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Alternative Monetary-Policy Instruments and Limited Credibility in Small and Open Economies: An Exploration

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Abstract

We evaluate the dynamics of a small and open economy under alternative monetary policy instruments, in a model with imperfectly anchored expectations. The consensus under inflation targeting is that rules for an interest rate are preferred, instead of using either some monetary aggregate or the exchange rate. Theses arguments are usually presented assuming rational expectations (RE) hold and there is full credibility. In contrast we consider deviations from RE, where a fraction of agents uses econometric models to form expectations, capturing imperfectly anchored expectations or limited credibility (LC). The model also features a non-trivial banking sector, allowing for different interest rates and monetary aggregates. We compare the dynamics after a shock to the cost of external borrowing (arguably one of the most important sources of fluctuations in emerging countries) under three policy instruments: a Taylor-type rule for the interest rate, a constant-growth-rate rule for base money, and a fixed exchange rate. The analysis allows to identify relevant trade-offs in choosing alternative policy instruments, showing that the differences between the alternatives are exacerbated under LC.

[*]The views and conclusions presented in this paper are exclusively those of the authors and do not necessarily reflect the position of the Central Bank of Argentina or its Board members. E-mail: javier.garcia@bcra.gob.ar

1 Introduction

This paper presents an exploration of the trade-offs associated with choosing alternative monetary policy instruments in small and open economies, in a context of imperfectly anchored expectations or lack of credibility. Along with the increased popularity of inflation targeting as a policy framework, the vast majority of studies analyzing policy rules focuses on a short-term interest rate as the instrument, in a context of rational expectations (where agents believe the policy rule will hold not only in the present but in the future as well, a form of policy credibility).[1] Even those papers relaxing the rational-expectations assumption mostly also focus on interest-rate rules.[2]

However, in many contexts credibility cannot be taken for granted. This has been historically the case, for instance, at the initial stages of inflation-stabilization programs. Indeed an earlier literature analyzes the dynamics of stabilization plans under alternative policy instruments; see, for instance, the surveys in Calvo and Végh (1994, 1999). More recently, Calvo (2018) presents concerns about implementing an interest-rate based inflation targeting to generate a permanent reduction in inflation. In addition to these credibility concerns, many argue that the interest rate may not be a powerful instrument if financial markets are not as deep.[3]

In addition, many central banks actually choose to implement monetary policy using other instruments. For instance, the Central Bank of Uruguay changed the policy instrument in 2013; from a short-term interest rate to a monetary aggregate. Peru implements an inflation-targeting regime where both the policy rate and the volatility of the exchange rate are key variables. More recently, Argentina also changed from an interest-rate-based framework to one with a target for the monetary base.

Conceptually, from the perspective of a general equilibrium model, there is a sense in which the choice of the instrument is irrelevant: an equilibrium obtained using a policy rule for a specific instrument can generally be implemented (as long as the equilibrium is unique) with a particular rule for an alternative instrument.[4] But the rule for the alternative instrument that implements the same equilibrium does not need to be as simple, and it will generally be model dependent. From that perspective, as long as simplicity of policy is a desirable feature, simple rules for alternative instruments will imply different outcomes; so its is worth analyzing how the economy performs under alternative simple rule for different instruments.

In this context, the goal of this paper is to provide an analysis of the relevant trade-offs in choosing simple rules for alternative instruments. To keep the analysis simple, we focus on the impact that alternative rules may have in smoothing the responses originated by an unexpected change in foreign-financing costs. This is a relevant shock to consider from at least two perspectives. First,

[1] Some examples in closed economy models are Schmitt-Grohe and Uribe (2007), Faia (2008), Faia and Monacelli (2007), Taylor and Williams (2010); while for open economies some relevant references are Faia and Monacelli (2008), De Paoli (2009), Corsetti et al. (2010), Devereux et al. (2006).

[2] For instance, Erceg and Levin (2003), Cogley et al. (2015), Gibbs and Kulish (2017), among others.

[3] For example, see Berg et al. (2010) and Andrle et al. (2013).

[4] Consider a simple model with a constant money-growth rule $\frac{M_t}{M_{t-1}} = \mu$ and money-demand equation given by $\frac{M_t}{P_t} = (R_t)^{-\xi}$, where M_t is the quantity of money, P_t is the price level and R_t the nominal rate. An equilibrium obtained with that rule can also be implemented with the following rule for the interest rate: $R_t = R_{t-1}\left(\frac{\pi_t}{\mu}\right)^{1/\xi}$, where $\pi_t = P_t/P_{t-1}$. This is simply obtained by replacing the money growth rule into the time-differenced demand, and solving for the current value of the interest rate.

many argue that it is an important driving force of the business cycle in emerging countries.[5] Second, because external interest rates are also key drivers of exchange rate movements, which in turn are key to inflation dynamics.

Our point of departure is a model of a small and open economy with incomplete financial markets, nominal rigidities in prices and wages, and capital accumulation. To discus the potential role of monetary aggregates, we include a non-trivial banking sector, following Edwards and Vegh (1997), subject also to reserve requirements.

In order to account for limited credibility, we consider a particular deviation from rational expectations by which a fraction of agents uses econometric models (based only on past data) to form expectations, while the rest operate under rational expectations (RE). This approach follows Gibbs and Kulish (2017), who argue that including a fraction of adaptive learners captures imperfectly anchored expectations or lack of credibility; for the effect of policy announcements may be less powerful than under rational expectations.

This deviation from rational expectations introduces two relevant channels for monetary policy. First, inflation is more persistent. Second, as inflation expectations also affect the real rate that is relevant for inter-temporal decisions, the power of the central bank to modify consumption, investment and activity will be limited. From this perspective, allowing for adaptive learning does not only introduce a backward-looking component in the phillips curve (as in the early literature on inflation dynamics) but has an impact for other policy-relevant decisions as well.

In this context, we compare three simple rules. The first is a Taylor-type rule for the short-term interest rate. The second is a constant growth rate for base money. Finally, we also consider an exchange-rate peg.

The results show that, qualitatively, there is a trade-off in choosing between an interest-rate rule vs. a constant-money-growth rule. In particular, limiting the fluctuations in the quantity of money insulates activity-related variables from the contractionary effects of the external shock, while at the same time increases the inflationary effects. This is due to the different behavior of nominal rates under both policy configurations. At the same time, a peg induces a larger contraction after the external shock, without a clear advantage in the inflationary front.

We also show that, while these qualitative trade-offs seem to be independent from the specific expectations-formation assumption, quantitatively the differences between alternative instruments is exacerbated under limited credibility. This is a consequence of both a more persistent inflation, once adaptive learners are considered, and a magnified effect of interest-rate changes in activity if expectations are not fully rational.

The rest of the paper is organized as follows. Section 2 presents the details of the model and its calibration. Section 3 compares the alternative policy instruments in a context of rational expectations, while Section 4 compares them under limited credibility. Section 5 concludes.

2 Model

The setup is one of a small and open economy with free international capital mobility and incomplete financial markets. There are several goods: home, imported, final and capital. The home

[5] See, for instance, Uribe and Yue (2006).

good is produced by combining labor and capital. The final-consumption good is composed by home and imported goods. Additionally, we consider nominal rigidities. In particular, the markets for final goods and for labor have a monopolistic-competitive setup, where prices are subject to Calvo-style frictions.

Households derive utility from consumption, leisure, as well as money and deposit holdings. They also have access to international borrowing and to treasury bonds. In turn, banks take household deposits and lend to firms to finance capital accumulation. Banks operate a technology with economies of scope. The central banks imposes reserve requirements for banks, and decides monetary policy.

The rest of this section describes the different agents in the model, the general-equilibrium conditions, the assumptions regarding expectations formation, the parametrization strategy, and the alternative policy rules considered.

2.1 Households

Households seek to maximize

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta^t U\left(c_t, h_t, \frac{M_t}{P_t}, \frac{D_t}{P_t} \right) \right\},$$

subject to the constraint

$$\begin{aligned} P_t c_t + D_t + S_t B_t^{*,H} + B_t^{T,H} + M_t + T_t^H \leq ... \\ W_t h_t + M_{t-1} + S_t B_{t-1}^{*,H} R_{t-1}^* + B_{t-1}^{T,H} R_{t-1} + R_{t-1}^D D_{t-1} + \Omega_t. \end{aligned}$$

Here, c_t denotes consumption, h_t are hours worked, D_t are deposits (with interest rate R_t^D), $B_t^{*,H}$ are holdings of foreign bonds (with rate R_t^*), $B_t^{T,H}$ are holdings of treasuries (with rate R_t), M_t^H denotes cash holdings, T_t^H are lump-sum transfers, S_t is the nominal exchange rate, P_t is the price of final consumption goods, W_t is the nominal wage, and Ω_t denotes profits from the ownership of firms.[6]

Letting $\beta^t \frac{\lambda_t}{P_t}$ denote the Lagrange multiplier associated with the resource constraint, we obtain the following optimality conditions

$$\lambda_t = U_{c,t}, \qquad \lambda_t = \beta R_t^* E_t \left\{ \frac{\pi_{t+1}^s \lambda_{t+1}}{\pi_{t+1}} \right\},$$

$$\lambda_t = \beta R_t E_t \left\{ \frac{\lambda_{t+1}}{\pi_{t+1}} \right\}, \qquad \frac{U_{\frac{M}{P},t}}{\lambda_t} = 1 - \frac{1}{R_t}, \qquad \frac{U_{\frac{D}{P},t}}{\lambda_t} = 1 - \frac{R_t^D}{R_t},$$

where $U_{x,t} = \frac{\partial U_t}{\partial x_t}$, $w_t \equiv \frac{W_t}{P_t}$, $\pi_t \equiv \frac{P_t}{P_{t-1}}$, and $\pi_t^s \equiv \frac{S_t}{S_{t-1}}$. The first of these just indicates that the Lagrange multiplier equals the marginal utility of consumption. The second and third characterize the inter-temporal trade-off in choosing domestic and foreign bonds, while the last two represent

[6]Throughout, uppercase letters denote nominal variables containing a unit root in equilibrium (due to long-run inflation), while lowercase letters indicate stationary variables. Variables without time subscript denote non-stochastic steady-state values in the stationary model.

the demand for cash and deposits. Additionally, define the stochastic discount factor for claims in domestic currency as $\chi_{t,t+s} = \beta^s \frac{\lambda_{t+s}}{\lambda_t}\frac{P_t}{P_{t+s}}$.

Following Schmitt-Grohé and Uribe (2006), labor decisions are made by a central authority (e.g. a union) which supplies labor monopolistically to a continuum of labor markets indexed by $i \in [0,1]$. Households are indifferent between working in any of these markets, and there are no differences in the quality of labor provided by the different types of households. In each of these markets the union faces a demand for labor given by $h_{it} = [W_{it}/W_t]^{-\epsilon_W} h_t^d$, where W_{it} denotes the nominal wage charged by the union in market i, W_t is an aggregate hourly wage index that satisfies $(W_t)^{1-\epsilon_W} = \int_0^1 W_{it}^{1-\epsilon_W} \mathrm{d}i$, and h_t^d denotes aggregate labor demand by firms. The union takes W_t and h_t^d as given and, once wages are set, it satisfies all labor demanded. In addition, the total number of hours allocated to the different labor markets must satisfy the resource constraint $h_t = \int_0^1 h_{it}\mathrm{d}i$.

Wage setting is subject to a Calvo-type problem, whereby each period the union can set its nominal wage optimally in a fraction $1-\theta_W$ of randomly chosen labor markets, and in the other markets the past wage is indexed to a generic indexation variable $\pi_t^{I,W} = (\pi_{t-1})^{\vartheta_W}(\pi)^{1-\vartheta_W}$. In other words, wage indexation depends on past- and steady-state inflation.

Under this setup, labor supply is characterized by two equations. One describing the trade-off between consumption and labor, given by

$$w_t mc_t^W = \frac{-U_{h,t}}{\lambda_t},$$

where mc_t^W is the relevant marginal cost for wage-related decisions (i.e. the gap in the efficient allocation). The other is the wage Phillips cure, which after a log-linearization around the non-stochastic steady state yields

$$\left(\widehat{\pi}_t^W - \vartheta_W \widehat{\pi}_{t-1}\right) = \beta E_t\left\{\widehat{\pi}_{t+1}^W - \vartheta_W \widehat{\pi}_t\right\} + \frac{(1-\theta_W)(1-\theta_W\beta)}{\theta_W}\widehat{mc}_t^W,$$

where $\widehat{x}_t = \ln(x_t/x)$ for a generic variable x_t, and $\pi_t^W = \frac{W_t}{W_{t-1}}$.

2.2 Final and Home Goods

The production of final goods is done in two stages. First, at a wholesale level, a set of competitive firms combine home (x_t^H) and foreign goods (x_t^F) using the production function:

$$y_t^{Cw} = \left[\omega^{1/\eta}\left(x_t^H\right)^{1-1/\eta} + (1-\omega)^{1/\eta}\left(x_t^F\right)^{1-1/\eta}\right]^{\frac{\eta}{\eta-1}}.$$

Nominal profits are given by $P_t^{Cw}y_t^{Cw} - P_t^H x_t^H - P_t^F x_t^F$, leading to the following optimality conditions:

$$x_t^F = (1-\omega)\left(\frac{p_t^F}{p_t^{Cw}}\right)^{-\eta} y_t^C, \qquad x_t^H = \omega\left(\frac{p_t^H}{p_t^{Cw}}\right)^{-\eta} y_t^C.$$

with $p_t^F \equiv P_t^F/P_t$, $p_t^H \equiv P_t^H/P_t$, $p_t^{Cw} \equiv P_t^{Cw}/P_t$.

At the retail level, a monopolistic-competitive structure is assumed. The production y_t^C is a combination of a continuum of varieties indexed by $j \in [0,1]$ using the technology

$$y_t^C = \left[\int_0^1 \left(x_{jt}^C\right)^{1-\frac{1}{\epsilon}} \mathrm{d}j\right]^{\frac{\epsilon}{\epsilon-1}},$$

leading for the following demand for variety j,

$$x_{jt}^C = \left(\frac{P_{jt}}{P_t}\right)^{-\epsilon} y_t^C.$$

The producer of a given variety j internalizes this demand, and purchases wholesale final goods at price P_t^{Cw}, and transforms into the variety j using a linear technology ($y_{jt}^C = x_{jt}^{Cw}$). In setting prices, it faces a Calvo probability of not baing able to change the price given by θ. An in case it is not able to choose optimally, the previous-period price is indexed by $\pi_t^I = (\pi_{t-1})^{\vartheta}(\pi)^{1-\vartheta}$. By the standard algebra of Calvo-pricing, after a log-linearization around the non-stochastic steady state we obtain the following Phillips curve

$$(\widehat{\pi}_t - \vartheta\widehat{\pi}_{t-1}) = \beta E_t\left\{\widehat{\pi}_{t+1} - \vartheta\widehat{\pi}_t\right\} + \frac{(1-\theta)(1-\theta\beta)}{\theta}\widehat{p}_t^{Cw},$$

where $\widehat{x}_t = \ln(x_t/x)$ for a generic variable x.

2.3 Home Goods

Home goods are producing by combining labor (h_t) and capital (k_t^d) according to the production function

$$y_t^H = z_t(h_t^d)^{\alpha}(k_t^d)^{(1-\alpha)}.$$

where z_t is an exogenous productivity shock.

Profit maximization leads to the following input demands:

$$p_t^H z_t \alpha \left(\frac{y_t^H}{h_t^d}\right) = w_t, \qquad p_t^H z_t (1-\alpha)\left(\frac{y_t^H}{k_t^d}\right) = r_t^K,$$

where R_t^K is the rental price of capital, $r_t^K = R_t^K/P_t$. In equilibrium, $k_t^d = k_{t-1}$ and $h_t^d = h_t$.

2.4 Capital Goods and Investment

Capital accumulation is organized in two steps. A first set of competitive firms buy used capital, $(1-\delta)k_{t-1}$, and combine it with final goods (i_t) to produce new capital (k_t), using the technology

$$k_t = (1-\delta)k_{t-1} + \left[1 - S\left(\frac{i_t}{i_{t-1}}\right)\right] i_t.$$

where $S(\cdot)$ denotes investment-adjustment costs satisfying $S(1) = 0$, $S'(1) = 0$, and $S''(\cdot) > 0$. Profit maximization leads to the following optimality condition

$$1 = q_t \left[1 - S\left(\frac{i_t}{i_{t-1}}\right) - S'\left(\frac{i_t}{i_{t-1}}\right)\frac{i_t}{i_{t-1}}\right] + E_t\left\{\beta\frac{\lambda_{t+1}}{\lambda_t}q_{t+1}S'\left(\frac{i_{t+1}}{i_t}\right)\left(\frac{i_{t+1}}{i_t}\right)^2\right\},$$

where $q_t = Q_t/P_t$ is the relative price of capital goods.

In a second stage, another set of competitive firms rent the stock of capital to firms and, after depreciation, they sell the used capital to capital goods producer. Afterwards, they buy new capital for next period. They need to finance a fraction α_L^K of their capital purchases with loans, $L_t^K \geq \alpha_L^K Q_t k_t$. Under these assumptions, the optimal choice of these firms is ,

$$(1 - \alpha_L^K) = E_t\left\{\chi_{t,t+1}\left[\frac{\pi_{t+1}[r_{t+1}^K + (1-\delta)q_{t+1}]}{q_t} - \alpha_L^K R_t^L\right]\right\}.$$

This equation can be used to show that, up to first order, the relevant opportunity cost for investment decisions is composed by a linear combination of the loan rate and the rate relevant for inter-temporal households decision, with the weight depending on α_L^K.

2.5 Banks

Banks operate a technology characterized by a cost function $\xi_t^B\Psi(D_t, L_t)$, where ξ_t^B is an exogenous variable and Ψ is increasing, convex and linear homogeneous ($\Psi \geq 0$, $\Psi_L > 0$, $\Psi_D > 0$, $\Psi_{LL} > 0$, $\Psi_{DD} > 0$, $\Psi_{LD} < 0$, $\Psi(0,0) = 0$, $\Psi(0,L) = 0$, $\Psi(D,0) = 0$). These assumptions, following Edwards and Vegh (1997), imply that loans and deposits are complements (e.g. due to economies of scale in monitoring borrowers). The banking sector is competitive. In addition, banks are required to holds reserves τ_t per unit of deposit, remunerated at a rate R_t^τ.

Dividends for the representative bank at $t+1$ are

$$\Omega_{t+1}^B = \left(R_t^L L_t - L_{t+1}\right) + D_{t+1}(1-\tau_{t+1}) - \left(R_t^D - R_t^\tau\tau_t\right)D_t - \xi_{t+1}^B\Psi(D_{t+1}, L_{t+1}).$$

The goal is to maximize the net-present-value of dividends (i.e. $E_t\left\{\sum_{h=0}^\infty \chi_{t,t+h}\Omega_{t+h}^B\right\}$) which yields the following optimality conditions (recalling that $1 = R_t E_t\{\chi_{t,t+1}\}$)

$$R_t^L = R_t\left(1 + \xi_t^B\Psi_{L,t}\right),$$

$$R_t^D = R_t(1 - \xi_t^B\Psi_{D,t}) - (R_t - R_t^\tau)\,\tau_t.$$

Re-arranging these we can obtain expressions for the two relevant spreads:

$$R_t - R_t^D = (R_t - R_t^\tau)\,\tau_t + R_t\xi_t^B\Psi_{D,t}, \tag{1}$$

$$R_t^L - R_t^D = (R_t - R_t^\tau)\,\tau_t + R_t\xi_t^B\left(\Psi_{L,t} + \Psi_{D,t}\right), \tag{2}$$

As can be seen, both spreads arise for two different reasons. First, in the presence of required reserves, the spread is positive as long as the policy rate is higher than the rate at which reserves are remunerated (which is usually the empirically relevant case). From this channel, a rise in the policy rate will, *ceteris paribus*, increase both spreads.

The second source of differences among rates is the technology that banks use to operate. In equation (1), the second term in the right hand side can be shown to be decreasing in the loans-to-deposits ratio. In equation (2), the second term in the right hand side is, given our calibration (which assumes that deposits are larger than loans in steady state), also increases with the loans-to-deposits ratio. Thus, *ceteris paribus*, both spreads rise as loans increase over deposits.

Finally, notice that under this setup we could also allow for banks to hold treasuries and/or foreign bonds. However, these choices will yield the same optimality conditions as in the household's problem. This is the case because, under the maintained assumptions, the holdings of these assets do not alter the banking problem in any fundamental way.

2.6 Fiscal and Monetary policy

The consolidated balance sheet of the government is given by

$$P_t g_t = (M_t - M_{t-1}) + \left(RR_t - RR_{t-1}R^{\tau}_{t-1}\right) + S_t\left(B^{*,T}_t - R^*_t B^{*,T}_{t-1}\right) + \left(B^T_t - R_{t-1}B^T_{t-1}\right) + T^H_t.$$

where $RR_t = \tau_t D_t$, $B^T_t = B^{T,H}_t$, and g_t is an exogenous process.[7] In this setup, Ricardian equivalence holds (only g_t matters for equilibrium determination).

The monetary authority chooses the reserve requirement scheme (τ_t and R^{τ}_t) and one additional instrument R_t, $MB_t = M_t + RR_t$, or π^S_t; with specific rules that we discuss below.

2.7 Rest of the world

The domestic economy has several interactions with the rest of the world. First, interest rates are given by

$$R^*_t = R^W_t \exp\left\{\phi\left(-b^*_t + \bar{b}\right)\right\}.$$

where R^W_t denotes the world interest rate and the second term is a debt elastic premium (with $b^*_t \equiv B^*_t/P^*_t$) which serves as the "closing" device (see Schmitt-Grohé and Uribe, 2003). The main shock that we will analyze in the next section is R^W_t.

The local price of foreign goods (P^F_t) satisfies the law of one price: $P^F_t = S_t P^*_t$. Additionally, define the real exchange rate as $rer_t = S_t P^*_t/P_t$. It follows that,

$$rer_t = p^F_t.$$

Finally, the world's demand for home goods is given by $x^{H*}_t = \left(\frac{P^H_t}{S_t P^*_t}\right)^{-\eta^*} y^*_t$, or

$$x^{H*}_t = \left(\frac{p^H_t}{rer_t}\right)^{-\eta^*} y^*_t,$$

where y^*_t is GDP from trading partners.

[7] Notice that from the point of view of the government, $B^{*,T}$ and B^T are liabilities.

2.8 Aggregation and Market clearing

Market clearing conditions have to be satisfied in all markets, i.e.

$$y_t^H = x_t^H + x_t^{H*},$$

$$y_t^C = c_t + g_t + i_t + \xi_t^B \Psi(d_t, l_t),$$
$$y_t^H = z_t (h_t)^\alpha (k_{t-1})^{(1-\alpha)},$$
$$l_t = l_t^K,$$

Also, the following equations relate rates of inflation with relative prices:

$$\frac{p_t^H}{p_{t-1}^H} = \frac{\pi_t^H}{\pi_t}, \qquad \frac{rer_t}{rer_{t-1}} = \frac{\pi_t^s \pi_t^*}{\pi_t}.$$

where $\pi_t^* \equiv P_t^* / P_{t-1}^*$ is an exogenous process.

Finally, the evolution of net foreign assets can be derived by combining the resource constraints of households and the government:

$$rer_t \left(b_t^* - b_{t-1}^* \frac{R_{t-1}^*}{\pi_t^*} \right) = p_t^H x_t^{H*} - p_t^F x_t^F.$$

where $b_t^* = \frac{B_t^{*,H} - B_t^{*,T}}{P_t^*}$ aggregate net-foreign assets. We can also define the trade balance (in terms of consumption goods):

$$tb_t = p_t^H x_t^{H*} - rer_t x_t^F = p_t^H y_t^H - c_t - g_t - i_t.$$

2.9 Deviations from rational expectations

Under rational expectations, agents forecast future values using the equilibrium distribution of the variables. Let $\mathbb{E}_t$ denote the expectations operator under this assumption, conditional on information available at time t. Then, the rational expectations version of the model sets,

$$E_t\{x_{t+1}\} = \mathbb{E}_t\{x_{t+1}\}$$

for a generic variable x_t.

To account for imperfect credibility, we follow Gibbs and Kulish (2017) and assume that only a fraction Γ of agents have rational expectations. The rest use the expectations operator $\mathcal{E}_t$, which is determined by a reduced-form econometric model, as in the adaptive learning literature (e.g. Evans and Honkapohja, 2001). This assumption is applied to the linearized model. Therefore

$$E_t\{\widehat{x}_{t+1}\} = \Gamma \mathbb{E}_t\{\widehat{x}_{t+1}\} + (1-\Gamma)\mathcal{E}_t\{\widehat{x}_{t+1}\}. \tag{3}$$

where $\widehat{x}_t$ denotes deviations relative to the steady state.

We use the following simplified forecasting model, taken from Eusepi and Preston (2018),

$$\widehat{x}_t = \bar{x}^e_t + e^x_t,$$

with e^x_t being i.i.d. normal. The unobserved drift, $\bar{x}^e_t$ evolves according to a random-walk

$$\bar{x}^e_t = \bar{x}^e_{t-1} + \eta^x_t,$$

with innovation η^x_t distributed as i.i.d. normal. In other words, agents use a local-level model, where the relevant variables is assumed to follow random-walk plus and i.i.d shock. We also assume that agents have immutable priors about the constant variances of e^x_t and η^x_t, implying a constant signal-to-noise ratio. The updating equation from the Kalman filter is

$$x^e_t = x^e_{t-1} + K_x(x_t - x^e_{t-1}), \tag{4}$$

where x^e_t is the current filtered value of $\bar{x}^e_t$, and K_x is a function of the signal-to-noise ratio.[8] Lastly, belief parameters defining the forecast function in period t are assumed to be predetermined.[9] Under these assumptions, $\mathcal{E}_t\{\widehat{x}_{t+k}\} = x^e_{t-1}$, for all $k > 0$, and therefore (3) is,

$$E_t\{\widehat{x}_{t+1}\} = \Gamma \mathbb{E}_t\{\widehat{x}_{t+1}\} + (1 - \Gamma)x^e_{t-1}. \tag{5}$$

To focus on the case of lack of credibility about inflation announcements, we impose the structure (4) and (5) for all inflation-related variables: $\{\pi_t, \pi^W_t\}$.

We calibrate the two relevant parameters as follows. The fraction of rational expectation agents is set to $\Gamma = 0.3$ and the kalman gain equal to $K = 0.15$. The latter follows the calibration by Erceg and Levin (2003) and Céspedes and Soto (2007). It implies that a surprise in inflation of one percentage point changes inflation expectations of adaptive learners by only 0.15 percentage points. It also means that it takes almost 4 periods to incorporate half of the inflation surprise into expectations. Given this choice, and the other parameters described in section 2.11 below, the value of Γ implies that, after a permanent reduction in steady-state inflation, actual inflation takes more than twice the time to reach its new steady-state value than under rational expectations (assuming that policy follows the interest-rate rule described in section 2.12 below).

2.10 Functional forms

We need to pick functional forms for the utility function, the bank's cost and the investment adjustment costs. In terms of the utility, we use a configuration that yields the following characteristics: (i) labor supply has no wealth effect, (ii) the inter-temporal consumption trade-off is independent from labor and liquidity related decisions, (iii) money and deposits demands have unitary elasticity with respect to consumption and a parameter governing the elasticity for the relevant rates, and (iv) consumption, money and deposits decisions are persistent. The first two

[8] If we let $\sigma_{e,x}$ and $\sigma_{\eta,x}$, respectively, denote standard error of e^x_t and η^x_t, we have $K_x = \frac{Z}{Z+1}$, where $Z = (q + \sqrt{q^2 + 4q})/2$ and $q = \sigma^2_{\eta,x}/\sigma^2_{e,x}$.

[9] This avoids an analytically intractable simultaneity which would otherwise arise from the joint determination of beliefs and equilibrium outcomes.

characteristics are desirable to obtain a negative effect in activity under interest rate shocks.[10] The other condition generate dynamics in consumption, money and deposits decisions that are empirically plausible.

Thus, we choose the following specification:

$$\frac{(\widetilde{c}_t)^{1-\sigma}}{1-\sigma} - \Xi_t^h \frac{(h_t)^{1+\varphi}}{1+\varphi} + \Xi_t^M \frac{(\widetilde{m}_t)^{1-\frac{1}{\sigma_M}}}{1-\frac{1}{\sigma_M}} + \Xi_t^D \frac{(\widetilde{d}_t)^{1-\frac{1}{\sigma_D}}}{1-\frac{1}{\sigma_D}}$$

where $\widetilde{c}_t, \widetilde{m}_t, \widetilde{d}_t$ denote habit-adjusted consumption as well as real cash and deposit.[11]

The utility shifters (taken as given by individuals) Ξ_t^h, Ξ_t^M and Ξ_t^D are set to get the desired restrictions. In particular:

- For labor we pick $\Xi_t^h = \xi^h (c_t - \phi_C c_{t-1})^{-\sigma}$, which yields:

  $$w_t mc_t^W = \xi^h h_t^{\varphi}$$

  where ξ^h is a parameter. This approach follows Galí et al. (2012), which argue that this externality in the supply of labor induces, in equilibrium, that labor-supply decisions are independent from consumption.

- Similarly, for money and deposits we set $\Xi_t^j = (\xi^j)^{\frac{1}{\sigma_j}-1}(c_t - \phi_C c_{t-1})^{\frac{1}{\sigma_j}-\sigma}$, for $j = \{M, D\}$, where ξ_t are parameters. This generates the following demands for money and deposits:

  $$m_t - \phi_M m_{t-1} = \left(1 - R_t^{-1}\right)^{-\sigma_M} (c_t - \phi_c c_{t-1})\, \xi_t^M,$$

  $$d_t - \phi_D d_{t-1} = \left(1 - \frac{R_t^D}{R_t}\right)^{-\sigma_D} (c_t - \phi_c c_{t-1}) \xi_t^D,$$

  which have the desired properties.

We set the following bank's cost function:

$$\Psi(D, L) = \psi_0 + \psi_D D + \psi_L L - 2\psi_{DL}\sqrt{DL}$$

which lead to the equilibrium conditions,

$$R_t^L = R_t \left(1 + \xi_t^B \left[\psi_L - \psi_{DL} \left(\frac{d_t}{l_t}\right)^{1/2}\right]\right),$$

$$R_t^D = R_t \left(1 - \xi_t^B \left[\psi_D - \psi_{DL} \left(\frac{l_t}{d_t}\right)^{1/2}\right]\right) - (R_t - R_t^{\tau})\, \tau_t.$$

[10] Otherwise, either the wealth effect on labor supply or the indirect effect of labor in the marginal utility of consumption may lead to expansionary effects after an interest rate increase.

[11] For a generic variable X_t, habit adjusted is given by $\widetilde{X} = X_t - \phi_X X_{t-1}^a$, with $X_t^a = X_t$ in equilibrium. We further assume that, individually, households take X_t^a as given (i.e. preferences exhibits external habits).

Combining these, one can derive that the parameter ψ_{DL} determines the elasticity of the spread with respect to the deposits-to-loans ratio, while the parameters ψ_D and ψ_L are related with the steady-state values of R^L and R^D, and ψ_0 pins down the size of banking costs relative to te rest of the economy.

Finally, for the adjustment cost function we set

$$S\left(\frac{i_t}{i_{t-1}}\right) = \frac{\phi_I}{2}\left(\frac{i_t}{i_{t-1}} - 1\right)^2$$

with $\phi_I > 0$.

2.11 Calibration

The time unit is meant to be a quarter, and the model is solved with a log-linearization approach around the non-stochastic steady state. We use the following calibration strategy. We choose values for all parameters and exogenous variables in the model, except for $\beta, \pi^*, R^W, \nu, y^*, \bar{b}, g, \xi^M, \xi^D, \psi_0, \psi_D, \psi_L, \sigma_M, \sigma_D$ that are endogenously determined to match the following steady-state values: CPI inflation (π), hours worked (h), relative price of home goods (p^H), the nominal interest rate (R), nominal depreciation (π^S), the trade-balance-to-output ratio ($s^{tb} = tb/(p^H y^H)$), the ratio of government expenditure to output ($s^g = g/(p^H y^H)$), the shares of money over GDP ($s^m = m/(p^H y^H)$), the ratio of deposits to loans ($s^{dl} = d/l$), the share of bank costs to GDP ($s^{Bcost} = \frac{Bcost_t}{p^H y^H}$), the lending and deposit rates (R^L and R^D), and the elasticity of money and deposits demand with respect to the relevant rates (ε^M and ε^D).

The calibrated values are shown in Table 1. Most-macro related variables are calibrated following the literature on estimated DSGE models for emerging countries (e.g. Medina and Soto, 2007, García-Cicco et al., 2015), and therefore we do not discuss them in detail here. In terms of bank-related parameters, we choose a lending deposit-spread of 6 annual percentage points (a.p.p.). The ratio of deposits to loans is larger than one (similar to the average ratio in Argentina between 2017 and 2018), indicating a relatively underdeveloped financial market. The share of banks costs on GDP is in line with the ratio of sectoral GDP of the financial sector in most Latinamerican countries. The parameter ψ_{DL} is set to a relatively small value to have a modest volatility of the spread. Finally, the elasticity of money and deposit demand follows the empirical literature (e.g. Aguirre et al., 2006).

Finally, it is worth mentioning the calibration for the process for the external interest rate, as it is the main shock that we will study. The parameters come from fitting an AR(1) process to the sum of the LIBOR rate and the JPMorgan EMBI Index for Argentina. The standard deviation of the shock represents an annualized value of around 160 basis points in a quarter. In turn, the calibrated persistence implies a half-life of almost 5 quarters.

2.12 Alternative policy rules

In the analysis that follows we consider simple rules for the following three instruments:

Table 1: Calibrated parameters and targeted steady state values.

Parameter	Description	Value
σ	Coef. of relative risk aversion	1
φ	Inverse Frisch elasticity of labor suppy	1
ϕ_C	Habit in consumption	0.6
ϕ_M	Habit in money demand	0.3
ϕ_D	Habit in deposits demand	0.3
α	Share of capital in production of H	0.33
δ	Capital depreciation	0.015
ϕ_I	Inv. adjustment cost	3
α_L^K	Share of capital financed by loans	0.5
ω	Share of home goods in consumption	0.7
η	Elast. of subst. between home and for. goods	1.3
η^*	Foreign demand elasticity	0.2
ϵ	Elast. of subst. between varieties of goods	11
ϵ_W	Elast. of subst. between varieties of labor	11
θ	Calvo probability of no price adjustment	0.7
θ_W	Calvo probability of no wage adjustment	0.9
ϑ	Indexation to past inflation in prices	0.4
ϑ_W	Indexation to past inflation in wages	0.8
ϕ_B	Debt elasticity of foreign interest rate	0.01
ψ_{DL}	Elasticity of the spread to the deposit-to-loan ratio	0.01
ρ_{R^W}	A.C. external interest rate	0.7
σ_{R^W}	St.Dev. external interest rate shock	0.004
π	Steady state inflation	$1.03^{1/4}$
h	Steady state hours worked	1/3
p^H	Steady state rel. price of home goods	1
R	Steady state domestic interest rate	$1.06^{1/4}$
π^S	Steady state exchange. rate growth	1
s^{tb}	Steady state trade-balance-to-GDP ratio	0.05
s^g	Steady state government-consumption-to-GDP ratio	0.1
s^m	Steady state inverse velocity of money	0.3
s^{dl}	Steady state deposits-to-loans ratio	1.2
s^{Bcost}	Steady state of banking costs	0.01
R^D	Deposit interest rate	$R\times 0.99^{1/4}$
R^L	Lending interest rate	$R\times 1.05^{1/4}$
τ	Required reserves	$1.03^{1/4}$
R^τ	Interest rate on required reserves	1
ε^M	Money demand elasticity	-1.5/4
ε^D	Deposits demand elasticity	1/4

1. Interest rate:
$$\left(\frac{R_t}{R}\right) = \left(\frac{R_{t-1}}{R}\right)^{\rho_R} \left[\left(\frac{\pi_t}{\pi}\right)^{\alpha_\pi} \left(\frac{y_t^H}{y_{t-1}^H}\right)^{\alpha_y}\right]^{1-\rho_R} e_t^{MP}, \tag{6}$$
where e_t^{MP} is an i.i.d. policy shock.[12] This is a Taylor-type rule, that we calibrate $\rho_R = 0.8$, $\alpha_\pi = 1.5$, $\alpha_y = 0.05$, following the estimates for Chile in Medina and Soto (2007).

2. Monetary base:
$$\Delta MB_t = \frac{MB_t}{MB_{t-1}} = \pi, \tag{7}$$
i.e. money grows at the long-run inflation rate.

3. Nominal depreciation:
$$\pi_t^S = \pi^S, \tag{8}$$
so that the exchange rate grows at the long-run depreciation rate. Given our calibration ($\pi^S = 1$) this is equivalent to an exchange rate peg.

3 Comparing Instruments under Rational Expectations

We begin by analyzing the model under its rational-expectations version. We first explore the monetary-transmission mechanism using the policy shock under the interest-rate rule in equation (6). The impulse responses are displayed in Figure 1.

As in most New-Keynesian models of small and open economies, a positive shock to the Taylor rule leads to a fall in consumption, investment and GDP, as well as an improvement in the trade balance. At the same time, due to the interest rate parity, the nominal exchange rate appreciates.[13] Both the drop in aggregate demand and the nominal appreciation lower inflation and, due to price stickiness, the real exchange also appreciates.

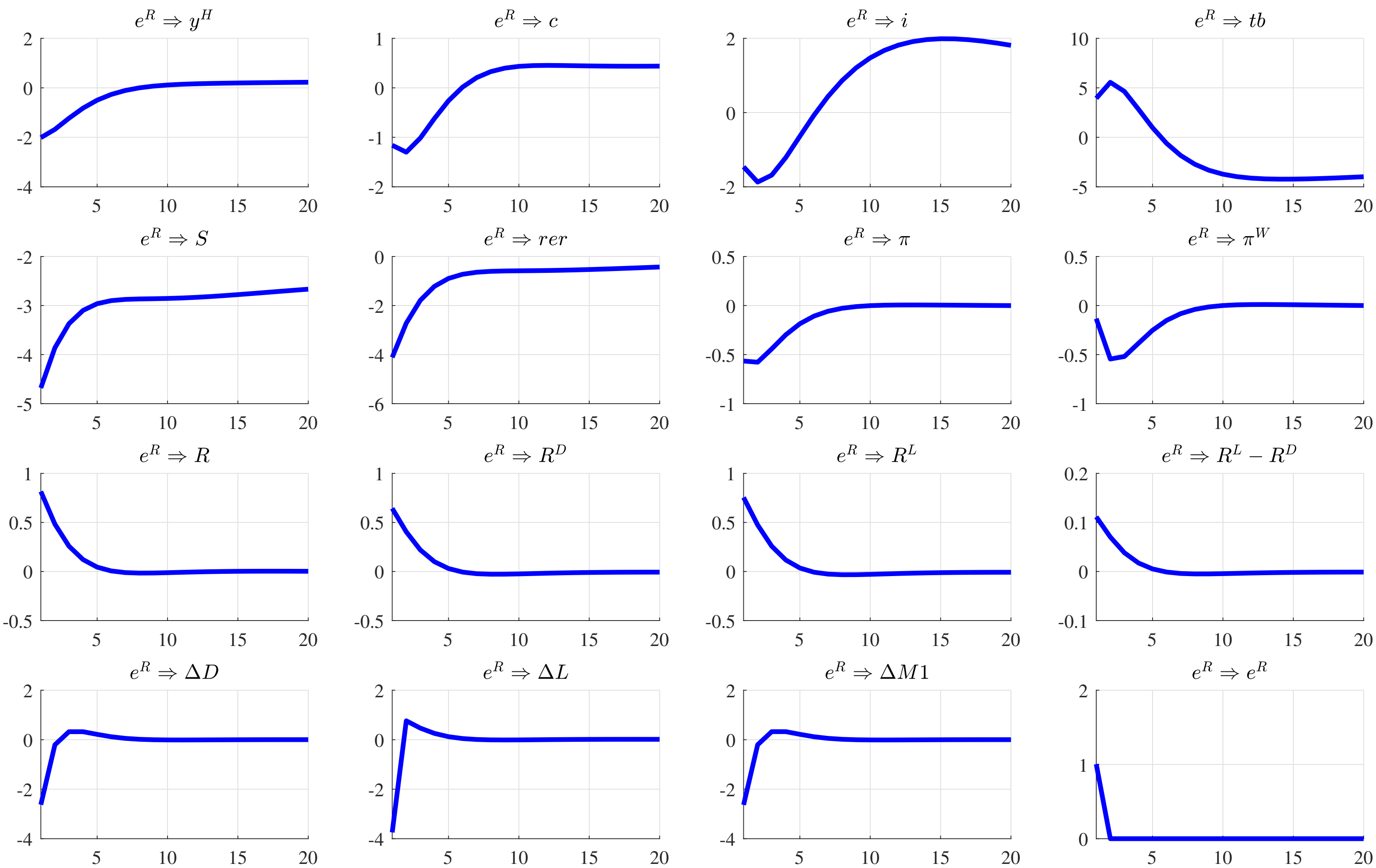
In the banking sector, as the policy rate rises, both deposit and lending rates go up. The spread also increases endogenously. Recalling the discussion in Section 2.5, this is due to the direct effect that a rise in the policy rate has on spreads (as long as required-reserves are positive) which outweighs the opposite force generated by the decrease in the loans-to-deposits ratio. Overall, money demand falls by both the decrease in cash and deposit holdings.

Next we turn to the impact of a shock that increases the external interest rate by one standard deviation, which is displayed in Figure 2. The solid-blue line depicts the responses under the interest-rate-policy configuration. This shock contracts consumption and investment. Consumption is reduced through both a negative wealth effect (as the country is a net-foreign borrower) and an intertemporal substitution effect (savings become relatively more attractive). It also reduces investment by increasing the real interest rate. This drop in aggregate absorption leads to a real depreciation, which in turn raises aggregate inflation (by the increase in the domestic price of foreign goods), outweighing the effect originated in the contraction of aggregate demand. Also, due to sticky prices and wages, the required real depreciation is achieved by an increase in nominal exchange rate.

[12] We use this shock to understand the monetary transmission mechanism.

[13] Up to a first order of approximation, the interest rate parity implies $\widehat{S}_t = \sum_{h=0}^{\infty} \widehat{R}^*_{t+h} - \widehat{R}_{t+h}$.

Figure 1: Policy Shock under Interest-Rate Rule. Rational Expectations



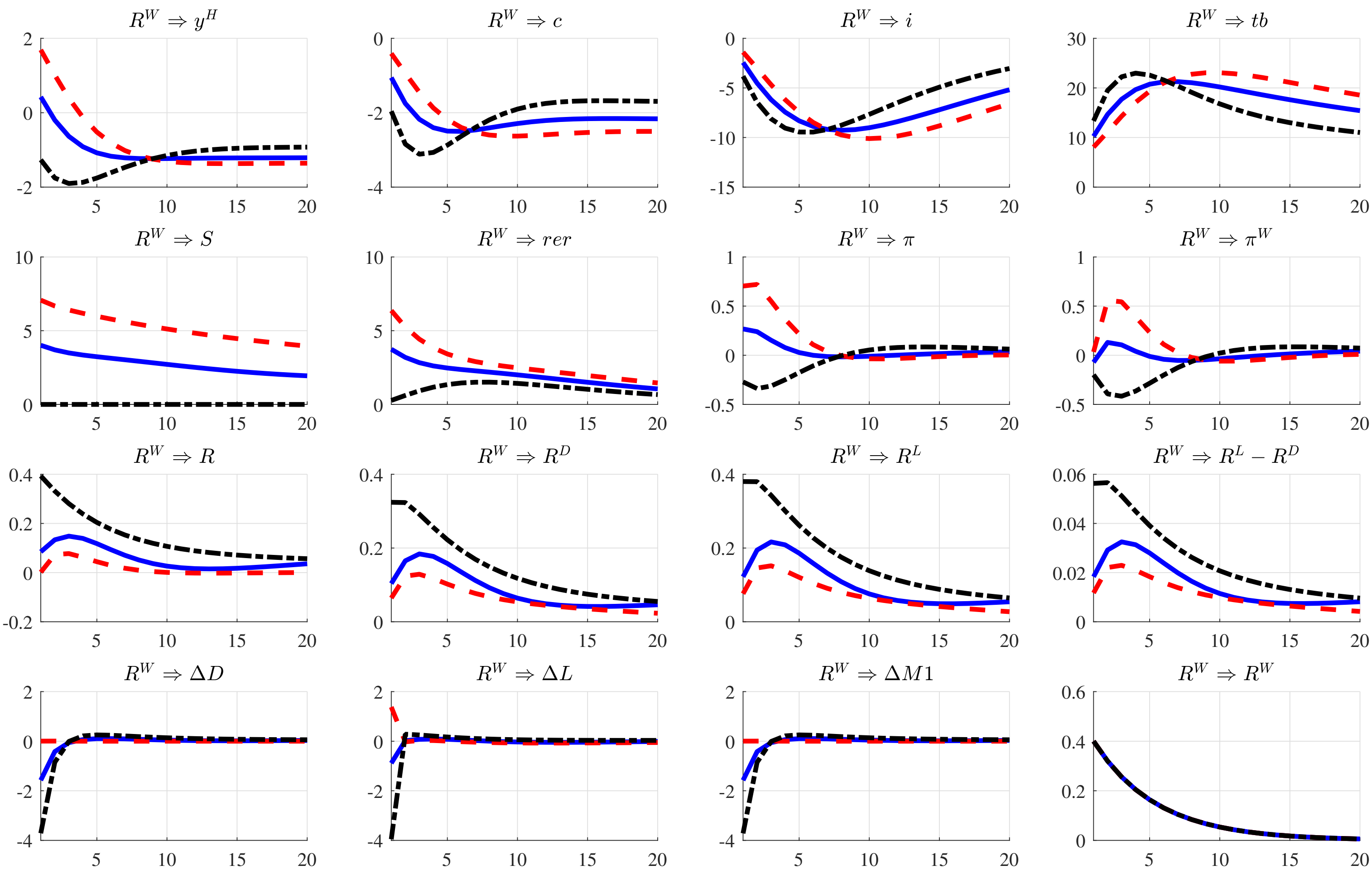
Notes: Each panel displays the impulse responses to the following variables: GDP (y^h), consumption (c), investment (i), the trade balance (tb), nominal exchange rate (S), rear exchange rate (rer), inflation (π), wage inflation (π^W), policy rate (R), deposit rate (R^D), lending rate (R^L), spread ($R^L - R^D$), deposits growth (ΔD), lending growth (ΔL), money demand growth ($\Delta M1$) and the shock hitting the economy. Al variables are measured in percentage deviations relative to the steady state.

The trade balance improves as the drop in domestic absorption leads to a contraction in imports, and the real depreciation induces a rise on exports. In the first periods GDP increases as the export-led effect dominates, but after two quarters output falls bellow the starting point, when the fall in absorption begins to dominate. Thus, the delayed response in output is a direct consequence of assuming habits in consumption and investment-adjustment costs.

As inflation increases, the policy rate rises following the rule in equation (6) (as we will see, this characteristic is key to understand the differences with other instruments). However, this increase is relatively mild, for the rise in inflation is not as large. Moreover, and relevant to the discussion below, the rising policy rate somehow dampens the exchange rate dynamics, and therefore its impact on inflation.

The other interest rates also rises and the spread increases, contributing to the drop in investment. Along the same lines, nominal quantities also fall, reflecting a drop in the demand for both

Figure 2: External-Interest-Rate Shock with Alternative Instruments. Rational Expectations



Notes: The solid-blue line is the version with an interest-rate rule, the dashed-red line uses an money growth rule, and dashed-dotted-black line corresponds to the exchange-rate peg. See the description in Figure 1 for variables' definitions.

types of liquidity-providing assets, and loans as well.

The dashed-red line in Figure 2 corresponds to the dynamics under the constant-money-growth rule in equation (7). Qualitatively, the contractionary effects of the shock in consumption and investment also occur under this configuration, and the exchange-rate and inflation dynamics are in the same direction. But the responses are quantitatively different. To understand the intuition, we can think of the responses under the interest-rate rule as a proxy of what would happen, *ceteris paribus*, if the policy rate remained constant. In such a case, money demand (deposits and cash) would fall due to the contraction in consumption. In a configuration with a constant-money-growth rule, the interest rates must fall to clear the money market. This in turn will lead to a larger nominal depreciation,[14] which puts upward pressure to inflation. At the same time, the real depreciation is larger.

In equilibrium, the rise in inflation dampens somehow the drop in money demand. As a result,

[14]By the interest rate parity, the exchange rate rises due to the direct effect of an increase in the foreign-interest rate, and the rise is exacerbated if the domestic rate falls.

in the dashed red-line we can see that interest rate experiences a minor increase, which is smaller than under the interest-rate rule. This also leads to a smaller increase in other interest rates and spreads. Thus, relative to the previous case, the effect on consumption and investment is milder here, which in turn implies a larger initial output expansion.

Overall, we can see that a money-growth rule implies milder activity effects relative to those with an interest-rate rule, at the cost of higher inflation and a larger nominal and real depreciation.

Finally, we turn to the exchange rate rule in equation (8), which corresponds to the dashed-dotted-black line in Figure 2. Qualitatively, in this case activity also falls as in the other alternatives. Quantitatively, however, the contraction is larger: by eliminating the nominal-exchange-rate effect, domestic rates and spreads experience a much larger increase.[15] This effect is quite large: it even eliminates the initial expansion in GDP.

In contrast, under this instrument inflation falls: as the exchange rate effect disappears, prices are only driven by aggregate demand (as in a closed-economy model). However, it is not obvious that a drop in inflation is desirable. For the welfare cost of inflation is associated with its volatility, which is not necessarily different than with an interest-rate rule.[16] Therefore, besides its effect on inflation, it seems that either and interest-rate or a money-growth rule may potentially be preferred to a strict peg.

4 Comparing Instruments under Limited Credibility

We now turn to the analysis under limited credibility. We proceed in three steps. First, we study how the monetary transmission mechanism changes in the presence of limited credibility. Second, we compare how the propagation of the external-interest-rate shock differs between rational expectation and limited credibility, assuming that policy follows an interest rate rule. Finally, we compare the three alternative rules under the limited credibility assumption.

Figure 3 displays the effects of a policy shock in equation (6) under both rational expectations (solid-blue lines, which are the same as in Figure 1) and limited credibility (dashed-red lines). The shock implies a larger and more persistent impact on activity when a fraction of the agents are adaptive learners, while inflation is relatively less sensitive. This is despite a larger nominal-exchange-rate appreciation.

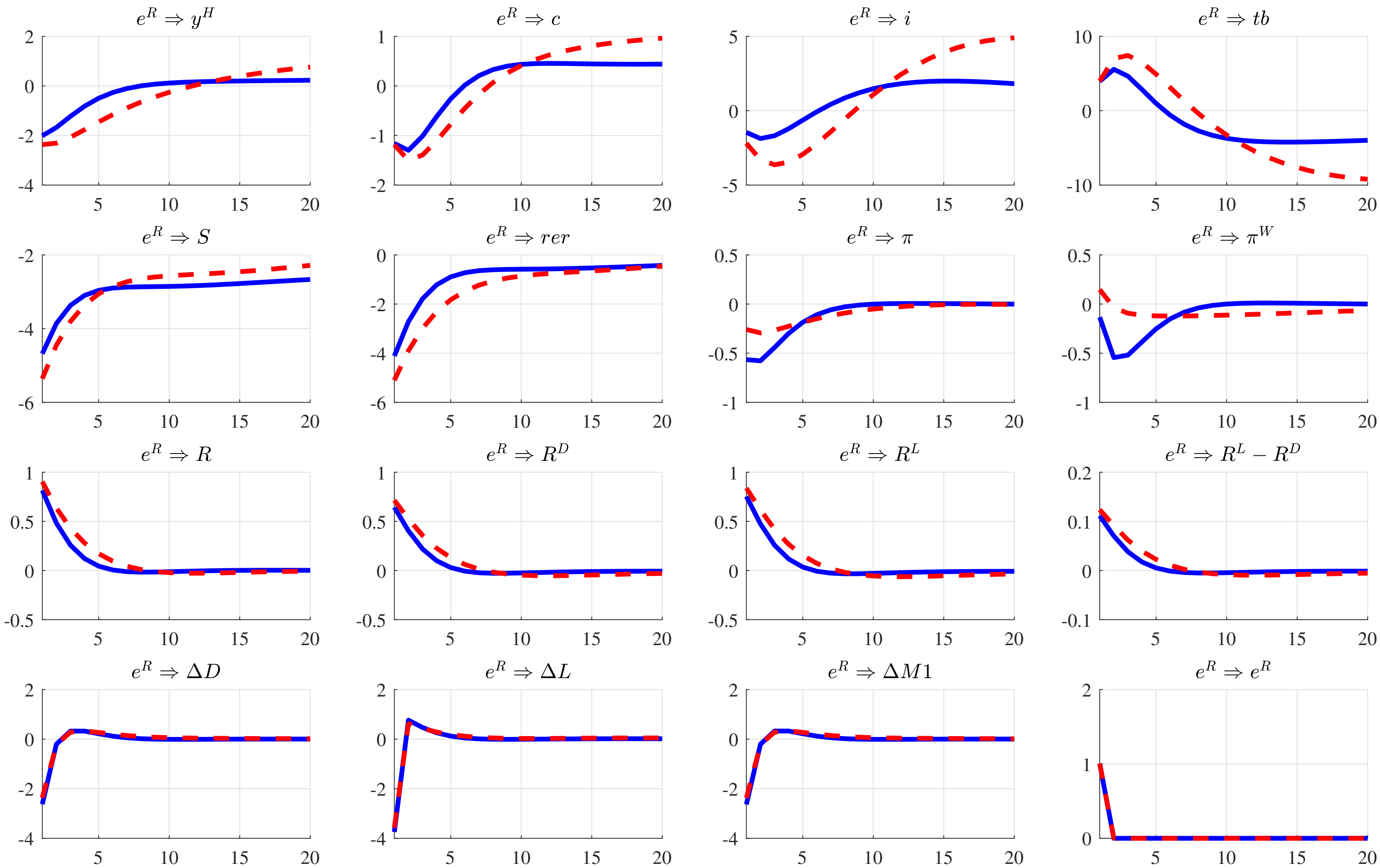
The intuition behind this results is as follows. The relevant real rate for consumption and investment decisions is, in a log-linear approximation, $\widehat{R}_t - E_t\{\widehat{\pi}_{t+1}\}$.[17] Under rational expectations, agents understand that the recession generated by a more contractionary policy stance will lower inflation in the future. Thus, the relevant real rate falls less than proportionally relative to the nominal rate.

[15] The interest rate parity under a peg forces the policy rate to replicate the expected path for the external rate.

[16] A graphic intuition of this results can be obtained by approximating the volatility using the area between the impulse response of inflation and the zero line. As can be seen in the graph, it is not obvious that they differ significantly. We can also compute the volatility of inflation conditional on the external-interest-rate shock which, although not shown, it is somehow smaller under the interest-rate rule using our calibration.

[17] For investment decisions the relevant real rate also depends on the lending rate; but we exclude this channel just to help fix the intuition.

Figure 3: Policy Shock under Interest-Rate Rule. Rational Expectations vs. Imperfect Credibility



Notes: The solid-blue line is the version under rational expectations, and the dashed-red line is under imperfect credibility. See the description in Figure 1 for variables' definitions.

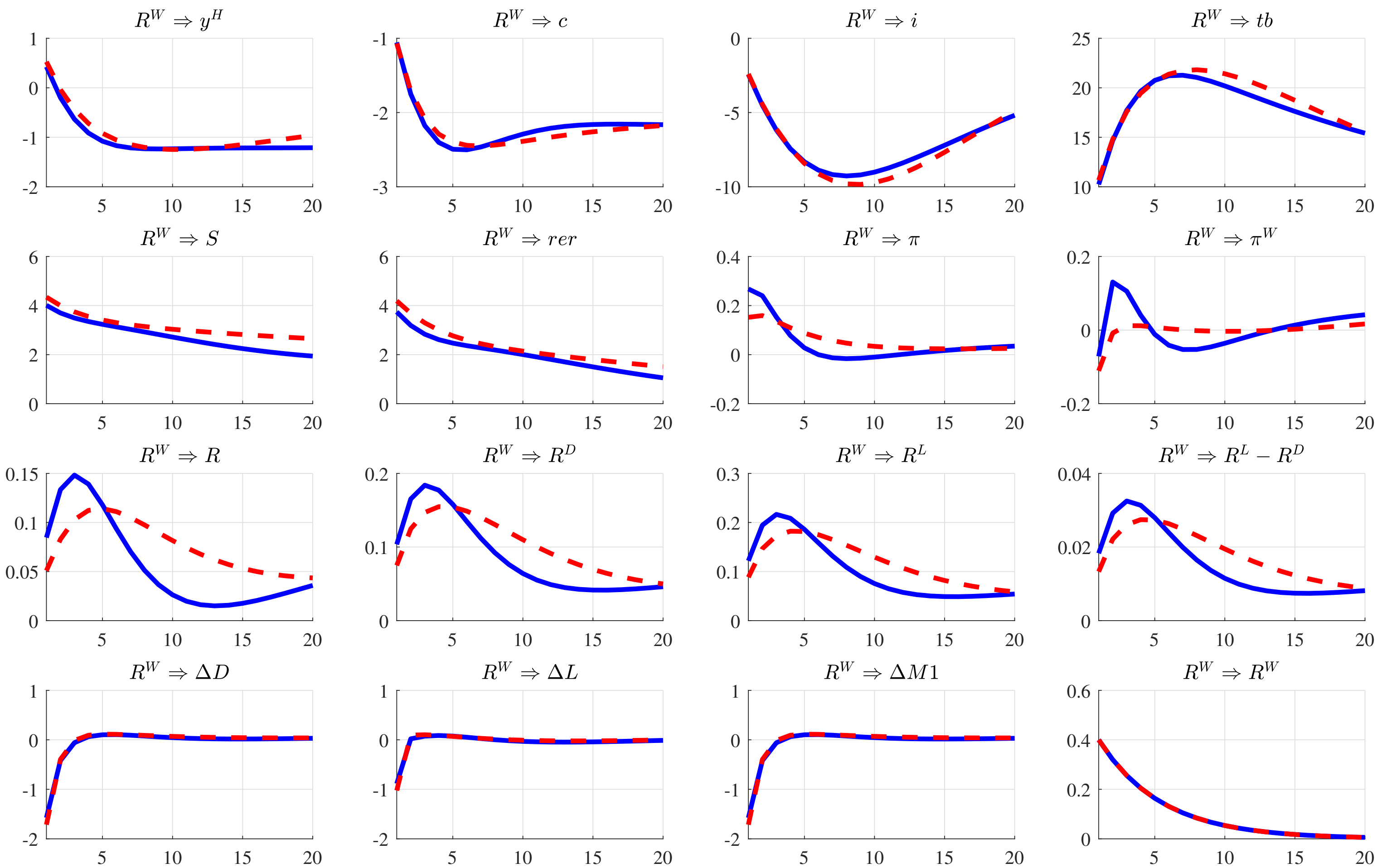
Once adaptive learners are included, inflation expectations will fall by less because these agents use past inflation (which is larger than after the shock) to form expectations. As a consequence, the real rate, *ceteris paribus*, falls by more in this alternative setup, leading to a larger contraction in domestic absorption.

While aggregate demand falls by more, inflation does not drop as much because the forward-looking part of the Phillips curve is determined in part by a higher past inflation. Thus, prices are less sensitive to the shock, although more persistent than under rational expectations.

A relevant implication is that, to achieve a given desired effect on inflation, the policy rate needs to increase by more (and for a longer period) if expectations are not fully rational. This in turn generally leads to larger sacrifice ratios, as documented by Gibbs and Kulish (2017).

Figure 4 compares the responses after an increases in the external interest rate, still assuming an interest-rate rule, under both rational expectations (solid-blue lines, which are the same as in Figure 2) and limited credibility (dashed-red lines). As can be see, the effect on consumption and investment are not as different; for the impact comes mainly trough a real channel (that will be present even under flexible prices) and it is less related to inflation expectations.

Figure 4: External-Interest-Rate Shock under Interest-Rate Rule. Rational Expectations vs. Imperfect Credibility



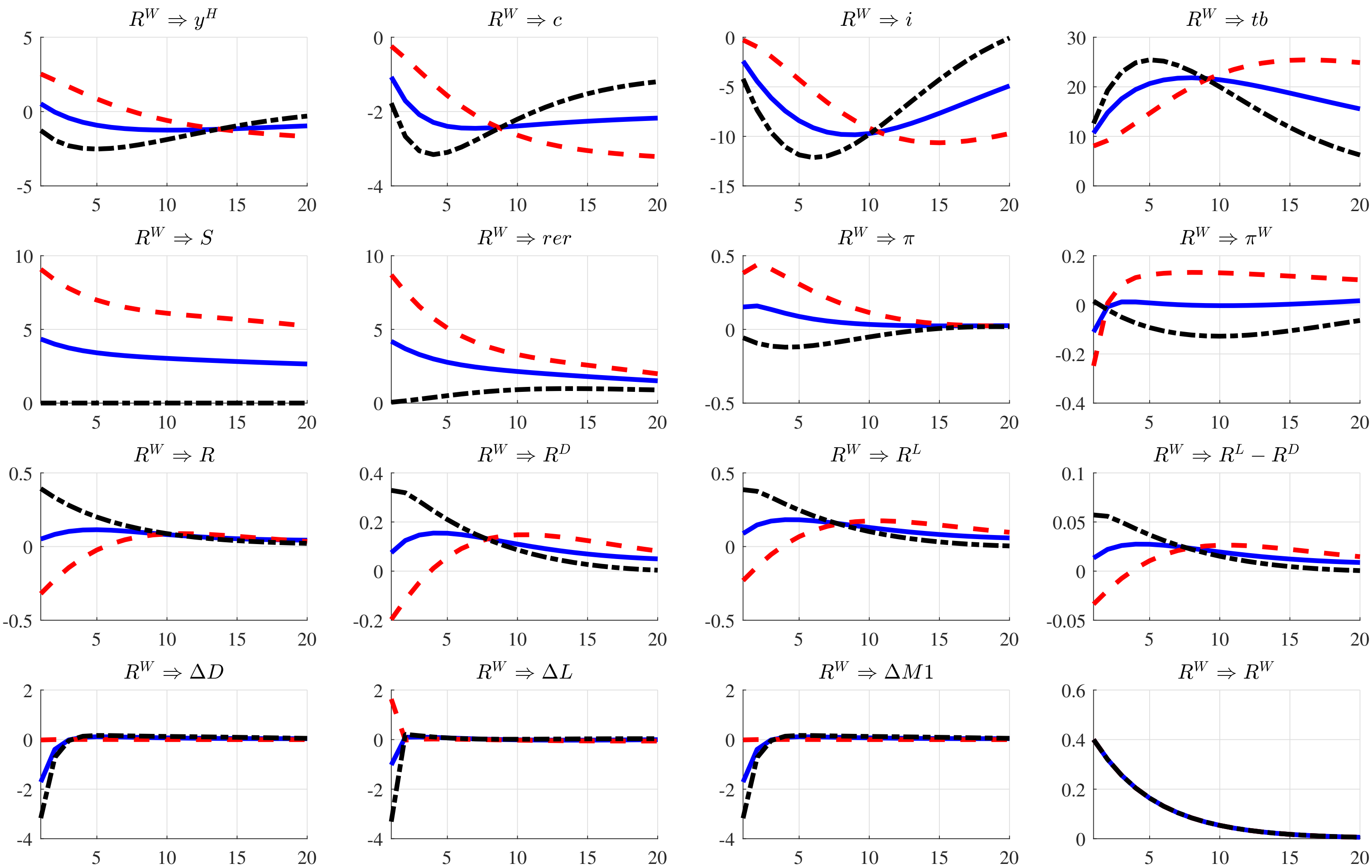
Notes: The solid-blue line is the version under rational expectations, and the dashed-red line is under imperfect credibility. See the description in Figure 1 for variables' definitions.

While the nominal exchange rate suffers a similar initial depreciation in both cases, inflation increases by less under limited credibility. This is due to a less powerful forward looking channel in the Phillips curve. This is reinforced by a smaller past inflation, which make adaptive learns to think that higher inflation is less likely, increasing expectations only with a lag.

With a smaller inflation, the interest-rate rule dictates a less contractionary policy stance, leading to a dampened effect on the other interest rates and spreads as well. In turn, this ameliorates the effect (described before) that a higher domestic rate has in activity under limited credibility; helping to explain the similar real effects under both configurations.

Finally, Figure 5 compares the three policy alternatives in the context of imperfect credibility. Qualitatively, the differences between them are analogous to the analysis in the previous section, so that imperfect credibility does not seems to alter the intuitive differences between the three alternatives in a fundamental way.

Figure 5: External-Interest-Rate Shock with Alternative Instruments. Imperfect Credibility



Notes: The solid-blue line is the version with an interest-rate rule, the dashed-red line uses an money growth rule, and dashed-dotted-black line corresponds to the exchange-rate peg. See the description in Figure 1 for variables' definitions.

Quantitatively the differences are exacerbated under limited credibility, due to two complementary effects. First, as previously identified, the presence of adaptive learners induces a more persistent responses of nominal variables. Thus, the part of the trade-off between instruments related to inflation dynamics gets amplified under lack of credibility. In particular, a constant-money-growth rule implies more inflation and nominal depreciation persistence than under an interest-rate rule.

The other relevant aspect is that the differences in the behavior of interest rates is exacerbated. This yields larger differences between the three cases in terms of real variables: the contraction is milder with constant-money-growth rule while its is even larger under a peg. This effect in activity is amplified by the presence of banks, as the difference in the spread is also magnified.

Overall, under limited credibility the trade-off between interest-rate- and money-based is more pronounced. And the contractionary effects under a peg are larger under imperfect credibility.

5 Conclusions

This paper presents a model-based analysis to identify the relevant trade-offs in choosing between simple rules for alternative monetary-policy instruments. The focus is understanding how the impact of shocks to external borrowing costs differ depending on the policy configuration. Importantly, we explore how conclusions are altered in the presence of imperfect credibility, which we capture by assuming that a fraction of agents do not operate under rational expectations (using instead simple time-series models to forecast inflation-related variables).

We document that, qualitatively, there is a trade-off in choosing between a Taylor-type rule for the interest rate vs. a constant-money-growth rule. In particular, limiting fluctuations in the quantity of money insulates activity-related variables from the contractionary effects of the shock. At the same time, the inflationary effects are magnified in a monetary targeting framework. Finally, an exchange-rate peg induces a larger contraction in the economy, without necessarily creating an improvement in the inflation front.

We also show that these trade-offs are amplified in the presence of limited credibility. This is due to a more persistent inflation process under this configuration, and also because of the different interest-rate behavior under the three policy alternatives (which is magnified by the presence of adaptive learners).

While this exploration allows to identify relevant dimensions of the policy-instrument discussion, it also suggest that further works is needed to provide a more detailed evaluation. In particular, the selection of the rules for each instrument was relatively basic, and one could think of including other feedback variables in the rules or different parameters. Thus, an interesting extension is to study optimal (from a welfare perspective) simple rules for a given instrument, comparing then between the best rule for each instrument. We leave this analysis for future research.

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