An Optimizing IS-LM Model Specification with Inflation Targeting. Microeconomic Evidence for Price Adjustment

Vîntu, Denis

Moldova Academy of Economic Studies (MAES)

March 2022

Published in the USA
European Journal of Economic Studies
Has been issued since 2012.
E-ISSN: 2305-6282
2022. 11(1): 14-34

DOI: 10.13187/es.2022.1.14
https://ejes.cherkasgu.press

An Optimizing IS-LM Model Specification with Inflation Targeting. Microeconomic Evidence for Price Adjustment

Denis Vintu [a], [*]

[a] Moldova Academy of Economic Studies (MAES), Republic of Moldova

Abstract

The article describes a specific canonical form of IS-LM model under Inflation Targeting. Throughout last two decades, economy of Republic of Moldova has gone through recurrent periods of boom and bust. This is the fascinating phenomenon of business cycles and economic fluctuations. Although long periods of high economic growth have sometimes led people to believe that the business cycle was dead, statistical data show that it is still alive and well: economic activity continues to fluctuate in an irregular cyclical manner around its long-run growth trend. and at the start of the present decade the growth rate of real GDP per capita turned negative in all of the three largest OECD economies. A fundamental challenge for macroeconomic theory is to explain why the economy goes through these cyclical movements rather than evolving smoothly over time.

The two previous years of COVID-19 implications derived the capitalist market economies of the world through recurrent periods of boom and bust. This is the fascinating phenomenon of business cycles: economic activity continues to fluctuate in an irregular cyclical manner around its long-run growth trend and at the start of the present decade the growth rate of real GDP per capita turned negative in all of the three largest Eastern European Economies. We concludes that that numerous disarrays identifying with the arrangement of strategies utilized by Monetary Policy in a specific space of study financial variables and parameters can reconsider anticipated time-arrangement and/or uncertainty in terms of model errors.

Keywords: IS-LM model, stochastic dynamic general equilibrium (SDGE), prices, business fluctuations and cycles, prediction and forecasting methods.

1 Introduction

Economic activity today depends crucially on expected economic conditions tomorrow. A drop in the economy's expected future growth rate will tend to reduce the propensities to consume and invest by reducing the expected future earnings of households and firms. Hence the aggregate demand curve will shift down, causing an immediate fall in current output. As another example, a change in the expected rate of inflation will shift the aggregate supply curve by feeding into the nominal wages negotiated by workers and firms. It may also move the aggregate demand curve through its impact on the expected real rate of interest. The expected inflation rate is thus an important determinant of current economic activity. Conventional macroeconomic models often assume that the expected future values of economic variables depend only on the past history of those variables. Indeed, we postulate that the expected inflation rate for the current period is

[*] Corresponding author
E-mail addresses: denis.vintu@hotmail.com (D. Vîntu)

simply equal to the actual inflation rate experienced in the previous period. The assumption of backward-looking expectations may be plausible in 'quiet' times when the macroeconomy is not subject to significant shocks. When people have no particular reason to believe that the tightness of labour and product markets next year will be much different from what it is today, it seems reasonable for them to assume that at next year's inflation rate will be more or less the same as this year's. However, if the economy is hit by an obvious and visible shock such as a dramatic change in the price of imported oil or if there is a clear change in the economic policy regime, say, due to a change of government it does not seem rational for people to assume that next year's economic environment will be the same as this year's.

The focal inspiration of our hypothetical observational investigation emerges from the craving for better understanding the varieties of the drawn out monetary development, with regards to the high-innovation organizations that focus on the little and medium-sized endeavors in our country. The primary commitment of the investigation is that it clarifies why models dependent on endogenous development, change of elements, discernment in business, probability of advancement can change the saving rates and in this way increment the potential outcomes of the creation, joined by the improvement of new example – the specialty of contributing and creating inside innovation development (R&D) area. The IS-LM model begin from the theory of the presence the inconsistency between the monetary development rates measurably enrolled not just in the European territorial setting, yet in addition in the particular instance of the economy of the Republic of Moldova. Schumpeterian thinking from a European point of view, has a solid likeness to the action of (Bronwyn, Ziedonis, 2001) when it connected monetary advancement with the social-financial setting of the locales. As the financial settings are distinctive for the situation of the Republic of Moldova, it is basic to consider the relative point of view. Notwithstanding, we consider that the model in its methodology, can discover its starting point of motivation inside the Anglo-Saxon and the Nippon-Rhine approach. In the event that we restrict ourselves to the traditional definition, advancement follows the hypothetical meaning of development as advancement in organization the executives (for instance, Heilbroner, 1984) and authoritative advancement (Hammond, 1984), are expressly avoided with regards to the condition. In any case, it ought to be referenced that development measures are normal for enormous organizations, where the first three theories are drawn, to be specific:

- huge firms are more fit than more modest firms of creating routine development by catching economies of scale.
- little firms assume a definitive part in making a monopolistic rivalry.
- the more noteworthy, the market power is, the more prominent motivator to be occupied with development, due to the chance of bringing down costs

Our analysis of macroeconomic fluctuations has developed two very incomplete pieces. We consider a full intertemporal macroeconomic model built from microeconomic foundations with explicit assumptions about the behavior of the underlying *shocks and inflation targeting mechanism*. The model generated quantitative predictions about fluctuations, and is therefore an example of a quantitative dynamic stochastic general-equilibrium, or DSGE, model. The problem is that, the model appears to be an empirical failure. For example, it rests on large aggregate technology shocks for which there is little evidence; its predictions about the effects of technology shocks and about business-cycle dynamics appear to be far from what we observe; and it implies that monetary disturbances do not have real effects. To address the real effects of monetary shocks, we introduce nominal rigidity and intertemporal assumption. It established that barriers to price adjustment and other nominal frictions can cause monetary changes to have real effects, analyzed some of the determinants of the magnitude of those effects, and showed how nominal rigidity has important implications for the impacts of other disturbances. But it did so at the cost of abandoning most of the richness of the model developed by Hicks in 1936. His models are largely static models with one-time shocks; and to the extent their focus is on quantitative predictions at all, it is only on addressing broad questions, notably whether plausibly small barriers to price adjustment can lead to plausibly large effects of monetary disturbances. Our ultimate goal is to build a model of fluctuations that combines the strengths of the models in a New Keynesian perspective. The fundamental problem is that there is no agreement about what such a model should look like. As we will see near the end of the paper, the closest thing we have to a consensus starting point for a micro founded DSGE model with *nominal rigidity and inflation targeting* has core implications that appear to be grossly counterfactual. There are two possible ways to address this problem. One is to modify the baseline model. But a vast array of modifications and extensions have been proposed, the extended models are often quite complicated, and there is a wide range of views about which modifications are most useful for understanding macroeconomic fluctuations. The other possibility is to find a different baseline. But that is just a research idea, not a concrete proposal for a model. Because of these challenges, this paper moves us only partway toward constructing a realistic DSGE model of fluctuations in the context of IS-LM framework.

2. Discussion and results

Over the whole of the modern era, cross-country income differences have widened on average. The fact that average incomes in the richest countries at the beginning of the Industrial Revolution were not far above subsistence means that the overall dispersion of average incomes across different parts of the world must have been much smaller than it is today (Pritchett, 1997). Over the past four decades (1990-2020), however, there has been no strong tendency either toward continued divergence or toward convergence. Over the past few centuries, standards of living in industrialized countries have reached levels almost unimaginable to our ancestors. Although comparisons are difficult, the best available evidence suggests that average real incomes today in the Republic of Moldova are 3 times times larger than 20 years ago (See Figure 6 in Appendix III), and between 1.5 times larger than 1990.*

In many situations, we are interested in the proximate determinants of growth. That is, we often want to know how much of growth over some period is due to increases in various factors of production, and how much stems from other forces. Growth accounting, which was pioneered by Abramovitz (1956) and Solow (1957), provides a way of tackling this subject. Perhaps the most exciting recent uses of growth-accounting-style techniques, however, involve their application to microeconomic data to shed light on macroeconomic questions. For example, an extremely influential contribution by Hsieh and Klenow (2009) applies growth-accounting techniques at the firm level to study the importance of misallocation of inputs across firms to low overall productivity in China and India (see also Restuccia, Rogerson, 2008). Hsieh and Klenow first estimate dispersions across manufacturing plants in the value of the marginal products of labor and capital. They then combine model-based and growth-accounting-style analyses to estimate how much overall productivity would rise if inputs were allocated more efficiently. They recognize that complete equalization of estimated marginal products is not realistic, both because there are frictions even in well-functioning economies and because their estimates of marginal products are surely imprecise. They therefore consider the effects of reallocations that would reduce the estimated dispersion in marginal products in China and India to the U.S. level. They find that such reallocations would raise overall productivity in manufacturing in those countries by roughly 50 percent only a small part of the overall difference between poor and rich countries, but still very substantial.

Modern economies undergo significant short-run variations in aggregate output and employment. At some times, output and employment are falling and unemployment is rising; at others, output and employment are rising rapidly and unemployment is falling. For example, the Moldova economy underwent a severe contraction in 2007 2009 an episode known as the Great Recession. From the fourth quarter of 2007 to the second quarter of 2009, real GDP fell 6.0 percent, the fraction of the adult population employed fell by 3.2 percentage points, and the unemployment rate rose from 4.0 to 6.4 percent. In contrast, over the previous 5 years (that is, from the fourth quarter of 2002 to the fourth quarter of 2007), real GDP rose at an average annual rate of 6.2 percent, the fraction of the adult population employed rose by 0.3 percentage points,

* Estimates of average real incomes for many parts of the world over long periods are available from the Maddison Project (Bolt, van Zanden, 2014). Most of the uncertainty about the extent of long-term growth concerns the behavior not of nominal income, but of the price indexes needed to convert those figures into estimates of real income. Adjusting for quality changes and for the introduction of new goods is conceptually and practically difficult, and conventional price indexes do not make these adjustments well. See Nordhaus (1997) and Boskin, Dulberger, Gordon, Griliches, and Jorgenson (1998) for two classic discussions of the issues involved and analyses of the biases in conventional price indexes.

and the unemployment rate fell from 8.0 to 5.1 percent. Understanding the causes of aggregate fluctuations is a central goal of macroeconomics.

It is natural to begin our study of aggregate fluctuations by asking whether they can be understood using a Walrasian model that is, a competitive model without any externalities, asymmetric information, missing markets, or other imperfections. If they can, then the analysis of fluctuations may not require any fundamental departure from conventional microeconomic analysis. The Ramsey model (1928) is the natural Walrasian baseline model of the aggregate economy: the model excludes not only market imperfections, but also all issues raised by heterogeneity among households. This chapter is therefore devoted to extending a variant of the Ramsey model to incorporate aggregate fluctuations. This requires modifying the model in two ways. First, there must be a source of disturbances: without shocks, a Ramsey economy converges to a balanced growth path and then grows smoothly. The classic early models of aggregate fluctuations in Walrasian economies focus on shocks to the economy's technology that is, changes in the production function from period to period (Kydland, Prescott, 1982; Long, Plosser, 1983; Prescott, 1986). But subsequent work considers a range of other shocks. Among the most prominent are changes in government purchases (Aiyagari et al., 1992; Baxter, King, 1993; Christiano, Eichenbaum, 1992) news about future changes in the economy's technology (Beaudry, Portier, 2004, 2006; Jaimovich, Rebelo, 2009; Alexopoulos, 2011) and shocks to the technology for producing investment goods (Greenwood et al., 1988; Hornstein, Krusell, 1996). All these types of shocks represent real as opposed to monetary, or nominal disturbances: technology shocks change the amount that is produced from a given quantity of inputs; government-purchases shocks change the quantity of goods available to the private economy for a given level of production; and so on. For this reason, the models are known as real-business-cycle (or RBC) models. The second change that is needed to the Ramsey model is to allow for variations in employment. In all the models we have seen, labor supply is exogenous and either constant or growing smoothly. Real-business-cycle theory focuses on the question of whether a Walrasian model provides a good description of the main features of observed fluctuations. The models therefore allow for changes in employment by making households' utility depend not just on their consumption but also on the amount they work; employment is then determined by the intersection of labor supply and labor demand. Although a purely Walrasian model is the natural starting point for studying macroeconomic fluctuations, we will see that the real-business-cycle models of this chapter do a poor job of explaining actual fluctuations. Thus we will need to move beyond them. At the same time, however, what these models are trying to accomplish remains the ultimate goal of business-cycle research: building a general-equilibrium model from microeconomic foundations and a specification of the underlying shocks that explains, both qualitatively and quantitatively, the main features of macroeconomic fluctuations. Thus the models of this chapter do not just allow us to explore how far we can get in understanding fluctuations with purely Walrasian models; they also illustrate the type of analysis that is the goal of business-cycle research. Fully specified general-equilibrium models of fluctuations are known as dynamic stochastic general-equilibrium (or DSGE) models. When they are quantitative and use additional evidence to choose parameter values and properties of the shocks, they are calibrated DSGE models.

A very different approach to testing whether monetary shocks have real effects stems from the work of Friedman and Schwartz (1963). Friedman and Schwartz undertake a careful historical analysis of the sources of movements in the money stock in the United States from the end of the Civil War to 1960. On the basis of this analysis, they argue that many of the movements in money, especially the largest ones, were mainly the result of developments in the monetary sector of the economy rather than the response of the money stock to real developments. Friedman and Schwartz demonstrate that these monetary movements were followed by output movements in the same direction. Thus, Friedman and Schwartz conclude, unless the money-output relationship in these episodes is an extraordinary fluke, it must reflect causation running from money to output. C. Romer and D. Romer (1989) provide additional evidence along the same lines. They search the records of the Federal Reserve for the postwar period for evidence of policy shifts designed to lower inflation that were not motivated by developments on the real side of the economy. They identify six such shifts, and find that all of them were followed by recessions. One example is the Volcker disinflation. In October 1979, shortly after Paul Volcker became chair of the Federal Reserve, the Federal Reserve tightened monetary policy dramatically. The change appears to have been motivated by a desire to reduce inflation, and not by the presence of other forces that would have caused output to de-cline in any event. Yet it was followed by one of the largest recessions in postwar U.S. history.

Framework

British economist John Hicks first introduced the IS-LM model in 1936, just a few months after fellow British economist John Maynard Keynes published "The General Theory of Employment, Interest, and Money". Hicks's model served as a formalized graphical representation of Keynes's theories, though it is used mainly as a heuristic device today. The IS-LM model, which stands for "investment-savings" (IS) and "liquidity preference-money supply" (LM) is a Keynesian macroeconomic model that shows how the market for economic goods (IS) interacts with the loanable funds market (LM) or money market. It is represented as a graph in which the IS and LM curves intersect to show the short-run equilibrium between interest rates and output.

Characteristics of the IS-LM framework

- The IS-LM model describes how aggregate markets for real goods and financial markets interact to balance the rate of interest and total output in the macroeconomy.
- IS-LM stands for "investment savings-liquidity preference-money supply."
- The model was devised as a formal graphic representation of a principle of Keynesian economic theory.
- On the IS-LM graph, "IS" represents one curve while "LM" represents another curve.
- IS-LM can be used to describe how changes in market preferences alter the equilibrium levels of gross domestic product (GDP) and market interest rates.
- The IS-LM model lacks the precision and realism to be a useful prescription tool for economic policy.

Characteristics of the IS-LM Graph

- The three critical exogenous, i.e. external, variables in the IS-LM model are liquidity, investment, and consumption. According to the theory, liquidity is determined by the size and velocity of the money supply. The levels of investment and consumption are determined by the marginal decisions of individual actors.
- The IS-LM graph examines the relationship between output, or gross domestic product (GDP), and interest rates. The entire economy is boiled down to just two markets, output and money; and their respective supply and demand characteristics push the economy towards an equilibrium point.
- The IS-LM graph consists of two curves, IS and LM. Gross domestic product (GDP), or (Y), is placed on the horizontal axis, increasing to the right. The interest rate, or (i or R), makes up the vertical axis.
- The IS curve depicts the set of all levels of interest rates and output (GDP) at which total investment (I) equals total saving (S). At lower interest rates, investment is higher, which translates into more total output (GDP), so the IS curve slopes downward and to the right.
- The LM curve depicts the set of all levels of income (GDP) and interest rates at which money supply equals money (liquidity) demand. The LM curve slopes upward because higher levels of income (GDP) induce increased demand to hold money balances for transactions, which requires a higher interest rate to keep money supply and liquidity demand in equilibrium.
- The intersection of the IS and LM curves shows the equilibrium point of interest rates and output when money markets and the real economy are in balance. Multiple scenarios or points in time may be represented by adding additional IS and LM curves.
- In some versions of the graph, curves display limited convexity or concavity. Shifts in the position and shape of the IS and LM curves, representing changing preferences for liquidity, investment, and consumption, alter the equilibrium levels of income and interest rates.

Before starting to make economic modeling, we will try to assume a few facts about the limitations of the IS-LM model. Many economists, including many Keynesians, object to the IS-LM model for its simplistic and unrealistic assumptions about the macroeconomy. In fact, Hicks later admitted that the model's flaws were fatal, and it was probably best used as "a classroom gadget, to be superseded, later on, by something better." Subsequent revisions have taken place for so-called "new" or "optimized" IS-LM frameworks. The model is a limited policy tool, as it cannot explain how tax or spending policies should be formulated with any specificity. This significantly limits its functional appeal. It has very little to say about inflation, rational expectations, or international markets, although later models do attempt to incorporate these ideas. The model also ignores the formation of capital and labor productivity.

Limitations of the IS-LM model

- Definition of IS-LM model is elusive - IS-LM model means something different for Balance of Payments
- IS-LM model is often inadequate
- IS-LM model can be non-linear and difficult to capture
- This makes it difficult to standardize data or use data in a systematic, consistent, continuous manner

Assumptions and Research questions

A fundamental challenge for macroeconomic theory is to explain why the economy goes through these cyclical movements rather than evolving smoothly over time. In short, this phenomenon raises two basic questions:

1. Why do movements in economic activity display persistence?
2. Why do these movements tend to follow a cyclical pattern?

Social infrastructure raises a host of issues:

1. Why should society be concerned about the variability and not just the average values of output and inflation?
2. Should output really be stabilized around its trend level regardless of the type of shocks hitting the economy?
3. What is the appropriate target level of inflation?
4. Will a macroeconomic policy which reduces the variance of output also reduce

Building a Dynamic New Keynesian IS-LM Model

The next step in constructing a complete model of fluctuations is to integrate a model of dynamic price adjustment into a larger model of the economy. Given the wide range of models of pricing behavior we have seen, it is not possible to single out one approach as the obvious starting point. Moreover, dynamic general-equilibrium models with the behavior of inflation built up from microeconomic foundations quickly become complicated. In this section, we therefore consider to build the New Keynesian IS-LM model.

In constructing a complete model of fluctuations (DSGE) we will integrate a model of dynamic price adjustment into a larger model of the economy. In this sense, the balance of the economy can be dynamic if and only if, it is able to adjust effectively and withstand shocks as a result of fiscal reform, monetary reform, competitive reform, energy reform, industrial reform, whatever be it, without causing significant damage to the real economy. This definition nuances economic and dynamic balance as the ability of the economic system to respond to fluctuations and shocks. The dynamic general equilibrium (EGE) and the stochastic component (S) would represent the system's ability to assess, establish inflation, and manage full employment, in fact more than endogenous economic growth. Given the wide range of models of pricing behavior we have seen, it is not possible to single out one approach as the obvious starting point. Moreover, dynamic general-equilibrium models with the behavior of inflation built up from microeconomic foundations quickly become complicated. In this section, we therefore consider only an illustrative, relatively simple general-equilibrium model.

The specific model we consider is the canonical three-equation new Keynesian model of Clarida, Galí, and Gertler (2000). The price-adjustment equation is the new Keynesian Phillips curve. This treatment of price adjustment has two main strengths. The first is its strong microeconomic foundations: it comes directly from an assumption of infrequent adjustment of nominal prices. The other is its comparative simplicity: inflation depends only on expected future inflation and current output, with no role for past inflation or for more complicated dynamics. The aggregate-demand equation of the model is the new Keynesian IS curve. The final equation describes monetary policy. So far, because our goal has been to shed light on the basic implications of various assumptions concerning price adjustment, we have considered only simple paths of the money supply (or aggregate demand). To build a model that is more useful for analyzing actual macroeconomic fluctuations, however, we need to assume that the central bank follows a rule for the interest rate. In particular, in keeping with the forward-looking character of the new Keynesian Phillips curve and the new Keynesian IS curve, we assume the central bank follows a forward-looking interest-rate rule, adjusting the interest rate in response to changes in expected future inflation and output. The other ingredient of the model is its shocks: it includes serially correlated disturbances to all three equations. This allows us to analyze disturbances to private aggregate demand, price-setting behavior, and monetary policy. Finally, for convenience, all the equations are linear and the constant terms are set to zero. Thus the variables should be interpreted as departures from their steady-state or trend values.

The three core equations are:

$$y_t = E_t[y_{t+1}] - \frac{1}{\theta} r_t + u_t^{IS}, \theta > 0 \quad (1)$$

$$\pi_t = \beta[\pi_{t+1}] + k y_t + u_t^{\pi}, 0 < \beta < 1, k > 0 \quad (2)$$

$$r_t = \varphi_\pi E_t[\pi_{t+1}] + \varphi_y E_t[y_{t+1}] + u_t^{MP}, \varphi_\pi > 0,\ \varphi_y \geq 0 \quad (3)$$

Equation (1) is the new Keynesian IS curve, (2) is the new Keynesian Phillips curve, and (3) is the forward-looking interest-rate rule. The shocks follow independent AR-1 processes:

$$u_t^{IS} = \rho_{IS} u_{t-1}^{IS} + e_t^{IS},\ -1 < \rho_{IS} < 1, \quad (4)$$

$$u_t^{\pi} = \rho_\pi u_{t-1}^{\pi} + e_t^{\pi},\ -1 < \rho_\pi < 1, \quad (5)$$

$$u_t^{MP} = \rho_{MP} u_{t-1}^{MP} + e_t^{MP},\ -1 < \rho_{MP} < 1, \quad (6)$$

where $e^{IS}, e_t^{\pi}\ and\ e_t^{MP}$ are white-noise disturbances that are uncorrelated with one another.

The model is obviously extremely stylized. To give just a few examples, all behavior is forward-looking; the dynamics of inflation and aggregate demand are very simple; and the new Keynesian Phillips curve is assumed to describe inflation dynamics despite its poor empirical performance. Nonetheless, because its core ingredients are so simple and have such appealing microeconomic foundations, the model is a key reference point in modern models of fluctuations. The model and variants of it are frequently used, and it has been modified and extended in many ways. The presence of the forward-looking elements implies that for some parameter values, the model has sunspot solutions.

The first step in solving the model is to express output and inflation in terms of their expected future values and the disturbances. Applying straightforward algebra to (1) (2) gives us

$$y_t = -\frac{\varphi_\pi}{\theta} E_t[\pi_{t+1}] + (1-\frac{\varphi_y}{\theta}) E_t[y_{t+1}] + u_t^{IS} - \frac{1}{\theta} u_t^{MP}, \quad (7)$$

$$\pi_t = -(\beta - \frac{\varphi_\pi k}{\theta} E_t[\pi_{t+1}] + (1-\frac{\varphi_y}{\theta}) k E_t[y_{t+1}] + k u_t^{IS} + u_t^{\pi} - \frac{k}{\theta} u_t^{MP}, \quad (8)$$

An important and instructive special case of the model occurs when there is no serial correlation in the disturbances (so $\rho_{IS} = \rho_\pi = \rho_{MP} = 0$. In this case, because of the absence of any backward-looking elements and any information about the future values of the disturbances, there is no force causing agents to expect the economy to depart from its steady state in the future. That is, the fundamental solution has $E_t[y_{t+1}]$ and $E_t[\pi_{t+1}]$ always equal to zero. To see this, note that with $E_t[y_{t+1}] = E_t[\pi_{t+1}] = 0$, equations (3), (7), and (8) simplify to

$$y_t = u_t^{IS} - \frac{1}{\theta} u_t^{MP}, \quad (9)$$

$$\pi_t = k u_t^{IS} + u_t^{\pi} - \frac{k}{\theta} u_t^{MP}, \quad (10)$$

$$r_t = u_t^{MP} \quad (11)$$

If (9) (11) describe the behavior of output, inflation, and the real interest rate, then, because we are considering the case where the u's are white noise, the expectations of future output and inflation are always zero. (9) (11) therefore represent the fundamental solution to the model in this case. These expressions show the effects of the various shocks. A contractionary monetary-policy shock raises the real interest rate and lowers output and inflation. A positive shock to private aggregate demand raises output and inflation and has no impact on the real interest rate. And an unfavorable inflation shock raises inflation but has no other effects. These results are largely conventional. The IS shock fails to affect the real interest rate because monetary policy is forward-looking, and so does not respond to the increases in current output and inflation. The fact that monetary policy is forward-looking is also the reason the inflation shock does not spill over to the other variables. The key message of this case of the model, however, is that the model, like the baseline real-business-cycle model, has no internal propagation mechanisms. Serial correlation in output, inflation, and the real interest rate can come only from serial correlation in the driving processes.

A straightforward way to solve the model in the general case is to use the method of undetermined coefficients. Given the model's linear structure and absence of backward-looking behavior, it is reasonable to guess that the endogenous variables are linear functions of the disturbances.

Data

To analyze the trade-off between the output gap and the inflation rate volatility, we used a backward-looking model. The data used in the empirical analysis are quarterly and were obtained from the National Institute of Statistics (from 2000: 1 to 2020: 4 for Republic of Moldova). We will analyze the various models of dynamic price adjustment in a common framework. The framework draws heavily on the model of exogenous nominal rigidity and the model of inflation targeting. Time is discrete. Each period, imperfectly competitive firms produce output using labor as their only input. As in, the production function is one-for-one; thus aggregate output and aggregate labor input are equal. The model omits government purchases and international trade, aggregate consumption and aggregate output are equal. Households maximize utility, taking the paths of the real wage and the real interest rate as given. Firms, which are owned by the households, maximize the present discounted value of their profits, subject to constraints on their price-setting (which vary across the models we will consider). Finally, a central bank determines the path of the real interest rate through its conduct of monetary policy.

Empirical application: Money and Output

The dimension on which the real-business-cycle view of macroeconomic fluctuations departs most fundamentally from traditional views concerns the effects of monetary disturbances. A monetary shock, such as a change in the money supply, does not change the economy's technology, agents' preferences, or the government's purchases of goods and services; nor does it provide news about any of those things. As a result, in models with completely flexible prices, including the RBC models of this chapter, its only effect is to change nominal prices; all real quantities and relative prices are unaffected. In traditional views of fluctuations, in contrast, monetary changes have substantial real effects, and they are often viewed as important sources of output movements. Moreover, as we will see in the next two chapters, the same factors that can cause monetary disturbances to have significant real effects have important consequences for the effects of other disturbances. This discussion suggests that a critical test of pure real-business-cycle models is whether monetary disturbances have substantial real effects. Partly for this reason, an enormous amount of research has been devoted to trying to determine the effects of monetary changes. Since our goal is to test whether monetary changes have real effects, a seemingly obvious place to start is to just regress output on money. Such regressions have a long history. One of the earliest and most straightforward was carried out by Leonall Andersen and Jerry Jordan of the Federal Reserve Bank of St. Louis (Andersen, Jordan, 1968). For that reason, the regression of output on money is known as the St. Louis equation. Here we consider an example of the St. Louis equation. The left-hand-side variable is the change in the log of real GDP. The main right-hand-side variable is the change in the log of the money stock, as measured by M2; since any effect of money on output may occur with a lag, the contemporaneous and four lagged values are included. The regression also includes a constant and a time trend (to account for trends in output and money growth). The data are quarterly, and the sample period is 2000 Q1 2020 Q4 (the start date is determined by data availability. The end date is chosen to not to omit the enormous financial and monetary changes associated with the COVID 19 Recession).

The results are:

$$\Delta lnY_t = C + \Delta lnm_t + \Delta lnm_{t-1} + \Delta lnm_{t-2} + \Delta lnm_{t-3} + \Delta lnm_{t-4} - t \quad (12)$$

where the numbers in parentheses are standard errors.

The sum of the coefficients on the current and four lagged values of the money-growth variable is 0.26, with a standard error of 0.10. Thus the estimates suggest that a 1 percent increase in the money stock is associated with an increase of 1 % in output over the next year, and the null hypothesis of no association is rejected at high levels of significance. Does this regression, then, provide important evidence in support of monetary over real theories of fluctuations? The answer is no. There are several basic problems with a regression like this one. First, causation may run from output to money rather than from money to output. A simple story, formalized by King and Plosser (1984), is that when firms plan to increase production, they increase their money holdings because they will need to purchase more intermediate inputs. Similarly, households may increase their money holdings when they plan to increase their purchases. Aggregate measures of the money stock, such as M2, are not set directly by the National Bank of Moldova but are determined by the interaction of the supply of high-powered money with the behavior of the banking system and the public. Thus shifts in money demand stemming from changes in firms' and households' production plans can lead to changes in the money stock. As a result, we may see changes in the money stock in advance of output movements even if the changes in money are not causing the output movements. The second and even more severe problem with the St. Louis equation involves the determinants of monetary policy. Suppose the National Bank of Moldova adjusts the money stock to try to offset other factors that influence aggregate output. Then if monetary changes have real effects and the NBM's efforts to stabilize the economy are successful, we will observe fluctuations in money without movements in output. Thus, just as we cannot conclude from the positive correlation between money and output that money causes output, if we fail to observe such a correlation we cannot conclude that money does not cause output. A more prosaic difficulty with the St. Louis equation is that there have been large shifts in the demand for money over this period. At least some of the shifts are probably due to financial innovation and deregulation, but their causes are not entirely understood. Models with sticky prices predict that if the NBM does not adjust the money supply fully in response to these disturbances, there will be a negative relationship between money and output. A positive money demand shock, for example, will increase the money stock but increase the interest rate and reduce output. And even if the NBM accommodates the shifts, the fact that they are so large may cause a few observations to have a disproportionate effect on the results.

As a result of the money demand shifts, the estimated relationship between money and output is sensitive to such matters as the sample period and the measure of money. For example, if equation (12) is estimated using M1 in place of M2, or if it is estimated over a somewhat different sample period, the results change considerably. Because of these difficulties, regressions like (12) are of little value in determining the effects of monetary changes on output.

3. Conclusion

The central assumption of the models we have been analyzing is that there is some kind of barrier to complete price adjustment at the level of individual firms. It is therefore natural to investigate pricing policies at the microeconomic level. By doing so, we can hope to learn whether there are barriers to price adjustment and, if so, what form they take. The microeconomics of price adjustment have been investigated by many authors. The broadest studies of price adjustment in the Moldova are the survey of National Bureau of Statistics (NBS). Blinder (1998) and Nakamura and Steinsson (2008) analyses show that the average interval between price changes for intermediate goods is about a year. In contrast, Klenow and Kryvtsov (2008) analyses find that the typical period between price changes for final goods and services is only about 4 months. The baseline new Keynesian model has considerable appeal. It is elegant and tractable, built up from microeconomic foundations, incorporates nominal rigidity and intertemporal optimization, and can easily be related to traditional Keynesian ideas. But those features do not ensure that it provides a useful guide to the behavior of actual economies. We have already seen that it lacks any mechanism that causes shocks to have persistent effects, and that the implications of the new Keynesian Phillips curve for the costs of disinflation are the opposite of conventional wisdom and of some empirical evidence. In addition, we will see in the next chapter that the evidence about consumption behavior does not support the assumption of full intertemporal optimization underlying the new Keynesian IS curve. More generally, the model's strong forward-looking elements and complete absence of backward-looking components mean that it implies that the economy's response to shocks is often immediate and strong. An experiment that shows the model's limitations starkly is the forward guidance puzzle (Carlstrom et al., 2015; Del Negro et al., 2015). Consider an economy described by equations (1) (3) where, for simplicity, the shocks are absent. Thus, y, π , and r are zero in all periods. Because r and π are zero, the nominal interest rate is zero as well.

4. Acknowledgements

This article is a result of the grant "ASEM doctoral grants for the period 2019–2023" funded from the state budget during the doctoral studies, but also during activity I carried out as a scientific researcher at the National Institute for Economic Research (NIER) in Chisinau, Moldova – between May 2019 and December 2019.

References

Acemoglu, 2009 – *Acemoglu, D.* (2009). Introduction to Modern Economic Growth. Princeton, NJ: Princeton University Press.

Aghion, Howitt, 1992 – *Aghion, P., Howitt, P.* (1992). A Model of Growth through Creative Destruction. *Econometrica*. 60 (March): 323-351.

Akerlof et al., 1996 – *Akerlof, G.A., William, T.D., George L.P. (*1996). 'The Macroeconomics of Low Inflation. *Brookings Papers on Economic Activity*. 1: 1-76.

Alesina, Drazen, 1991 – *Alesina, A., Allan, D.* (1991). Why Are Stabilizations Delayed? *American Economic Review*. 81 (December): 1170-1188.

Alexopoulos, 2004 – *Alexopoulos, M.* (2004). Unemployment and the Business Cycle. *Journal of Monetary Economics*. 51 (March): 277-298.

Allais, 1947 – *Allais, M.* (1947). Économie et Intérêt [Economy and Interest]. Paris: Impremerie Nationale. [in French]

Backus, Driffill, 1985 – *Backus, D., Driffill, J.* (1985). Inflation and Reputation. *American Economic Review*. 75 (June): 530-538.

Ball et al., 1988 – *Ball, L., Gregory Mankiw, N., Romer, D.* (1988). The New Keynesian Economics and the Output-Inflation Tradeoff. *Brookings Papers on Economic Activity*. 1: 1-65.

Ball, Moffitt, 2001 – *Ball, L., Moffitt, R.* (2001). Productivity Growth and the Phillips Curve. In Alan B. Krueger and Robert M. Solow, eds. The Roaring Nineties: Can Full Employment Be Sustained? New York: Russell Sage Foundation. Pp. 61-91.

Barro, 1976 – *Barro, R.J.* (1976). Rational Expectations and the Role of Monetary Policy. *Journal of Monetary Economics*. 2 (January): 1-32.

Barro, Xavier, 2003 – *Barro, R.J., Xavier, S.* (2003). Economic Growth, 2d ed. Cambridge, MA: MIT Press.

Bean, 1994 – *Bean, Ch.R.* (1994). European Unemployment: A Survey. *Journal of Economic Literature*. 32 (June): 573-619.

Bernanke, Mihov, 1998 – *Bernanke, B.S., Mihov, I.* (1998). Measuring Monetary Policy. *Quarterly Journal of Economics*. 113 (August): 869-902.

Blanchard, 1985 – *Blanchard, O.J.* (1985). Debts, Deficits, and Finite Horizons. *Journal of Political Economy*. 93 (April): 223-247.

Blanchard, Summers, 1986 – *Blanchard, O.J., Summers, L.H.* (1986). Hysteresis and the European Unemployment Problem. *NBER Macroeconomics Annual*. 1: 15-78.

Blinder, 1998 – *Blinder, A.S.* (1998). Asking about Prices: A New Approach to Understanding Price Stickiness. New York: Russell Sage Foundation.

Clarida et al., 2000 – *Clarida, R., Galí, J., Gertler, M.* (2000). Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory. *Quarterly Journal of Economics*. 115 (February): 147-180.

Cochrane, 1998 – *Cochrane, J.H.* (1998). What Do the VARs Mean? Measuring the Output Effects of Monetary Policy. *Journal of Monetary Economics*. 41 (April): 277-300.

Danziger, 1999 – *Danziger, L.* (1999). A Dynamic Economy with Costly Price Adjustments. *American Economic Review*. 89 (September): 878-901.

Fischer, Summers, 1989 – *Fischer, S., Summers, L.H.* (1989). Should Governments Learn to Live with Inflation? *American Economic Review*. 79 (May): 382-387.

Friedman, 1968 – *Friedman, M.* (1968). The Role of Monetary Policy. *American Economic Review*. 58 (March): 1-17.

Galí, 1992 – *Galí, J.* (1992). How Well Does the IS-LM Model Fit Postwar U.S. Data? *Quarterly Journal of Economics*. 107 (May): 709-738.

McCallum et al., 1999 – *McCallum, B.T., Nelson, E.* (1999). An Optimizing IS-LM Specification for Monetary Policy and Business Cycle Analysis. *Journal of Money, Credit, and Banking*. 31 (August, Part 1): 296-316.

Gertler, Karadi, 2011 – *Gertler, M., Karadi, P.* (2011). A Model of Unconventional Monetary Policy. *Journal of Monetary Economics*. 58 (January): 17-34.

Hamilton, 1994 – *Hamilton, J.* (1994). Time Series Analysis. Princeton, NJ: Princeton University Press.

Koopmans, 1965 – *Koopmans, T.C.* (1965). On the Concept of Optimal Economic Growth. In The Economic Approach to Development Planning. Amsterdam: Elsevier.

Kydland, Prescott, 1982 – *Kydland, F.E., Prescott, E.C.* (1982). Time to Build and Aggregate Fluctuations. *Econometrica*. 50 (November): 1345-1370.

Ljungqvist, Sargent, 1998 – *Ljungqvist, L., Sargent, Th.J.* (1998). The European Unemployment Dilemma. *Journal of Political Economy*. 108 (June): 514-550.

Ljungqvist, Sargent, 2004 – *Ljungqvist, L., Sargent, Th.J.* (2004). Recursive Macroeconomic Theory, 2d ed. Cambridge: MIT Press.

Lucas, 1987 – *Lucas, R.E.Jr.* (1987). Models of Business Cycles. Oxford: Basil Blackwell.

Mankiw, 1989 – *Mankiw, N.G.* (1989). Real Business Cycles: A New Keynesian Perspective. *Journal of Economic Perspectives*. 3 (Summer): 79-90.

Nordhaus, 2013 – *Nordhaus, W.D.* (2013). The Climate Casino: Risk, Uncertainty, and Economics for a Warming World. New Haven, CT: Yale University Press.

North, 1981 – *North, D.C.* (1981). Structure and Change in Economic History. New York: W.W. Norton.

Okun, 1962 – *Okun, A.M.* (1962). Potential GNP: Its Measurement and Significance. Proceedings of the Business and Economics Statistics Section, American Statistical Association, 98 103. Washington: American Statistical Association.

Prescott, 1986 – *Prescott, E.C.* (1986). Theory Ahead of Business-Cycle Measurement. Carnegie-Rochester Conference Series on Public Policy 25 (Autumn): 11-44.

Romer et al., 2004 – *Romer, Ch.D., David, H.R.* (2004). A New Measure of Monetary Shocks: Derivation and Implications. *American Economic Review*. 94 (September): 1055-1084.

Sargent, Neil, 1975 – *Sargent, Th.J., Neil, W.* (1975). Rational Expectations, the Optimal Monetary Instrument, and the Optimal Money Supply Rule. *Journal of Political Economy*. 83 (April): 241-254.

Tobin, 1972 – *Tobin, J.* (1972). Inflation and Unemployment. *American Economic Review*. 62 (March): 1-18.

Appendix I: Case of Rational Expectations

The bulk of the appendix I extends the analysis of the microeconomic foundations of incomplete nominal flexibility to dynamic settings. This material vividly illustrates the lack of consensus about how best to build a realistic dynamic model of fluctuations: counting generously, we will consider seven distinct models of dynamic price adjustment. As we will see, the models often have sharply different implications for the macroeconomic consequences of microeconomic frictions in price adjustment. This analysis shows the main issues in moving to dynamic models of price-setting and illustrates the list of ingredients to choose from, but it does not identify a specific "best practice" model. In considering dynamic models of price adjustment, it is therefore tempting to assume that the only nominal imperfection is that firms must pay a fixed cost each time they change their price. There are two reasons not to make this the only case we consider, however. First, it is complicated: analyzing models of dynamic optimization with fixed adjustment costs is technically challenging and only rarely leads to closed-form solutions. Second, the vision of price-setters constantly monitoring their prices and standing ready to change them at any moment subject only to an unchanging fixed cost may be missing something important. Many prices are reviewed on a predetermined schedule and are only rarely changed at other times. For example, many wages are reviewed annually; some union contracts specify wages over a three-year period; and many companies issue catalogues with prices that are in effect for six months or a year. Thus price changes are not purely state dependent (that is, triggered by developments within the economy, regardless of the time over which the developments have occurred); they are partly time dependent (that is, triggered by the passage of time). Because time-dependent models are easier, we will start with them: the Fischer, or Fischer-Phelps-Taylor, model (Fischer, 1977; Phelps, Taylor, 1977); the Taylor model (Taylor, 1979); and the Calvo model (Calvo, 1983). All three models posit that prices (or wages) are set by multiperiod contracts or commitments. In each period, the contracts governing some fraction of prices expire and must be renewed; expiration is determined by the passage of time, not economic developments. The central result of the models is that multiperiod contracts lead to gradual adjustment of the price level to nominal disturbances. As a result, aggregate demand disturbances have persistent real effects. The Taylor and Calvo models differ from the Fischer model in one important respect. The Fischer model assumes that prices are predetermined but not fixed. That is, when a multiperiod contract sets prices for several periods, it can specify a different price for each period. In the Taylor and Calvo models, in contrast, prices are fixed: a contract must specify the same price each period it is in effect. The difference between the Taylor and Calvo models is smaller. In the Taylor model, opportunities to change prices arrive deterministically, and each price is in effect for the same number of periods. In the Calvo model, opportunities to change prices arrive randomly, and so the number of periods a price is in effect is stochastic. In keeping with the assumption of time-dependence rather than state-dependence, the stochastic process governing price changes operates independently of other factors affecting the economy. The qualitative implications of the Calvo model are the same as those of the Taylor model. Its appeal is that it yields simpler inflation dynamics than the Taylor model, and so is easier to embed in larger models. There are two differences between the models. First, money growth is always positive in the Caplin-Spulber model, while the version of the Danziger-Golosov-Lucas model we will consider assumes no trend money growth. Second, the Caplin-Spulber model assumes no firm-specific shocks, while the Danziger-Golosov-Lucas model includes them.

In the paper before, we discussed elements of other DSGE models with monetary non-neutrality. Because of the models' complexity and the lack of agreement about their key ingredients, however, it stops short of analyzing other fully specified models. Instead of just mechanically extrapolating the past into the future, rational households and firms will seek to utilize all the relevant information available to them when they form expectations about the future state of the economy. In the early 1970s, some macroeconomists took this idea of forward-looking expectations to its logical limit by advancing the rational expectations hypothesis (REH)[*].

The rational expectations hypothesis takes the above line of reasoning one step further by suggesting that economic agents do not make systematic forecast errors. To be sure, since the economy is often hit by stochastic shocks (which were ignored for simplicity in Figure 1) agents usually do make mistakes when they try to predict the future state of the economy. In the theory of rational expectations, people use all the available information to make the best possible forecasts of the economic variables which are relevant to them. Moreover, the available information includes information about the structure of the economy. The idea is that, even though in practice the layman may not know much about the way the economy works. The economic forecasts produced by professional economists are available to the public through the media. So in this way people have access to the most competent forecasts of, say, next year's rate of inflation. Economists should therefore model the formation of expectations as if people use the relevant economic model to predict inflation and other economic variables which are important for their economic decisions. In other words, rational expectations are model-consistent expectations: they are identical to the forecasts one would make by using the available knowledge of the structure of the economy as embodied in the relevant economic models. Another way of putting it is to say that economic analysts should not assume that they are smarter than the economic agents whose behaviour they are trying to predict. Instead, they should assume that agents form their expectations in accordance with the analysts' own description of the economy. If they did not and if the analysts' model is

[*] The rational expectations hypothesis was originally introduced in a microeconomic setting by John Muth, 'Rational Expectations and the Theory of Price Movements', Econometrica, 29, 1961, pp. 315-335. Later on, the REH was introduced into 11acroeconomic theory by Robert E. Lucas, 'Expectations and the Neutrality of Money', Journal of Economic Theory, 4, 1972, pp. 103-1 24, and by Thomas J. Sargent, 'Rational Expectations, the Real Rate of Interest, and the Natural Rate of Unemployment', Brookings Papers on Economic Activity, 2, 1973, pp. 429-472; followed by many others.

correct, then agents would be making systematic expectational errors, and presumably this would induce them to change the rules of thumb by which they form their expectations until there is no discernible systematic pattern in their forecast errors. This idea of rational expectations essentially revolutionized macroeconomic theory. The REH is obviously a very strong assumption. It can be criticized on theoretical as well as empirical grounds. But before addressing these criticisms, this chapter will explain the case for the REH in more detail and derive some of its striking implications. Our main purpose is to illustrate the importance of the way expectations are formed. In particular, we will show how the effects of macroeconomic stabilization policy may differ significantly depending on whether expectations are rational or backward-looking.

The case against backword-looking expectations. One way of justifying the assumption of rational expectations is to examine more carefully the implications of a macro model with backward-looking expectations. As we will illustrate in this section, in some circumstances the assumption of backward-looking expectations implies that economic agents are implausibly naive. Consider the model of aggregate demand and aggregate supply, and suppose for simplicity that public spending always stays on trend so that $g_t = \bar{g}$. In the usual notation, our AS-AD model may then be restated as follows:

Goods market equilibrium:

$$y_t - \bar{y} = \vartheta_t - a_2(r_t - \bar{r}) \quad (1)$$

Real interest rate:

$$r_t = i_t - \pi^e_{t+1} \quad (2)$$

Price formation:

$$\pi_t = \pi^e_t + \gamma(y_t - \bar{y}) + s_t \quad (3)$$

Monetary policy rule:

$$i_t = r_t + \pi^e_{t+1} + h(\pi_t - \pi_t{}^*) + b(y_t - \bar{y}) \quad (4)$$

Expectations:

$$\pi^e_t = \pi_{t-1} \quad (5)$$

Equation (5) assumes a particularly simple form of backward-looking expectations by postulating that the expected inflation rate for the current period equals the actual inflation rate observed during the previous period. We will now illustrate the implications of this assumption of 'static' expectations by solving the model (1)- (5). For the moment, we will simplify by setting the exogenous aggregate demand and supply shock variables equal to their zero mean values, $\vartheta_t = s_t$. On this assumption we find by substituting (2), (4) and (5) into (1) that the aggregate demand curve may be written as:

$$y_t - \bar{y} = \alpha(\pi_t - \pi_t{}^*), \quad \alpha \equiv \frac{a_2\, h}{1+a_2\, b} \quad (6)$$

while substitution of (5) into (3) yields the aggregate supply curve:

$$\pi_t = \pi_{t-1} + \gamma(y_t - \bar{y}) \quad (7)$$

Inserting (6) into (7) and rearranging, we obtain the first-order linear difference equation:

$$\pi_t = \pi_{t-1} + \gamma\alpha(\pi_t{}^* - \pi_t) \Leftrightarrow \quad \pi_t - \pi_t{}^* = \pi_{t-1} - \pi_t{}^* - \gamma\alpha(\pi_t{}^* - \pi_t) \quad \Leftrightarrow$$

$$\pi_t - \pi_t{}^* = \beta(\pi_{t-1} - \pi_t{}^*), \ \beta \equiv \frac{1}{1+\gamma\alpha}, \quad (8)$$

which has the solution:

$$\pi_t = \pi_t{}^* + \beta^t(\pi_0 - \pi_t{}^*), \quad t = 0,1,2,\ldots \quad (9)$$

where π_0 – is the predetermined initial value of the inflation rate in period 0. Since we see from (8) that $0 < \beta < 1$, it follows from (9) that the inflation rate will converge monotonically towards its target rate $\pi_t{}^*$ as t tends to infinity. From (9) we may calculate the *inflation forecast error*, defined as the difference between the actual and the expected inflation rate. Given the assumption of static expectations ($\pi_t{}^e = \pi_{t-1}$), the inflation forecast error during the phase of adjustment to long-run equilibrium is:

$$\pi_t - \pi_t{}^e = \pi_t - \pi_{t-1} = \beta^i(\pi_0 - \pi_t{}^*) - \beta^{t-1}(\pi_0 - \pi_t{}^*) \Leftrightarrow \ \pi_t - \pi_t{}^e = \beta^{t-1}(\pi_0 - \pi_t{}^*)$$
$$(\beta - 1) \quad (10)$$

Suppose now that at the end of period 0 the government appoints a 'tough' new central bank governor who announces a significant reduction in the target inflation rate from the start of period 1. For concreteness, suppose the inflation target $\pi_t{}^*$ is reduced from 3 per cent to 0 per cent per year. Using empirically plausible parameter values like γ= 0.18 and α = 0.878, we may then simulate the evolution of the inflation forecast error implied by Eq. (10), assuming that the initial inflation rate: no was equal to the previous inflation target of 3 per cent. The result of the simulation is shown in Figure 1. We see that throughout the period of adjustment to the new inflation target of 0, the public systematically overestimates the actual rate of inflation. The reason for these systematic mistakes in forecasting inflation is that the public mechanically extrapolates last period's observed inflation rate into the filture. Thus, even though the central bank is determined to bring inflation down by setting a high interest rate as long as $\pi_t > \pi_t^*$, people nevertheless continue to believe period after period that next year's inflation rate will be the same as this year's.

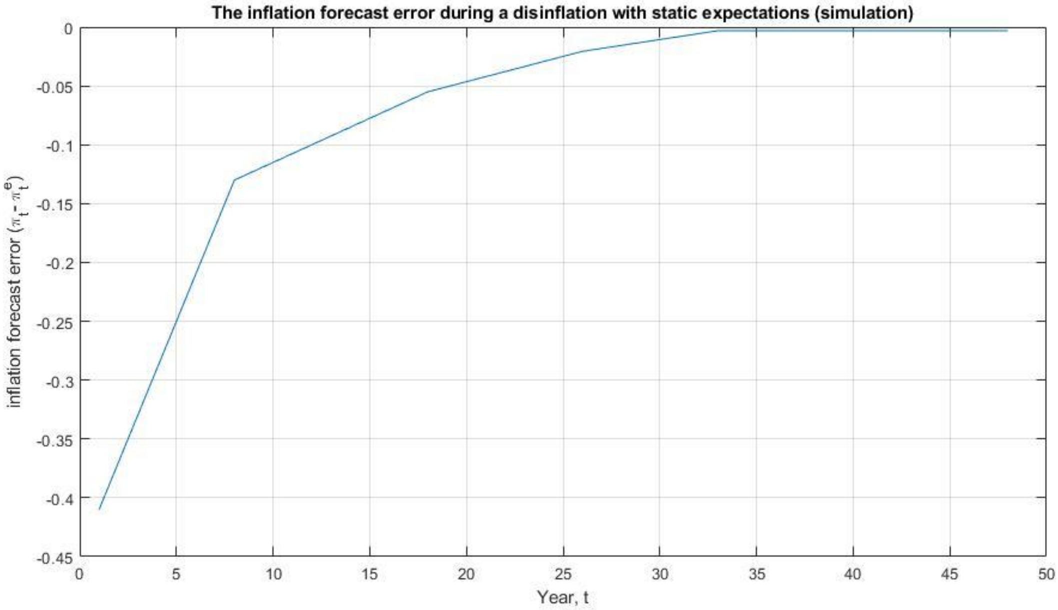


Fig. 1. The inflation forecast error during a disinflation with static expectations (simulation)

Clearly, this behaviour is not very intelligent, especially not if the new central bank governor has publicly announced his determination to kill inflation. Presumably, informed citizens will observe or at least gradually learn that the monetary policy regime has changed, and this should affect the way they form their expectations of inflation. This is a statement of the case against the assumption of backward-looking expectations: if important aspects of the economic environment (such as the economic policy regime) change, rational agents are likely to realize that the future path of the economy cannot be projected by simply observing how the economy behaved in the past. To put it another way, rational economic agents will utilize all relevant information when they form their expectations about the future, including information about changes in economic policy and other new developments which are likely to influence the course of the economy. According to the REH there will be no systematic bias in these forecast errors. For example, sometimes the rate of inflation will be overestimated, and sometimes it will be underestimated, but on average people's inflation forecasts will be correct. The justification for this assumption is that economic actions based on erroneous expectations cause losses of profits and utility, and hence agents have an incentive to minimize their forecast errors. If the forecast errors revealed a systematic pattern such as persistent overestimation or underestimation, rational agents should be able to detect this pattern and would have an incentive to revise their methods of expectations formation to weed out systematic biases in their guesses about the future. In an uncertain environment the economic variables about which agents form their expectations may be seen as stochastic variables. In such a setting we may formalize the hypothesis of rational expectations by saying that the subjective expectation of some economic variable X for time t, X_t^e is equal to the objective mathematical expectation of X, conditional on all available information at the time the expectation is formed.

Thus, if the expectation for period t is formed at the end of period *t - 1*. the expected value of *X* for period *t* is:

$$X_t^c A = E\lfloor X_t \ / \ I_{t-1} \rfloor \quad (11)$$

Where E[.] is the mathematical expectations operator, and I_{t-1} is the information set available to the agent at the end of period t-1. Hence $E\lfloor X_t \ / \ I_{t-1} \rfloor$ is the mean value of the stochastic economic variable *X* for period *t*, calculated at the end of period *t - 1* using all the information available at that time.

Appendix II: Pollution and Climate Change

In context of IS-LM framework, it is possible that our attempts to interpret the scientific evidence and estimate the likely welfare effects are far from the mark. There appear to be two main considerations that could lend support to much stronger views of the costs of climate change and the value of measures to address it. The first is tail risks (or tipping points) that is, the perhaps small chance that outcomes will be vastly worse than the point estimates. Nordhaus (2013) tries to account for uncertainty and concludes that it does not greatly change his conclusions; one reason is simply that just as outcomes could be worse than his point estimates, they could also be better. Likewise, Greenstone, Kopits, and Wolverton (2013) find that there are alternative assumptions that lead to, say, a doubling of the estimated social cost of carbon, but that it is hard to make a case for estimates that are qualitatively different from their baseline. In contrast, Weitzman (2009) argues that tail risks fundamentally change the analysis of climate change and support much more dramatic policy changes.

The second important issue is the appropriate discount rate: even small changes in the discount rate have very large effects on analyses of policies that involve costs today in exchange for benefits extending decades into the future. And with a sufficiently low discount rate, impacts at horizons beyond the 50 to 100 years usually examined in analyses of climate change could have large effects on the conclusions. A good introduction to the question of how to discount the costs and benefits of actions to mitigate climate change is the debate between Nordhaus (2007) and Stern (2008). Despite these complications, the fact remains that most (though certainly not all) economists who have studied climate change seriously, even ones whose initial positions were very sympathetic with environmental concerns, have concluded that the impact of climate change on growth is likely to be no more than moderate. Finally, it is important to remember that climate change is not the only type of pollution. Indeed, using an approach similar to his analysis of climate change, Nordhaus (1992) estimates that the welfare costs of the externalities from other types of pollution are probably slightly larger than those from climate change; his point estimate is that they are lowering appropriately measured annual growth by roughly 0.04 percentage points. Thus, policy-makers and concerned citizens should not lose sight of more conventional types of pollution.

Appendix III: Social Infrastructure

The analysis in the previous section tells us about the roles of policy stabilization in the light of cross-country income differences. We would like to go deeper and investigate the determinants of these sources of income differences. A leading candidate hypothesis is that differences in these determinants of income stem largely from differences in what Hall and Jones (1999) call social infrastructure. By social infrastructure, Hall and Jones mean institutions and policies that align private and social returns to activities. There is a tremendous range of activities where private and social returns may differ. They fall into two main categories. The first consists of various types of investment. If an individual engages in conventional saving, acquires education, or devotes resources to R&D, his or her private returns are likely to fall short of the social returns because of taxation, expropriation, crime, externalities, and so on. The second category consists of activities intended for the individual's current benefit. An individual can attempt to increase his or her current income through either production or diversion. Production refers to activities that increase the economy's total output at a point in time. There are many different aspects of social infrastructure. It is useful to divide them into three groups. The first group consists of features of the government's fiscal policy. For example, the tax treatment of investment and marginal tax rates on labor income directly affect relationships between private and social returns. Only slightly more subtly, high tax rates induce such forms of rent-seeking as devoting resources to tax evasion and working in the underground economy despite its relative inefficiency. The second group of institutions and policies that make up social infrastructure consists of factors that determine the environment that private decisions are made in. If crime is unchecked or there is civil war or foreign invasion, private rewards to investment and to activities that raise overall output are low. At a more mundane level, if contracts are not enforced or the courts' interpretation of them is unpredictable, long-term investment projects are unattractive. Similarly, competition, with its rewards for activities that increase overall output, is more likely when the government allows free trade and limits monopoly power. The final group of institutions and policies that constitute social infrastructure are ones that affect the extent of rent-seeking activities by the government itself. As Hall and Jones stress, although well-designed government policies can be an important source of beneficial social infrastructure, the government can be a major rent-seeker. Government expropriation, the solicitation of bribes, and the doling out of benefits in response to lobbying or to actions that benefit government officials can be important forms of rent-seeking. Because social infrastructure has many dimensions, poor social infrastructure takes many forms. There can be Stalinist central planning where property rights and economic incentives are minimal. There can be "kleptocracy" an economy run by an oligarchy or a dictatorship whose main interest is personal enrichment and preservation of power, and which relies on expropriation and corruption. There can be near-anarchy, where property and lives are extremely insecure. And so on. One way to move beyond the view that social infrastructure is important is to be more specific about what features of it matter. Ideally, we could identify a specific subset of institutions and policies that are critical to cross-country income differences, or provide a list of different elements of social infrastructure with weights attached to each one. Our current knowledge does not come close to this ideal. Rather, research is actively considering a range of features of social infrastructure. For example, Glaeser, La Porta, Lopez-de-Silanes, and Shleifer (2004) and, especially, Jones and Olken (2005) ask whether "policies" defined as features of social infrastructure that can be changed by a country's leaders, with no change in the institutions that determine how leaders are chosen or how they exercise their power are important to growth. Another line of work examines whether institutional constraints on executive power are important to economic performance. North (1981) argues that they are critical, while Glaeser, La Porta, Lopez-de-Silanes, and Shleifer argue that they are of little importance. Many other papers (and many informal arguments) single out specific features of social infrastructure and argue that they are particularly important. Examples include *the security of property rights, political stability, market orientation, and lack of corruption*. Unfortunately, obtaining persuasive evidence about the effects of a specific aspect of social infrastructure is very hard. Countries that perform well on one measure of social infrastructure tend to do well on others. Thus a cross-country regression of income on a specific feature of social infrastructure is subject to potentially severe omitted-variable bias: the right-hand-side variable is likely to be correlated not just with determinants of income other than social infrastructure, but also with other elements of social infrastructure. And because social infrastructure is multifaceted and hard to measure, we cannot simply control for those other elements. In the absence of a way to comprehensively analyze the effects of each component of social infrastructure, researchers search for tools that provide insights into the roles of particular components. The work of Jones and Olken on policies is an excellent example of this approach. Their strategy is to look at what happens to growth in the wake of essentially random deaths of leaders from accident or disease. One would expect such deaths to result in changes in policies, but generally not in institutions. Thus asking whether growth rates change unusually (in either direction) provides a test of whether policies are important. Jones and Olken find strong evidence of such changes.

Appendix III: Variables and Parameters

Table 1. Variables

	Endogenous variables	Exogenous variables
1.	y_t	
2.		r_t
3.	$E_t[y_{t+1}]$	
4.	π_t	
5.		$[\pi_{t+1}]$
6.		m_t

Table 2. List of parameters

The model parameters are given below (description on the right):	
$\frac{1}{\theta}$	Intercept (weight) of Interest rate
β	Intercept (weight) of Expected inflation
k	Intercept (weight) of Production (output)
φ	Intercept (weight) of Expected inflation
ρ	Intercept (weight) of Monetary policy, inflation and IS

Table 3. Time Series Forecasting for IS-LM Specification Model for the Republic of Moldova economy

Year	Interest rate	Inflation rate	Economic Growth (Production output, constant prices, bln MDL)	Unemployment rate	Exchange rate
2025*	1.7	4.3	102516028	3.8	18.75
2024*	1.6	4.7	98971267	3.9	18.37
2023*	1.8	4.9	95397816	3.9	18.21
2022*	2.0	4.1	95163413	4.0	17.77
2021*	2.0	1.0	90898440	4.0	17.18
2020	3.3	3.8	90375990	3.8	17.32
2019	6.8	4.9	87383203	5.1	17.57
2018	6.5	3.0	87008990	3.0	16.80
2017	8.0	6.5	85575492	4.1	18.49
2016	12.8	6.5	83386768	4.2	19.92
2015	16.3	9.6	80988475	5.0	18.80
2014	3.6	5.0	76784875	3.8	14.03
2013	3.8	4.7	76608053	5.2	12.58
2012	5.0	4.7	76221744	5.6	12.11
2011	8.7	7.6	72427406	6.7	11.73
2010	6.8	7.4	71885473	7.5	12.36
2009	8.7	0.0	71400254	6.4	11.11
2008	16.7	13.0	67123674	4.0	10.39
2007	14.5	12.1	66210916	5.1	12.14
2006	12.8	12.8	64283423	7.6	13.13
2005	12.8	11.8	61348128	7.3	12.59

2004	14.3	12.5	57067285	8.2	12.32
2003	12.3	11.6	53153450	8.0	13.94
2002	11.4	5.3	49851598	6.8	13.57
2001	18.3	9.9	46240392	7.2	12.86
2000	21.0	31.8	43564887	8.5	12.43

Source: statistica.md (National Bureau of Statistics); own calculations information with asterisk represent forecasted data
Software: Matlab R2020b

Table 4. Granger Causality Specification

X does not Granger Cause X		Y CPI	Y YER	Y STN	Y EXR	Y URX
X	CPI		F-Statisic (2.30941) Prob (0.1062)	F-Statisic (1.85025) Prob (0.1641)	F-Statisic (3.03215) Prob (0.0540)	F-Statisic (0.55342) Prob (0.5772)
X	YER	F-Statisic (2.29683) Prob (0.1074)		F-Statisic (1.19100) Prob (0.3095)	F-Statisic (3.23244) Prob (0.0449)	F-Statisic (1.34637) Prob (0.2662)
X	STN	F-Statisic (2.58508) Prob (0.0819)	F-Statisic (3.67271) Prob (0.0300)		F-Statisic (2.51864) Prob (0.0872)	F-Statisic (0.84039) Prob (0.4355)
X	EXR	F-Statisic (0.65924) Prob (0.5201)	F-Statisic (4.83200) Prob (0.0105)	F-Statisic (0.26365) Prob (0.7689)		F-Statisic (3.42024) Prob (0.0378)
X	URX	F-Statisic (3.38257) Prob (0.0391)	F-Statisic (5.40084) Prob (0.0064)	F-Statisic (1.36608) Prob (0.2612)	F-Statisic (3.30923) Prob (0.0418)	

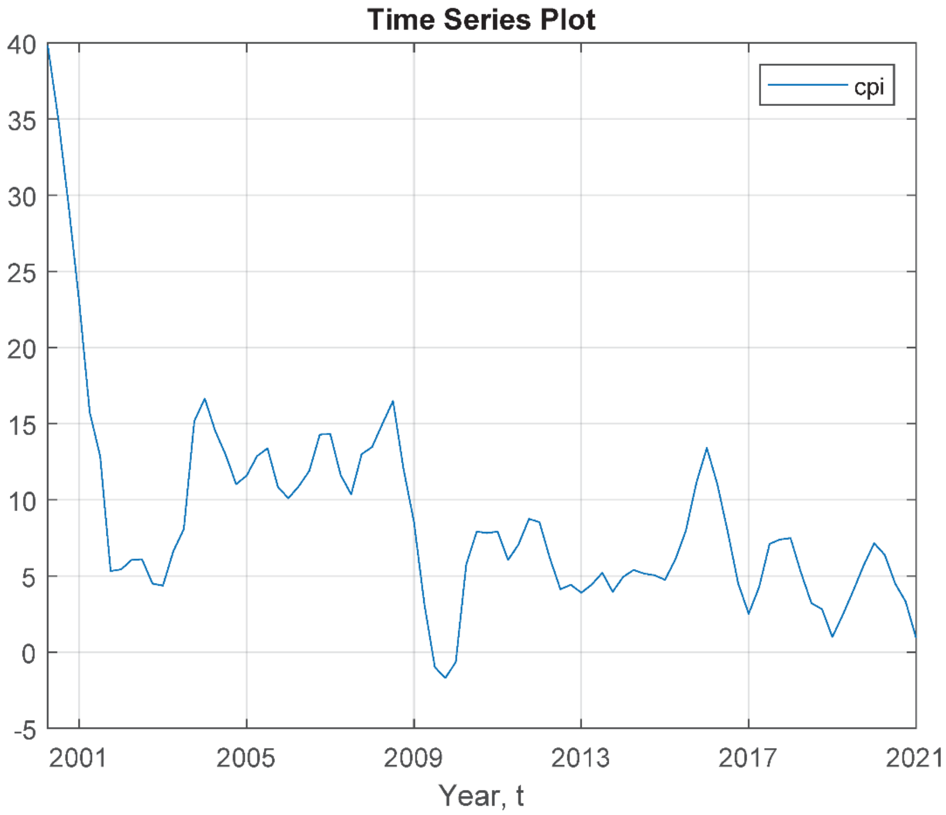


Fig. 2. Evolution of the inflation rate between 2000–2020 in the Republic of Moldova

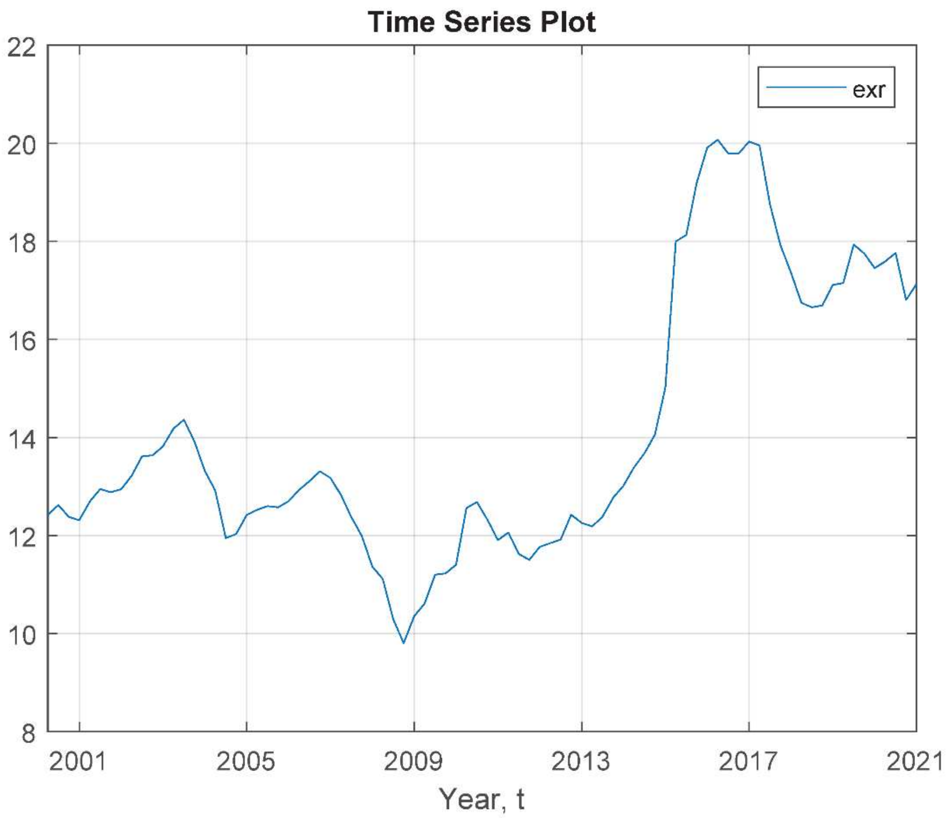


Fig. 3. Evolution of the exchange rate between 2000–2020 in the Republic of Moldova

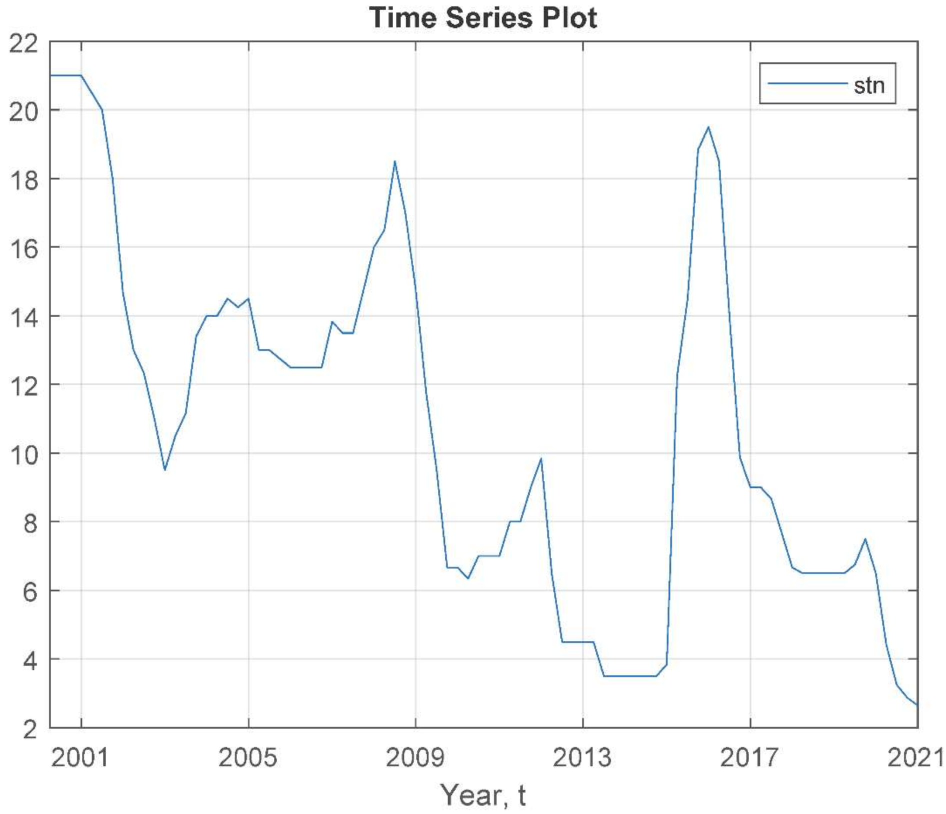


Fig. 4. Evolution of the short term (3 months) interest rate between 2000–2020 in the Republic of Moldova

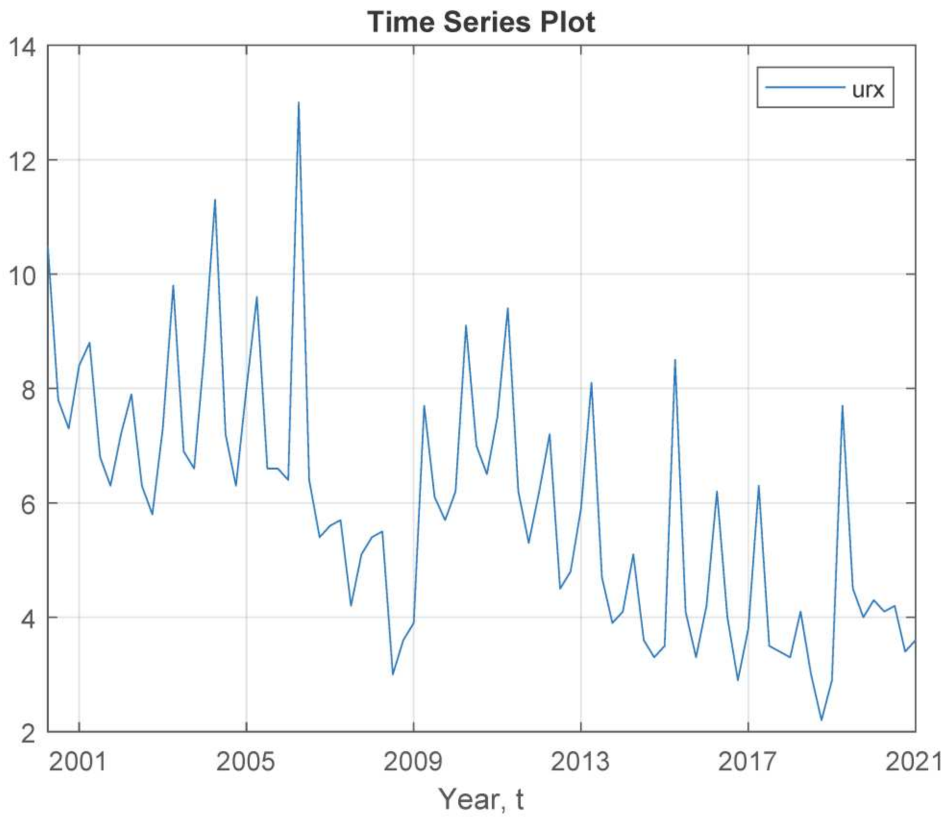
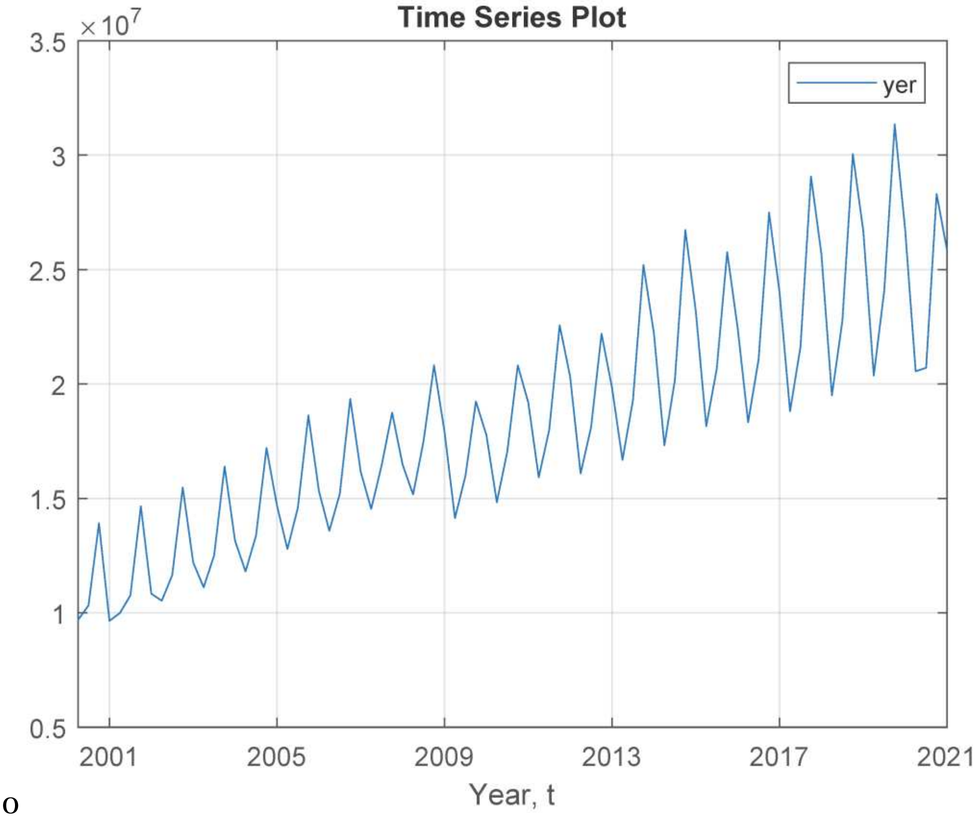


Fig. 5. Evolution of the unemployment rate between 2000–2020 in the Republic of Moldova



0

Fig. 6. Evolution of the national GDP (output) between 2000–2020 in the Republic of Moldova