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 inflation-targeting consensus is that interest-rate rules are preferred, instead of using either a monetary aggregate or the exchange rate. These arguments are usually presented under rational expectations (RE) and full credibility. In contrast, we consider deviations from RE where agents uses econometric models to form inflation expectations, capturing limited credibility (LC). In particular, we emphasize the role of the exchange-rate in shaping inflation forecasts. 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 relative benefits of each alternatives can change depending on how agents form inflation-related expectations.

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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 focus on a short-term interest rate as the instrument, in a context of rational expectations (where agents believe the policy rule holds not only in the present but in the future as well, a strong form of policy credibility).[1] Even those papers relaxing the rational-expectations assumption mostly 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. Moreover, many argue that the interest rate may not be a powerful instrument if financial markets are not as deep.[3]

In addition, some 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 shifted in 2018 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 the equivalence will generally be model dependent. From that perspective, as long as simplicity is a desirable characteristic, simple rules for alternative instruments may 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 rise in foreign-financing costs. This is a relevant shock to consider from at least two perspectives.

[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 money demand, and solving for the current value of the interest rate.

First, 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. We use a model of a small and open economy with incomplete financial markets, nominal rigidities in prices and wages, and capital accumulation. Moreover, 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.

To account for limited credibility, we consider a deviation from rational expectations by which agents uses econometric models (based only on past data) to form inflation-related expectations. This is motivated by previous studies that highlight how adaptive learning might limit the impact of monetary policy.[6] In particular, the forecasting model is a VAR with a time-varying mean, where news may have a persistent impact if they change the inference about long-run inflation.

We emphasize two different components of the learning process. One appears if inflation expectations are shaped by past inflation, which has been the focus of most of the related literature (particularly those using closed-economy models). This has two main consequences. First, inflation is more persistent. Second, as inflation expectations also affect the relevant real rate for intertemporal decisions, the power of the central bank to impact aggregate demand is limited.

The second component is specific of open economies and it is related to exchange-rate volatility. The literature has extensively explored the role of exchange rates in shaping inflation dynamics.[7] Besides the several general-equilibrium channels emphasized elsewhere, here we consider the possibility that long-run inflation expectations are directly influenced by exchange-rate surprises. While this link has not been explored in the literature to the best of our knowledge, there is some evidence documenting that both the cross-country and time-variation in exchange-rate-pass-through measures can be linked to different degrees of monetary policy credibility (see, for instance, Carriere-Swallow et al., 2016). Moreover, in general equilibrium the exchange-rate-pass-through is influenced by expected monetary policy (García-Cicco and García-Schmidt, 2020).

To further explore this channel, we analyze market-expectations data for both Argentina and Chile, to contrast two cases with different degrees of credibility. We find reduced-form evidence that large exchange-rate surprises significantly change the one-year-ahead inflation expectation in Argentina, while this is not the case in Chile. Clearly additional empirical analysis is required to further explore this link. But our model-based analysis suggests that dynamics and policy prescriptions can potentially change if, due to limited credibility, agents adjust long-term inflation expectations following exchange-rate movements.

We compare the dynamics in our model under different expectation-formation assumptions, with three alternative 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. The last one is an exchange-rate peg. The comparison under rational expectations shows that, qualitatively, there is a trade-off in choosing between an interest-rate rule and a constant-money-growth rule. Limiting fluctuations in the quantity of money seems to insulate activity-related variables from the contractionary effects of the external shock, while at the same time increasing the inflationary effects. This is due to the different behavior of nominal rates under both policy configurations. Instead, a peg

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

[6] Eusepi and Preston (2018b) present a survey of this literature.

[7] e.g. see the survey in Burstein and Gopinath (2014).

induces a larger contraction following the negative external shock, without a clear advantage in the inflationary front.

In the limited-credibility setup that allows for past realizations of inflation to influence long-run expectations, the qualitative trade-offs between the three rules are still present. Quantitatively the differences are exacerbated under this form of learning. This is a consequence of (i) a more persistent inflation, once adaptive learners are considered, and (ii) a magnified effect of interest-rate changes in activity if expectations are not fully rational.

When exchange-rate movements can directly affect long-term inflation expectations, the dynamics under different rules are modified. The dampening effect on activity obtained with a constant growth rate of money is more limited: the dynamics of GDP under interest-rate and money rules are closer to each other. At the same time money-based rules generate worst outcomes in terms of inflation. Thus, the potential benefits of a rule targeting money growth are less clear under this form of learning. Finally, limiting exchange-rate fluctuations might be useful to prevent significant shifts in long-term expectations.

The rest of the paper is organized as follows. Section 2 presents the details of the model, with a detailed discussion of the learning assumptions 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 The 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 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 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

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

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.[8]

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

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

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

[8]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.

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 curve, which after log-linearization 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 we use the notation $\widehat{x}_t = \ln(x_t/x)$ for a generic variable x_t, and $\pi_t^W = \frac{W_t}{W_{t-1}}$.

2.2 Final and Home Goods

Final goods are produced in two stages. 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 demands:

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

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

The retail level features a monopolistic-competitive structure. 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, 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 being able to optimally change its price given by θ. If it is not able to choose optimally, the previous-period price is indexed by $\pi_t^I = (\pi_{t-1})^{\vartheta}(\pi)^{1-\vartheta}$. After a log-linearization around the non-stochastic steady state we obtain the following Phillips curve

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

2.3 Home Goods

These are produced competitively 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, and $r_t^K = R_t^K/P_t$. 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, 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 rate for 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. The optimality conditions are,

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

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

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 in interest rates is bank costs. The second term in the right-hand-side of equation (1) is decreasing in the loans-to-deposits ratio. In addition, the second term in the right-hand-side of (2) is (given our calibration, which assumes that deposits are larger than loans in steady state), also increasing in the loans-to-deposits ratio.

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.[9] 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 discussed 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 following sections 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.

[9] 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.

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

Also, the following equations relate inflation rates 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.

The evolution of net foreign assets can be derived by combining the resource constraints of households, firms, banks 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 $b_t^* = \frac{B_t^{*,H} - B_t^{*,T}}{P_t^*}$ is denotes aggregate net-foreign assets.

The time unit is set to a quarter and the model is solved with a log-linearization approach around the non-stochastic steady state. Appendix A includes the details regarding functional forms and calibration of the parameters described so far, which mostly follows related studies for emerging countries.

2.9 Limited Credibility

Under rational expectations, agents forecast future values using the equilibrium distribution of the variables. In particular, they known and take as given the goals and policy rule implemented by the government. This is our benchmark for full credibility. In contrast, imperfect credibility is captured by assuming that agents forecast inflation-related variables using econometric models, as in the adaptive learning literature (e.g. Evans and Honkapohja, 2001). Many studies have used learning alternatives to capture limited credibility. For instance, Gibbs and Kulish (2017) assume that only a fraction of agents have rational expectations, analyzing how the real cost of alternative disinflation policies depends on this fraction. Carvalho et al. (2020) set up a model featuring endogenous changes in long-term inflation expectations of adaptive learners to study anchoring. A detailed survey on the importance of learning for monetary policy can be found, for instance, in Eusepi and Preston (2018b).

Specifically, we assume agents forecast price and wage inflation using an econometric model.[10] To account for the prominent role of the exchange rate in shaping inflation dynamics in emerging countries, the forecasting model also includes the nominal depreciation rate. Letting $x_t =$

[10] We could, in principle, assume a full learning setup, where agents use econometric models to infer all relevant variables. We focus only in inflation-related variables to highlight the limits faced by a central bank in achieving inflationary goals, while maintaining tractability at the same time. The fully-fledge learning configuration is left for future research.

$[\widehat{\pi}_t^S, \widehat{\pi}_t, \widehat{\pi}_t^W]'$, expectation are based on the following model,

$$\begin{aligned} x_t &= (I - \Phi)Z\alpha_t + \Phi x_{t-1} + \varepsilon_t \qquad && \varepsilon_t \sim \mathcal{N}(0, H) \\ \alpha_t &= \alpha_{t-1} + \eta_t, && \eta_t \sim \mathcal{N}(0, \sigma_\eta^2) \end{aligned} \tag{3}$$

where α_t is a scalar, i.e. a VAR model with a common time-varying long-run trend affecting all variables.[11] To be consistent with the steady state behavior of the model, we assume $Z = [1, 1, 1]'$.

Following the related literature we assume that agents have immutable priors about the constant variances of H and σ_η^2. Thus, the inference about $\bar{\alpha}_t = E_t\{\alpha_t\}$ (the filtered value of α_t) can be represented by the Kalman-filter recursion under a constant gain,

$$\bar{\alpha}_t = \bar{\alpha}_{t-1} + K\left[x_t - \Phi x_{t-1} - (I - \Phi)Z\bar{\alpha}_{t-1}\right], \tag{4}$$

where K is a 1×3 matrix containing the steady-state Kalman gains (obtained by solving the relevant Ricatti equation). In other words, surprises in either the nominal exchange rate, inflation and wages can in principle change the belief about the long-run values of these variables.[12] Lastly, belief parameters defining the forecast function in period t are assumed to be predetermined.[13] Thus, the one-period-ahead forecast is given by

$$E_t\{x_{t+1}\} = (I - \Phi)Z\bar{\alpha}_{t-1} + \Phi x_t. \tag{5}$$

Therefore, the model with limited credibility replaces $E_t\{\widehat{\pi}_{t+1}\}$ and $E_t\{\widehat{\pi}_{t+1}^W\}$ in all relevant equations with the corresponding forecast from (5), with $\bar{\alpha}_t$ determined by (4).

This setup requires to calibrate Φ and K. We estimate model in (3) using both Argentine and Chilean data. The former was the first country in Latin America to adopt an inflation targeting setup (the current framework started in 2001, but monetary policy was characterized by inflation targets since the early 90s) and since 2001 market expectations for one-year-ahead inflation was above the target range during only 9 months.[14] Argentina, in contrast, has experience an increasing average inflation rate from 2004 to 2019, alternating several policy frameworks during this period. Thus, Argentina will be the case of limited credibility, while looking at Chilean data will allow to check if the model can tell apart these two cases.

[11] Many papers in the adaptive-learning literature consider VAR models where all parameters can change over time. We choose to work only with time-varying constants to retain tractability, and also motivated by Eusepi and Preston (2011, 2018a) who suggest that the quantitatively-relevant dynamics come mainly from incomplete information about constants and not about the slope coefficients.

[12] The related literature assumes that each constant in the VAR is determined by a different process. In our notation, this would be the model: $x_t = \gamma_t + \Phi x_{t-1} + \varepsilon_t$, $\gamma_t = \gamma_{t-1} + \upsilon_t$, where γ_t is 3×1, $\varepsilon_t \sim \mathcal{N}(0, H)$, and $\upsilon_t \sim \mathcal{N}(0, Q)$. Moreover, it is assumed that the matrices H and Q are proportional to each other, which yields the updating equation $\bar{\gamma}_t = \bar{\gamma}_{t-1} + \kappa\left[x_t - \Phi x_{t-1} - \bar{\gamma}_{t-1}\right]$, where κ is a scalar. However, such a framework prevents surprises in one variable to move the long-run expectation of another (e.g. in our case, this would prevent changes in the exchange rate to influence directly the expected long-run value of inflation). Moreover, while the matrix Q could in principle accommodate a single common trend (if $rank(Q) = 1$), the assumption that H is proportional to Q will almost surely rule out that possibility when the model is taken to the data (i.e. it is highly unlikely that the estimated H will satisfy $rank(H) = 1$ as well).

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

[14] See Arias and Kirchner (2019) for a study of inflation anchoring in Chile.

The set of observables include the three variables in x_t (we use core inflation as the observable), plus one-year-ahead market expectations for inflation and exchange-rate depreciation (unfortunately, wage-related forecasts are not available in either country). The sample goes from 2004 to 2019, although for Argentina expectation variables are only available for the periods 2004-2007 and 2016-2019.[15] Table 1 report the results for both countries.[16]

Table 1: Estimated Learning Parameters

	Argentina			Chile		
Parameter	Mean	5 %	95 %	Mean	5 %	95 %
$100 \times V(\alpha_t)/V(\pi_t)$	13.8	8.1	21.9	2.9	2.0	3.8
K_{π^S}	-0.02	0.0	0.0	0.00	0.0	0.0
K_{π}	0.20	0.1	0.3	0.14	0.1	0.2
K_{π^W}	0.23	0.1	0.4	0.04	0.0	0.1

The first line in the table displays the ratio between the sample variance of the unconditional mean (obtained from the Kalman smoother) and that of observed inflation.[17] In the case of Argentina, around 14% of inflation fluctuations can be explained by changes in this long run trend. In the case of Chile this ratio is close to 3%. Clearly, the model identifies the perceived differences in expectations anchoring between countries.

In terms of Kalman gains, those related with inflation and nominal wage growth (K_2, K_3) are around 0.2 for the case of Argentina. This means that a 1% surprise in either of these variables changes the long-run inflation average by 0.2 percentage points. For the case of Chile, the gain for inflation is somehow smaller (around 0.15), while the influence of wage surprises is more limited.[18]

The influence of exchange rate surprises is estimated to be near cero for both countries. This results, while somehow surprising, reflects the influence of these variables on **average**. However, we could be in the presence of some conditional effects: large exchange-rate surprises could shift inflation expectations more than small fluctuations.

To explore this possibility, the first row in Figure 1 presents scatter plots of changes in one-year-ahead inflation expectations between two consecutive months (vertical axes), against the surprise in the exchange rate of that month (measured as the observed exchange rate minus the expected value from the previous month) for both countries.[19] Blue dots correspond to months

[15] This gap in the data is handled by using the Kalman filter for missing observations. The model also includes a measurement error for the exchange-rate forecast, to avoid stochastic singularity. The Metropolis-Hastings algorithm was used to draw 200k random values from the likelihood function (equivalently, the posterior under flat priors). Quarterly data was used for the estimation, although all variables are available at a monthly frequency, to match the time period in the model. While not reported, the values of the Kalman gains K are similar with monthly data, although Φ varies reflecting the different frequencies.

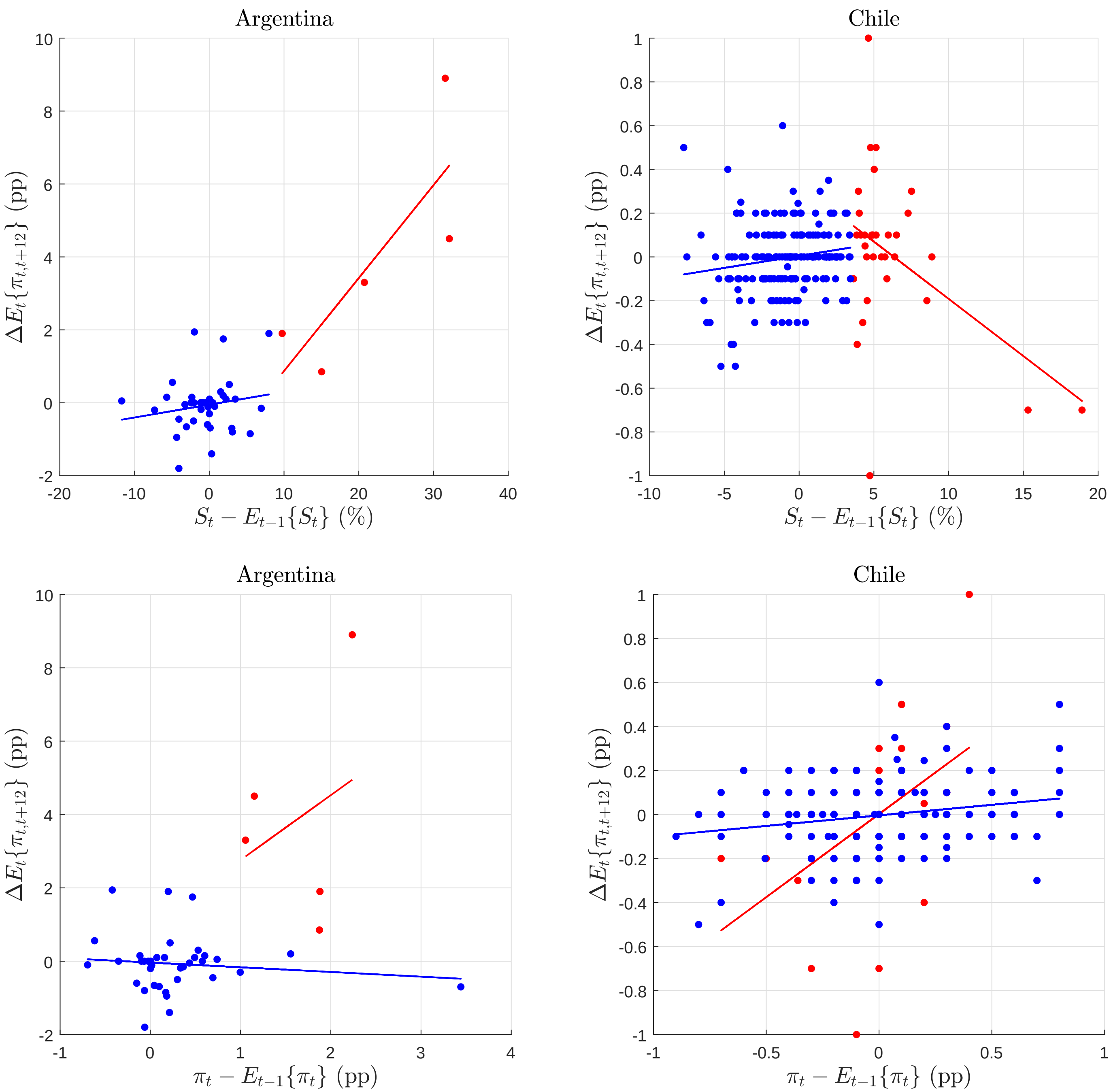
[16] The estimated values for Φ are reported in Appendix B.

[17] The usual unconditional variance decomposition cannot be performed: variables are non-stationary according to the forecasting model.

[18] The obtained gains for inflation are similar to values in the literature studying learning about inflation trends (e.g. Erceg and Levin (2003), Céspedes and Soto (2007)).

[19] The data for Argentina covers de 2016-2019 (constrained by availability of market-expectations surveys), while for Chile the sample goes from 2004-2019.

Figure 1: Inflation Expectations vs. Exchange Rate and Inflation Surprises



Note: The vertical axes are always the change in 12-month-ahead inflation expectations between month t and $t-1$, expressed in percentage points ($E_t\{\pi_{t,t+12}\} - E_{t-1}\{\pi_{t-1,t-1+12}\}$). In the top row of graphs, the horizontal axes display the difference between the observed nominal exchange rate at t and the market forecast from month $t-1$, expressed in percentage change ($S_t/E_{t-1}\{S_t\} - 1$). In the bottom row, the horizontal axes are the difference between the observed inflation at t and the market forecast from period $t-1$, expressed in percentage change ($\pi_t - E_{t-1}\{\pi_t\}$).

when exchange-rate surprises were smaller than one standard-deviation, while red dots are those for larger surprises.[20] As can be seen, under small movements, in both countries there is positive but small relationship between these surprises and changes in inflation expectations. However, in periods with large surprises, one-year-ahead inflation expectations seem to shift significantly in Argentina, while that does not seem to be the case in Chile.[21]

The bottom raw in the figure is analogous to the top, but plotting inflation surprises in the horizontal axes, separating also the months of large exchange-rate surprises. In the case of Argentina, the positive relationship on average seems to be driven mainly by episodes of large exchange-rate news. This also appears to be the case in Chile, but to a smaller degree.

Given these results, in what follows we will use two calibrations for limited credibility: one with $K_{\pi^S} = 0$, $K_\pi = K_{\pi^W} = 0.2$ and another where $K_{\pi^S} = K_\pi = K_{\pi^W} = 0.2$.[22] The first tries to capture lack of credibility under normal-size shocks, while the later is meant to capture situations where exchange rate volatility further hinders credibility.

2.10 Alternative policy rules

Our exploration of alternative simple rules considers the following:

1. Interest-rate rule:

$$\left(\frac{R_t}{R}\right) = \left(\frac{R_{t-1}}{R}\right)^{\rho_R} \left[\left(\frac{\pi_t}{\pi}\right)^{\alpha_\pi} \left(\frac{y_t^H}{y_{t-1}^H}\right)^{\alpha_y}\right]^{1-\rho_R} e_t^{MP}, \tag{6}$$

   where e_t^{MP} is an i.i.d. policy shock.[23] 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 rule:

$$\Delta MB_t = \frac{MB_t}{MB_{t-1}} = \pi, \tag{7}$$

   i.e. money grows at the long-run inflation rate.

3. Nominal-exchange-rate rule:

$$\pi_t^S = \pi^S, \tag{8}$$

   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 rational-expectations. We first explore the monetary-transmission mechanism by studying the responses of a policy shock under the interest-rate rule

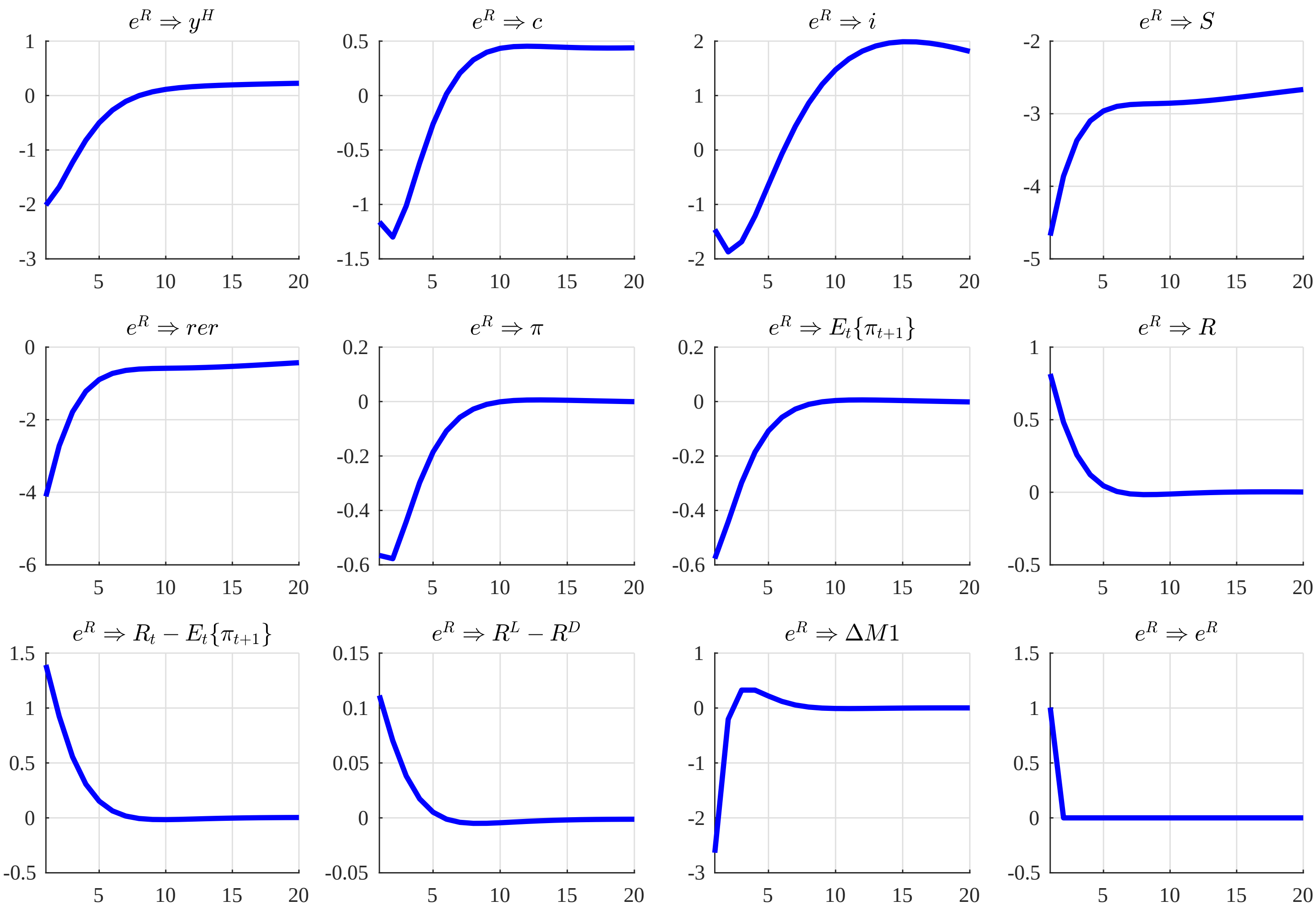
[20] The blue and red lines are simple OLS regressions for each set of observations.

[21] A simple regression with a dummy variable to account for different slopes shows a statistically-significant different coefficient for Argentina but not for Chile.

[22] The matrix Φ is calibrated using the posterior mean for the case of Argentina (the first column in the table shown in Appendix B).

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

Figure 2: 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), nominal exchange rate (S), real exchange rate (rer), inflation (π), expected inflation ($E_t\{\pi_{t+1}\}$), policy rate (R), ex-ante real rate ($R_t - E_t\{\pi_{t+1}\}$), spread ($R^L - R^D$), money demand growth ($\Delta M1$) and the shock hitting the economy. Al variables are measured in percentage deviations relative to the steady state.

in equation (6), displayed in Figure 2. 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 a trade-balance deterioration (not shown). At the same time, due to the interest rate parity, the nominal exchange rate appreciates.[24] Both the drop in aggregate demand and the nominal appreciation lower inflation and, due to price stickiness, the real exchange also appreciates. We can also see that the path of inflation forecasts just equals that of actual inflation starting from period one (i.e. there is perfect foresight under rational expectations).

Next we turn to the impact of a shock that increases the external interest rate by one standard deviation, displayed in Figure 3.[25] The solid-blue line depicts the responses under the interest-rate

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

[25] As described in Appendix A, this is calibrated by estimating an AR(1) model to the sum of the LIBOR rate plus the J. P. Morgan EMBI Index for Argentina. The shock represents an increase of 140 basis points (in annualized

rule. This shock contracts consumption and investment. The former 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.[26] 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 influence of aggregate-demand contraction. Also, due to sticky prices and wages, the required real depreciation is achieved by an increase in nominal exchange rate.

The trade balance improves (not shown) as the drop in domestic absorption leads to a contraction in imports, and the real depreciation induces a rise on exports (the former is quantitatively larger). In the first period GDP slightly increases as this trade-balance effect dominates, but afterwards output falls bellow the starting point, when the contraction in absorption begins to dominate (the delayed output response 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). However, this increase is relatively mild, for the rise in inflation is not as large. Moreover, 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, monetary aggregates also fall, reflecting a drop in the demand for both types of liquidity-providing assets.

The dashed-red line in Figure 3 are the dynamics under the constant-money-growth rule in equation (7). Qualitatively, the contractionary effects of the shock on absorption also occurs under this configuration. The exchange-rate and inflation dynamics also go 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 leads to a larger nominal depreciation,[27] which puts upward pressure on inflation. At the same time, the real depreciation is larger (the addition nominal depreciation outweighs the higher inflation).

In equilibrium, the rise in inflation dampens somehow the drop in money demand. As a result, in the dashed red-line we can see that interest rate experiences a minor increase, but the path lies below that obtained with 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, which in turn implies a larger initial output expansion. Overall, we can see that a money-growth rule produces milder activity effects, at the cost of higher inflation and a larger nominal and real depreciation.

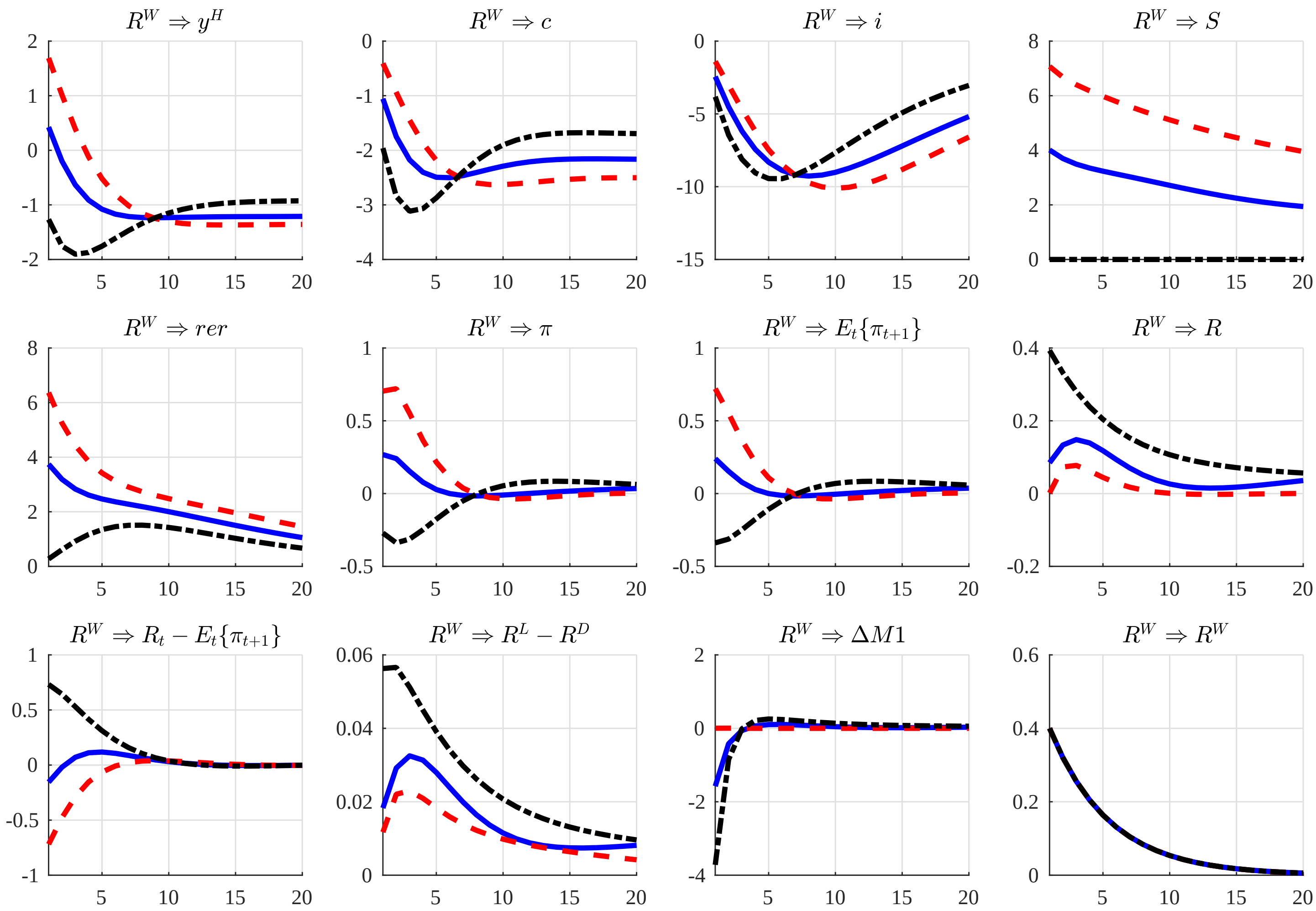
Finally, the exchange-rate peg, equation (8), corresponds to the dashed-dotted-black line in Figure 3. The contraction in absorption is larger in this case: by eliminating the nominal-exchange-

terms) in the cost of foreign borrowing.

[26] The relevant real rate for investment also depends on the lending rate, which also rises after this shock.

[27] By the interest rate parity, the exchange rate increases here due to both the direct effect of an increase in the foreign-interest rate and the fall in domestic rate.

Figure 3: 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 2 for variables' definitions.

rate effect, domestic rates and spreads experience a larger increase.[28] This effect even eliminates the initial GDP expansion observed in the other cases.

In contrast, under this instrument inflation falls: as the nominal-exchange-rate channel disappears, prices are only driven by aggregate demand (as in a closed-economy). However, it is not obvious that a drop in inflation is desirable. For the welfare costs of inflation are associated with its volatility, which is not necessarily different than with an interest-rate rule.[29] Therefore, it seems that either and interest-rate or a money-growth rule may potentially be preferred to a strict peg under rational expectations.

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

[29]A graphic intuition of this results can be obtained if we approximate the volatility by 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 smaller under the interest-rate rule using our calibration.

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 both limited-credibility configuration (which recall differ on the assumption about K_{π^S}). Second, we compare how the propagation after the external-interest-rate shock differs depending on the expectations setup, assuming that policy follows an interest rate rule. Finally, we compare the three alternative rules under both deviations from rational expectations.

4.1 Transmission of Shocks Under Learning

In Figure 4 the effects of a policy shock in equation (6) under rational expectations are the solid-blue lines (the same as in Figure 2), while the case of limited credibility with $K_{\pi^S} = 0$ is displayed with dashed-red lines. The shock implies a larger and more persistent impact on activity when agents use the empirical model to forecast inflation, while prices are relatively less sensitive. To understand this result consider the real rate that affects consumption and investment decisions: $\widehat{R}_t - E_t\{\widehat{\pi}_{t+1}\}$ (in the log-linear approximation). 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 increases more than the nominal rate.

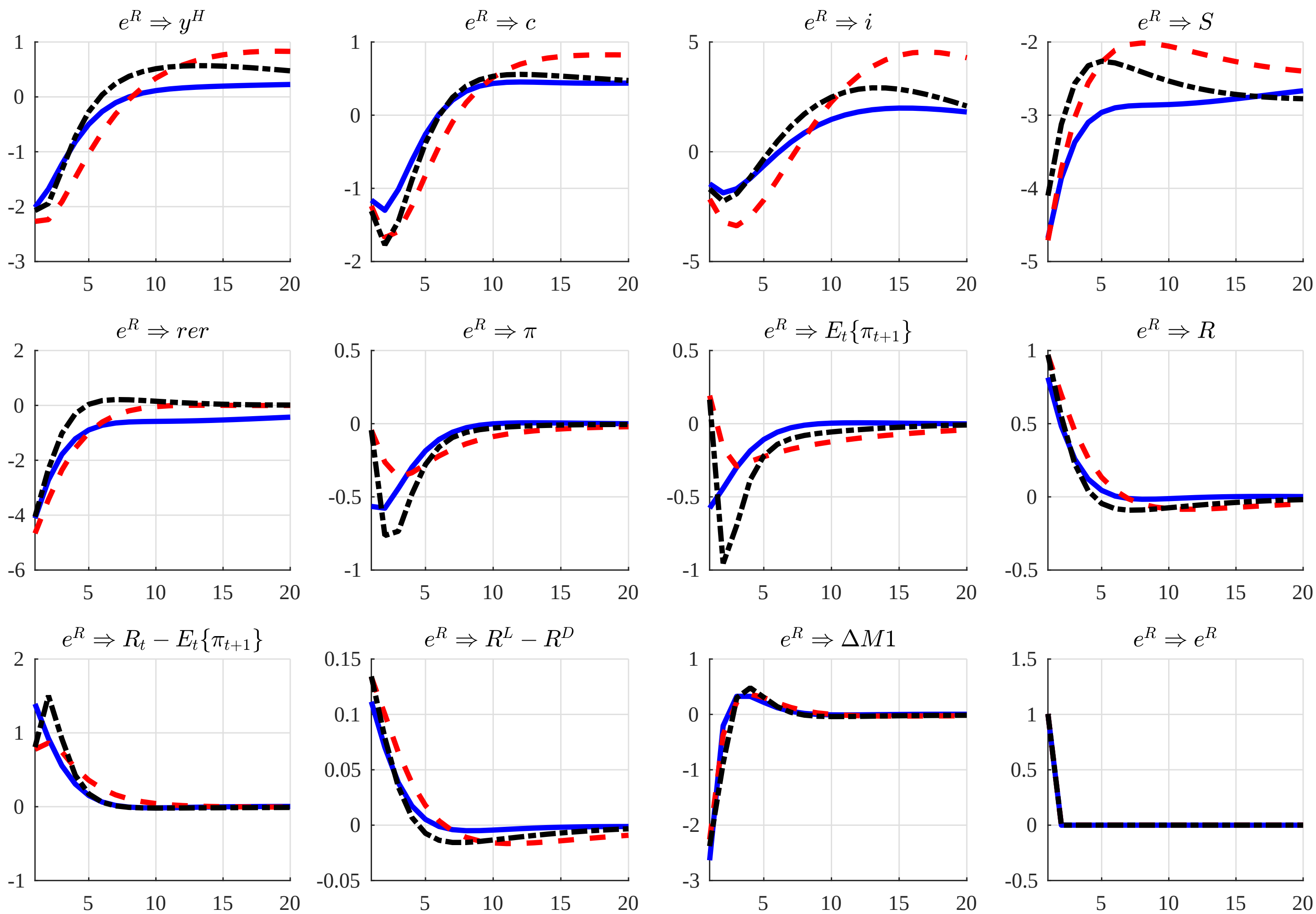
If expectations incorporate only slowly inflation surprises, *ceteris paribus* the real rate increases by less on impact but it remains at a high level for a longer period (as inflation expectations are more persistent). This leads to a somehow larger contraction in domestic absorption. However, inflation does not drop as much despite the lower demand because the forward-looking channel of the Phillips curve is significantly dampened under learning. Thus, prices are less sensitive to the shock on impact, although more persistent than under rational expectations. We can also see that the path of expected inflation doesn't match that of realized inflation: instead of perfect foresight as in rational expectations, past inflation shape agents' forecast.

A relevant corollary of this analysis 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), and it is the main channel emphasized by the learning literature in closed-economy setups (e.g. Eusepi et al. (2020)).

In the same Figure, dashed-dotted-black lines show the case with $K_{\pi^S} = 0.2$. Here inflation expectations drop by more than when they are rational, with a one-period delay because the inference about α_t is predetermined on impact (recall the assumption discussed in Section 2.9). The relevant real rate rises by more in this case, which further reduces absorption during the early periods. Inflation drops by more after the second period, influenced by expectation dynamics.

To the extent that the policy shock can induce a nominal appreciation, if learning features a positive feedback from exchange rate surprises, a given inflationary goal could be achieved with a smaller increase in the policy rate. However, we should recall that the evidence presented in Section 2.9 pointed that a positive K_{π^S} is more likely to appear under depreciations. So the relevant comparison will be to interpret the responses with the opposite sign: an expansionary policy stance could lead to more inflation than intended if $K_{\pi^S} > 0$. Or, as we will analyze

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



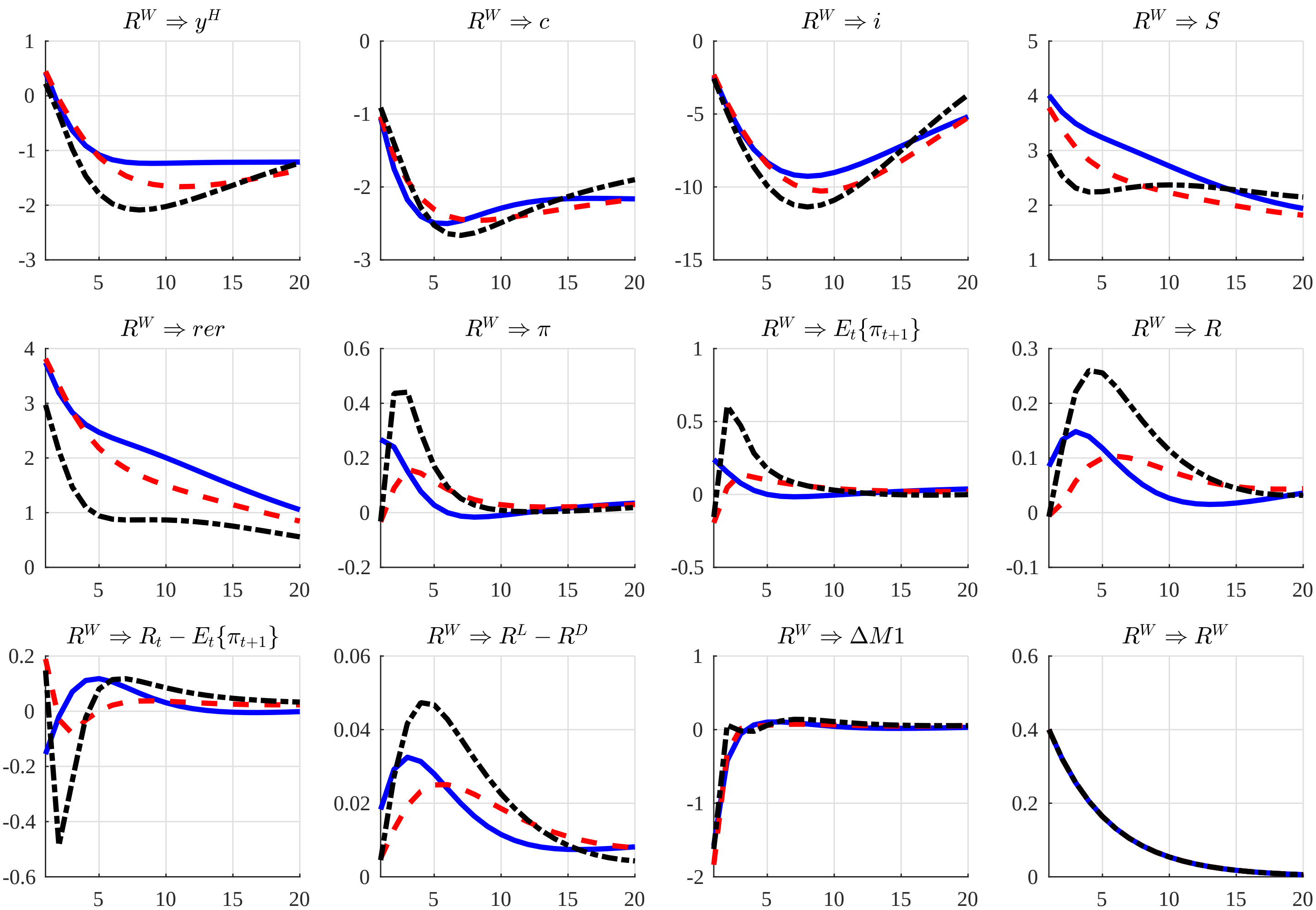
Notes: The solid-blue line is the version under rational expectations, the dashed-red line is the version of imperfect credibility with $K_{\pi^S} = 0$, and the dashed-dotted-black lines use $K_{\pi^S} = 0.2$. See the description in Figure 2 for variables' definitions.

next, the relevant policy trade-off could be exacerbated following a contractionary that induces a depreciation.

Figure 5 compares the responses after an external-interest rate increase, still assuming the interest-rate-policy rule. As can be seen, if learning features $K_{\pi^S} = 0$ (dashed-red lines) the effects on consumption and investment are not as different in the initial quarters; for the impact comes mainly trough a real channel and it is less related to inflation expectations.

While the nominal exchange rate suffers a similar initial depreciation in both cases, inflation increases by less on impact under limited credibility. This is due to a less powerful forward looking channel in the Phillips curve: adaptive learners take some time to realize inflation will be higher. With a reduced inflation on impact, 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.

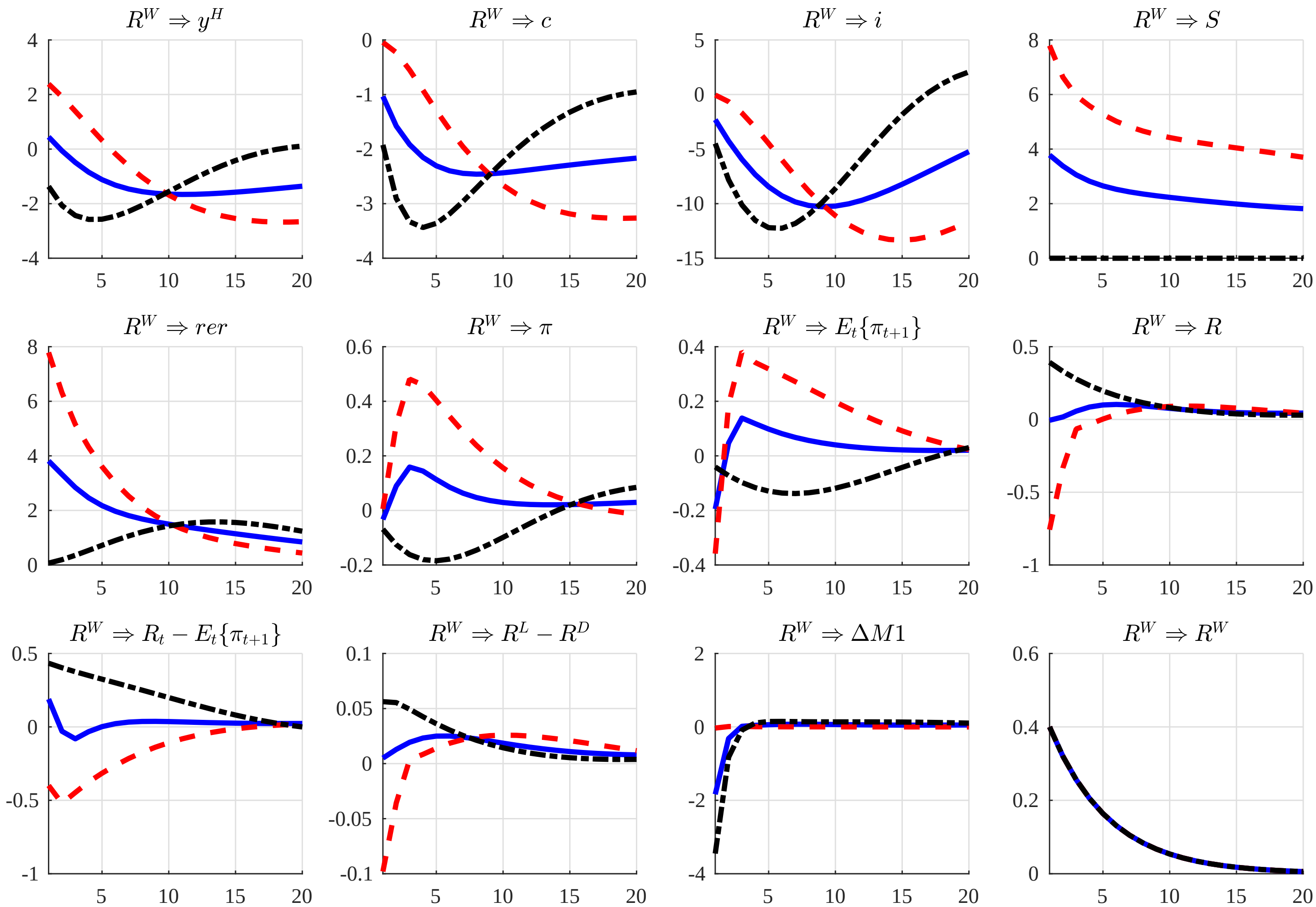
Figure 5: External-Interest-Rate Shock under Interest-Rate Rule. Rational Expectations vs. Imperfect Credibility



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 2 for variables' definitions.

If instead expectations are affected by the exchange-rate surprises (dashed-dotted-black lines show the case with $K_{\pi^s} > 0$) dynamics are significantly altered. Inflation increases by more once expectations are shifted, and GDP also falls by more. This effect in activity comes from two channels. On one hand, the policy rule dictates a larger rate hike, leading to a larger fall in demand. On the other, the real depreciation is smaller in this case (inflation increases by more, and the rise in domestic rates dampens the nominal depreciation), thus the improvement in the trade balance is limited. Therefore, if the exchange rate jump feeds into expectations (as the evidence presented in section B seems to suggest) policy will face a worse trade-off between inflation and activity after such this shock.

Figure 6: External-Interest-Rate Shock with Alternative Instruments. Imperfect Credibility with $K_{\pi^S} = 0$.



Notes: All responses correspond to the learning model with $K_{\pi^S} = 0$, The solid-blue lines is the version with an interest-rate rule, the dashed-red lines uses an money growth rule, and dashed-dotted-black lines corresponds to the exchange-rate peg. See the description in Figure 2 for variables' definitions.

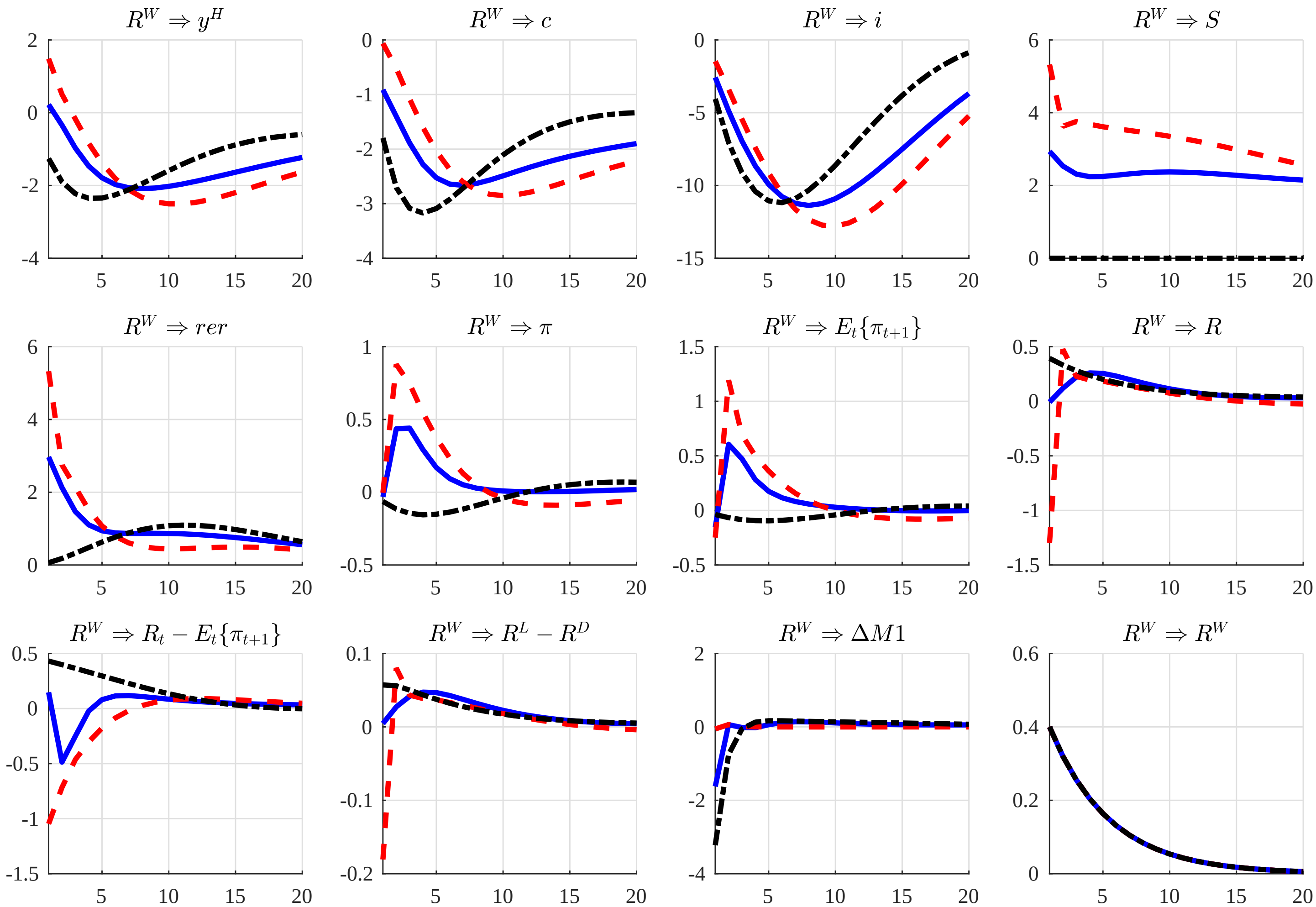
4.2 Alternative Policy Rules

Figure 6 compares the three policy alternatives in the context of limited credibility if $K_{\pi^S} = 0$. Qualitatively, the differences between these rules are analogous to the analysis in Section 3: a learning mechanism where only past values of inflation shape long-term expectations does not seems to alter the intuitive differences between the three alternatives.

Quantitatively the differences are exacerbated in this setup, due to two complementary effects. First, as previously identified, the presence of adaptive learners induces a more persistent responses in 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 a more persistent depreciation than with an interest-rate rule.

The differences in the behavior of interest rates are also amplified, yielding larger discrepancies

Figure 7: External-Interest-Rate Shock with Alternative Instruments. Imperfect Credibility with $K_{\pi^S} = 0.2$.



Notes: All responses correspond to the learning model with $K_{\pi^S} = 0.2$, The solid-blue lines is the version with an interest-rate rule, the dashed-red lines uses an money growth rule, and dashed-dotted-black lines corresponds to the exchange-rate peg. See the description in Figure 2 for variables' definitions.

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. Overall, if long-term expectations are only affected by past values of inflation, the trade-off between interest-rate and money-based rules is more pronounced. Moreover, the contractionary effects under a peg are larger under imperfect credibility, and its still is not obvious that inflation volatility is reduced.

If expectations are also affected by exchange rate dynamics (Figure 7), the comparison between rules is somehow different. Under both money and interest-rate rules inflation expectations are higher due to this additional learning channel. However, the path for the ex-ante real rate is not as different in these two cases. Therefore the dampening effect in activity brought about by the money-growth rule is less significant. In contrast, the peak in inflation is still almost twice as large than with the interest rate rule.

The exchange rate peg induces similar dynamics regardless of the type of learning assumed.

However, if $K_{\pi^S} > 0$ the difference in activity with the other rules are somehow smaller. In addition, the path of inflation is now less volatile under the peg than with the other alternatives.

Overall, the trade-off in choosing the policy instrument seems to change depending on whether exchange-rate movements directly influence expectations or not. If they do, the potential for money-based rules to dampen the contraction is more limited. Moreover, there might be some advantages in limiting exchange-rate fluctuations that are not present if learning is influenced by past inflation only.

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 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 if the learning mechanism is mainly driven by past inflation observations (the channel generally emphasized by the related literature). 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).

If the exchange rate can directly influence long-term inflation expectations, the comparison among alternative rules changes somehow. In particular, the potential benefits of money-growth rules are reduced, and there might be a role for limiting exchange rate fluctuations to prevent large shifts in inflation expectations. Moreover, we presented evidence suggesting that this additional exchange-rate channel in the learning process might be empirically relevant in cases with limited credibility.

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. On one hand, a more thorough empirical analysis of the influence of exchange rate surprises in shaping inflation expectations could shed light on the relevant channels contributing to inflation anchoring. On the other, the simple rules analyzed here were relatively basic, and one could include other feedback variables in the rules (the exchange rate in particular) or different parameters. A study optimal of simple rules (from a welfare perspective) for a given instrument, and a comparison between the best rule for each instrument should be desirable. We leave these for future research.

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A Functional Forms and Calibration

For the utility function, 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 characteristics are desirable to obtain a negative effect in activity under interest rate shocks.[30] The other conditions generate dynamics for consumption, money and deposits decisions that are empirically plausible. The chosen specification is,

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

where $\widetilde{c}_t, \widetilde{m}_t, \widetilde{d}_t$ denote habit-adjusted consumption as well as real cash and deposit.[31] 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:

[30]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.

[31]For a generic variable X_t, habit adjusted is given by $\widetilde{X}_t = X_t - \phi_X X_{t-1}^a$, 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).

– For labor we pick $\Xi_t^h = \xi^h(c_t - \phi_C c_{t-1})^{-\sigma}$. This yields a labor supply given by:

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

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, yielding at the same time separability of between in the utility.

– 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^j are parameters. This generates the following demands for money and deposits:

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

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

which have the desired properties.

We set the following bank's cost function:

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

following Agénor and Pereira da Silva (2017). The parameter ψ_{DL} determines the elasticity of the spread with respect to the deposits-to-loans ratio, 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 $\phi_I > 0$.

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 2. 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

Table 2: 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}	Autocorr. 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

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 Latin American countries. The parameter ψ_{DL} is set to a relatively small value to have a modest volatility of the spread. The elasticity of money and deposit demand follows the empirical literature for Latinamerica (e.g. Aguirre et al., 2006).

Finally, the process for the external interest rate (which will be the main focus of the analysis) is parametrized by 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.

B Learning Parameters

Table 3: Other Estimated Learning Parameters

	Argentina			Chile		
Parameter	Mean	5 %	95 %	Mean	5 %	95 %
$\Phi_{1,1}$	-0.020	-0.17	0.14	-0.307	-0.43	-0.19
$\Phi_{1,2}$	0.223	-0.48	0.95	0.962	0.05	1.82
$\Phi_{1,3}$	-0.154	-0.77	0.50	-0.911	-1.31	-0.52
$\Phi_{2,1}$	-0.059	-0.12	0.00	0.005	0.00	0.01
$\Phi_{2,2}$	0.602	0.33	0.87	0.215	0.14	0.29
$\Phi_{2,3}$	-0.169	-0.42	0.07	0.029	-0.01	0.07
$\Phi_{3,1}$	-0.069	-0.13	-0.01	0.008	-0.01	0.03
$\Phi_{3,2}$	0.491	0.30	0.69	-0.073	-0.27	0.12
$\Phi_{3,3}$	0.183	-0.03	0.41	0.723	0.59	0.86