Shock Therapy in Transition Countries:
A Behavioral Macroeconomic Approach

Abstract

I use a behavioral model to analyze how reforms in transition countries (such as price liberalization and competition policy) may affect their business cycle. The novelty of such a model is that the business cycle is generated endogenously interacting with confidence factors. It is assumed that agents do not form rational expectations, and they use simple rules and evaluate the forecasting performances of these rules ex-post. This paper generates policy implications that shock therapy may not be the ideal option for these countries as it may generate macroeconomic instability. The result of this model is in line with the recent macroeconomic literature that the size and the sequencing of reforms matter.

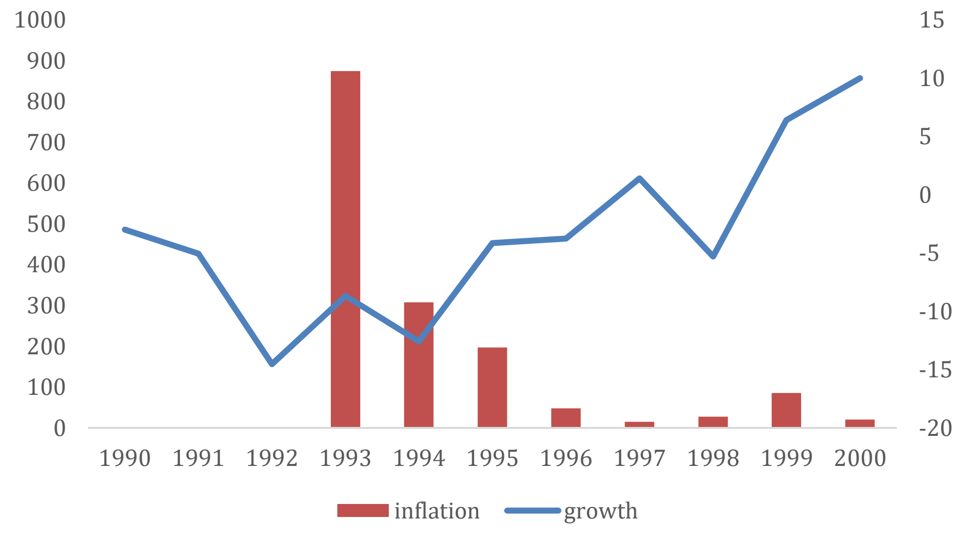
Keywords: behavioral macroeconomics, shock therapy, gradualism, price liberalization, competition reforms

JEL codes: E1, E12, E32

1. Introduction

Structural reforms in transition countries are not only a key driver of long-term economic development, but also affect the business cycle. The negative impact of reforms on the business cycle can be found in the historical experience of some former Soviet Union countries. Russia, for example, followed the shock therapy approach in reforming its economy but experienced a prolonged deep recession and hyperinflation throughout the 1990s as shown in Figure 1. Russia experienced a GDP decline for seven consecutive years during the transition period and its inflation rate was persistently high (more details about the former Soviet Union countries see Marek (2022)).

Figure 1. Inflation (left axis %) and Growth (right asix %): Russia 1990-2000



Data source: world bank (World Development Indicators)

In this paper, I use a behavioral macroeconomic model to analyze how structural reforms (such as price liberalization and competition policy) may affect the business cycle. To analyze this, a large supply shock triggered by a full price liberalization will be introduced in the model. The novelty of such a model is that the business cycle is generated endogenously interacting with behavioral factors such as confidence[1]. Agents in this model are assumed to experience cognitive

[1] see the seminal papers such as Akerlof (2002) and Akerlof and Shiller (2010) on confidence. Confidence is integrated in macroeconomic modelling either in standard DSGE literature (see e.g. Roth and Wohlfart (2020) and Angeletos and Lian (2022)) or in the behavioural macroeconomics related to heterogenous expectations (see e.g. Hommes (2021) and De Grauwe and Ji (2019)).

limitations preventing them from having rational expectations. These agents use simple forecasting rules and evaluate the forecasting performances of these rules ex-post. This evaluation leads them to switch to the rules that produce the best forecasts. This trial-and-error learning mechanism produces endogenous waves of confidence that drive the business cycle (see De Grauwe and Ji (2019) for general features of this model).

This paper is relevant for an earlier literature on two opposite reform approaches, i.e. the shock therapy adopted by countries such as Russia and the gradualism approach used by other countries such as China. One of the reasons why shock therapy may fail is that it may create prolonged recessions and persistent inflation which are associated with negative public confidence. In other words, shock therapy may fail to generate sufficient political support for further reforms despite its long-term benefit (see Douarin and Mickiewicz (2017) on support for reforms). So far most of the relevant literature has been focused on distributional issues (winners vs. losers). There has been little analysis of the business cycle implications of reforms. The aim of this paper is to fill this gap by using a general equilibrium model that allows supply-side reforms such as price liberalization to interact with aggregate demand (see comments by Peter Murrell (1993)).

The result of this model is in line with the recent macroeconomic literature which stresses the complexity of the transmission process of reforms. For a comprehensive discussion of this topic, see Campos, De Grauwe, and Ji (2018). This complexity has much to do with the fact that reforms that affect the supply-side interact with aggregate demand (De Grauwe and Ji (2020) and Cacciatore and Fiori (2016)).

My analysis shows that the size and the sequencing of reforms matter greatly. The problem of shock therapy reforms during the late 1980s and early 1990s is that they generated macroeconomic instability, greatly reducing the public support for structural reforms in some transition countries (see empirical findings in Natkhov and Pyle (2022)).

The paper is organized as follows. Sections 2 discusses the literature on the economics of transition covering different reform approaches. Section 3 presents the behavioral model. Section 4 presents the impulse responses of a reform shock in different set-ups. I compare the shock therapy with the gradualism approach. I consider how a competition policy in product markets may affect the dynamics of a shock therapy. Section 6 analyzes the role of confidence. Section 7 concludes.

2. Literature Review: Economics of Transition

There is a large literature evaluating the transition experience from centrally planned to market economies (see e.g. Campos and Coricelli (2002)). By 2000, all the Central and Eastern European and former Soviet Union countries enjoyed economic benefits from structural changes implemented earlier and they all returned to their long-term growth path with poorer countries growing faster than those with a higher GDP level. However, the transition costs for many countries were huge (see Douarin and Mickiewicz (2017) on the pro-longed reduction in living standards for people in this region). These costs are very much related to the macroeconomic instability that occurred in the region. This can be illustrated by the fluctuations of GDP (though one must be careful in using GDP data in describing the whole transition experience). During the first decade of transition, countries experienced a decrease in output followed by a period of recovery. The loss in output varied across countries. In 1993 (three years after the transition started), the average GDP level in CEE countries dropped to 75% of the 1989 level. In 1996 (three years after the transition started) the former Soviet Union countries saw their GDP level drop to 50% of their 1989 level.

Not every transition country experienced the same transition problems. A well-known exception is China[2]. As shown in Figures 2a and 2b, there was a clear divergence in economic performance (measured by inflation and economic growth rate) between China and transition countries in Europe in the first ten years of transition. China did not experience negative economic conditions during the transition in the 1990s. The experience of individual countries in Europe also differed radically: while Russia's economy was seriously affected, Poland, Central Europe and the Baltic countries recovered relatively quickly. Moreover, the duration of the negative impact (measured by inflation) was much longer than what was expected by policy makers and experts in the region. This contrasts with China, which experienced the lowest inflation and the highest economic growth among transition countries.

[2] One may argue that using China as a comparison to Russia, Poland and Central and Eastern European and Baltic countries may not be appropriate as their pathways and institutional settings were different. The differences in institutional settings are not a very good reason not to include China. First, prior to the transition, the institutional settings were very similar as they all had communist inspired central-planning. Second, according to economic historians (see e.g. Weber (2021)), the political motivation in implementing radical price reforms in China was very strong in 1988. Deng Xiaoping, the Chinese leader, personally took the initiative pushing for great price reforms. Chinese political leaders were very much influenced by policy advice from other transition countries. It is not the intention of the paper to analyse the rationale for reforms which are often determined by political institutions. The purpose of the paper is to analyse the impact of reforms on the business cycle and hence evaluate the reform strategies adopted by different countries.

Much theoretical work has been done to explain the large divergence in economic performances outlined above (see a review by Campos and Coricelli (2002)). For example, China (and other Asian economies in transition) did not experience political and economic transitions simultaneously[3]. Other factors such as initial conditions, institutions, industrial structure, and the share of agriculture in GDP may have contributed to the differences in how and what reforms were implemented[4]. Still, there has been a strong consensus among economists that the collapse of output in Central/Eastern Europe and especially the former Soviet Union indicated a lack of coherence in the reform strategies. It is widely believed that a comparative analysis of the experience of different transition countries (in particular China) could prove useful in drawing lessons from unsuccessful reform experiences (Campos and Coricelli (2002)).

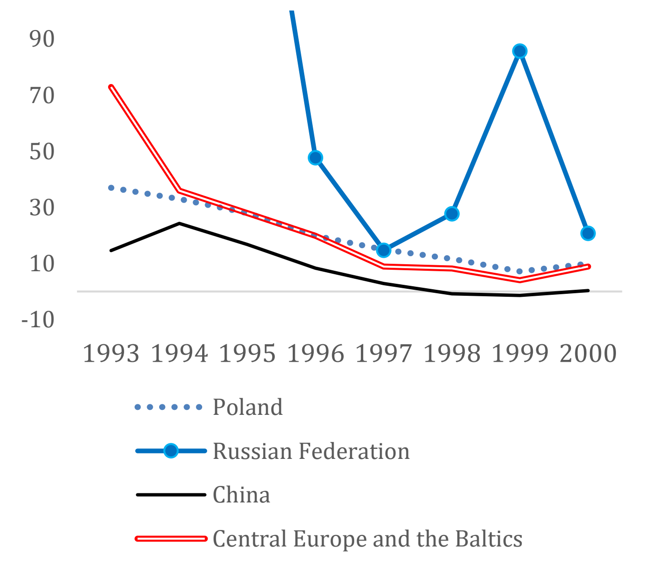


Figure 2a. Annual inflation rate (%) 1993-2000

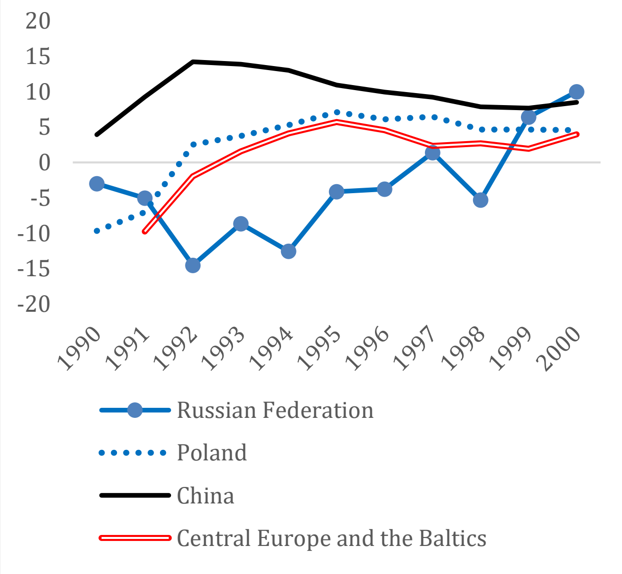


Figure 2b. Annual growth rate % (1990-2000)

Note: inflation rate in Russia during 1993-1995 on average reached more than 300%

Data source: world bank (World Development Indicators)

My focus in this paper is on price liberalization and competition policy which are important reforms in the initial stage of transition. Lawrence Lau, Qian, and Roland (2000) discuss the advantages of the Chinese approach to price liberalization (see also Weber (2021) who provides

[3] This is a very important point, but it is not the focus of the research in this paper.

[4] Yingyi Qian, Gérard Roland, and Chenggang Xu (1999) pointed out the Chinese economy was organized on a regional basis, allowing for experimentation and thus for a gradualism approach. In Russia, this is not possible as the Soviet-type economy was organized in specialized ministries nationally.

a comprehensive study for that period). Price liberalization in China was not radical but it involved the government slowly phasing out the planning of prices and quantities. The adoption of a reform strategy marked by gradualism and sequencing concerns may have contributed to a better economic performance of China. In the following sections, I provide a brief literature review on gradualism versus shock therapy and on the sequencing of reforms.

Shock therapy (“Big-bang”) vs. gradualism

In the late 1980s, there was a consensus among policymakers that the transition from a planned economy to a market-oriented one is inevitable. The question of when and how to implement market-oriented reforms became prominent after the opening-up to market systems of previously communist countries. One of the overriding policy questions after the collapse of the Communist regimes in the 1990s was how quickly structural reforms should be implemented. Should they be introduced in a “big-bang” or rather in a gradual manner? The initial views of economists were very much influenced by Jeffrey Sachs who had become the strongest advocate of a big-bang approach. He wrote a comprehensive plan for the transition from central planning to a market economy in Poland and was instrumental in implementing this approach in the country. Together with David Lipton, he advised that the conversion of public to private properties should be done quickly pushing for American-style corporate structures, where professional managers should answer to shareholders (Lipton and Sachs (1990)). He also stressed that all elements constitutive to the market economy should be introduced simultaneously in an all-encompassing way. Speed was of the essence because there was a “window of opportunity” created by the establishment of democracy which would allow governments to create irreversibility for the reforms they introduced. He also argued that partial reform would yield lower efficiency gains than a complete reform and might even end up being pure noise, chaotic and disorganizing.

This big-bang approach was heavily criticized later. Campos and Coricelli (2002) used the method of principal components to analyze how the size of liberalization negatively affected economic performance after the reforms. It appears that big-bang economists underestimated the economic and political constraints of transition. As a result, the voices of those who favored a more "gradualist" approach and emphasized a proper sequencing of reforms became louder. Dewatripont, and Roland (1992&1995), for example, stressed the aggregate uncertainty surrounding the reform outcomes and advised for a more gradual approach. In this view, gradualist reform packages would be easier to get started, leading to great certainty, and creating constituencies for further reform, thus guaranteeing the sustainability of this process (See also Fernandez and Rodrik (1991), Wei, 1997; McMillan and Naughton, 1992; Litwack and Qian, 1998). Existing empirical work on political support of reforms confirms the theoretical arguments on the gradualist approach. Good economic outcomes such as higher growth and employment are associated with public support for reform (for example Fidrmuc (2000a, b), Falcetti et al. (2006)). This may further boost public trust and confidence in the government and institutions.

Partial reform and sequencing of reforms

Reform is costly as it may lead to losers who should be compensated as they are less likely to support reform. As argued by Dewatripont and Roland (1992), partial reforms imply that it is less costly to compensate the losers than a full reform. If the economic outcome given by early reform are promising enough, then reforms can continue with greater support. Thus, partial reforms lower the cost of experimenting with reform and thus make a move away from the status quo more easily acceptable to a majority. In this logic, what matters to the success of transition is the sequencing of reforms: governments should start with the reform areas that are mostly likely to generate positive outcomes and create fewer losers.

In connection with this view, Campos and Coricelli (2002) argued that the basic structure of market institutions and some experience with market-oriented decisions are preconditions for the success of market reforms. They found evidence that is consistent with this view, i.e. countries which experienced partial market reforms with some independence in enterprise decision making and some forms of market behaviour prior to the 1990s were better positioned along the growth path to become a market economy.

Empirical evidence shows that countries such as Hungary, China, and Vietnam which gave priority to liberalizing their small private sector were economically more successful later. In Hungary, the small private sector was already producing about 10 percent of industrial output by 1990 (see e.g. Hare and Revesz (1992)). When, in Vietnam, radical price liberalization and stabilization programs were implemented in 1989, the private sector in agriculture and manufacturing already reached 60 percent of GDP and 85 percent of the labor force. When in 1991 China engaged in further liberalization, the non-state sector's share of industrial output already reached 47 percent. Roland (2002) pointed out that a viable private sector could offset the negative impact of a decline in output following a radical price liberalization in other sectors. The experience of these countries has shown that the strategy to prioritize reforms in private sectors can build the necessary support for more comprehensive reforms later in the less competitive state sector.

In a related literature, there are both theoretical and empirical studies revealing that reforms are not so successful in countries that started reforms from a more rigid system of central planning (see Campos and Coricelli (2002), Easterly and Fischer (1995), Ericsson (1991)). This problem is most severe in the Eastern bloc economies such as Russia. Roland (2002) pointed out that privatization and price liberalization without effective competition policy put existing monopolies in private hands which in turn may have strengthened their market power. The original intention of privatization was that by giving shares to workers and managers, workers would sell their shares to outsiders to assure outsider control. The Russian experience has shown this has not happened. On the contrary, workers in many firms were prevented from selling their shares. As a result, mass privatization created a sudden and strong concentration of a power among insider managers which helped them in capturing policymakers and in opposing competition policy (for relevant studies see Earle, Frydman and Rapaczinski (1993), Boycko et al (1993) and Roland (1994) of the Russian privatizations; for empirical evidence that large firms influenced government reform policy see Campos (1999)).

By contrast, for a very long time, the central government in China, continued to exert price and production controls over key sectors (such as essential raw materials and intermediate goods) in the manufacturing stream. These heavy industries all have very high degree of monopoly power and are rigid in their response to market changes. As documented in Weber (2021), the Chinese policy makers were well-aware of the risk of high inflation resulting from price liberalization in these sectors. With demand and supply unable to adjust to the price signals, liberalizing the prices for these sectors can only lead to higher prices which tend to increase costs for other industries, to higher prices for the consumers and ultimately to lower aggregate output.

3. The behavioral model

As discussed in section 2, two issues concern policy makers of transition economies. The first one is whether the government should adopt a big-bang reform (shock therapy) with an immediate price liberalization; the second one concerns the sequencing of reforms. To analyze these two questions, I will first present the basic behavioural model in this section. In section 4, I will use this model to answer the policy questions raised here.

3.1 Basic model

The model consists of an aggregate demand equation, an aggregate supply equation and a Taylor rule. As the shock therapy only concerns the product market, I will not include a component of the labour market. This simple macroeconomic model can be derived from a micro-foundation (see De Grauwe and Ji (2019)). Different from other theoretical work on reforms, the behavioural model assumes representative consumers and firms. The only heterogeneity in the model arises from divergences of expectations which arise from the fact that economic agents use different forecasting rules.

The aggregate demand equation can be expressed in the following way:

$$y_t = \widetilde{\mathrm{E}}_t y_{t+1} + a_2\left(r_t - \widetilde{\mathrm{E}}_t \pi_{t+1}\right) + v_t \qquad (1)$$

where y_t is the output gap in period t, r_t is the nominal interest rate, π_t is the rate of inflation. The tilde above E refers to the fact that expectations are not formed rationally. How exactly these expectations are formed will be specified subsequently in section 3.2 and 3.3. The output gap y_t is related to the expected future output gap, $\widetilde{\mathrm{E}}_t y_{t+1}$, and to the real interest rate, which is defined as the difference between the nominal interest rate r_t and the expected future inflation, $\widetilde{\mathrm{E}}_t \pi_{t+1}$. The sensitivity of the output gap to the real interest rate is given by a_2.

The aggregate supply equation is shown in (2). This Philips curve includes a forward-looking component, $\widetilde{\mathrm{E}}_t \pi_{t+1}$ and inflation π_t is sensitive to the output gap y_t. The parameter b_2 measures the extent to which inflation adjusts to changes in the output gap. It is therefore indicative of the degree of price flexibility in product market. A low value of b_2 indicates that firms are less likely to change their price in each period so that prices are rigid in product markets; a high value of b_2 indicates that firms frequently change their prices and hence prices are flexible.

$$\pi_t = \widetilde{\mathrm{E}}_t \pi_{t+1} + b_2 y_t + \eta_t \qquad (2)$$

The model also includes a Taylor rule describing the behavior of the central bank

$$r_t = (1 - c_3)[c_1(\pi_t - \pi^*) + c_2 y_t] + c_3 r_{t-1} + u_t \qquad (3)$$

where π^* is the inflation target. Thus, the central bank raises the interest when the observed inflation rate increases relative to the announced inflation target. The intensity with which it does this is measured by the coefficient c_1. Similarly, when the output gap increases, the central bank raises the interest rate. The intensity with which the central bank does this is measured by c_2. The c_1 and c_2 parameters are important to ensure stability of the model. It has been shown that c_1 must exceed 1 and c_2 should be positive for the model to be stable (see Woodford (2003) and De Grauwe and Ji (2019)). Finally, the central bank smooths the interest rate. This smoothing behavior is represented by the lagged interest rate r_{t-1} in equation (3).

There are stochastic error terms in each of the three equations representing the nature of the different shocks that can hit the economy. They include demand shocks v_t, supply shocks η_t, and interest rate shocks u_t. These shocks are assumed to be normally distributed with mean zero and a constant standard deviation.

3.2 Heuristic rules in forecasting

The transition period creates great uncertainty. It is not unreasonable to assume that agents lack the cognitive capacity to form rational expectations. The latter requires agents to understand the complexities of the underlying model and to know the frequency distributions of the shocks that will hit the economy. In this paper, I assume that cognitive limitations of agents prevent them from understanding and processing this kind of information. These cognitive limitations have been confirmed by laboratory experiments and survey data. Evidence from laboratory experiments support behavioural assumptions that agents use simple heuristics to forecast output gap and inflation (see Carroll, 2003; Branch, 2004; Pfajfar and Zakelj, (2011 &2014); Hommes, 2011, Kryvtsov and Petersen (2013) and also Assenza et al.(2014a)).

I assume there are two types of forecasting rules for output gap. A first rule is called a “fundamentalist” one. Agents estimate the steady state value of the output gap (normalized at 0) and use this to forecast the future output gap. Agents who use this rule believe in the long-term benefits of reforms. This is a typical mean reverting forecasting rule[5].

[5] More complex fundamentalist forecasting rules can be used. One can assume that agents do not know the steady state of output gap and only have biased estimates of it (see De Grauwe (2012) and De Grauwe and Ji (2019)). Note that complex rules do not affect the results in a fundamental sense.

A second forecasting rule is an extrapolator one. This is a rule that does not presuppose that agents know the steady state output gap. They are agnostic about it. Instead, they extrapolate the previous observed output gap into the future[6]. These two rules are described in more detail in Appendix 1.

In terms of inflation forecasting, agents use a similar heuristic. I assume an institutional set-up in which the central bank announces an explicit inflation target. The fundamentalist rule then is based on this announced inflation target, i.e., agents using this rule have confidence in the credibility of this rule and use it to forecast inflation. Agents who do not have confidence in the announced inflation target use the extrapolator rule, which consists in extrapolating inflation from the past into the future. I describe these rules further in Appendix 1.

3.3 Adaptive learning based on discrete choice theory

The use of simple heuristics described in 3.2 does not mean that the agents are irrational and that they do not want to learn from their errors. Individuals learn and update their forecast. This updating can be done using an evolutionary 'trial and error' process, also called "adaptive learning" (see Brock and Hommes (1997), Branch and McGough (2010), De Grauwe (2012)). In this paper, I use this approach in which agents use simple rules (heuristics) to forecast future output gap and inflation[7]. Rationality is introduced by assuming a willingness to learn from mistakes and therefore a willingness to switch between different heuristics so as to improve forecast performances (see e.g. Tesfatsion (2001), Colander, et al. (2008), Farmer and Foley (2009), Delli Gatti, et al. (2005), Westerhoff and Franke(2012), also see Assenza et al.(2014b) which supports this approach based on experiments). Thus, the agents in the model are rational, not in the sense of having rational expectations. Instead, they are rational in the sense that they learn from their mistakes.

In Appendix 1, I apply discrete choice theory (see Anderson, de Palma, and Thisse, (1992) and Brock & Hommes (1997)) in specifying the procedure agents follow in this evaluation process. This discrete choice approach generates the probabilities (i.e. $\alpha_{f,t}$, $\alpha_{e,t}$, $\beta_{f,t}$, $\beta_{e,t}$,) that agents use

[6] See De Grauwe and Ji (2019) for more complex rules in which some AR1 process is introduced in this extrapolation process

[7] There is a large literature on expectations formation (Evans (2001)). Other modelers adopt weaker forms of rational expectations, namely "eductive learning" or statistical methods as in Evans and Honkapopja (2001).

particular rules when forecasting output gap and inflation[8]. In particular, $\alpha_{f,t}$ and $\alpha_{e,t}$ are the probabilities agents choose the the fundamentalist respectively the extrapolator rule in forecasting the output gap and $\beta_{f,t}$ and $\beta_{e,t}$ are the probabilities that agents use the fundamentalist respectively the extrapolator rule in forecasting inflation.

3.4 Defining two confidence indicators

The probabilities that agents use the fundamentalist and the extrapolator rules (i.e. $\alpha_{f,t}$, $\alpha_{e,t}$, $\beta_{f,t}$, $\beta_{e,t}$,) can be employed to generate public confidence in the reforms. The two indicators are:

a. Market sentiments indicator (also called 'animal spirits'). It reflects how optimistic or pessimistic agents are concerning the future output. It is obtained from the fraction of extrapolators ($\alpha_{e,t}$) and fundamentalists ($\alpha_{f,t}$) as follows:

$$S_t = \begin{cases} \alpha_{e,t} - \alpha_{f,t} & \text{if } y_{t-1} > 0 \\ -\alpha_{e,t} + \alpha_{f,t} & \text{if } y_{t-1} < 0 \end{cases} \quad (4)$$

S_t ranges between -1 and +1. As extrapolators and fundamentalists forecast different directions of the future output gap, the difference of the fractions $\alpha_{e,t}$ and $\alpha_{f,t}$ determines whether market sentiments are positive or negative. When the fraction of pessimists (optimists) exceeds the fraction of optimists (pessimists), S_t becomes negative (positive).

b. The other indicator concerns the confidence in the credibility of the central bank. As defined earlier, $\beta_{f,t}$ measures the fraction of agents in period t who have confidence in the central bank, i.e. who use the announced inflation target as their forecasting rule.

3.5 Model calibration

The model has a non-linear feature making it difficult to arrive at an analytical solution (see Appendix 2 for how to solve the model). That is why I use a numerical method to analyze its dynamics. In order to do so, I calibrate the model, i.e. I select numerical values for the parameters of the model. In Table 1 the parameters used in the calibration exercise are presented. The values of the parameters are obtained from the macroeconomic literature related to the advanced

[8] Note that the two prediction rules for the output gap and inflation are made independently. The selection criterion is exclusively based on the forecasting performances of these rules. Agents in this model do not have a psychological predisposition to become fundamentalists or extrapolators

economy. For the Taylor rule, the parameters used in the simulation are obtained from estimations by Esanov, Merkl and De Souza (2005).

The results of the simulations using these parameters are shown in section 4. One may criticize these simulations as transition economies may behave differently and hence some of the parameters used in the aggregate demand and supply may not reflect the true state of these economies. However, these differences may not matter that much. First, the analysis in this paper focuses on qualitative rather than quantitative features generated by this model. Second, the parameter a_2 describes the interest elasticity of output demand and is related to access to credit in the banking sector. Given that the focus of my analysis will be on product markets (where reforms started), it is plausible to assume that there is little difference in the banking sectors between transition and advanced countries. So, it is reasonable to assume that the a_2's of the two type of economies are the same. Third, b_2, in the supply equation describes the price elasticity (i.e. coefficient of output in inflation equation). I will use two values: a low one, i.e. $b_2=0.1$, which assumes the product markets are rigid before structural reforms and a high one, i.e. $b_2=5$, which assumes that product markets become flexible after the reforms (due to competition policy).

Table 1: Parameter values of the calibrated model

a2 = -0.2	interest elasticity of output demand, McCallum and Nelson (1999).
b2=0.1	coefficient of output in inflation equation, rigid case (without competition policy)
b2= 5	coefficient of output in inflation equation, flexible case (with competition policy)
$\pi^*=0$	inflation target level
c1 = 1.5	coefficient of inflation in Taylor equation
c2 = 0.5	coefficient of output in Taylor equation
c3 = 0.5	interest smoothing parameter
$\sigma_v = 0.5$	standard deviation shocks output equation
$\sigma_\eta = 0.5$	standard deviation shocks inflation equation
$\sigma_u = 0.5$	standard deviation shocks Taylor equation

4. Simulation results

Structural reforms in transition economies involve many economic changes. In this analysis, I will only focus on price liberalization and competition policy. These two reforms will be introduced in the context of the behavioral model through two channels.

The price liberalization is introduced through a supply shock. Price liberalization (i.e. removing price controls) in the context of transition economies leads to an increase in inflation in the initial stage of reform (see Peter Murrell (1993)) and Campos and Coricelli (2002)). The latter authors find that repressed inflation is a very good predictor of inflation expectations in the beginning of transition. It produces a positive shock to inflation in the supply equation (2). I will analyze this reform in this section.

The second channel to introduce reforms is to change the sensitivity of inflation to the output gap in the aggregate supply equation (i.e. parameter b_2). A low sensitivity of the rate of inflation with respect to the output gap is indicative of price rigidities. For example, if prices are rigid, it means that a decline in the output gap during a recession has a low effect on price changes. An analysis will be performed under the rigid regime in section 4.1. An increase in the degree of competition in the economy (our second reform policy) leads to more flexibility in prices. When prices are flexible, a decline in the output leads to a stronger decline in the rate of inflation. An analysis will be performed of the flexible regime in section 4.2.

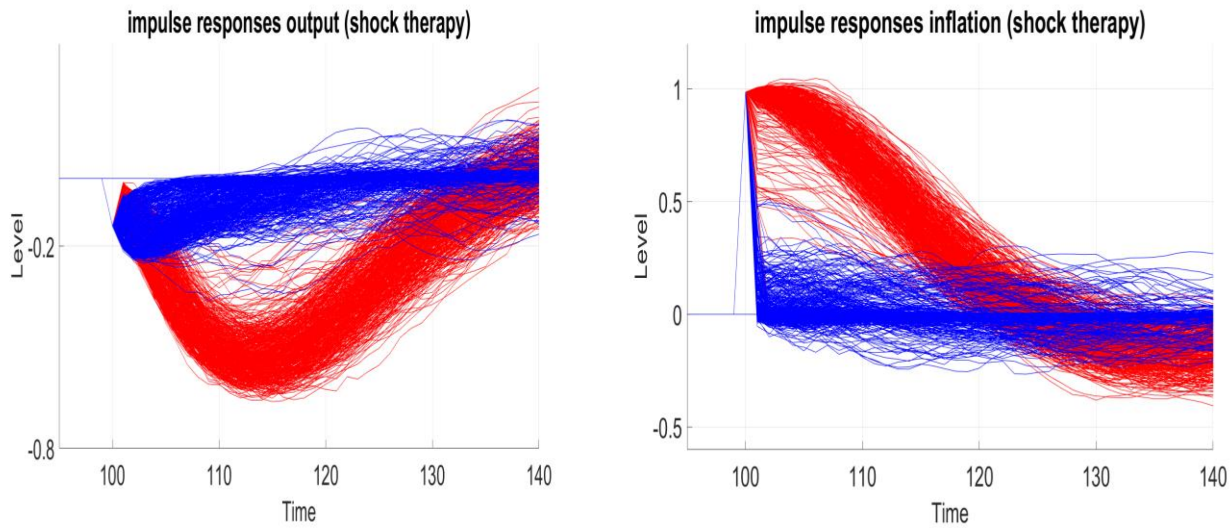
4.1 Impulse responses: shock therapy vs. gradualism in a rigid economy

I analyze the impulse responses to a negative supply shock due to price liberalization (i.e. removing price control leads to a positive inflation shock). To do so, I introduce a very large shock in equation (2) with a size of 15 standard deviations. This is a truly large one but it corresponds to the size of the shock observed in late 1980 and early 1990s when the annual inflation dramatically shot up and the annual GDP declined by 10-15% after the price liberalization in many transition countries. To construct the impulse response functions, I compute the output gap and inflation after this exogenous shock and compare this series with the series of the output gap, inflation, and interest rate without the policy shock. Algebraically I have:

$$(Ys_t - Yb_t)/\sigma \qquad (5)$$

where Ys_t is the output gap after the shock, Yb_t is the output gap without the shock (the base series of the output gap), and σ is the standard deviation of the shock in the supply equation ($\sigma = 15$ in the case of shock therapy). Expression (5) can be interpreted as a multiplier, i.e. it measures the extent to which after the shock the output gap deviates from the base output gap expressed as a percent of the shock σ. I compute 1000 impulse responses and each impulse response is computed for different realizations of the stochastic shocks (i.e. v_t, η_t and u_t in the model). I did the same exercise for inflation. The results are shown in Figure 3.

Figure 3. Impulse responses: shock therapy



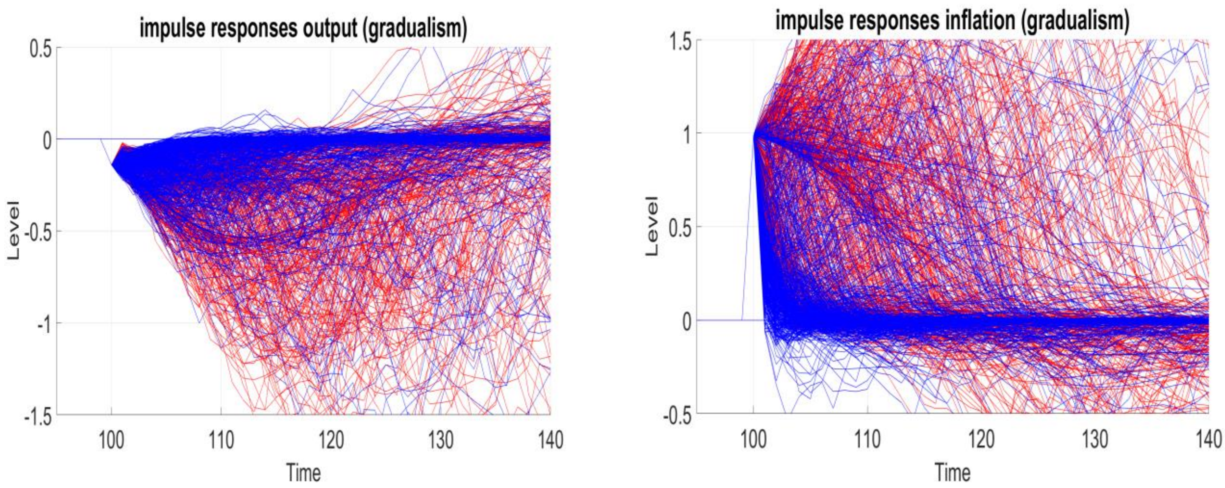
One observes from Figure 3 that there are very large differences in the responses of the endogenous variables (output gap and inflation) after the shock therapy. This is because when the shock hits, the state of the economy is stochastically determined in the model[9]. In other words, each impulse response occurs under different initial conditions. Over time these impulse responses tend to converge, but it takes a very long time (30-40 quarters) for convergence to be reached. During the transition the trajectories can be very different. For example, in Figure 3 there exist two sets of trajectories in the output gap responses.

The initial conditions play a crucial role in generating the two sets of trajectories. The first set, the "good" trajectories (colored blue) correspond to the situation in which just prior to the shock the expectations of inflation are negative (i.e. below the central bank inflation target). One then observes relatively small declines of the output gap and relatively quick returns to the steady state value. The second set of trajectories, the "bad" trajectories (colored red) correspond to the situation in which the expectations of inflation just prior to the shock are positive (i.e. above the central bank inflation target). One then observes very deep declines in output and slower recoveries. Similar good and bad trajectories are detected in the impulse responses of inflation with the good trajectories of rapid declines in inflation and the bad trajectories characterized by a slower decline in inflation. (A detailed and technical analysis of the two sets of trajectories and

[9] This is a very strong feature of the behavioural model. In section 5, a rational expectation model is used and it does not generate the large differences in the responses of inflation and output.

their relation to initial inflation expectations and other factors can be found in De Grauwe and Ji (2022)). There is also strong empirical evidence showing the importance of initial conditions such as inflation expectations: for example, Campos and Coricelli (2002) finds that repressed inflation and black-market premiums are good predictors of economic performance after the shock therapy.

Figure 4. Impulse responses: gradualism



I now compare the previous result with the one obtained from a small shock (i.e. 'gradualism' approach). It is assumed to be a 1.5 standard deviation shock which is still a sizable shock compared to a normal stochastic shock of 0.5 standard deviation. Figure 4 shows the impulse responses of output and inflation. One observes that there is significant uncertainty in the responses. However, the trajectories after a 'small' shock (i.e. the case of gradualism) do not tend to coalesce around two adjustment paths (i.e. the good trajectories and the bad trajectories as observed in Figure 3). In most impulse responses, there are small decreases in output and small increases in inflation. It also takes a shorter time for convergence to be reached. It is noticeable that the initial inflation expectations do not play an equally crucial role in shaping the trajectories of output gap and inflation. This suggests that compared to the gradualism approach, a shock therapy generates very different transmissions.

To contrast the uncertainty derived from the gradualism approach with the uncertainty from the therapy shock, I show in Figures 5 and 6, the frequency distributions of inflation and output gap at a given time (i.e. 12 quarters after the shock). These distributions show the following. In a gradualism approach, the distribution of impulses responses is one modal allowing one to make relatively precise predictions, i.e. the effect is close to zero for most of the observations.

This contrasts with the shock therapy where one observes a bi-modal distribution confirming that the adjustment can follow two very different sets of trajectories (the 'good' ones and the 'bad' ones). This means that in the shock therapy it is not possible to predict the outcome with any precision. This can be good or bad with equal probability. The nature of the uncertainty in the shock therapy scenario is fundamentally more intense than in the gradualist scenario (see again in De Grauwe and Ji (2022)). This more intense uncertainty also has implications for the political economy of shock therapy. The recessionary forces generated in a bad trajectory may be so intense as to create political instability.

Figure 5. Frequency distribution of output gap and inflation (gradualism)

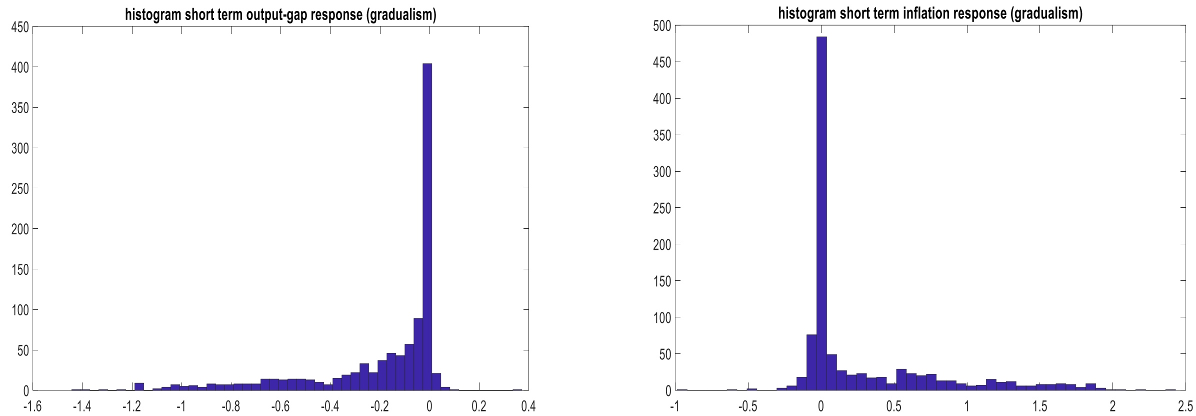
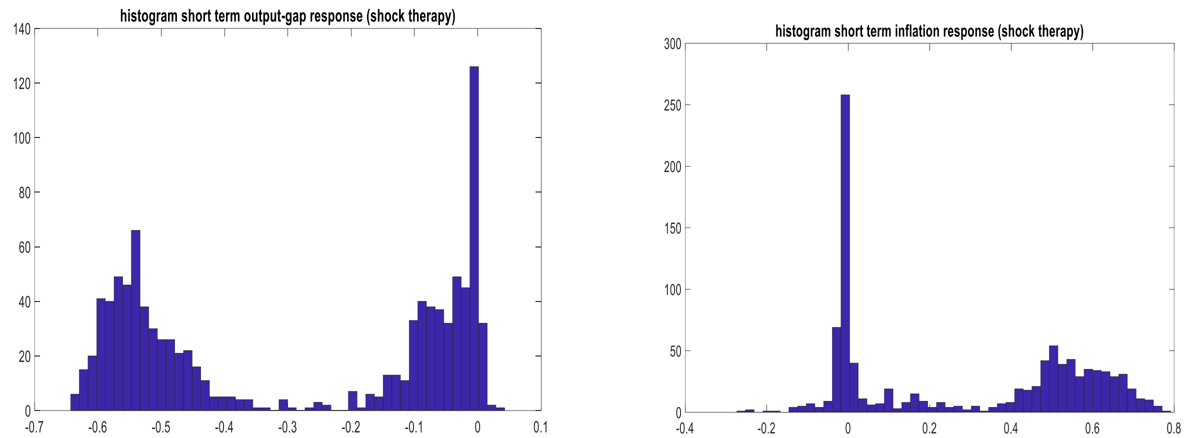


Figure 6. Frequency distribution of output gap and inflation (shock therapy)



4.2. Shock therapy under a flexible economy

The second policy I analyze is related to competition policy which increases price flexibility in the economy. Does shock therapy work better after the economy becomes more flexible? As indicated earlier, an increase in flexibility increases the coefficient b_2 in the Philips curve (in equation (2)), i.e. when structural reform increases flexibility, changes in the output gap have a stronger effect on prices, so that the inflation reacts strongly to such changes. Competition policy increases the flexibility of the economy so that b_2 becomes large. I will set $b_2 = 5$. The simulation result under this scenario will be compared with the results under a rigid economy where b_2 is assumed to be 0.1 (as discussed in Section 4.1, Figure 2).

Figure 7 shows the effect of a shock therapy under a flexible regime. In contrast to Figure 3 (shock therapy under a rigid economy), I find several important features. First, there is little bifurcation into bad and good trajectories after the shock therapy when the economy operates with high flexibility. Initial inflation expectations ('red' represents positive initial inflation expectations and 'blue' negative inflation expectations) do not play an important role. Second, one can observe very small declines (less than 0.1) of the output gap and very quick returns to the steady state value. Third, the volatility of inflation is larger than the volatility of output gap. Still, the volatility of inflation is milder compared to the rigid case (in Figure 3) and after 12 quarters inflation rates return to the steady state with a very small fluctuation band. These features can be illustrated in Figure 8 where I show the frequency distributions of inflation and output (12 quarters after the shock). Compared to Figure 6 where a shock therapy is introduced in a rigid regime, the distribution of impulses responses exhibits one modal instead of the original bi-modal. This allows us to make relatively precise predictions, i.e. the effect will be close to zero for most of the observations for output and inflation, leading to greater certainty.

Figure 7. Shock therapy under flexible regime (b2=5)

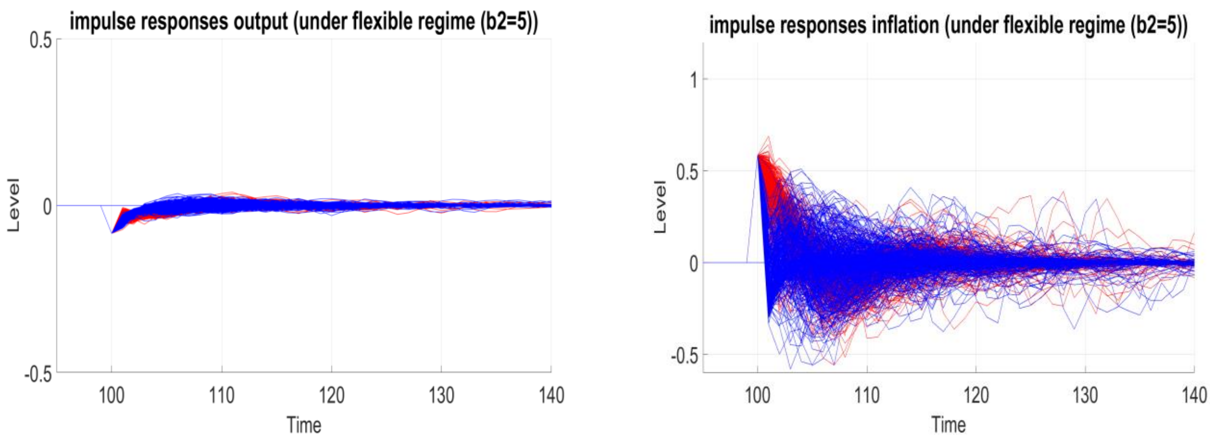
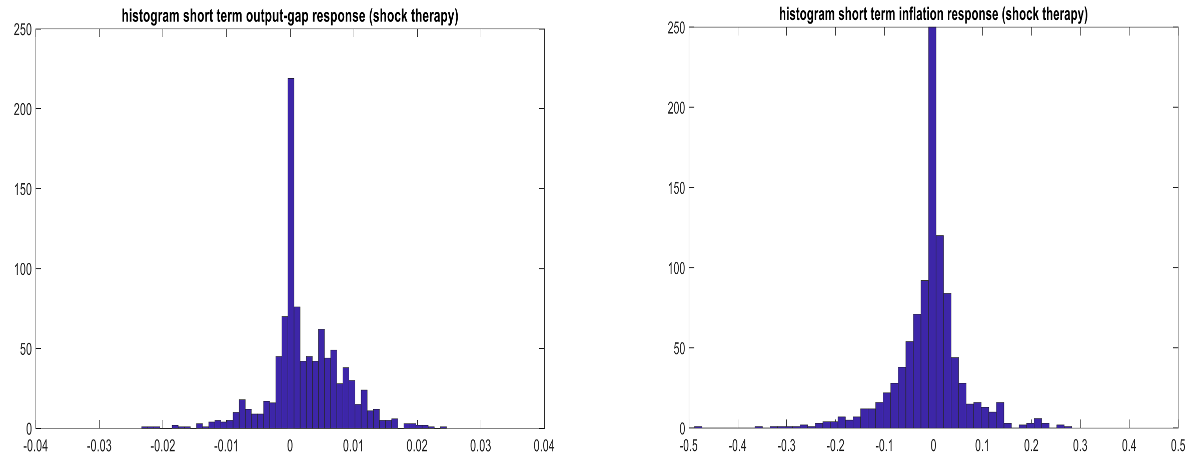


Figure 8. Frequency distribution of output gap and inflation (shock therapy, flexible regime)



In this section, I compared the dynamics of output gap and inflation under a flexible product market regime with those obtained under a rigid market regime. There are two important conclusions. First, in a rigid economy, a gradualism approach of price liberalization is better than a shock therapy as the latter leads to great uncertainty of economic outcomes including the possibility of a very bad trajectory that may have grave political economy consequences. Second, the results confirm that a shock therapy may generate much smaller short-term economic costs when the product markets are flexible. Quick price adjustments can lead to a much faster return of output and inflation to their steady state values.

The analysis makes clear that a shock therapy can only be successful if implemented in sectors that have sufficient market competition and price flexibility. For sectors that have sufficient competition and are highly flexible, 'big-bang' price liberalizations are effective in achieving positive reform results. For those sectors that have a monopoly-like position and experience rigid price and output adjustments, reforms should be gradual. This implies that in these sectors government control over prices is still key to ensure macroeconomic stability during the transition period. Or put differently, at early stages of reforms, policymakers should not remove price controls for the whole economy.

The behavioral model also suggests that the sequencing of reforms matters: governments should start with the reform areas that are most likely to generate positive outcomes. These theoretical insights are consistent with empirical evidence that reforms are more successful in countries which give priority to liberalizing their small competitive private sector while not so successful in countries that started reforms from a more rigid system of central planning (Campos and Coricelli (2002)).

5. Role of confidence

5.1 Rational expectation (RE) model vs. behavioral model

I compare the results of the behavioral model to those of a rational expectation (RE) model. This comparison allows us to understand the role of the behavioral factors in generating different results. To do so, the RE model includes the same aggregate demand equation (1), the aggregate supply equation (2) and the Taylor rule (3) assuming rational expectations (RE). The model uses the same parameter values and the same distribution of the stochastic shocks as those in Table 1. I perform this exercise for the gradualism reform (σ=1.5) and the therapy shock (σ=15). The impulse responses are shown in Figure 9. These results should be compared to the impulse responses of the behavioral model in Figures 3 and 4.

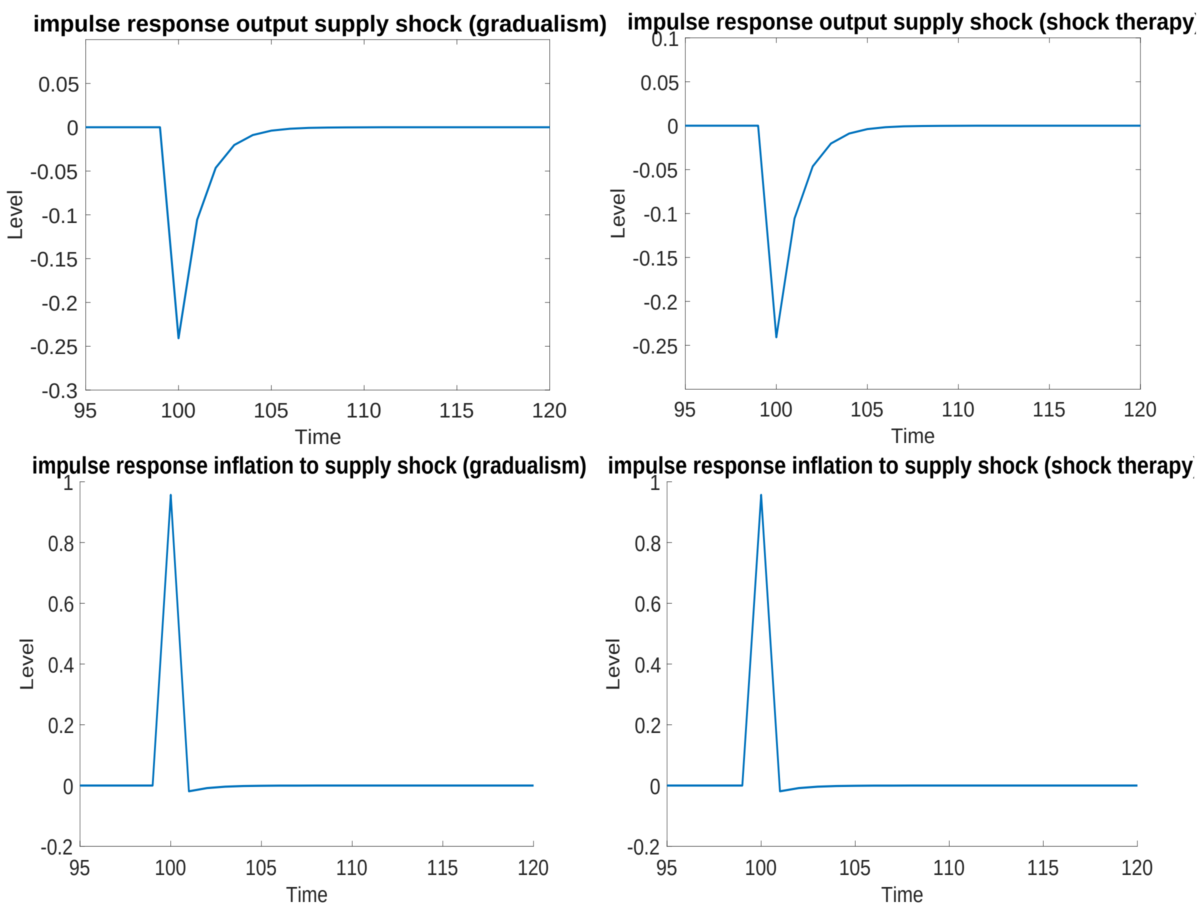
The differences in the two models are striking. First, the impulse responses (expressed as multipliers) in the RE-model show that the size of reforms (shock therapy or gradualism approach) does not matter. The multipliers of output and inflation in the gradualism approach are the same as the ones in the shock therapy. In the behavioral model, the size of shocks matters greatly.

Second, there is no uncertainty about the impulse responses in the RE-model. There is no sensitivity to initial conditions and hence the impulse responses are not influenced by the timing of the supply shock. They are the same for all realizations of the stochastic shocks. In contrast, the behavioral model produces uncertainty, and the impulse responses are sensitive to initial conditions as shown in section 4.

Third, the rational expectations model produces much weaker multipliers of the same supply shocks. The multiplier effects are higher in the behavioral model. This difference is related to the fact that the behavioral features of the model, in particular the movements of optimism and pessimism (animal spirits), tend to amplify the supply shock. These movements of optimism and pessimism are absent in the RE-model (see discussions in (De Grauwe and Ji (2020))).

Fourth, the economy takes a longer time to adjust to its long-term equilibrium in the behavioral model than in the rational expectations model. This difference is large: for example, in response to a shock therapy it takes at least 30-40 quarters in the behavioral model to go back to equilibrium versus less than 5 periods in the rational expectations model.

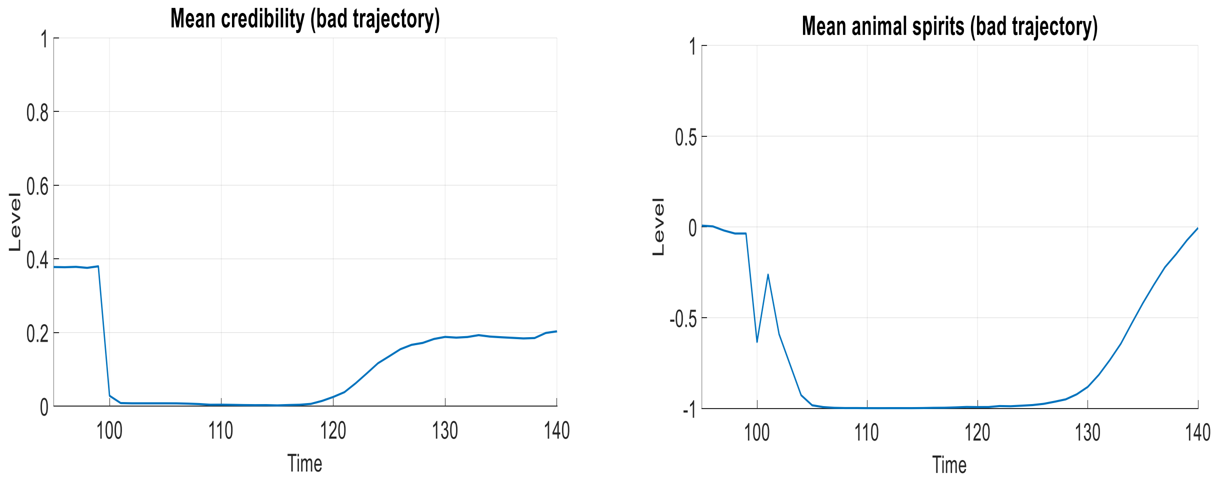
Figure 9. Impulse responses (RE model): gradualism vs. shock therapy



5.2. Confidence and bad trajectories

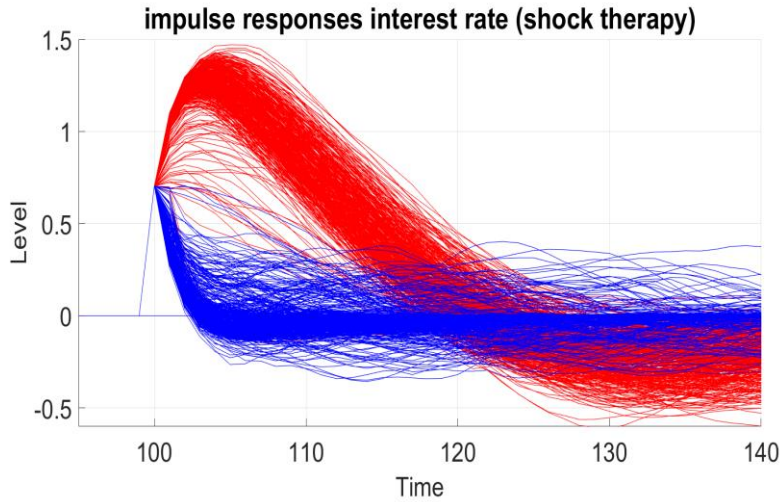
The analysis in section 4.1 shows that there exist bad trajectories when a shock therapy is introduced. In this section, I provide a discussion on the role of confidence in amplifying the business cycle and the policy response of the central bank. Figure 10 shows what occurs to the two confidence indicators following a very large shock of 15 standard deviation under unfavorable initial conditions. The inflation credibility drops to zero and the animal spirits drop to -1. This reveals that the mean reverting forecasting processes (i.e. agents using the 'fundamentalist' rule) are switched off and only the extrapolating dynamics is left over. There is a complete breakdown of confidence for 20-30 quarters. This creates a destabilizing dynamic that keeps the output gap low and the inflation high (see the red trajectories in Figure 3). To be specific, when confidence is zero, there are no agents anymore who expect the inflation to return to the target set by the central bank. As a result, the inflation dynamics is driven by extrapolative behaviour. The same dynamics occurs for the output gap in the bad trajectories. This intense loss of confidence (in the central bank and in the future) amplifies the negative effects of the supply shock. It makes the economy less resilient to absorb large exogenous shocks.

Figure 10. Confidence with shock therapy



The interest rate policy adopted by the central bank is also related to the bad trajectories. In Figure 11, I show that in the bad trajectories the central bank is forced to raise the interest rate dramatically. The interest rate path in the bad trajectories only starts to decline after more than 5 periods. Thus, when confidence is low in the bad trajectories, the central bank is obliged to increase the interest rate to gain public confidence in its inflation credibility. However, the central bank faces a classical tradeoff in dealing with a supply shock, i.e. interest rate increases may be used to stabilize the inflation but this comes at the cost of less output gap stabilization. As a result, the action of central bank to gain confidence in its inflation target comes at the cost of a sever loss in output. This explains the reason why it can take a long time for confidence to recover.

Figure 11. Impulse responses (interest rate)

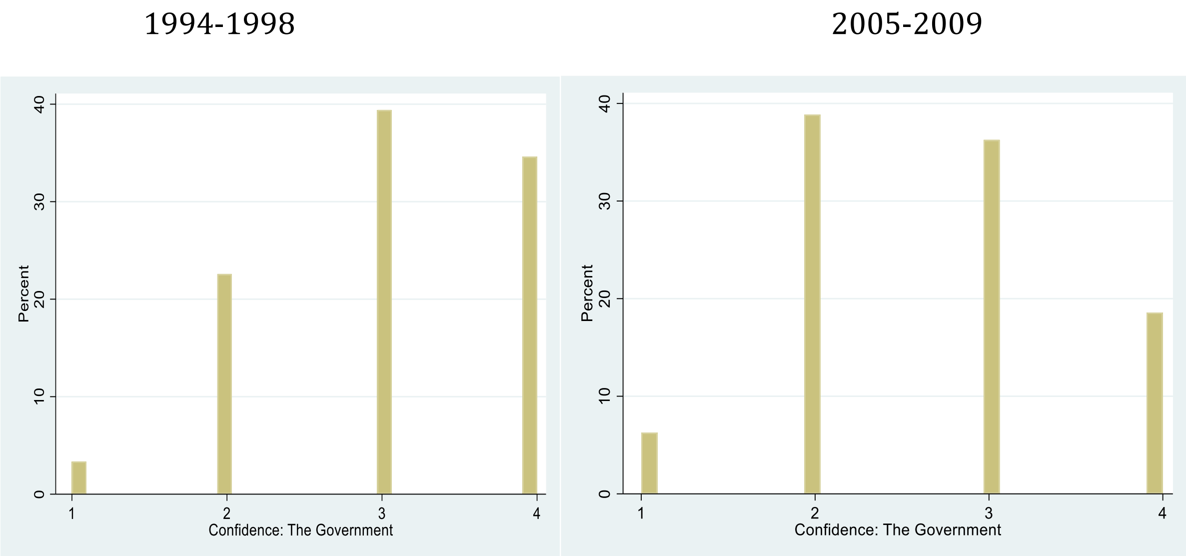


The behavioural model predicts that countries implementing a shock therapy under unfavorable conditions will suffer from low public confidence and poor economic outcomes. This was in fact the experience of Russia in the 1990s. The Central Bank of the Russian Federation was established in 1990 with very little credibility. Due to repressed inflation in the past, the inflation expectations of the Russian public were very high. This unfavourable initial condition predicts that the Russian shock therapy was bound to fail. The macroeconomic data in Figure 12 confirm this theoretical insight. Figure 12 shows how business confidence was the lowest during the transition period of the 1990s. Figure 13 reveals that public confidence in the government was very low also: during the 1990s, around 75% of the respondents in the world value survey reported that they did not have confidence in their national government while this number dropped to around 55% one decade later. Another piece of evidence about the Russian confidence crisis comes from the fact that in 1997 the country experienced a major currency crisis which suggests that the confidence in the Russian government and in its central bank was very limited.

Figure 12 Business confidence in the Russian economy

Data source: OECD business confidence data

Figure 12. Public confidence in the government



Data source: World Values Survey Time Series 1981-2020 data; respondents were asked the following question: could you tell me how much confidence you have in the government (in your nation's capital)? Answers include: 1. a great deal of confidence, 2. quite a lot of confidence, 3. not very much confidence or 4. none at all

8. Conclusions

More than 30 years ago, shock therapies were introduced in some transition countries aiming at transforming their planned economy into a free market economy through big-bang liberalization reforms. The latter included ending price controls, privatization and other measures that significantly reduced the role of governments in the economy. When, after many years, economists evaluated the impact of these reforms, a strong consensus emerged that there are great long-term benefits of these reforms for economic growth. However, economists still do not seem to fully agree on whether it was wise to implement sudden and drastic reforms. Some believe that the short-term costs in the form of economic recession, high unemployment and high inflation were too large for the public to bear, while others disagree (see an excellent article by Havrylyshyn (2001) reviewing this issue). This debate on 'short term pain versus substantial gain later' was not only relevant for the transition economies in the 1990s but also for some advanced economies when European policy makers attempted to introduce structural reforms in their countries after the Eurozone sovereign debt crises (see De Grauwe and Ji (2020) and Campos, De Grauwe and Ji (2018)).

In this paper, I analyzed the short-term cost of shock therapy using a behavioral macroeconomic model. This is a model characterized by the assumption that agents experience cognitive limitations, which leads them to use simple forecasting rules while evaluating the forecasting performances of these rules ex-post. This evaluation leads them to switch to the rules that perform best producing endogenous waves of confidence. The basic feature of this model compared to a RE model is that it generates great complexities about the transmission of reform shocks to the economy. These complexities are found to be sensitive to initial conditions. This behavioural model provides a new theoretical perspective in explaining why the transition experience of individual countries differed radically.

The first issue I analyzed was whether policy makers should adopt a 'big-bang' or small step liberalization reforms in removing price controls. The simulation results showed that a shock therapy that immediately liberalizes all prices leads to more intense uncertainty than a gradualism approach. I also found that if initial conditions are unfavourable (such as high inflation expectations), a shock therapy generates a prolonged recession and persistent high inflation. These bad trajectories coincide with a loss of public confidence in the central bank. As a result the central bank has to substantially increase its interest rate to reduce the inflation expectations at the cost of large output losses.

The second issue I analyzed relates to the degree of flexibility in the economy when reforms are implemented. I showed that big bang reforms are costly when the economy is characterized by rigidities in price adjustments. When, however, the economy is very flexible, i.e. prices adjust quickly to disequilibria, big bang reforms do not lead to the same kind of macroeconomic costs as in rigid economies. The mechanism that produces this can be described as follows. When the central bank attaches a great importance to inflation stabilization, the central bank's stabilization efforts will be more effective in a flexible than in a rigid economy. This reduces the amplitude of the business cycles and, as a result, creates more scope for stabilization (for a detailed discussions on this topic see De Grauwe and Ji (2020)).

The findings of this paper have some political economy implications. First, the same reform package may lead to different results in different countries. The effects of reforms very much depend on "initial conditions". The latter can be institutional in nature. It can also be the business cycle conditions. Policy makers should adopt a well-designed strategy in implementing complicated reforms.

Second, structural reforms, in the form of shock therapy, may lead to great uncertainty, a total loss of confidence in the government and severe economic pain leading to strong resistance to further reforms. Policymakers should be cautious and should take into account the short-term economic and political costs when implementing reforms. Reforms implemented under unfavourable conditions (such as low public confidence) may turn out to be unsuccessful. The Russian experience in 1990s confirms these insights.

Third, partial reforms may be optimal. That is, it may be desirable for the authorities to start the reform process in those sectors of the economy that are characterized by much competition and price flexibility. In these sectors big bang reforms can be implemented without creating large short-term adjustment problems that may jeopardize the reform process. This approach should be supplemented by strong competition policies aiming at keeping strong competition alive. In sectors characterized by high concentration levels and absence of competition, the reforms should be introduced gradually, thereby avoiding the large short-term macroeconomic costs of abrupt reforms processes.

Finally, the results of this paper have implications for the optimal sequencing of reforms. Reforms should focus first on sectors with a lot of competition and flexibility, where these reforms can be of the "big-bang" type. Second, reforms should be introduced in a gradual way in those sectors where rigidities prevail. This finding supports the policy practice in countries where this kind of sequencing of reforms has been used (see section 2 on Hungary, China, and Vietnam).

Appendix 1: Heuristics and the optimal choice of rules

The fundamentalist rule and the extrapolator rule of output forecasting are:

$$\tilde{E}_t^f y_{t+1} = 0 \qquad (A1)$$

$$\tilde{E}_t^e y_{t+1} = y_{t-1} \qquad (A2)$$

The market forecast is obtained as a weighted average of these two forecasts,

$$\tilde{E}_t y_{t+1} = \alpha_{f,t}\tilde{E}_t^f y_{t+1} + \alpha_{e,t}\tilde{E}_t^e y_{t+1} \qquad (A3)$$

where $\alpha_{f,t}$ and $\alpha_{e,t}$ are the probabilities that agents use the fundamentalist and the extrapolator rules respectively. Also, $\alpha_{f,t} + \alpha_{e,t} = 1$.

Concerning inflation forecast, agents also use a similar heuristic. As the central bank announces an explicit inflation target, the fundamentalist rule is based on this announced inflation target, i.e., agents using this rule have confidence in the credibility of this rule and use it to forecast inflation.

$$\tilde{E}_t^f \pi_{t+1} = \pi^* \qquad (A4)$$

Agents who do not have confidence in the announced inflation target use the extrapolator rule (see Brazier et al. (2008)).

$$\tilde{E}_t^e \pi_{t+1} = \pi_{t-1} \qquad (A5)$$

The market forecast is:

$$\tilde{E}_t \pi_{t+1} = \beta_{f,t}\tilde{E}_t^f \pi_{t+1} + \beta_{e,t}\tilde{E}_t^e \pi_{t+1} \qquad (A6)$$

where $\beta_{f,t}$ and $\beta_{e,t}$ are the probabilities that agents use the fundamentalist and the extrapolator rules respectively in forecasting inflation. Also $\beta_{f,t} + \beta_{e,t} = 1$.

I now define a criterion of success for forecast performances. As often used in the literature, this is the forecast performance (utility) of a particular rule. Define the utility of using the fundamentalist and the extrapolative rules as follows[10].

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[10] (A7) and (A8) can be derived from the following equation:

$$U_t = \rho U_{t-1} + (1-\rho)[y_{t-1} - \tilde{E}_{t-2} y_{t-1}]^2 \quad (A7')$$

where ρ can be interpreted as a memory parameter. When $\rho = 0$ only the last period's forecast error is remembered; when $\rho = 1$ all past periods get the same weight and agents have infinite memory. Assume that $\rho = 0.5$. Using (A7') one writes:

$$U_{t-1} = \rho U_{t-2} + (1-\rho)[y_{t-2} - \tilde{E}_{t-3} y_{t-2}]^2 (A7'')$$

Substituting (A7") into (A7') and repeating such substitutions ad infinitum yields the expression (A7) where

$$U_{f,t} = -\sum_{k=0}^{\infty} \omega_k \left[y_{t-k-1} - \widetilde{E}_{f,t-k-2} y_{t-k-1}\right]^2 \qquad \text{(A7)}$$

$$U_{e,t} = -\sum_{k=0}^{\infty} \omega_k \left[y_{t-k-1} - \widetilde{E}_{e,t-k-2} y_{t-k-1}\right]^2 \qquad \text{(A8)}$$

where $U_{f,t}$ and $U_{e,t}$ are the utilities of the fundamentalist and extrapolator rules, respectively. These are defined as the negative of the mean squared forecasting errors (MSFEs) of the forecasting rules; ω_k are geometrically declining weights. These weights decline as agents tend to forget and they give a lower weight to errors made far in the past.

How do agents evaluate these utilities (forecast performances)? I apply discrete choice theory in specifying the procedure agents follow in this evaluation process. As argued earlier, the selection mechanism used should be interpreted as a learning mechanism based on "trial and error". When observing that the rule they use performs less well than the alternative rule, agents are willing to switch to the more performing rule.

If agents were purely rational they would just compare $U_{f,t}$ and $U_{e,t}$ in (A7) and (A8) and choose the rule that produces the highest value. Thus under pure rationality, agents would choose the fundamentalist rule if $U_{f,t} > U_{e,t}$, and vice versa. However, psychologists have stressed that when choosing among alternatives one may also be influenced by one's state of mind (see Kahneman(2002)). The latter can be influenced by many unpredictable things. One way to formalize this is that the utilities of the two alternatives have a deterministic component (these are $U_{f,t}$ and $U_{e,t}$ in (A7) and (A8)) and a random component $\xi_{f,t}$ and $\xi_{e,t}$ The probability of choosing the fundamentalist rule is then given by

$$\alpha_{f,t} = P\left[(U_{f,t} - U_{e,t}) > (\xi_{e,t} - \xi_{f,t})\right] \qquad \text{(A9)}$$

This means that the probability of selecting the fundamentalist rule is equal to the probability that the stochastic utility associated with using the fundamentalist rule exceeds the stochastic utility of using the extrapolator rule. In the discrete choice literature (see Anderson, de Palma, and Thisse, (1992) and Brock & Hommes(1997)), it is assumed that these random variables $(\xi_{e,t} - \xi_{f,t})$ are logistically distributed. One then obtains the following expressions for the probability of choosing the fundamentalist rule:

$$\alpha_{f,t} = \frac{exp(\gamma U_{f,t})}{exp(\gamma U_{f,t}) + exp(\gamma U_{e,t})} \qquad \text{(A10)}$$

$$\omega_k = (1-\rho)\rho^k$$

Similarly, the probability that an agent will use the extrapolator rule is:

$$\alpha_{e,t} = \frac{exp(\gamma U_{e,t})}{exp(\gamma U_{f,t}) + exp(\gamma U_{e,t})} \qquad \text{(A11)}$$

Equation (A10) says that as the past forecast performance (utility) of the fundamentalist rule improves relative to that of the extrapolator rule, agents are more likely to select the fundamentalist rule for their forecasts of the output gap. Equation (A11) has a similar interpretation. The parameter γ measures the "intensity of choice". The parameter γ can also be interpreted as expressing a willingness to learn from past performance. When $\gamma = 0$ this willingness is zero; it increases with the size of γ.

Finally, the same selection mechanism is used in the case of inflation forecasting. $\beta_{f,t}$ and $\beta_{e,t}$ can be expressed as in equations (A10) and (A11) respectively.

Appendix 2. Solving the model

The solution of the model is found by first substituting (3) into (1) and rewriting in matrix notation. This yields:

$$\begin{bmatrix} 1 & -b_2 \\ -a_2 c_1 & 1 - a_2 c_2 \end{bmatrix} \begin{bmatrix} \pi_t \\ y_t \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ -a_2 & 1 \end{bmatrix} \begin{bmatrix} \widetilde{\mathrm{E}}_t \pi_{t+1} \\ \widetilde{\mathrm{E}}_t y_{t+1} \end{bmatrix} + \begin{bmatrix} 0 \\ a_2 c_3 \end{bmatrix} r_{t-1} + \begin{bmatrix} \eta_t \\ a_2 u_t + \varepsilon_t \end{bmatrix}$$

i.e.

$$\boldsymbol{A Z_t} = \boldsymbol{B \widetilde{E_t}\, Z_{t+1}} + \boldsymbol{b} r_{t-1} + \boldsymbol{v_t} \qquad \text{(A12)}$$

where bold characters refer to matrices and vectors. The solution for $\boldsymbol{Z_t}$ is given by

$$\boldsymbol{Z_t} = \boldsymbol{A^{-1}}\left[\boldsymbol{B \widetilde{E_t}\, Z_{t+1}} + \boldsymbol{b} r_{t-1} + \boldsymbol{v_t}\right] \qquad \text{(A13)}$$

The solution exists if the matrix $\boldsymbol{A}$ is non-singular, i.e. $(1-a_2c_2)-a_2b_2c_1 \neq 0$. System (A13) describes the solutions for y_t and π_t given the forecasts of y_t and π_t. The latter have been specified in Appendix 1. The solution for r_t is obtained by substituting y_t and π_t obtained from (A13) into (3).

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