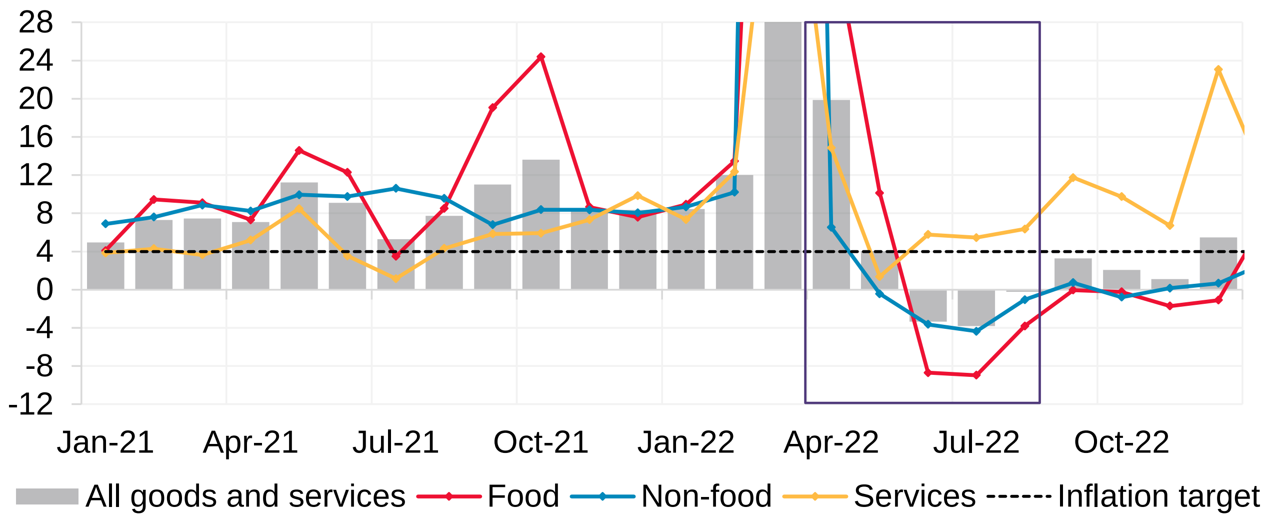
2. This exchange rate appreciation translated into inflation and inflation expectations through the exchange rate pass-through effect (Figure 131).

Figure 131. The exchange rate pass-through effect



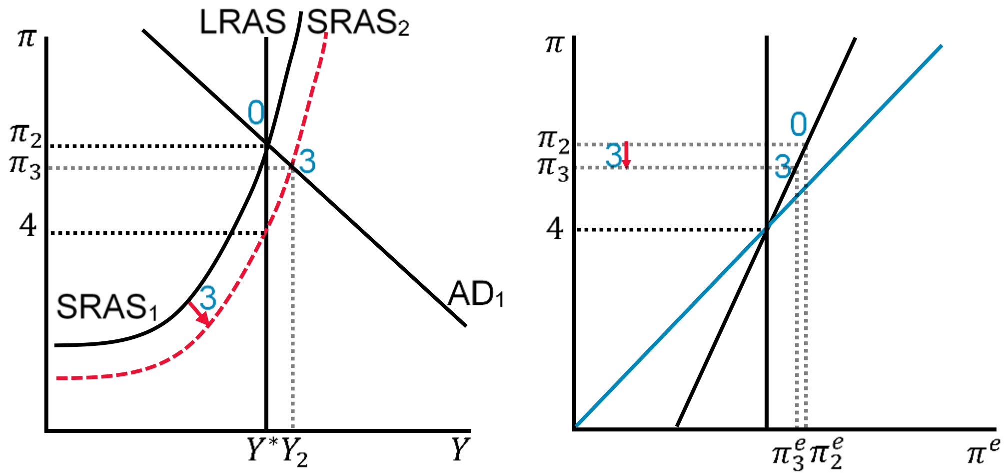
3. A decrease in inflation expectations shifts the short-run aggregate supply (SRAS) curve. The resulting inflation slows down sharply (Figures 132–134).

Figure 132. Seasonally adjusted price growth, % MoM SAAR



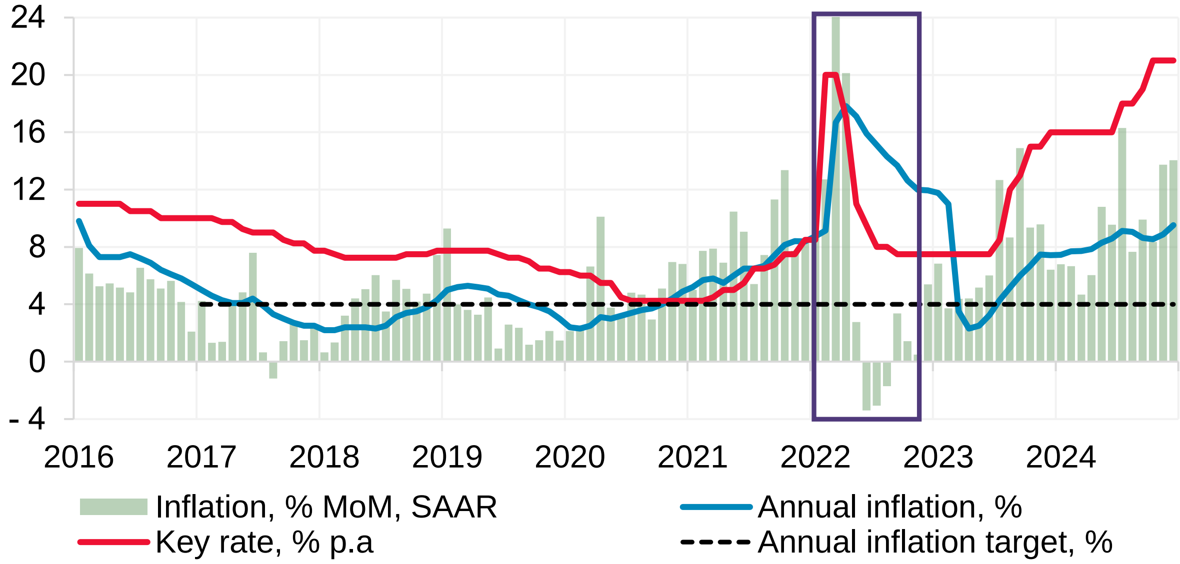
Sources: Rosstat, Bank of Russia data and estimates.

Figure 133–134. The effect of the SRAS shift (left) on inflation and inflation expectations (right)



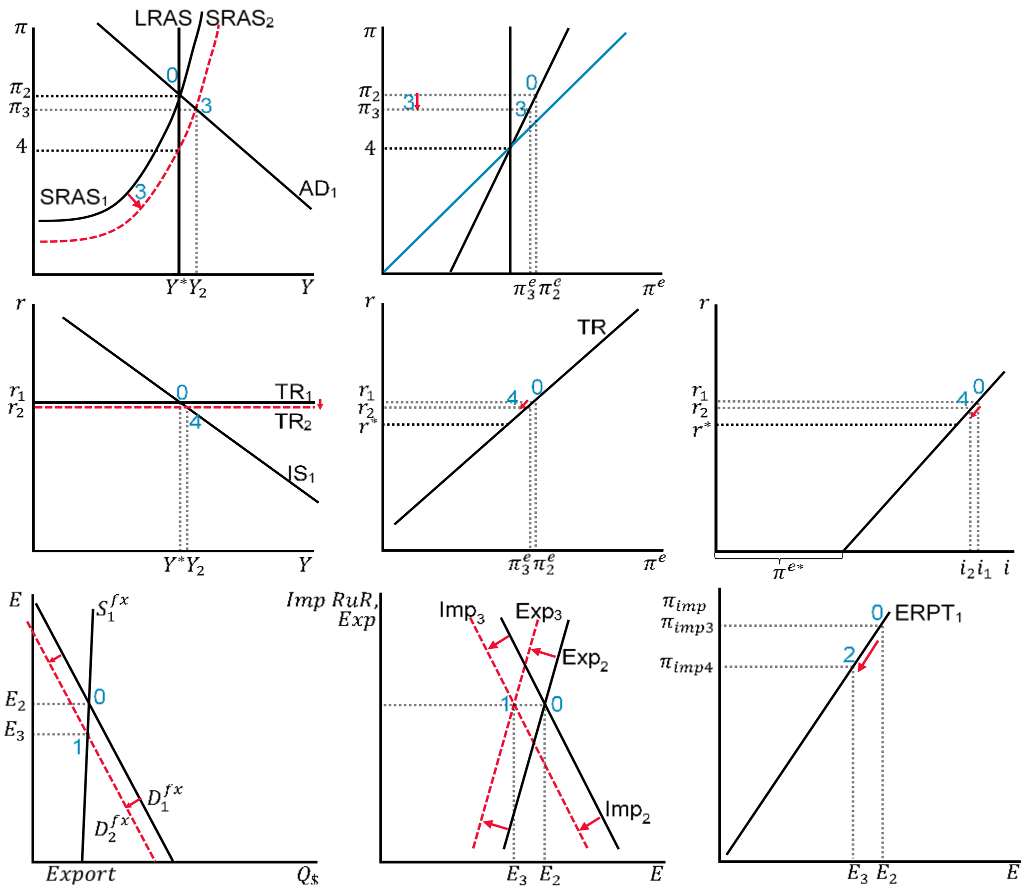
5 This enabled the Bank of Russia to begin normalising monetary policy and lowering the key rate (Figure 136). The Bank of Russia key rate remained at 7.5% until mid-2023 (Figure 135).

Figure 135. Bank of Russia key rate and CPI inflation



Sources: Rosstat, Bank of Russia data and estimates.

Figure 136. Description of the macroeconomic situation and monetary policy decisions in the second to fourth quarters of 2022



4.3 Developments in 2023–2024

This period is characterised by:

- the build-up of new logistics and payment networks and, as a consequence, the restoration of imports;

- a reduction in exports (including due to quantitative restrictions and price ceilings on oil and petroleum products exported by Russia);

- increased demand for foreign currency for settlements with non-residents for imports;

- an increase in government spending and employment in certain sectors.

As a result, the current account surplus declines sharply (Figure 127).

Graphically, the situation began to reverse compared to the previous episode.

1. Increased government spending and demand associated with import substitution shifted the IS and AD curves to the right (Figures 137–140).

Figures 137–138. Illustration of the aggregate demand growth in the model in 2023–2024

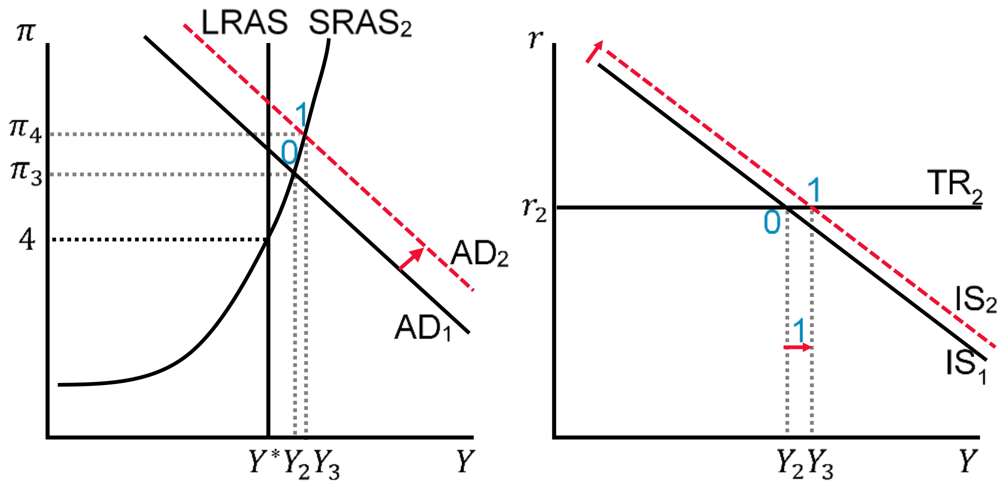
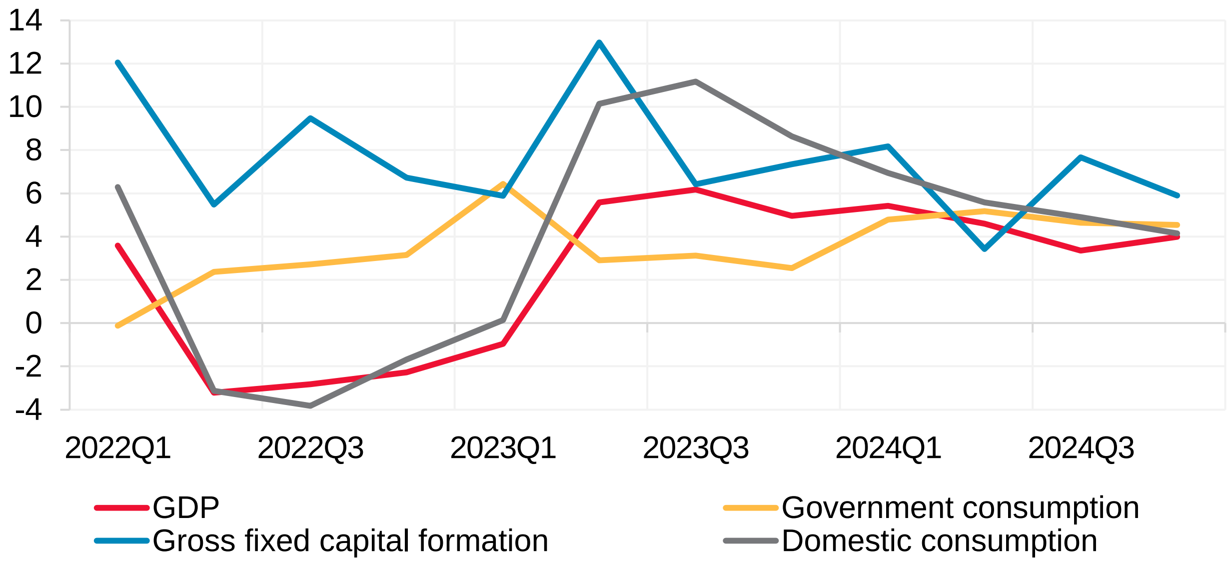
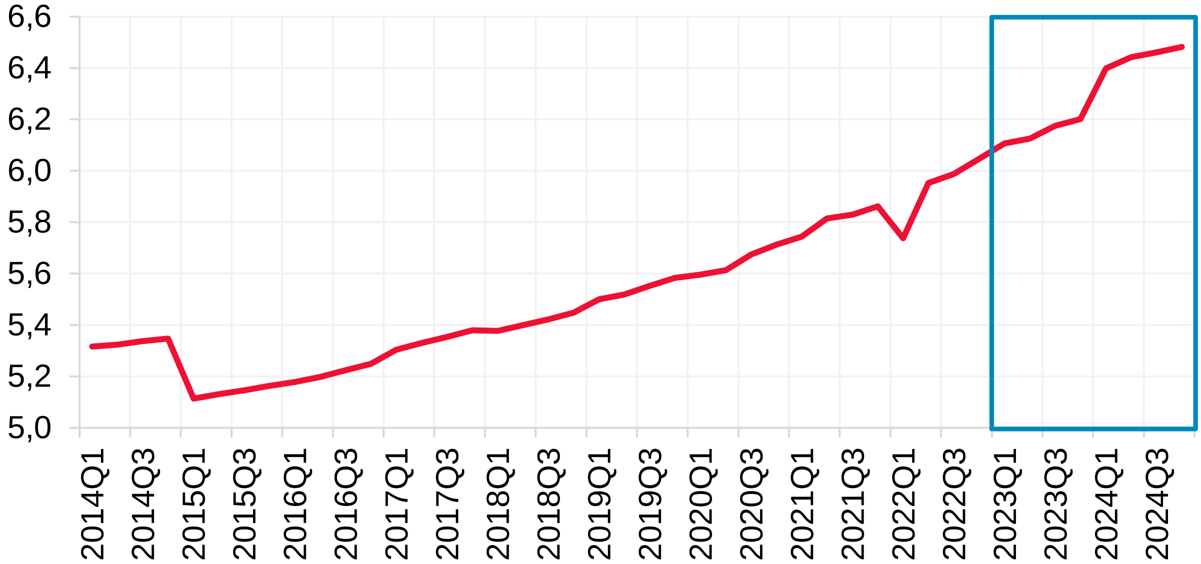


Figure 139. GDP and its components (in real 2021 prices), % YoY, SA



Sources: Rosstat, Bank of Russia estimates.

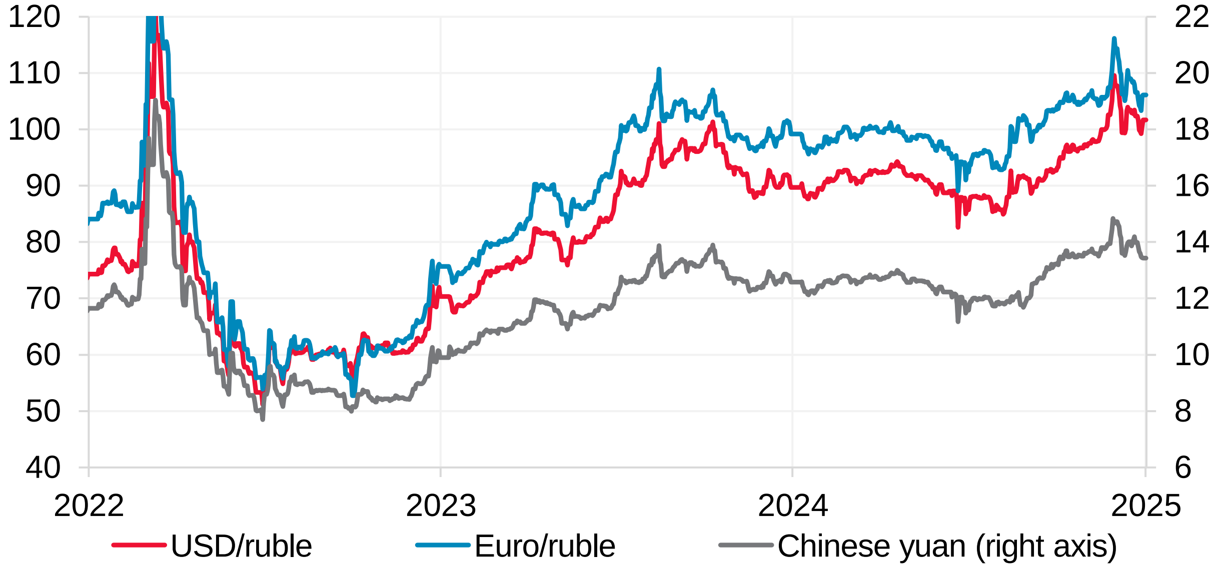
Figure 140. Government consumption, (in real 2021 prices), trln rubles, SA



Source: Rosstat.

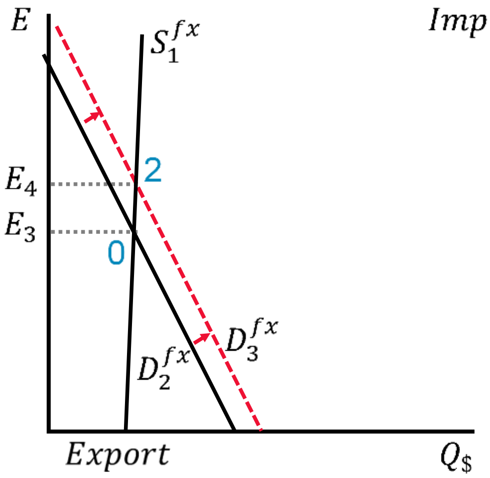
2. Imports were recovering and export revenues were declining, partly due to quantitative restrictions on exports related to international sanctions (Figure 143). As a result, the exchange rate weakened (Figures 141–142).

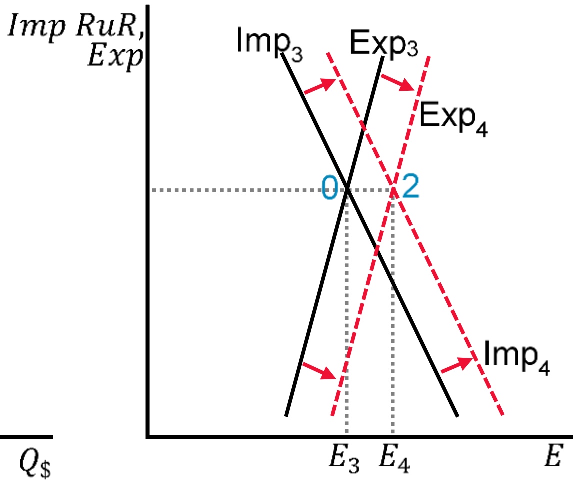
Figure 141. Bank of Russia exchange rates



Source: Bank of Russia.

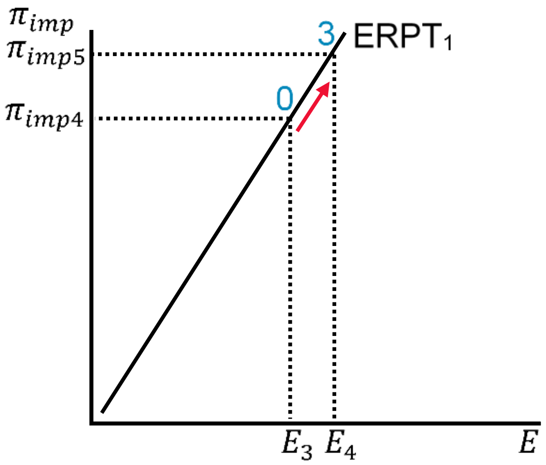
Figures 142–143. Illustration of the foreign exchange market adjustment to equilibrium in 2023–2024





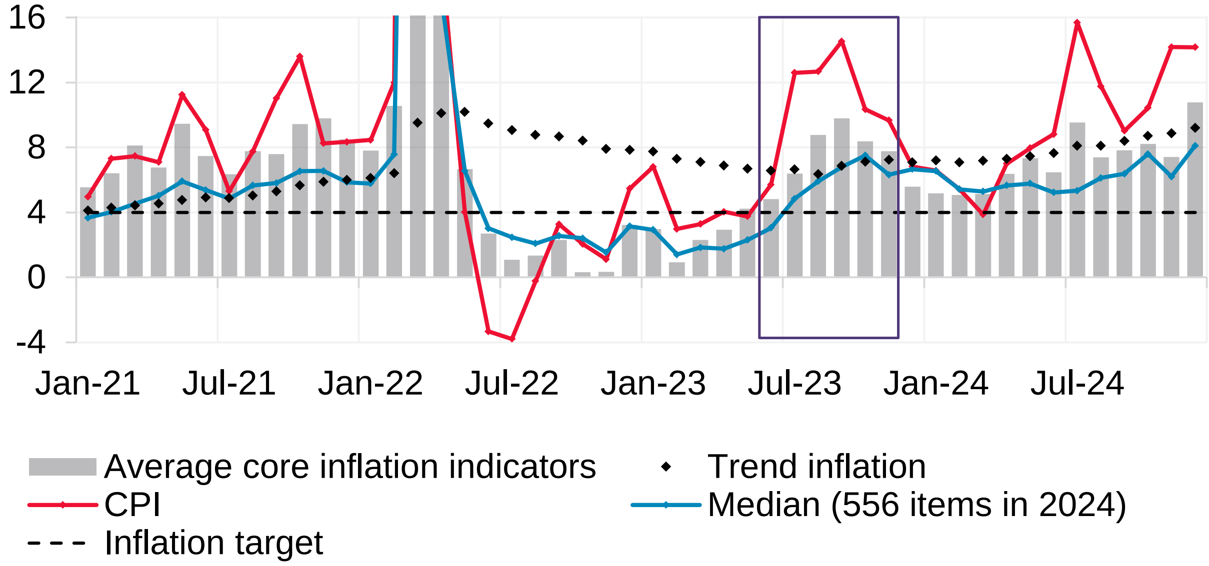
3. The exchange rate depreciation passed through to import prices (Figure 144).

Figure 144. Illustration of the exchange rate pass-through effect to consumer prices



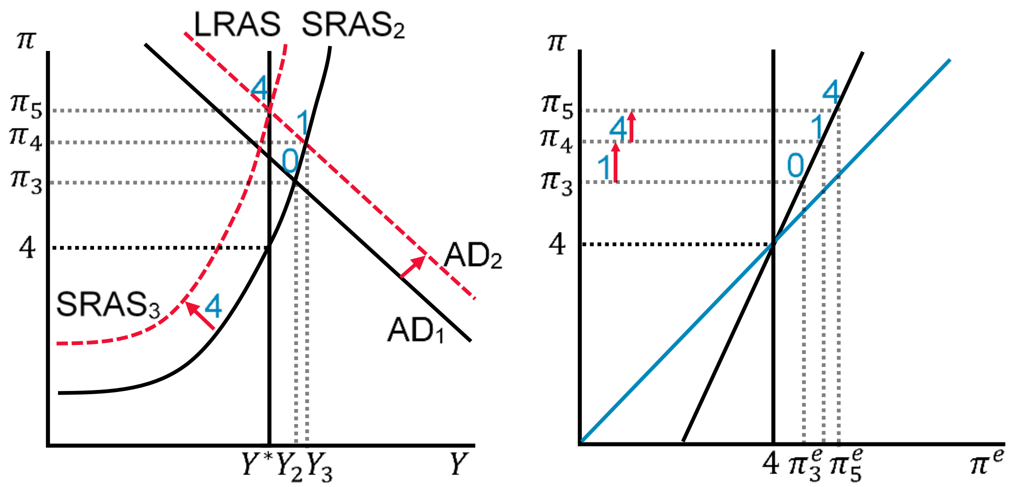
4. Overheating demand again fuelled inflation expectations (Figure 145–147).

Figure 145. Modified core inflation indicators (% in annualised terms) and trend inflation estimate (% YoY)



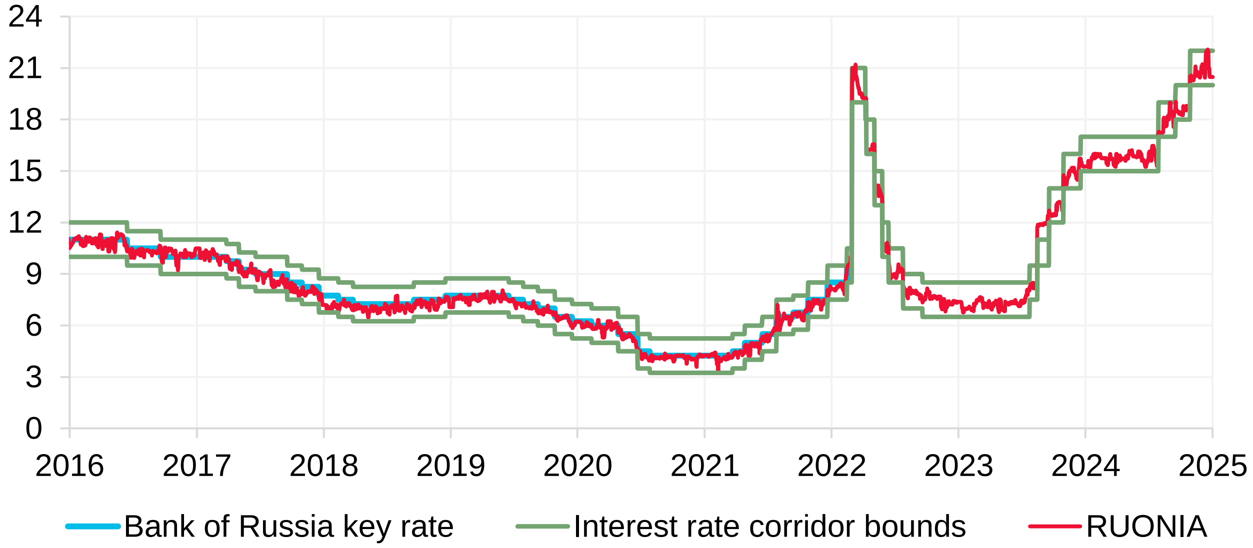
Sources: Rosstat, Bank of Russia data and estimates.

Figures 146–147. Inflationary effects of changes in supply and demand in 2023–2024



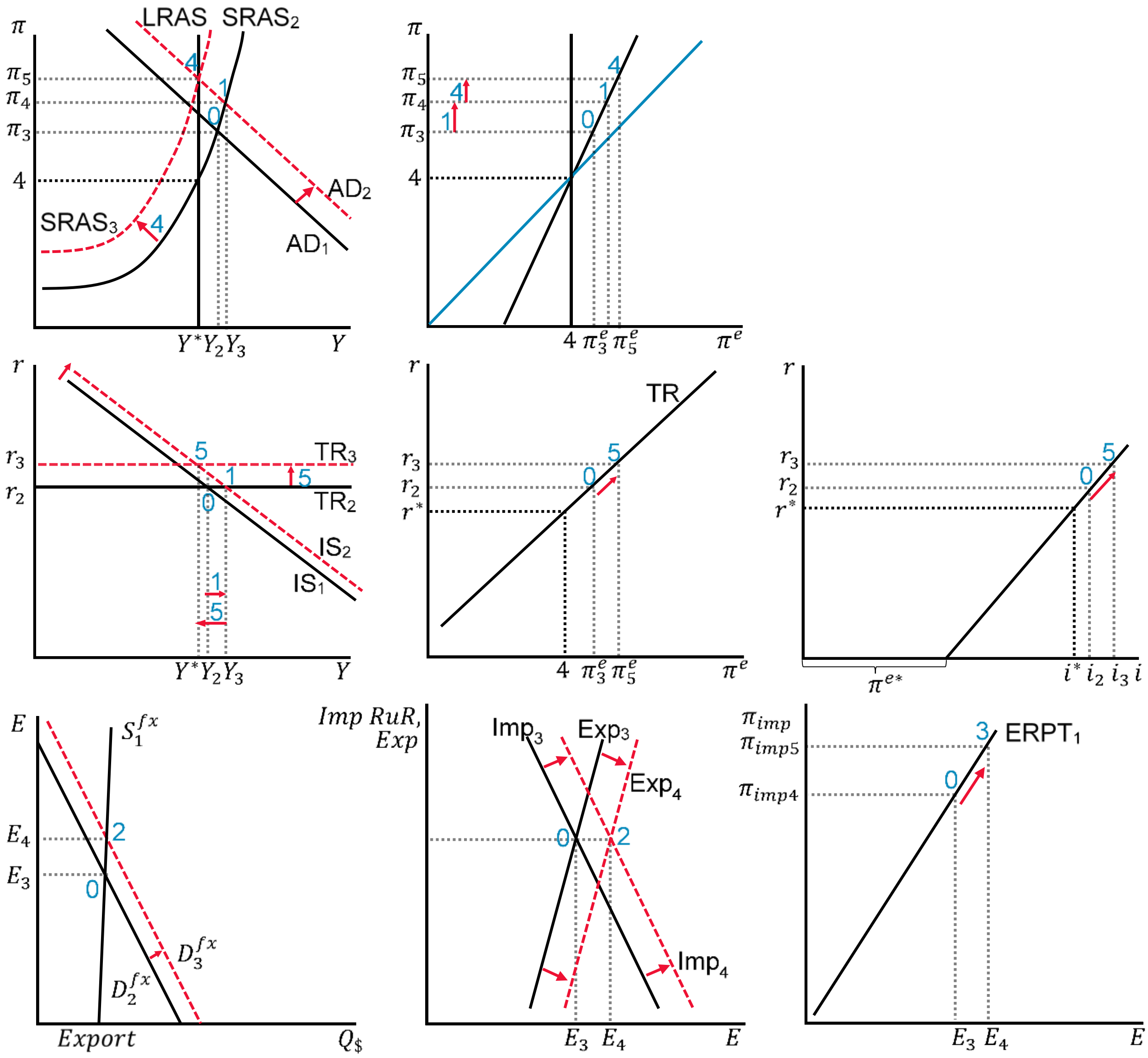
5. The Bank of Russia began raising its key rate from July 2023 onwards (Figure 148). The goal was to return aggregate demand to equilibrium. This would help reduce inflation expectations, including via exchange rate appreciation (a movement along the AD line, Figure 149).

Figure 148. Bank of Russia key rate and money market rates, % p.a.



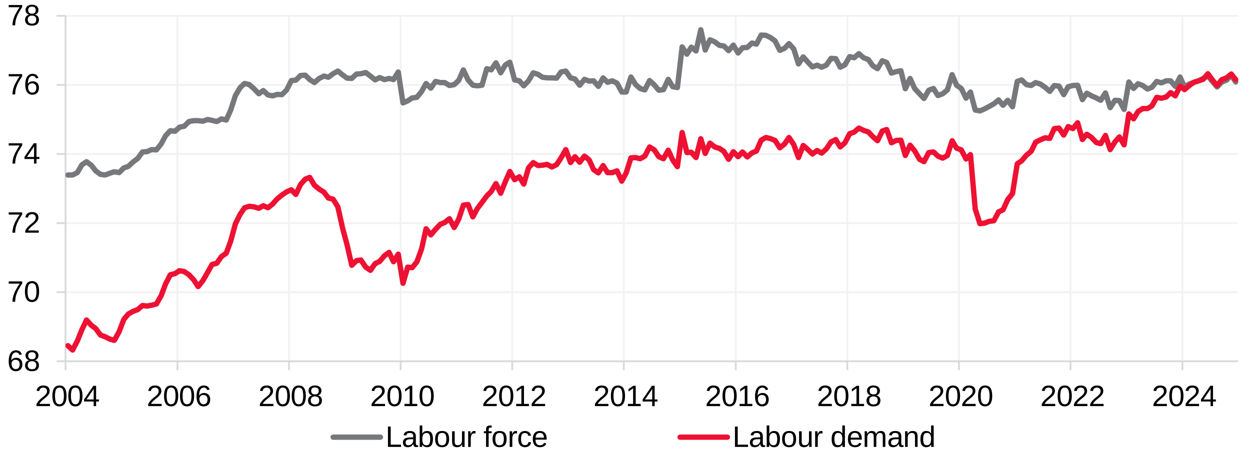
Sources: Bank of Russia data and estimates.

Figure 149. Description of the macroeconomic situation and monetary policy decisions in 2023–2024



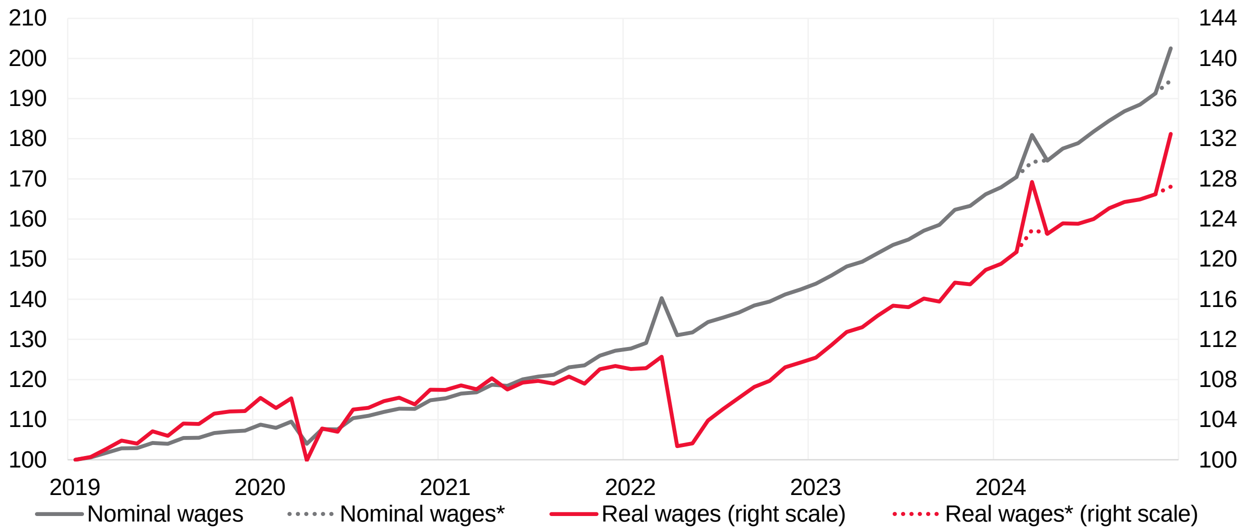
In 2024, some of these trends continued to play out. The economy showed clear signs of demand-side overheating (Figures 150–151).

Figure 150. Labour force and labour demand, mln people, SA



Sources: Rosstat, Bank of Russia data and estimates.

Figure 151. Nominal and real wages, January 2019 = 100

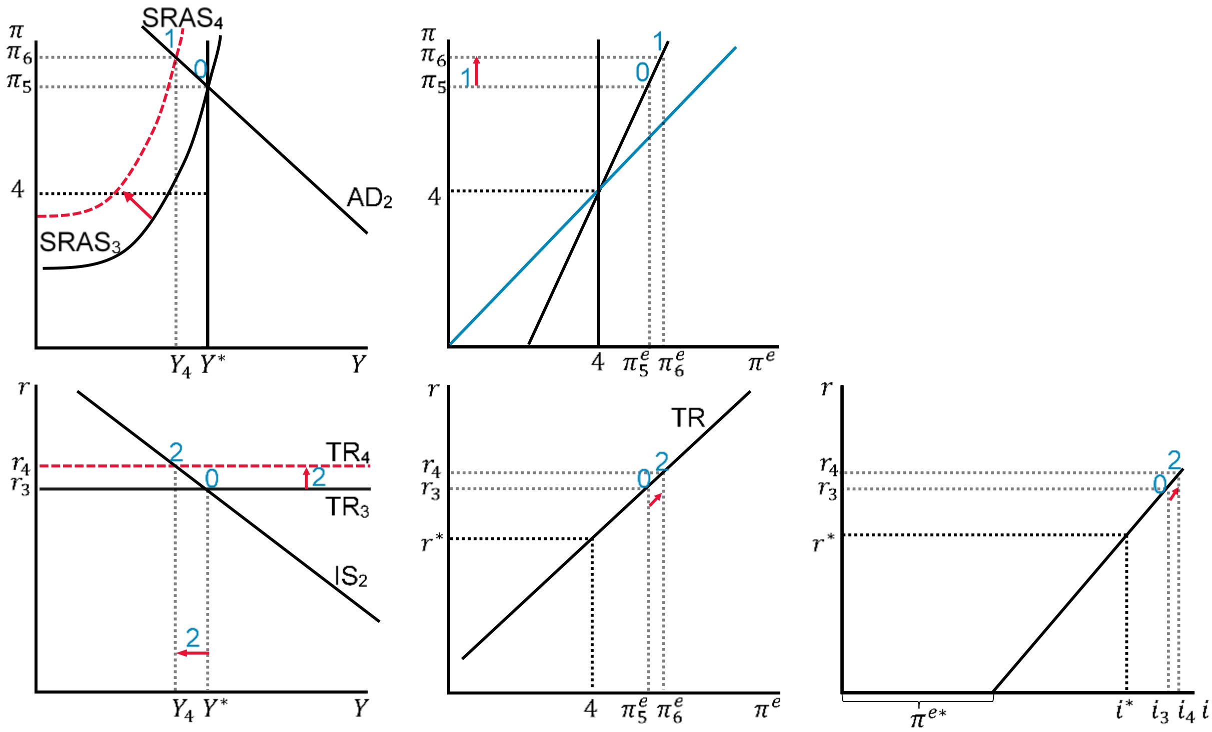


Note: Dotted lines represent the adjusted trend, excluding the effects of the temporary acceleration of the wage growth in Mining and quarrying, Finance and Other services in March 2024, and the shift of bonus payments from 2015 Q1 to December 2024 due to changes in the income tax scale.
Sources: Rosstat, Bank of Russia data and estimates.

This required the Bank of Russia to further tighten monetary policy from the summer of 2024 (Figure 148).

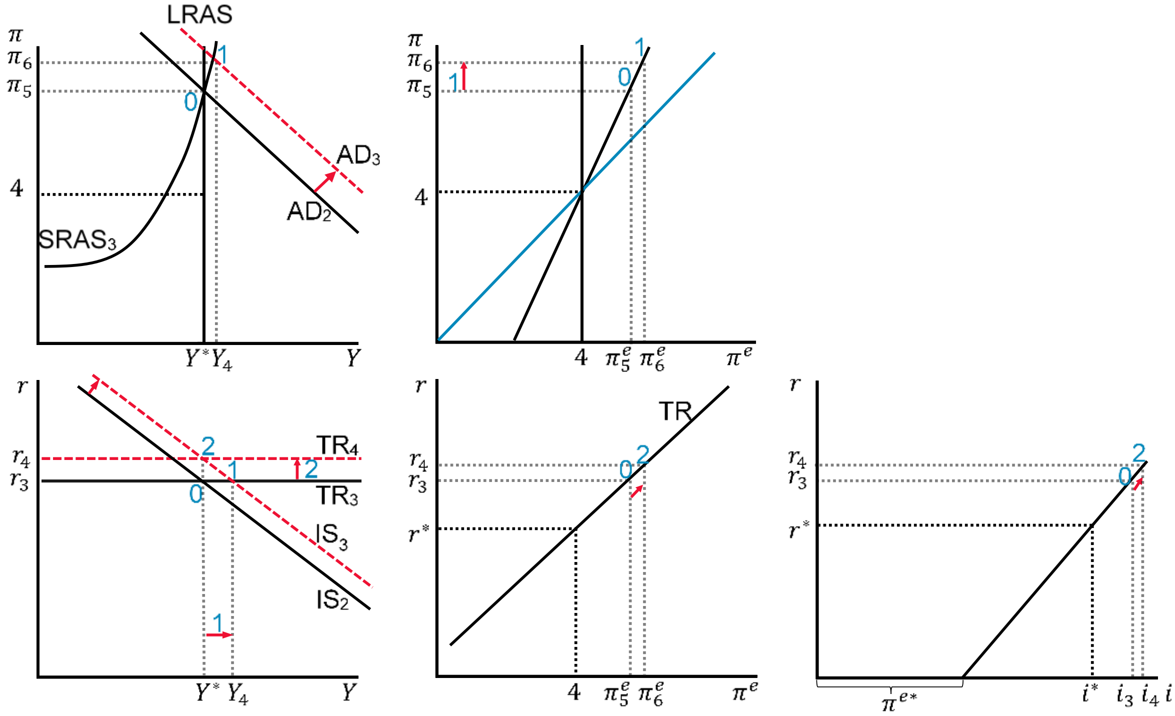
As noted in the Bank of Russia's October 2024 press release: '*According to the Bank of Russia's forecast, given the current monetary policy, annual inflation will decline to 4.5–5.0% in 2025, 4.0% in 2026, and remain on target thereafter.'* The press release mentions the risk of a deterioration in terms of trade. Within the model's framework, this implies a permanent decline in export revenues (in nominal, not real terms—aggregate demand remains unchanged). Foreign exchange market equilibrium would require a weaker real and nominal exchange rate to reduce imports. An exchange rate depreciation would be accompanied by rising import prices and higher headline inflation. Under unanchored expectations, such a temporary increase in inflation due to higher import prices is analogous to a cost shock—a leftward shift of the SRAS curve. This, as analysed in the section on monetary policy responses to supply shocks, could necessitate a tightening of monetary policy and lower business activity to bring the economy to equilibrium and stabilise inflation (Figure 152).

Figure 152. Illustration of cost-push shock in the model (shift of the SRAS line to the left), its inflationary effects and monetary policy decisions



Another risk is a weakening of fiscal policy parameters (an increase in the budget deficit) (Figure 153). The materialisation of this risk would imply a rightward shift in the aggregate demand curve. However, if such additional spending is directed towards increasing the economy's potential, the inflationary effects of increased demand in the medium term would be partially offset by an expansion of the economy's potential output. This would help reduce the inflationary effects of such demand expansion. Conversely, if additional spending is directed towards sectors that do not expand the economy's production potential for consumer goods and do not contribute to increased labour productivity, potential output would remain unchanged in the medium term, and monetary policy would shoulder the entire burden of adjusting the economy to a low-inflation equilibrium. Therefore, in the latter case, monetary policy would need to be tighter.

Figure 153. Illustration in the model of the consequences of the transition to a long-term higher value of the government budget deficit



The graphical model presented thus far proves useful in analysing real-world situations faced by central banks. However, such a model describes economic dynamics in a highly simplified manner. A limitation of the graphical model is that it treats some key endogenous variables as fixed for clarity—in particular, exchange rate expectations. To illustrate the dynamics more rigorously in a graphical model, the next section analyses the reactions of macroeconomic variables to shocks (impulse responses) using a simple yet mathematically sound semi-structural model of a small open economy. This model is semi-structural in the sense that its individual equations are not derived from an optimisation problem for economic agents but are instead taken from a DSGE model in a ready-made, linearised form with reduced parameters. Models of this class are actively used at the Bank of Russia due to their flexibility and intuitively understandable variable dynamics, whereas rigorous DSGE models are often compared to 'black boxes'.

5. Illustration of the diagram model dynamics in a semi-structural model

The model described in this section belongs to the class of Quarterly Projection Models (QPM)—semi-structural models in gaps. This class of models is used by the Bank of Russia as a core model for calculations conducted within the Joint Forecast Round (JFR) preceding the key rate decision (Orlov and Sharafutdinov, 2024).

The Quarterly Projection Model is a widely used tool in the practice of central banks and government agencies. The semi-structural QPM is based on the structural Dynamic Stochastic General Equilibrium (DSGE) model. However, unlike the latter, its equations are usually supplemented by *ad hoc* mechanisms. These mechanisms cannot be strictly derived within a DSGE framework for various reasons, yet they are observed empirically. This helps better align the model with the actual processes occurring in an economy. This approach, on the one hand, improves the fit with the data and facilitates economic intuition, but on the other hand, it undermines the inherent rigour of DSGE models, which can lead to inaccuracies.

Recent years have seen a renewed interest in the QPM, driven by rapidly changing global conditions. In this context, the QPM may become preferable, as incorporating new mechanisms into it is much less labour-intensive than in a structural model. Furthermore, to maintain mathematical rigour, DSGE models require a relatively complex structure, whereas regulators typically prefer to base their decisions on more transparent and less technically opaque tools. As discussed above, this also benefits the explainability and public communication of monetary policy.

The QPM is an excellent tool for our educational decision-making model. On the one hand, it allows readers to understand the functioning of the economy within the general equilibrium paradigm—a topic that is fundamental to the foundations of macroeconomics but is given little or no attention in most undergraduate and graduate programs. On the other hand, it is a flexible and transparent tool for illustrating the modern approach to monetary policy.

Next we will examine:

- A basic model. We will present the dynamics of macroeconomic variables in response to supply and demand shocks.

- ‘A dilemma, not a trilemma’. This will illustrate the reduction in the effectiveness of monetary policy transmission.

- Imperfect financial markets: closing a financial account. We will demonstrate the change in the operation of the exchange rate channel.

- An analysis of the 2022–2024 episode and the responses of monetary policy and the exchange rate.

5.1 Basic model: illustration of the dynamics of macroeconomic variables in response to supply and demand shocks

We construct a model of a small open economy that exports raw materials (an example of such an economy is the Russian economy).

5.1.1 Equations[57]

List of variables:

Designation	Variable Description
Y_t	GDP
$A_t = C_t + G_t + I_t$	Absorption = consumption + government spending + investment
EX_t	Exports
IMP_t	Imports
IR_t	Nominal interest rate
CPI_t	Inflation
RER_t	Real exchange rate
R_t	Real interest rate
$CPId_t$	Inflation of domestic goods
$CPIt_t$	Inflation of tradable goods

[57] To maintain maximum clarity, we present the equations in a form that is easier to understand and interpret. For example, standard equations like the Phillips curve are already linearised. Additional equations, such as those for residents’ demand for OFZs, are left in a nonlinear form. From a technical perspective, this is not a problem, as the model is linearised around a steady state during solution. This process leaves the already linearised equations unchanged, while the nonlinear ones are linearised.

$CPIf_t$	Inflation of imported goods
Q_t	Non-residents' demand for OFZs
IF_t	Foreign nominal interest rate
CPI_t^F	Foreign inflation
F_t	Capital outflow by residents
sh_t^{IS}	Demand shock
sh_t^f	Capital outflow shock
sh_t^{PC}	Cost shock
sh_t^{iF}	Foreign interest rate shock

Goods and money markets

Aggregate demand (AD) curve links the inflation rate and the output gap on the demand side. For a given inflation rate, real interest rates are determined by the Taylor rule (MP curve). These rates are then transmitted (outside the model) to lending and deposit rates. Ultimately, the volume of demand in the goods market is determined for the resulting real lending rates. Thus, the intersection of the IS and MP curves defines demand in the 'inflation – output gap' space.

AD	$Y_t = A_t + EX_t - IMP_t$	$\boxed{1'}$
IS	$A_t = A_{t+1} - \delta^{ir} * (IR_t - CPI_t - theta) - \delta^{rer} * (RER - RER^{ss}$[58]$) + sh_t^{IS}$	$\boxed{2'}$
MP	$IR_t = w^{MP} * (IR_{t-1}) + (1 - w^{MP}) * (1 + IR^{ss} + psi * (CPI_{t+1} - CPI^{ss}))$	$\boxed{3'}$
Fisher's equation	$R_t = \frac{IR_t}{CPI_{t+1}}$	$\boxed{4'}$

Aggregate supply curve AS = PC (Aggregate Supply = Phillips Curve)

Supply in the goods market is also defined in the 'inflation – output gap' space by the standard Phillips curve. The modelled economy takes into account changes in relative prices—one-off shifts in the price level (this allows for the analysis of monetary policy decisions under both anchored and unanchored expectations). The consumer price index (CPI) consists of two components:

- domestic inflation (domestically generated inflation), which depends on the output gap;
- import price inflation, which depends on the exchange rate via the pass-through effect.

PC^d (domestic)	$CPId_t = (1 - \beta^{cpid}) * CPI^{ss} + \beta^{cpid} * CPId_{t+1} + \beta^Y (Y_t - Y^{ss}) + res^{PC}$	$\boxed{5'}$
cpi^{td} (traded goods inflation)	$CPItd_t = 0.5 * CPItd_{t-1} + 0.5 * CPI^{ss}$	$\boxed{6'}$
PC^t (tradable)	$CPIt_t = CPI^{ss} + 0.5 * (RER_t - RER_{t-1}) + 0.5 * (CPItd_t - CPI^{ss}) + 0.5 * (Y_t - Y^{ss})$	$\boxed{7'}$
PC^i (import)	$CPIf_t = CPIf^{ss} + \beta^{rer} * (RER_t - RER_{t-1})$	$\boxed{8'}$
Aggregate inflation	$CPI_t = 0.4 * CPId_t + 0.3 * CPIf_t + 0.3 * CPIt_t$	$\boxed{9'}$

[58] The superscript ss indicates that the corresponding parameter relates to the model's stable state.

We model the foreign exchange market following Maggiori (2020). The exchange rate is defined by the ratio of two flows:

- the outgoing ruble flow: demand for foreign currency from importers; residents wishing to move capital abroad; and non-residents who previously invested in OFZs and wish to withdraw capital;

- the incoming US dollar flow: export proceeds; capital inflows from non-residents wishing to purchase ruble-denominated OFZs; and the repatriation of previously exported capital by residents.

Ex (AR(1) process)	$EX_t = \rho^{Ex} * EX_{t-1} + (1-\rho^{Ex}) * EX^{ss}$	$\boxed{10'}$
Imp (demand)	$IMP_t = \alpha^{IMP} * Y_t - \beta^{IMP} * RER_t$	$\boxed{11'}$
Q – non-residents' demand for OFZs	$Q_t \;=\; \beta/H * (IR_t * RER_t - IF_t * RER_{t+1} * \frac{CPI_{t+1}}{CPI_{t+1}^F})$	$\boxed{12'}$
F – capital outflow by residents (AR(1) process with a non-zero mean)	$F_t = \rho^f * F^{ss} + (1-\rho^f) * F_{t-1} + sh_t^f$	$\boxed{13'}$
Real exchange rate	$RER_t = (IMP_t + F_t)/(EX_t + Q_t - IR_t * Q_{t-1})$	$\boxed{14'}$
Foreign inflation AR(1)	$CPI_t^F = 0.2 * CPI_{t-1}^F + 0.8 * cpi^{F\,ss}$	$\boxed{15'}$
Foreign interest rate AR(1)	$IF_t = 0.2 * IF_{t-1} + 0.8 * IF^{ss} + sh_t^{IF}$	$\boxed{16'}$
Shock IS	$sh_t^{IS} = 0.5 * sh_{t-1}^{IS} + 0.5 * res^{IS}$	$\boxed{17'}$
Shock f	$sh_t^F = 0.5 * sh_{t-1}^F + 0.5 * res^F$	$\boxed{18'}$
PC Shock	$sh_t^{PC} = 0.5 * sh_{t-1}^{PC} + 0.5 * res^{PC}$	$\boxed{19'}$
Shock iF	$sh_t^{IF} = 0.5 * sh_{t-1}^{IF} + 0.5 * res^{IF}$	$\boxed{20'}$

A necessary condition for solving a QPM model is that the number of variables equals the number of equations. As shown, in our model, 20 variables are determined by 20 equations.

To facilitate the alignment of the graphical model and the formal semi-structural model, we provide a correspondence table of equations:

	Graphical model	QPM
AD	(1)	$\boxed{1'}$
IS	(2)	$\boxed{2'}$
MP	(6)	$\boxed{3'}$
Fisher's equation	(6.1)	$\boxed{4'}$
PC^d (domestic)	Part one in (3.1)	$\boxed{5'}$
CPI^{td} (traded goods inflation)	Excessive due to fixed price levels in the past	$\boxed{6'}$
PC^t (tradable)	Part two in (3.1)	$\boxed{7'}$
PC^i (import)	(3.2)	$\boxed{8'}$
Aggregate inflation	(3)	$\boxed{9'}$

Ex (AR(1) process)	The term in (8)	$\boxed{10'}$
Imp (demand)	The term in (9)	$\boxed{11'}$
Q – non-residents' demand for OFZs	(11)	$\boxed{12'}$
F – capital outflow by residents	The term in (9)	$\boxed{13'}$
Real exchange rate	(12)	$\boxed{14'}$
Foreign inflation AR(1)	Constant	$\boxed{15'}$
Foreign interest rate AR(1)	Constant	$\boxed{16'}$
Shock IS	-	$\boxed{17'}$
Shock f	-	$\boxed{18'}$
PC Shock	-	$\boxed{19'}$
Shock iF	-	$\boxed{20'}$

5.1.2 Calibration[59]

Parameter	Description	Value
δ^{ir}	Coefficient of deviation of the rate in the IS curve	0.7
δ^{rer}	Coefficient of exchange rate deviation in the IS curve	0
w^{MP}	MP inertia (weight of the lagged interest rate)	0.5
psi	MP response to the inflation deviation from target	2.5
β^{cpid}	Coefficient on expected inflation in PC^d	0.5
β^{Y}	Coefficient on the output gap in PC^d	0.5
β^{rer}	Coefficient on expected inflation in PC^i	0.5
w^{cpi}	Weight of domestic inflation in aggregate inflation	0.5
ρ^{Ex}	Export inertia	0.2
α^{Imp}	Income elasticity of import demand	0.4
β^{Imp}	Exchange rate elasticity of import demand	0.2
H	Coefficient of financial friction $H \in [0, \infty)$: if $H = 0$ – UIP holds, if $H = \infty$[60] – financial autarky	0.99
ρ^{f}	Inertia of currency outflow	0.2
$\frac{A}{Y}$	Absorption-to-output ratio	0.9
$\frac{EX}{Y}$	Export–to-output ratio	0.3
$\frac{IMP}{Y}$	Import-to-output ratio	0.2

---

[59] This calibration does not aim to capture all quantitative regularities of the Russian economy, given the model's relative simplicity and its educational purpose. Nevertheless, the calibration incorporates key features, such as the component-to-GDP ratios and the coefficients of the Taylor rule.
[60] In practice, calibrating a parameter as infinity is impossible, so this case is approximated by a sufficiently larger number.

We calibrate the component-to-output ratios based on statistical data for Russia's GDP and its components.

In the Taylor rule, we set the coefficient on the inflation deviation at a relatively high level, $\text{psi} = 2.5$[61], reflecting the Bank of Russia's strict commitment to inflation targeting. We also include inertia in this equation, $\text{w}^{\text{MP}} = 0.5$. This reflects the fact that most central banks pursuing an inflation targeting regime seek to avoid abrupt changes in the policy rate and focus on the underlying trend that persists in the economy for some time. Therefore, we typically observe cycles of rate increases and decreases.

In the baseline version, we set the direct effect of the exchange rate on absorption to zero ($\delta^{\text{rer}} = 0$). We will adjust this coefficient in subsequent experiments.

5.1.3 Impulse responses (deviations from steady state)

Impulse Response Function (IRF) analysis is a standard method for examining DSGE or QPM models, allowing researchers to test the adequacy of the variables' responses to exogenous shocks. The analysis begins with the introduction of an exogenous shock that pushes all or some of the model's variables out of equilibrium. The qualitative and quantitative responses of the variables to the shock, along with their paths back to the steady state, are then analysed and compared with established economic mechanisms. Based on this analysis, a conclusion is reached on the adequacy of the model. This analysis essentially represents a narrative the researcher constructs using the model. We will consider several shocks in sequence.

Shock IS

As a result of a positive demand shock (sh^{IS}), absorption (A) increases via the IS curve. This leads to an increase in output (Y). The increased output is transmitted to prices through the Phillips curve for domestic goods (domestic inflation, cpid, deviates upward from the target).

Imports are positively related to output and also increase. Higher import demand is linked to increased demand for foreign currency, so the currency weakens (rer deviates upward from its equilibrium state). This, in particular, affects imported goods inflation (cpif), which deviates upward from the target.

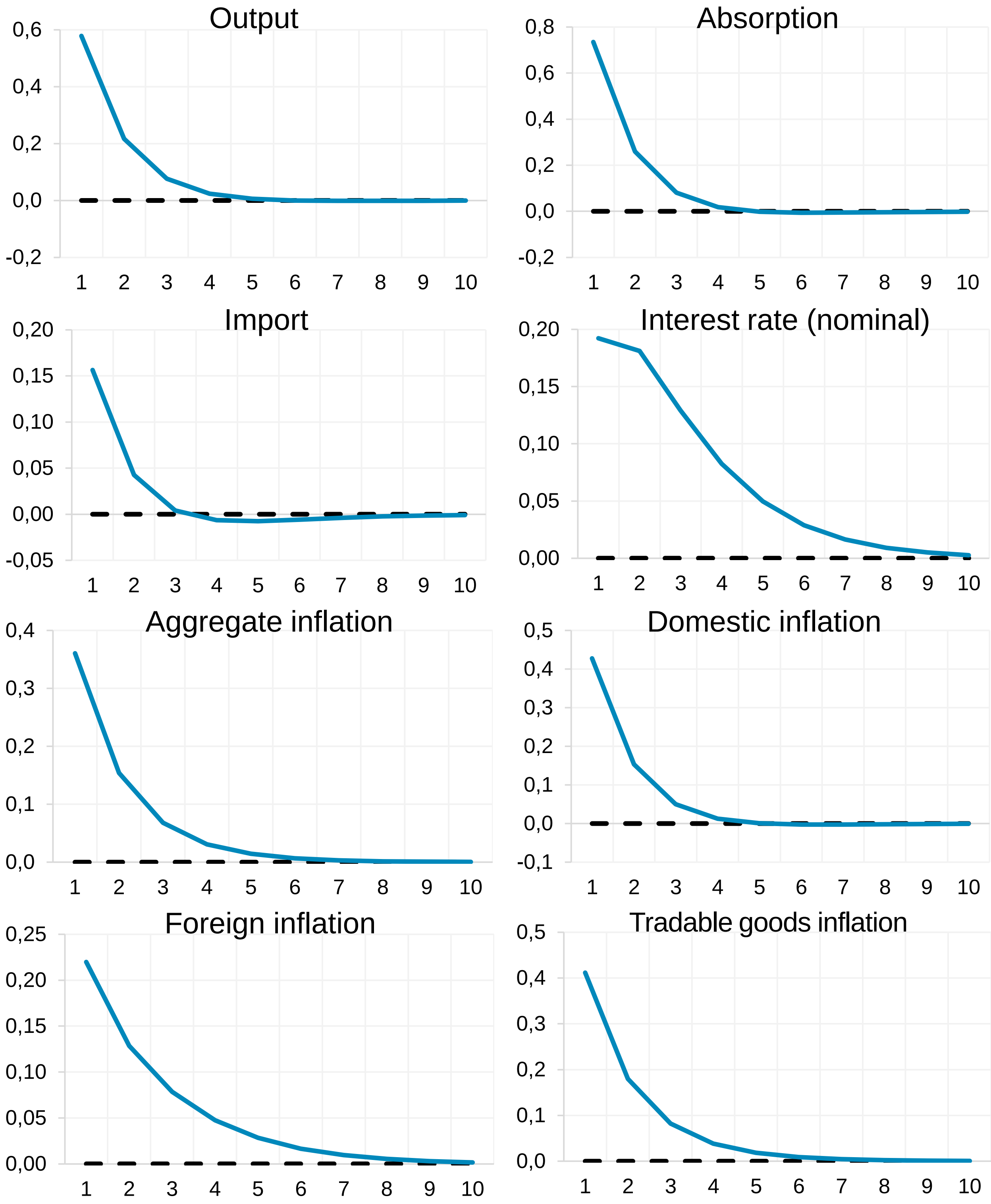
Aggregate inflation (cpi) rises as a result of the increase in both its components. The central bank raises the key rate in accordance with the Taylor rule, leading to an increase in both the nominal (ir) and real (r) interest rates. The higher real interest rate, through the IS curve, stabilises demand, facilitating its return to the steady state.

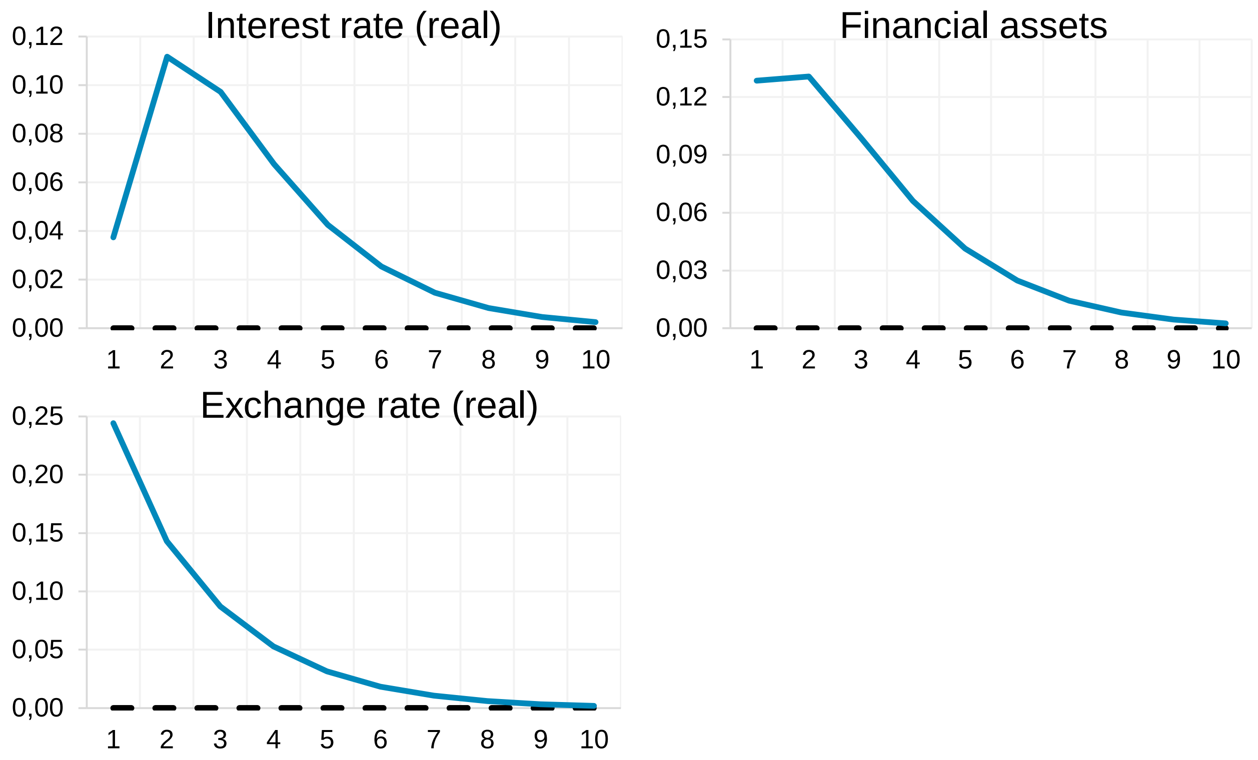
Rational investors, observing the currency depreciation, expect it to revert to its steady state, i.e. to appreciate. They increase their investments in the domestic economy (Q rises). This supports the domestic currency and facilitates its return to equilibrium.

Thus, as the shock subsides, all variables return to a steady-state levels (Figure 154).

[61] The Taylor rule primarily requires that $\text{psi} > 1$ to ensure model stability. Typically, a neutral central bank stance is calibrated with $\text{psi} = 1.5$, while for a more hawkish stance corresponds to $\text{psi} > 1.5$ (see, e.g. Ascari, 2012). For Russia, existing literature estimates a Taylor rule that includes both inflation and output, with psi is estimated at ≈1.3–1.8. We choose a slightly higher value for psi and a Taylor rule that excludes output to underscore the central bank's commitment to the inflation target.

Figure 154. Impulse response function (IRF) to an IS shock





In the graphical model, this shock is described in Section 2.1. However, the presence of lagged components in the inflation equations and the persistence of the shock itself necessitate central bank intervention to stabilise the economy after the shock.

PC Shock

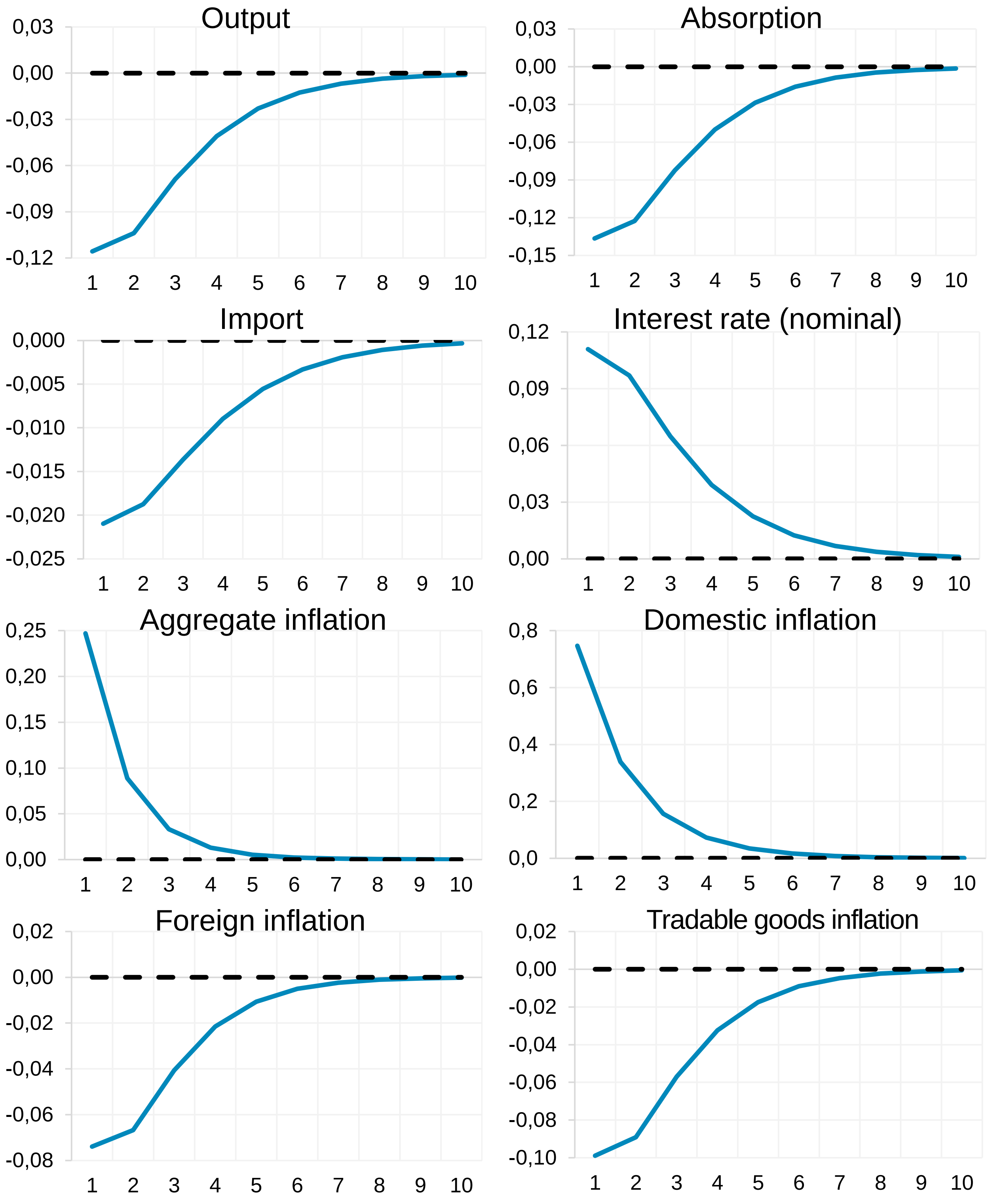
As a result of a positive cost shock ($\mathrm{sh}^{\mathrm{PC}}$), domestic inflation rises via the Phillips curve. This affects aggregate inflation (cpi), causing it to increase. The central bank raises the key rate in accordance with the Taylor rule, resulting in an increase in both the nominal (ir) and real (r) interest rates. Due to the higher interest rate, absorption (A) and, consequently, output (Y) decrease.

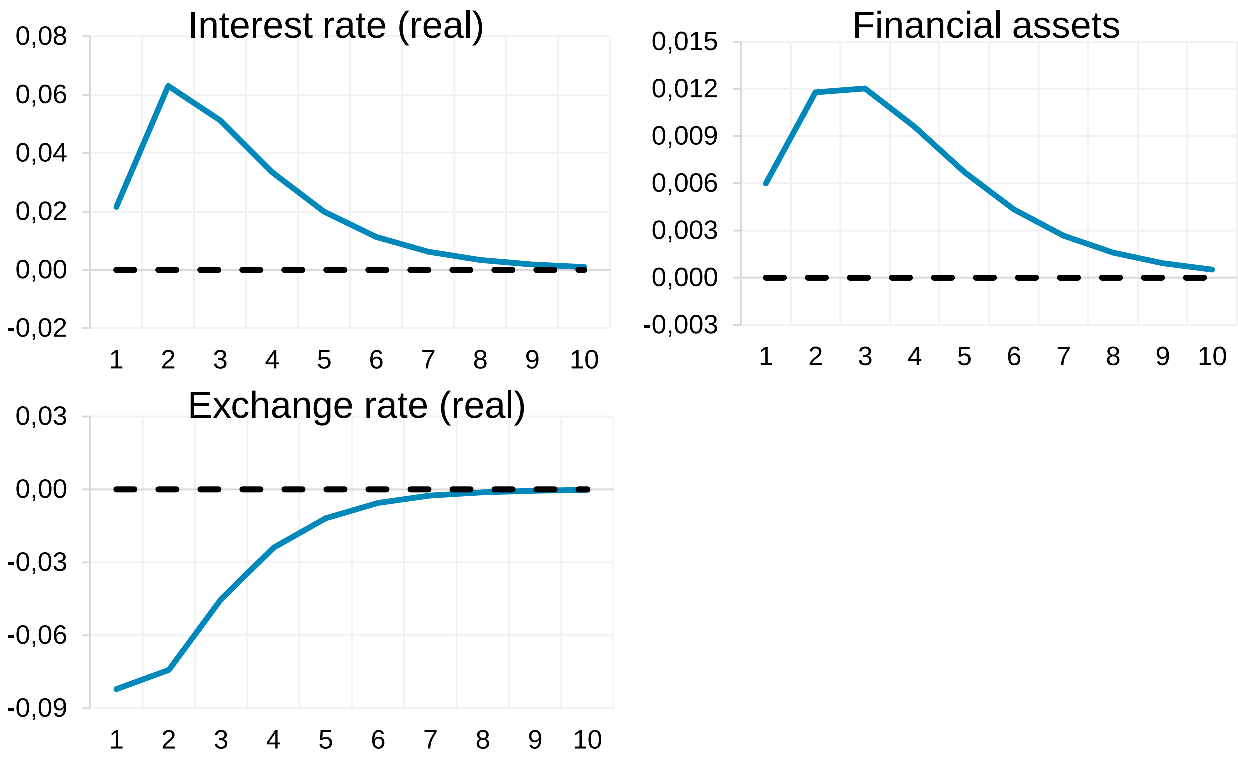
The interest rate differential between the domestic economy and abroad leads to an increase in Q, encouraging investors to invest in the domestic assets.

The decline in output via the PC curve begins to reduce inflation and prompts the central bank to return the key rate to its neutral level. This leads rational investors to reduce Q, returning it to the steady state. As Q declines, the currency weakens. This exerts an additional negative effect on absorption. However, as the interest rate and the exchange rate stabilise near their steady-state levels, absorption also returns to equilibrium.

Thus, as the shock dissipates, all variables return to their steady-state levels (Figure 155).

Figure 155. Impulse response function (IRF) to a PC shock





This shock is described in the graphical model in Section 2.2. Similar to the previous shock, it has a prolonged effect on the economy and forces the central bank to intervene. It is also worth noting that in the semi-structural model, the central bank's Taylor rule includes only the inflation deviation from target and omits the output gap, which reflects the central bank's strong commitment to the inflation target. Thus, when a cost shock occurs, the central bank is not forced to trade off between fighting inflation and worsening the recession.

'A dilemma, not a trilemma': illustrating weaker monetary policy transmission

The applicability of the impossible trilemma to a small open economy and the mechanisms that reduce it to a dilemma were discussed in detail in Section 3, with reference to the relevant literature. In this section, we will only briefly recap the main idea before demonstrating the mechanisms that lead to the dilemma within the framework of a formal semi-structural model.

Thus, as discussed earlier, many standard macroeconomic textbooks and models rely on the trilemma assumption. A central bank cannot simultaneously maintain free capital flows, manage the exchange rate, and conduct an independent monetary policy (i.e. set interest rate freely); it must choose only two out of the three goals. However, as discussed above, more recent research suggests that for a small open economy, even this is choice represents an unaffordable luxury. Under conditions of free capital mobility, the exchange rate loses its stabilising function in the event of an external shock and, on the contrary, begins to create imbalances. In such a situation, the central bank is forced to adjust its monetary policy, effectively tracking the interest rate of the large open economy that is the source of the shock. We will illustrate the differences in the responses of the main macroeconomic variables in our QPM.

In our model, we consider two channels of the dilemma. First, we assume that foreign investors are risk-sensitive, based on Maggiori (2020). Second, we assume the exchange rate influences absorption, following Gourinchas (2018). Let us consider these two channels in turn.

5.1.4 Risk sensitivity of foreign investors (H is an endogenous variable)

We assume that the exchange rate influences investors' risk sensitivity; specifically, if the exchange rate weakens, investors become more risk-sensitive. Formally, this relationship can be described as follows:

$$\mathrm{H} = 0{,}5 * \mathrm{H}(-1) + 0{,}5 * \mathrm{H}^{\mathrm{ss}} + \mathrm{RH} * (\mathrm{rer} - \mathrm{rer}^{\mathrm{ss}}).$$

As the equation shows, only deviations of the exchange rate from its steady-state level affect risk propensity. When $\mathrm{rer} = \mathrm{rer}^{\mathrm{ss}}$, H follows an AR (1) process.

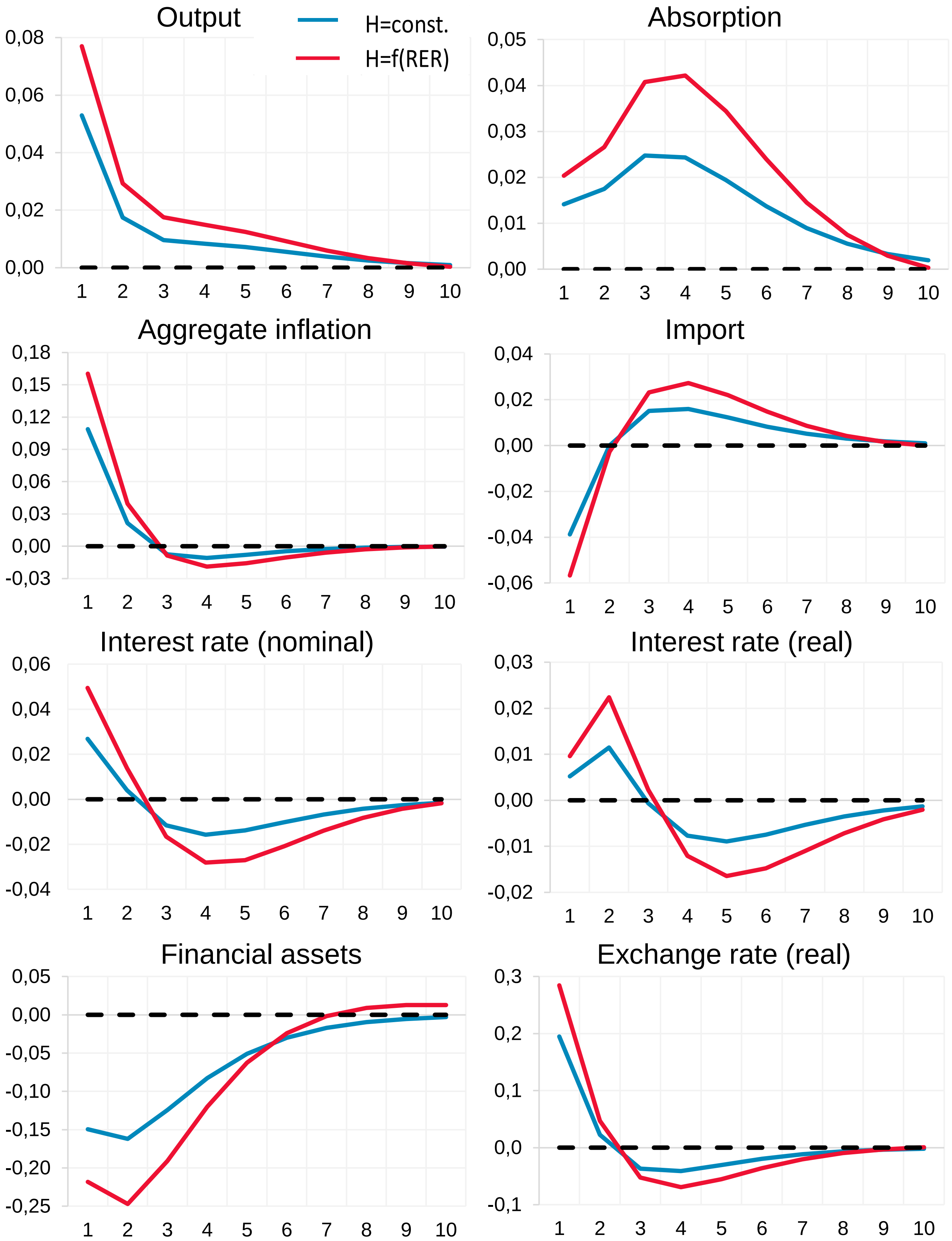
Let us consider the situation where H follows this relationship and the situation when $\mathrm{H} = \mathrm{const}$. To illustrate the impact of this assumption, we analyse the impulse response to a foreign rate shock in both scenarios.

Suppose the foreign interest rate rises. A higher foreign interest rate makes investments in foreign assets more attractive, leading to capital outflow. This outflow is accompanied by increased demand for foreign currency and, consequently, a depreciation of the domestic currency (the exchange rate rises). This mechanism operates regardless of the functional form of H; the differences emerge at the next stage:

- If the exchange rate has no effect on risk sensitivity ($\mathrm{H} = \mathrm{const}$.), inflation rises due to the currency depreciation, and the central bank raises the key rate to stabilise the situation. Investors begin investing in the domestic economy due to the expected exchange rate appreciation and the rise in the domestic interest rate. Thus, the economy returns to its steady state.
- If the exchange rate affects risk appetite, a currency depreciation (a rise in rer) leads to an increase in H. This increase in H, in turn, causes further depreciation. This process is transmitted to inflation, raising it more than in the case of a constant H. Therefore, the central bank raises the key rate more than it would if risk appetite were independent of the exchange rate in order to return the economy to its steady state.

This example illustrates that if the exchange rate influences risk appetite, the central bank is forced to further account for the currency depreciation in its policy and raise the key rate more aggressively to stabilise the situation than it otherwise would. Thus, the domestic central bank's monetary policy more closely tracks that of the foreign central bank (Figure 156).

Figure 156. Impulse response functions for different risk sensitivities of foreign investors



5.1.5 The impact of the exchange rate on absorption

Here, we assume that the exchange rate affects absorption. In this case, the standard IS curve is augmented by one more element:

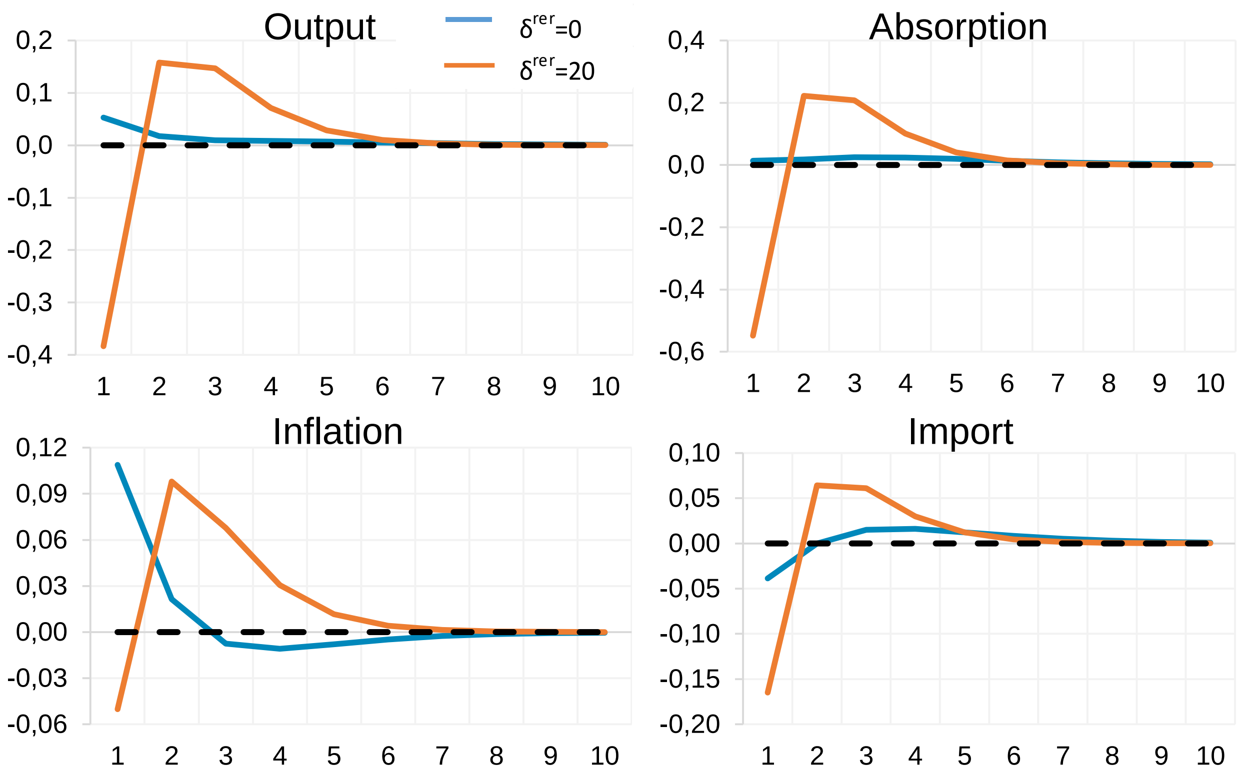
$$A_t = A_{t+1} - \delta^{ir} * (ir_t - cpi_{t+1} - theta) - \boldsymbol{\delta^{rer}} * (\mathbf{rer} - \mathbf{rer_{ss}}) + sh_t^{IS}$$

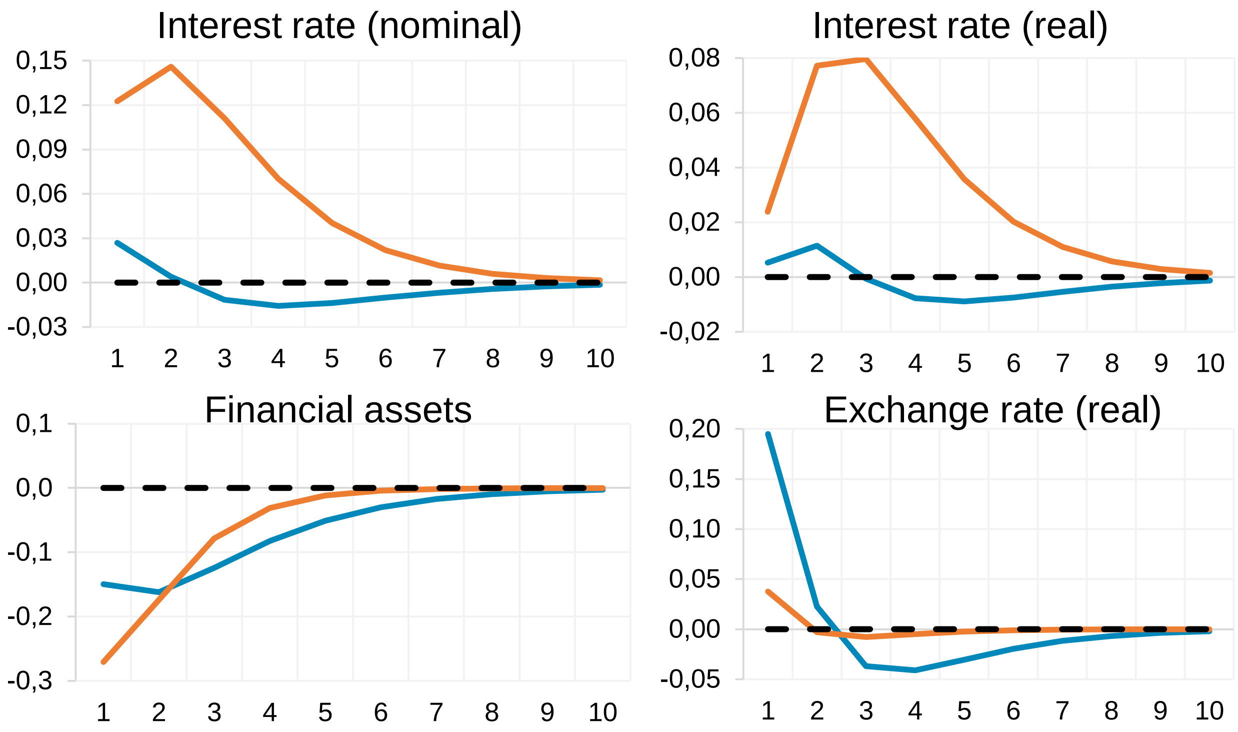
Now let us analyse two scenarios: $\delta^{rer} = 0$ (i.e. the standard IS curve) and $\delta^{rer} \neq 0$ (i.e. a weaker exchange rate reduces absorption).

To illustrate this mechanism, we again consider a positive foreign interest rate shock. The initial mechanism is the same as in Section 2.2.1: a higher foreign interest rate makes investments in foreign assets more attractive, leading to capital outflow. This capital outflow is accompanied by a weakening of the domestic currency (the exchange rate appreciates). The subsequent response of these variables will vary depending on the scenario (Figure 157).

- If the exchange rate has no direct effect on absorption ($\delta^{rer} = 0$), then imports decline while absorption remains virtually unchanged, resulting in output growth. The exchange rate depreciation passes through to prices, and inflation rises. The central bank raises the rate to stabilise the situation. Thus, the economy returns to its steady state.
- If the exchange rate does affect absorption ($\delta^{rer} \neq 0$), then imports decline, but absorption contracts even more sharply. Consequently, output declines in the first period rather than growing, as in the previous scenario. To counteract the exchange rate's effect on output, the central bank must raise the interest rate. However, the central bank recognises that a stronger exchange rate will not only reduce inflation but also increase absorption, which is proinflationary. To offset the impact of absorption on inflation, the central bank raises the interest rate more sharply than it would in the standard case. Thus, the central bank is forced to rely on the exchange rate channel and loses some freedom in its monetary policy.

Figure 157. Impulse response functions with and without the influence of the exchange rate through the financial channel on absorption





5.2 Illustration of dynamics in an imperfect financial market

We will conduct several experiments to analyse how varying the parameters of our model allows us to simulate both an economy with free capital movement and an economy close to financial autarky (FA).

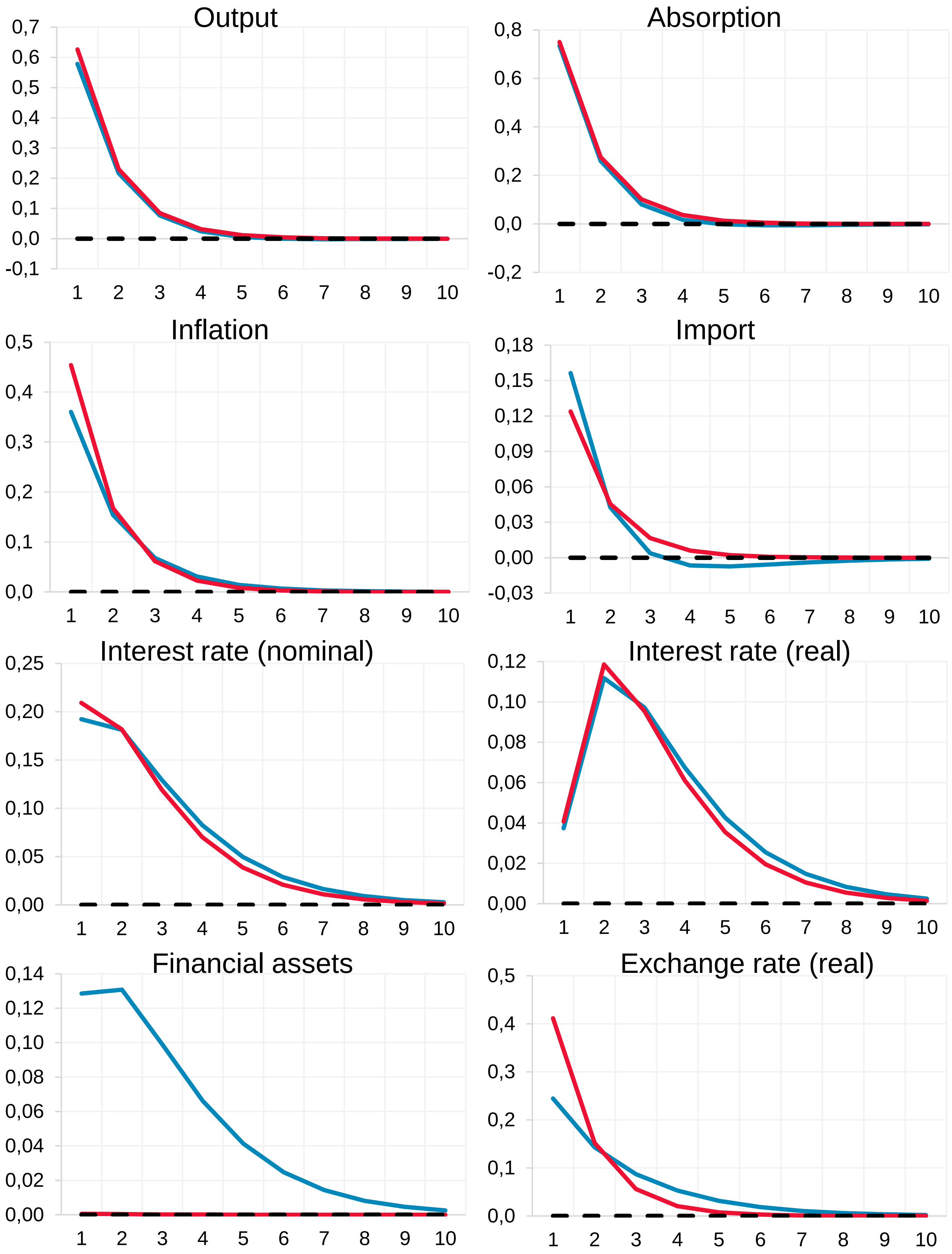
Let us examine the effect of a change in H on the economy using the example of a demand (IS) shock.

As discussed above, the parameter $\mathrm{H} \in [0; \infty)$. We consider two calibration cases $\mathrm{H} = 0.99$ (an economy closer to the absence of financial frictions and the fulfilment of UIP, hereinafter referred to as the 'UIP case' for brevity, blue lines in Figure 158) and $\mathrm{H} = 500$ (an economy closer to financial autarky, hereinafter referred to as the 'FA case' for brevity, red lines in Figure 158). For both calibrations, we consider the impulse responses to a demand shock.

The output and its components within the model are quite stable to changes in the parameter H, their responses are very close under different calibrations.

In the FA case, the currency depreciates more sharply in the initial periods than in the UIP case, as it receives virtually no support from investments in the domestic economy (financial assets ≈ 0). However, the recovery in the FA case is also faster, as the withdrawal of financial assets in subsequent periods does not exert additional pressure on the exchange rate. A more rapidly stabilising exchange rate leads to a more rapid stabilisation of inflation and, consequently, allows for a faster rate reduction than in the UIP case.

Figure 158. Impulse response functions in an economy with UIP and in an economy with financial autarky



5.3 Illustration of dynamics in the 2022–2023 episodes: the reaction of monetary policy and the exchange rate

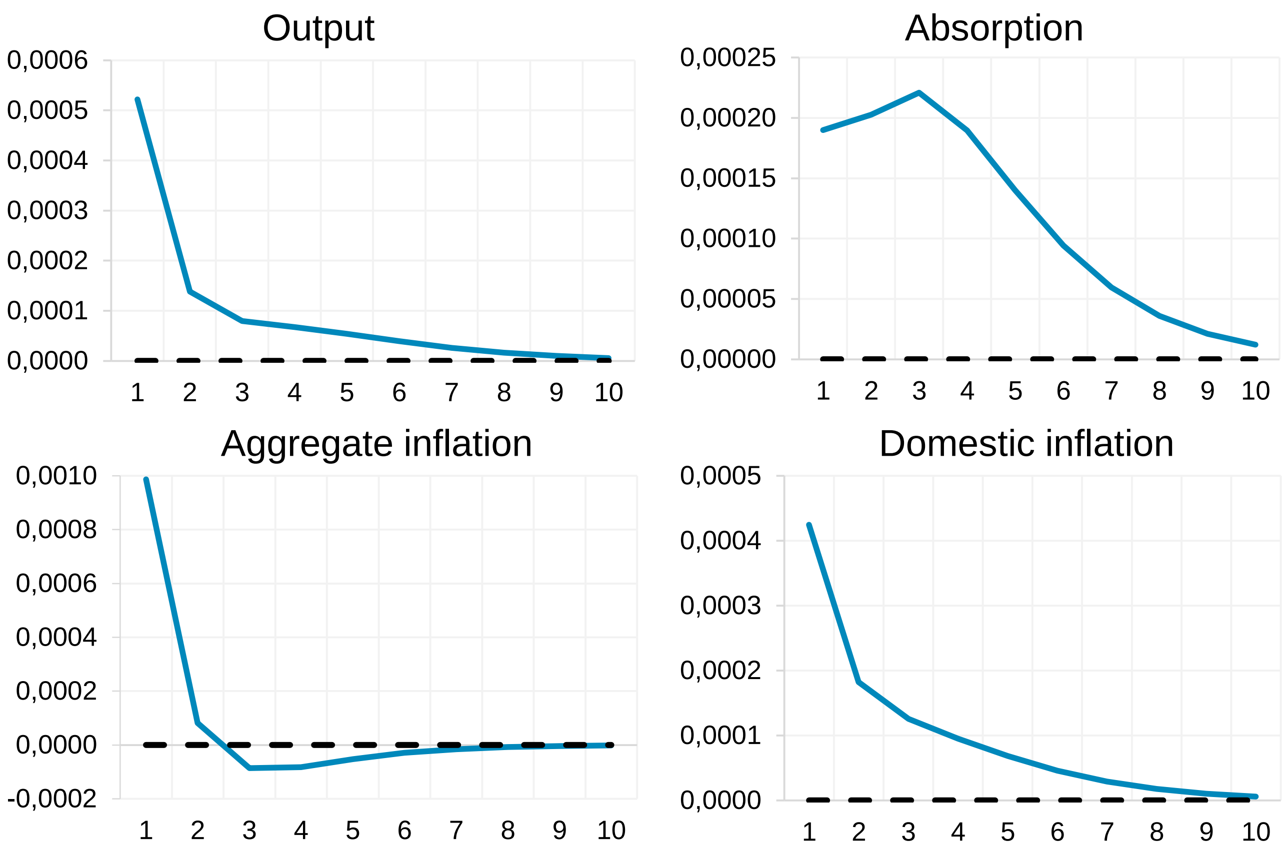
5.3.1 February–March 2022

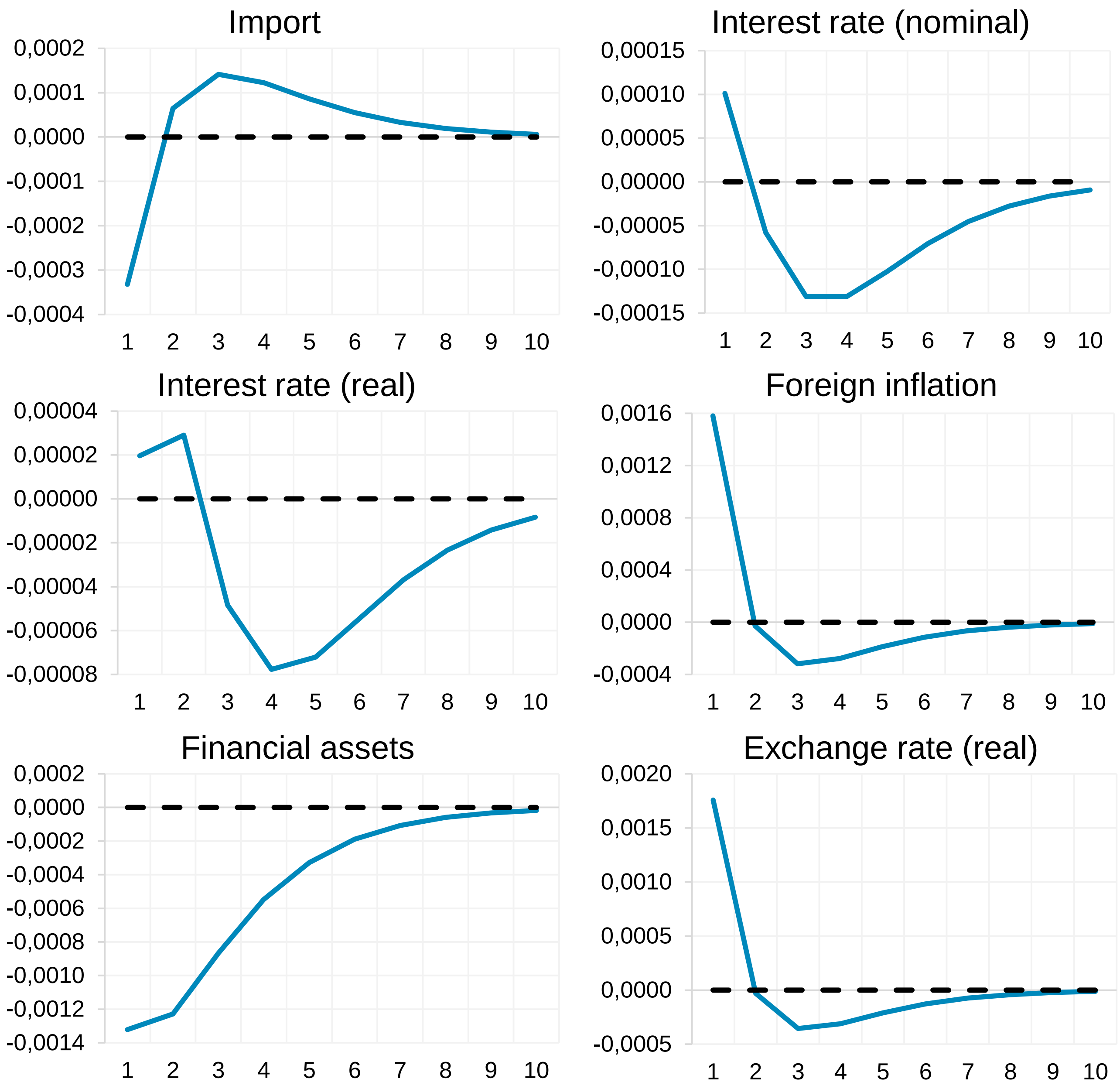
Risk premium increase

Given that we aimed to maintain maximum simplicity and clarity in constructing the model, we deliberately avoid overloading it with the rather complex technical apparatus required for transitions from one equilibrium to another. In this section, we assume a single-period shock to the risk premium and discuss the direction of the variables' movements resulting from this shock (Figure 159). If such a shock lasts for several periods, then, accordingly, all variables will take a similarly long time to return to equilibrium. However, we specifically refer to a shock, which in the context of the QPM means that the economy will return to equilibrium after the shock dissipates.

The rising risk premium leads to capital outflow and currency depreciation. Imports also decline. The weakening exchange rate leads to higher inflation and forces the Bank of Russia to raise the interest rate to stabilise it.

Figure 159. Impulse response functions for a positive risk premium shock

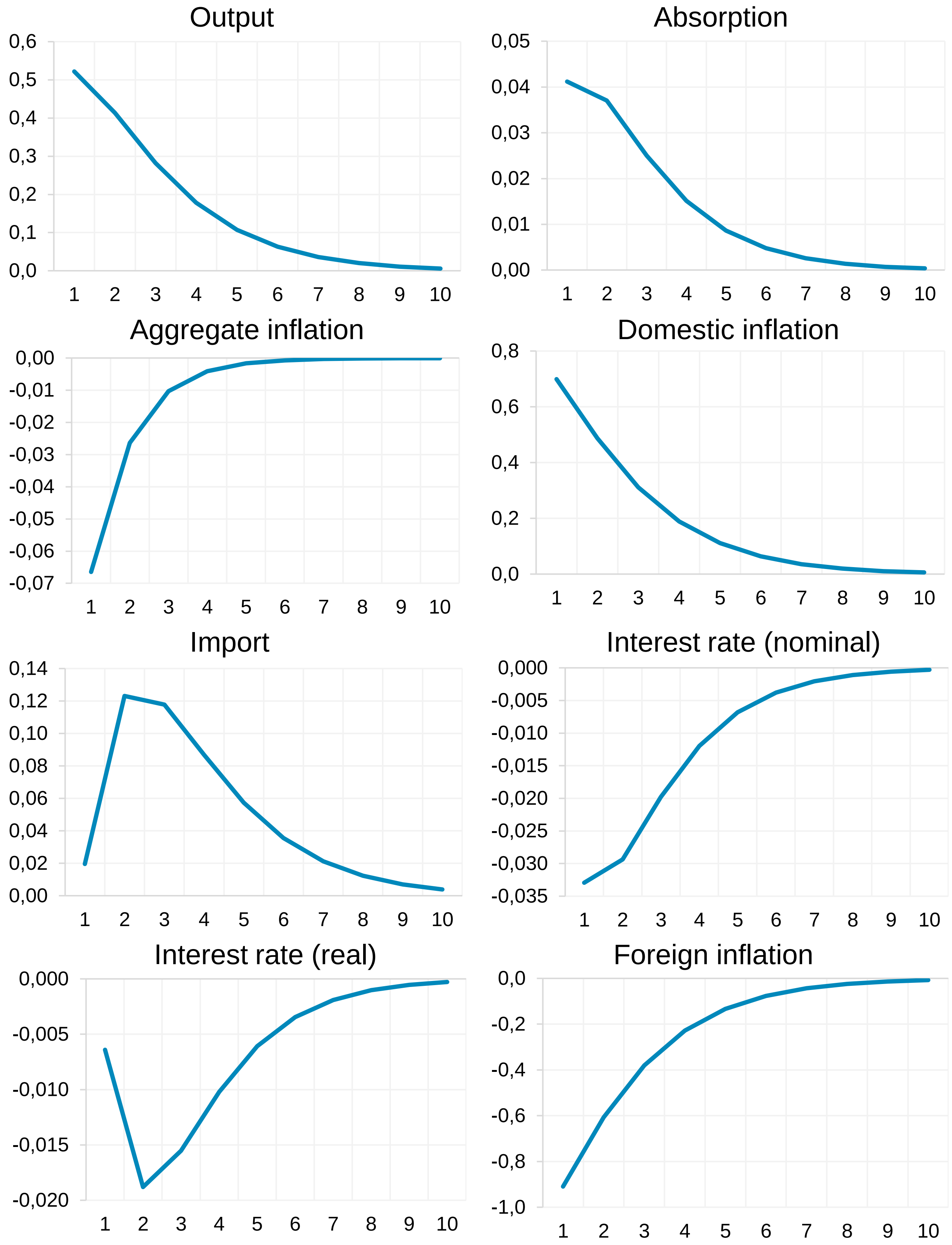


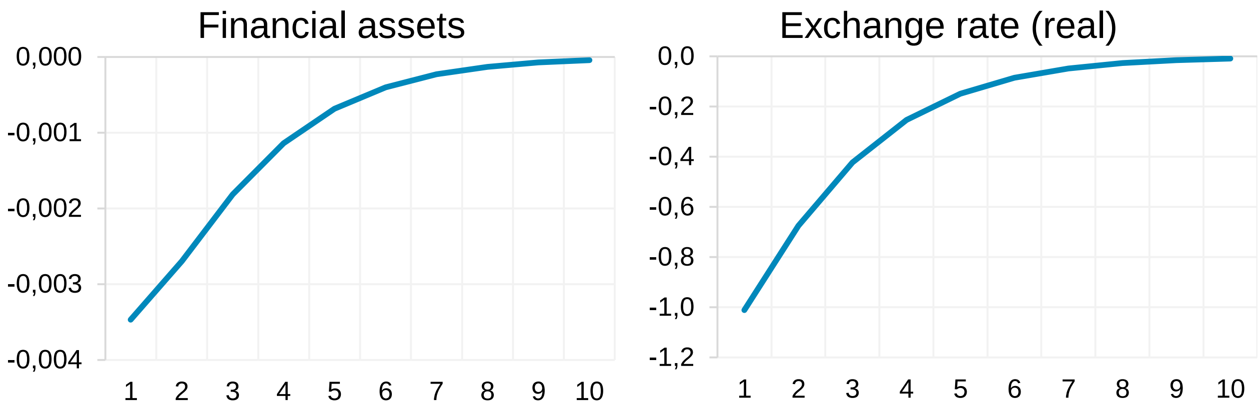


5.3.2 March to third quarter of 2022

The economy begins to operate in a regime of financial autarky, so we recalibrate the coefficient Η from 0.99 to 100. Against this backdrop, a positive net export shock occurs, leading to an appreciation of the exchange rate. The exchange rate movement, in turn, leads to a reduction in inflation and allows the Bank of Russia to lower the key rate to stabilise it (Figure 160).

Figure 160. Impulse response functions for a positive net export shock

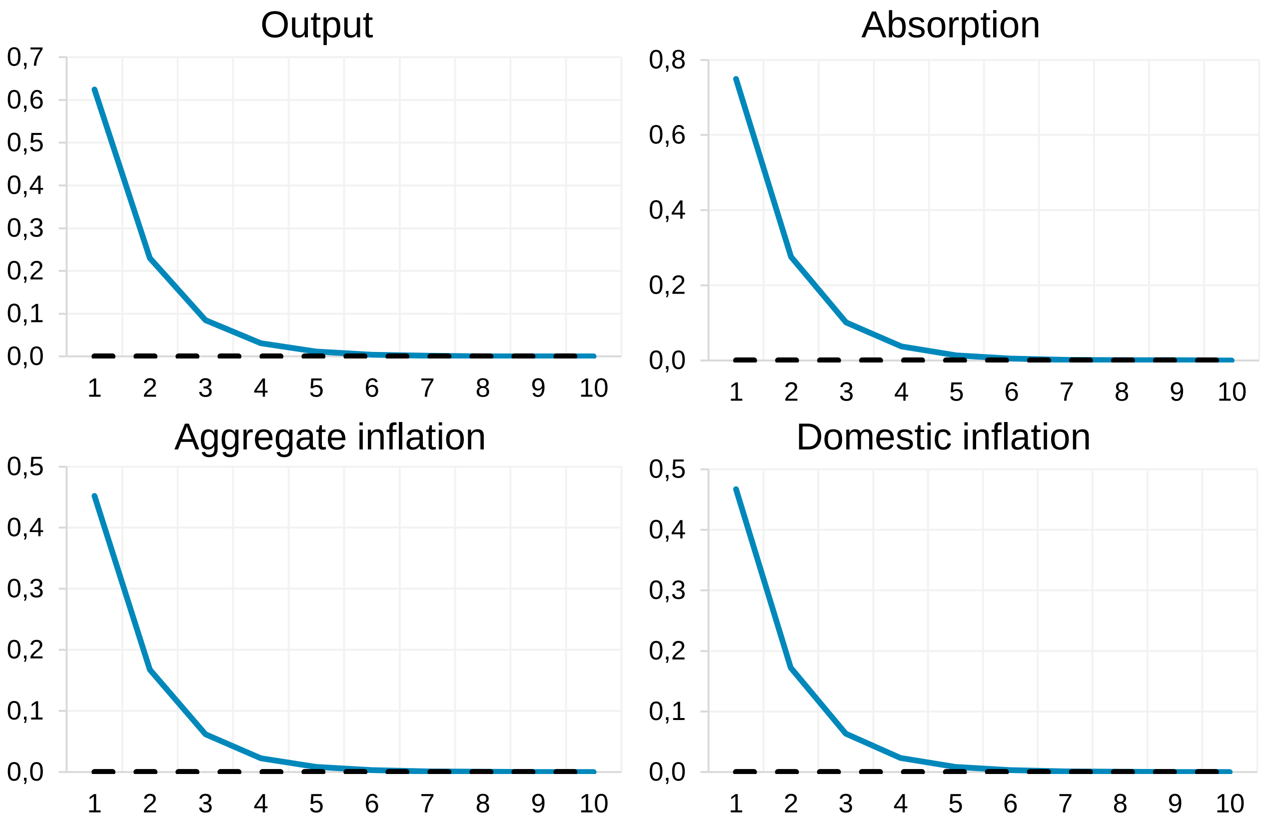


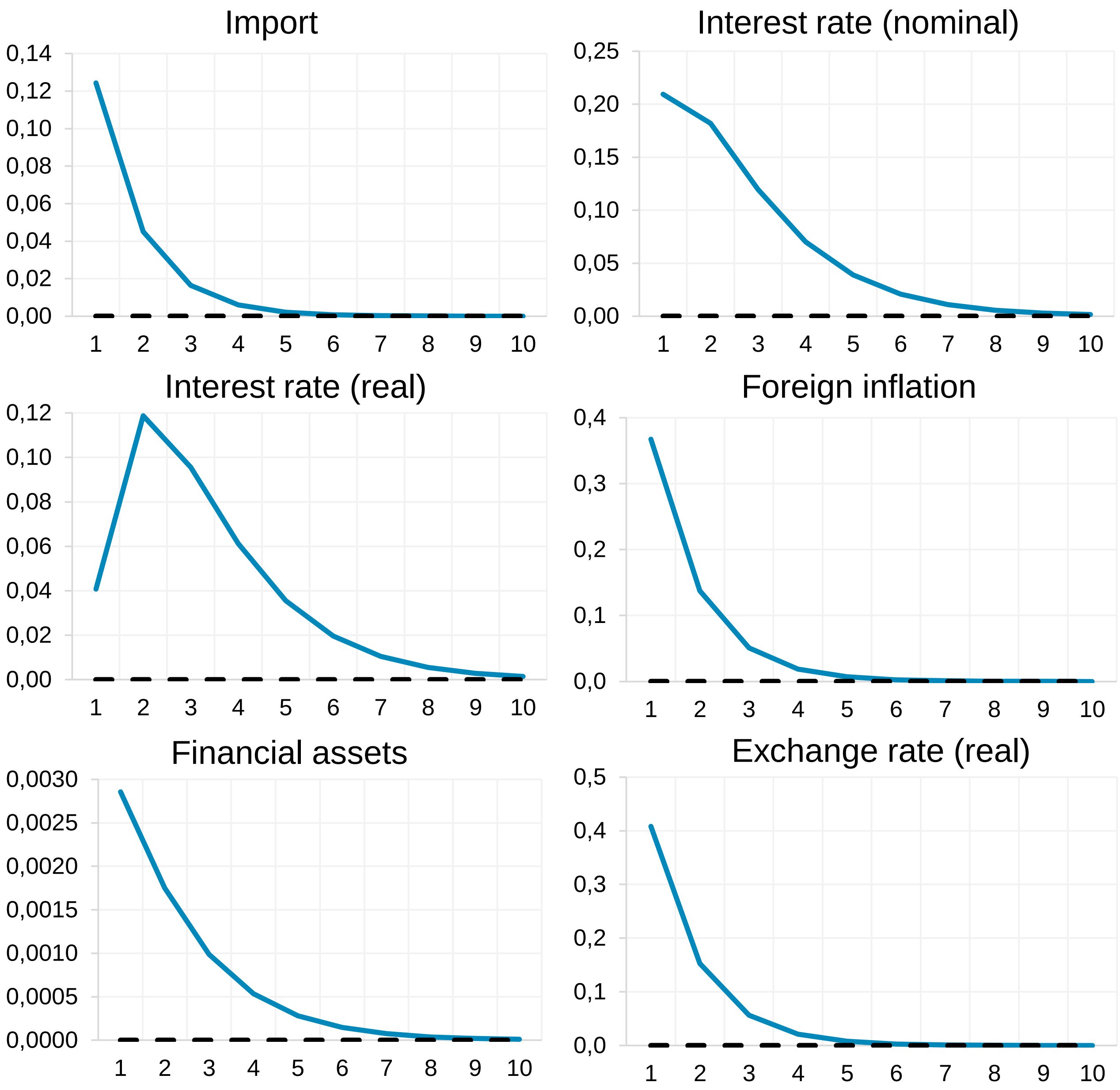


5.3.3 2023–2024

The model does not separately identify government spending, so we model the shock occurring during this period as a simple demand shock. This demand shock leads to higher inflation, and the Bank of Russia is forced to raise the key rate again (Figure 161).

Figure 161. Impulse response functions to a positive aggregate demand shock





Conclusion

The presented graphical and corresponding semi-structural model can be extended in several directions.

First, a more detailed description of the budget sector is promising—in particular, the addition of a fiscal rule as a fiscal policy rule analogous to the Taylor rule for monetary policy. This expansion would allow for an analysis of the interaction between monetary and fiscal policy.

Second, it would be useful to consider the effects of various shocks on potential GDP and to incorporate the economic structure more explicitly (at least in terms of tradable/non-tradable goods, imports, and import-substituting goods). This extension would allow for an analysis of economic restructuring following external shocks and the role of monetary policy in such a process.

Third, a further expansion could address the domestic credit cycle (for example, in the mortgage market) and the distinction between different types of loans. This would allow for an analysis of the relationship between monetary and macroprudential policies focused on domestic credit (rather than external credit, as in the dilemma discussed above), its structure, and the associated risks to financial stability.

We hope that the publication of this work will encourage other researchers to describe these components in a simple, graphical form.

Furthermore, we hope that the presented model, either in its entirety or in its individual sections (or simply the model's logic), will be useful for teaching courses in 'Macroeconomics' or 'Monetary Policy' to undergraduate economics students. Depending on the student's level, either the basic model (Sections 1–2 for macroeconomics students) or the more advanced model (the remaining sections for advanced students) can be used.

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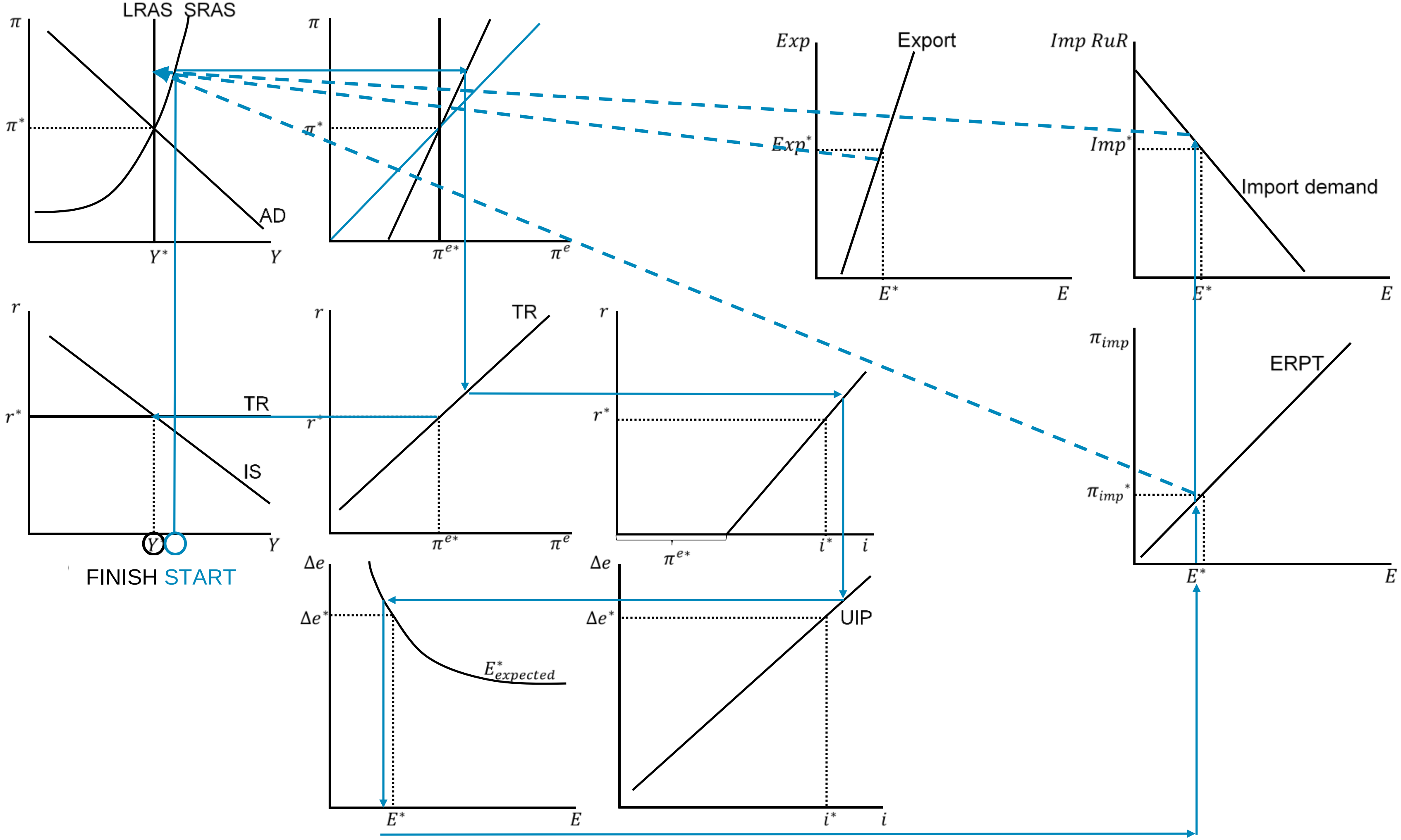
Appendix 1

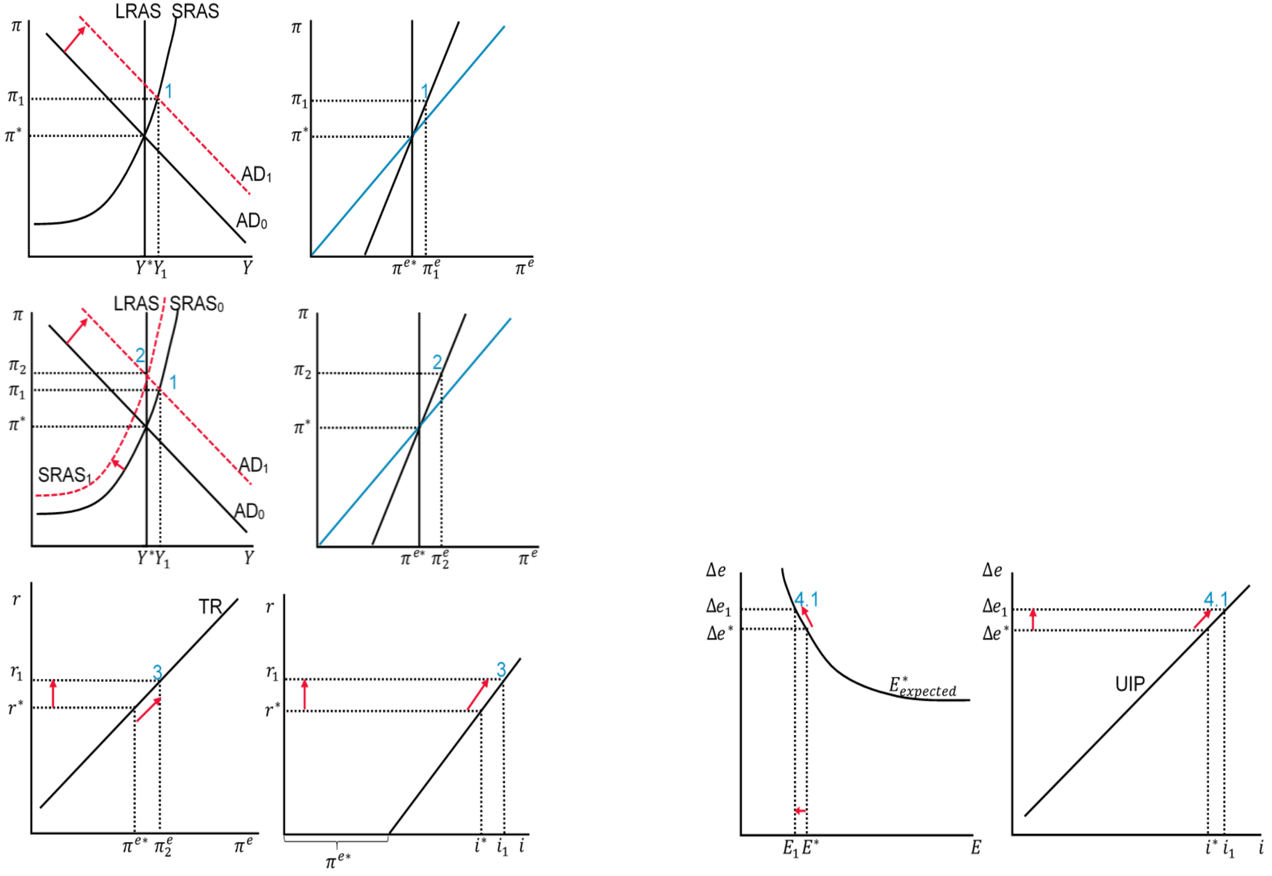
Adjusting the economy to equilibrium after a demand shock



Appendix 2

Summary illustration of inflation stabilisation under a positive demand shock

1. Positive demand shock, an overheating economy, higher inflation and inflation expectations.
2. Rising inflation expectations shift the SRAS curve.
3. In response to elevated inflation expectations, the central bank raises the real interest rate.
4. Higher real and nominal interest rates lead to an appreciation of the nominal and real exchange rates.



Appendix 2 (continued)

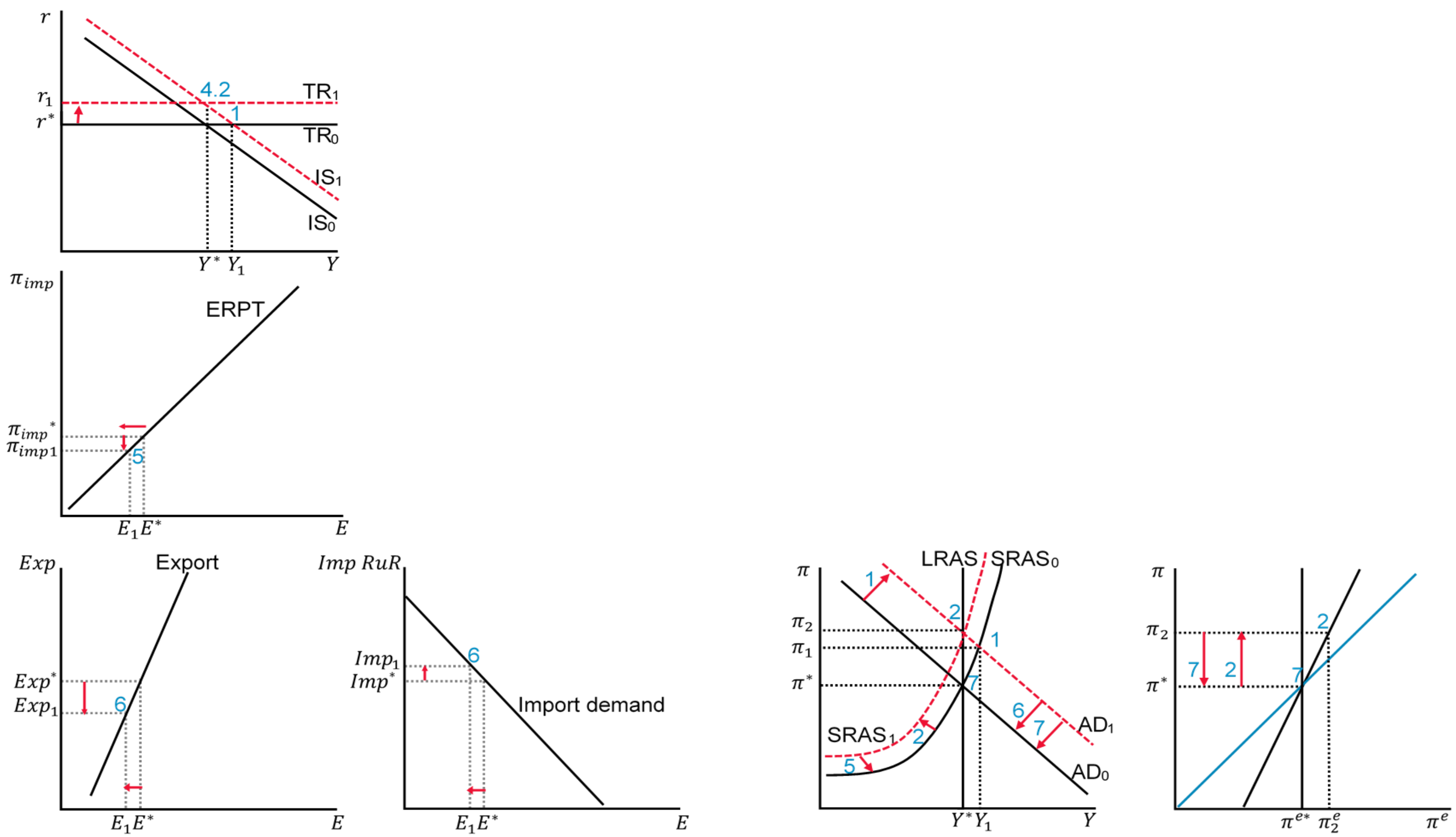
Summary illustration of inflation stabilisation under a positive demand shock

4.2 A higher real interest rate reduces demand (i.e. a movement from point 1 to point 2 along the AD line).

5. The appreciation of the exchange rate slows inflation of imported goods (contributing to a reverse shift in the SRAS curve).

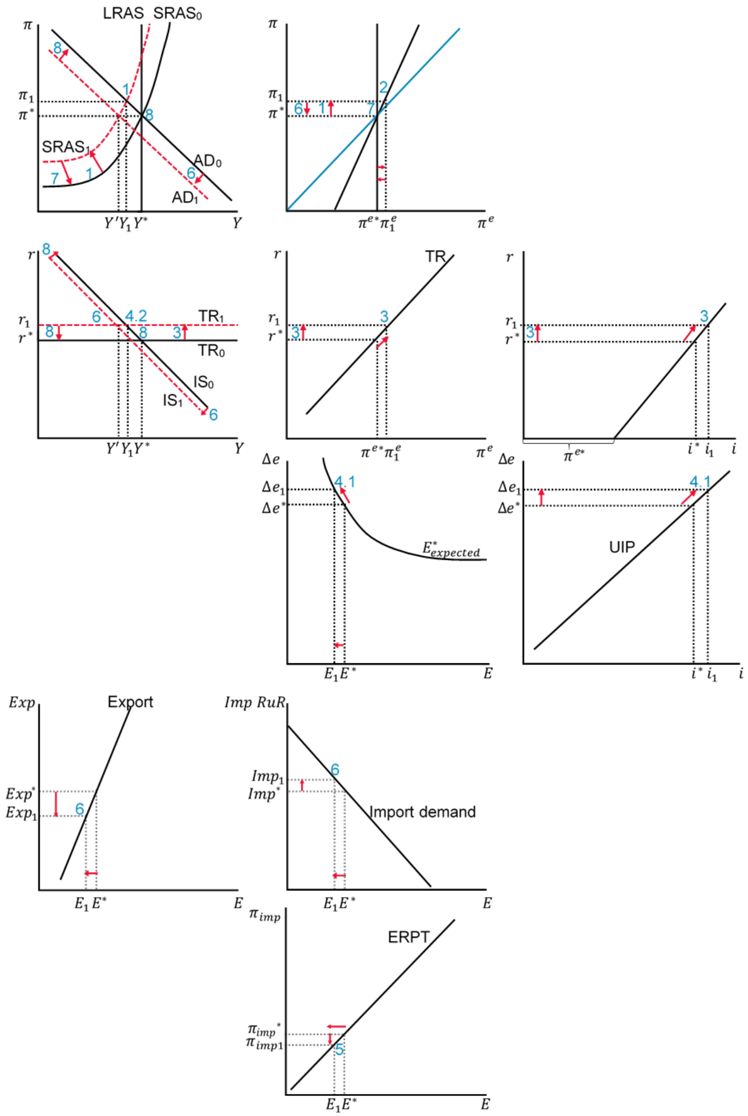
6. The appreciation of the exchange rate increases demand for imports and slightly reduces export volumes (due to low elasticity).

7. The combined effect of increased imports and decreased exports, which reduces aggregate demand, alongside the pass-through effect, returns inflation and inflation expectations to their initial equilibrium. Output also returns to equilibrium.



Appendix 3

Summary illustration of inflation stabilisation under a negative supply shock



1. The shock results in a leftward shift of the SRAS curve.

2. Rising inflation increases unanchored inflation expectations.

3. The central bank, in response to elevated inflation expectations, raises the real interest rate.

4.1 A higher real and nominal interest rate leads to an appreciation of the nominal and real exchange rates.

4.2 A higher real rate reduces aggregate demand (i.e. a movement from point 1 to point 2 along the AD line).

5. The appreciation of the exchange rate slows price inflation of imported goods (contributing to a reverse shift of the SRAS curve).

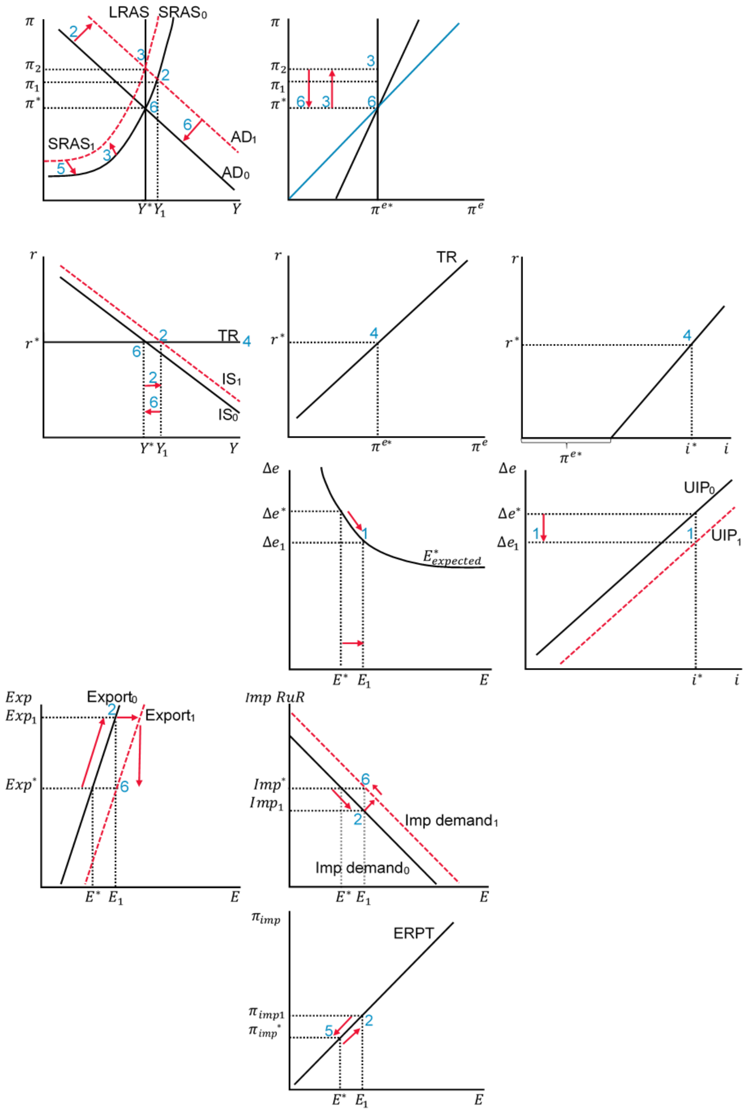
6. The appreciation of the exchange rate increases demand for imports and slightly reduces export volumes (due to low elasticity).

7. The combined effect of increased imports and decreased exports, which reduces aggregate demand, alongside the pass-through effect, returns inflation and inflation expectations to their initial equilibrium. However, the economy remains below its equilibrium.

8. The normalisation of monetary policy (rate reduction) through the exchange rate channel alters exports/imports, which shifts the AD line back.

Appendix 4

The monetary policy trilemma



1. The foreign central bank raises its key rate. Given exchange rate expectations, this leads to a weakening of the exchange rate, resulting in an expected appreciation.

2. Imports decline, and exports increase slightly.

3. Due to exchange rate pass-through, acting as a cost-push shock, inflation rises—the SRAS curve shifts leftward and upward.

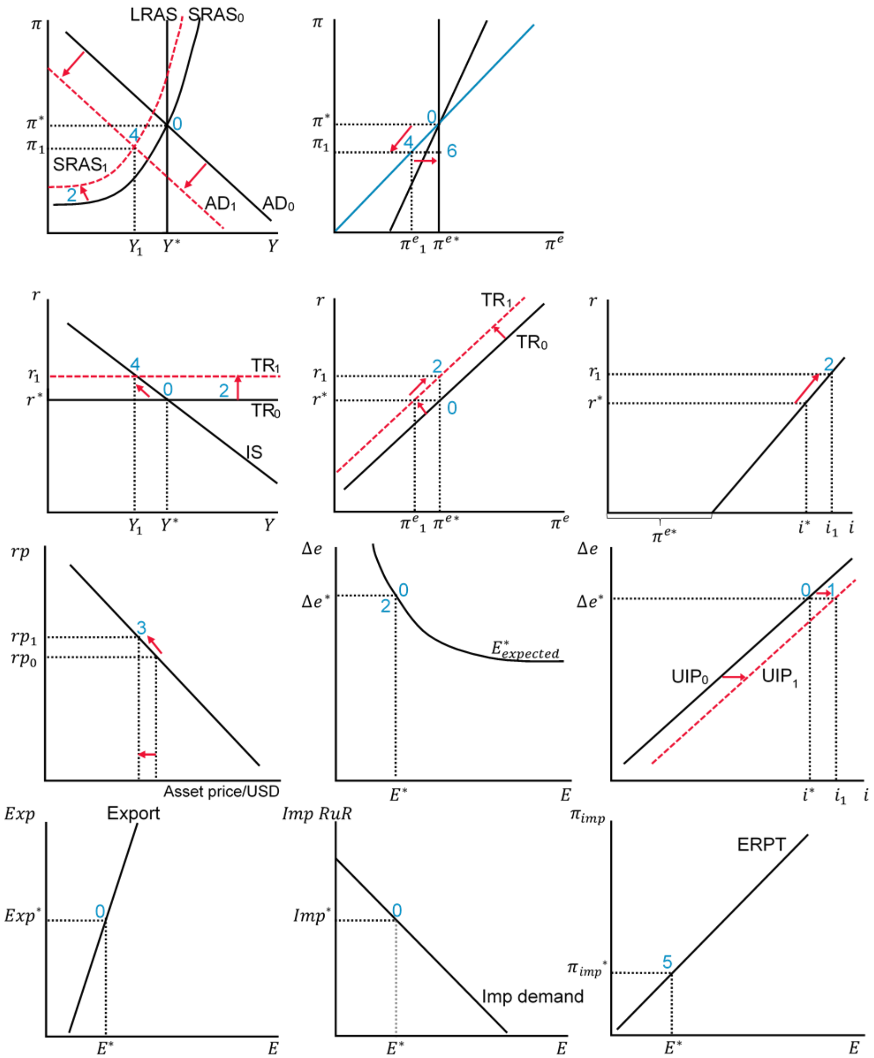
4. Due to anchored inflation expectations, the domestic central bank does not need to change its real key rate following the foreign central bank's move.

5. Due to the temporary nature of the pass-through, import price inflation slows over time. The SRAS curve shifts back.

6. The rise in domestic prices that has already occurred offsets the nominal exchange rate depreciation, so the real exchange rate remains unchanged. Consequently, the relative price of imports returns to its long-run equilibrium, and with it, import (and export) demand. The import and export lines shift in terms of the (weaker) nominal exchange rate.

Appendix 5

The monetary policy dilemma



1. An increase in the foreign interest rate shifts the UIP condition. The central bank responds by raising its key rate (not in response to higher inflation, but to the risks to financial stability due to exchange rate depreciation). This response does not alter the exchange rate.

2. Higher domestic rates, with inflation unchanged, lead to a shift in the TR line—the monetary policy rule itself changes.

3. Higher rates reduce the value of collateral assets for non-residents (with an unchanged exchange rate), resulting in an increased risk premium. This requires an additional compensatory increase in the key rate.

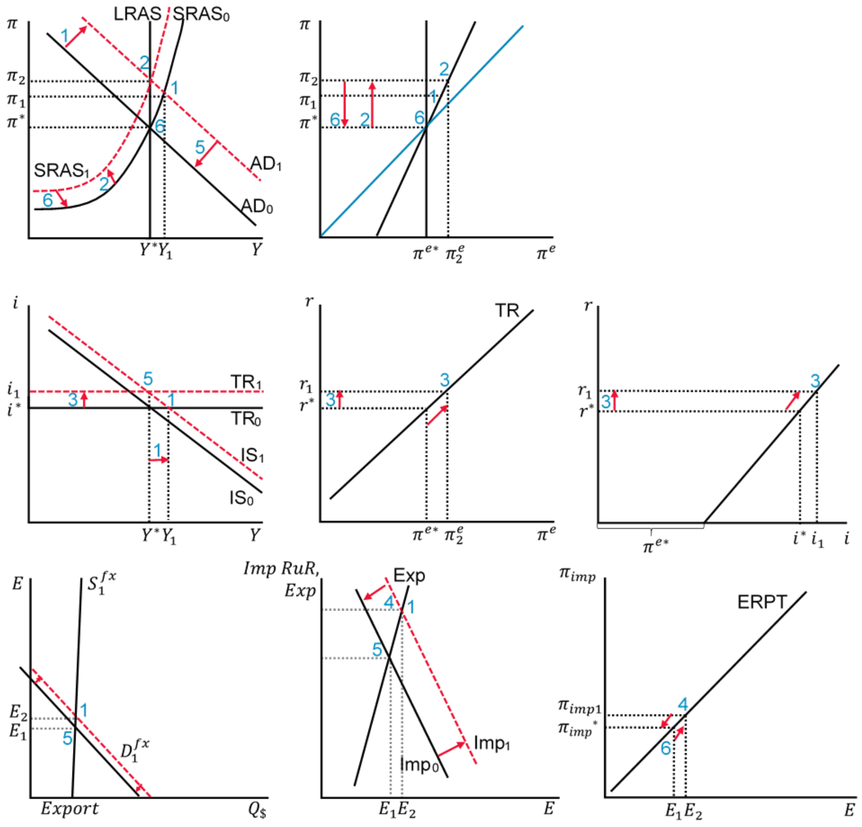
4. Higher rates reduce aggregate demand and dampen inflation. This leftward shift of the AD curve may actually be smaller than it would have been with unchanged (i.e. lower) monetary policy rates (equilibrium ‘4’). Higher rates thus help avoid larger losses in GDP.

5. Import prices remain stable due to the stability of the exchange rate.

6. Inflation below target and GDP below potential are the price to pay for securing financial stability in the context of the ‘monetary policy dilemma’.

Appendix 6

Response of a general equilibrium model with imperfections in the foreign exchange market to a demand shock



1. Rising demand shifts the IS and AD lines upward and to the right. Rising income increases demand for imports. Inflation rises.

2. If the inflationary pressure is persistent, it translates into higher inflation expectations: the SRAS curve shifts upward and to the left.

3. In response to rising inflation expectations, the central bank tightens monetary policy. The real key rate rises.

4. Unlike in an economy with an open financial account, a rate increase **does not lead** to capital inflows. Therefore, the rapid, associated appreciation of the exchange rate does not occur.

5. The appreciation of the exchange rate is a consequence of a decline in aggregate demand, due to tight monetary policy, and income, which reduces imports.

6. The appreciation of the exchange rate dampens imported price inflation and shifts the SRAS curve back.