UNIVERSIDAD DEL CEMA
Buenos Aires
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Serie
DOCUMENTOS DE TRABAJO

Área: Economía

ALTERNATIVE MONETARY-POLICY INSTRUMENTS AND LIMITED CREDIBILITY: AN EXPLORATION

Javier García-Cicco

Enero 2022
Nro. 822

www.cema.edu.ar/publicaciones/doc_trabajo.html
UCEMA: Av. Córdoba 374, C1054AAP Buenos Aires, Argentina
ISSN 1668-4575 (impreso), ISSN 1668-4583 (en línea)
Editor: Jorge M. Streb; asistente editorial: Valeria Dowding ved@ucema.edu.ar

Alternative Monetary-Policy Instruments and Limited Credibility: An Exploration*

Javier García-Cicco
Universidad del CEMA

January, 2022

Abstract

We evaluate the dynamics of a small and open economy under simple rules for alternative monetary-policy instruments, in a model with imperfectly anchored expectations. The inflation-targeting consensus indicates that interest-rate rules are preferred, instead of using either a monetary aggregate or the exchange rate as the main instrument; with arguments usually presented under rational expectations and full credibility. In contrast, we assume agents use econometric models to form inflation expectations, capturing limited credibility. In particular, we emphasize the exchange rate's role in shaping medium- and long-term inflation forecasts. We compare the dynamics after a shock to external-borrowing costs (arguably one of the most important sources of fluctuations in emerging countries) under three policy rules: a Taylor-type rule for the interest rate, a constant-growth-rate rule for monetary aggregates, and a fixed exchange rate. The analysis identifies relevant trade-offs in choosing among alternative instruments, showing that the relative merits of each of them is indeed influenced by how agents form inflation-related expectations.

*This paper benefited from comments by Ozge Akinci, José De Gregorio, Gianlucca Begnino, Fernanda Cuitiño and participants in the 5th BIS-CCA Research Network on "Monetary Policy Frameworks and Communication," and the LIV Annual Meeting of the Economic-Policy Association of Argentina. The views and conclusions presented in this paper are exclusively those of the author and do not necessarily reflect the position of Universidad del CEMA.
E-mail: jgarciac@ucema.edu.ar

1 Introduction

This paper explores the trade-offs associated with the choice of monetary-policy instruments in small and open economies, with especial focus in contexts with imperfectly anchored expectations or limited 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] An exception that has received some attention is the complementary role of exchange-rate interventions under inflation targeting, but still maintaining the policy rate as the main instrument.[3]

This predominance of studies analyzing interest-rate rules is not representative of the way policy is conducted around the world. According to the IMF AREAER database, in 2019 only 23% of a total of 184 countries (excluding those in the European Monetary Union) had an inflation-targeting framework in place; all of them using a policy rate as the main instrument. In turn, 12% had a monetary-target setup, 49% use an exchange-rate anchor, and the other 15% implemented some other hybrid framework. This distribution is mostly influenced by low-income and emerging countries (e.g. no developed economy has a monetary target in place). Moreover, 18% of those implementing inflation targeting choose to *de facto* manage the exchange rate to some extent, while 92% of those using a money-target or a hybrid setup also actively intervene in the foreign exchange market.

Our goal is to understand if limited credibility could influence the policy-instrument choice; for in many contexts credibility cannot be taken for granted (particularly in low-income and emerging countries). Indeed, an earlier literature studies the dynamics after inflation-stabilization programs under alternative policy instruments, emphasizing also the role of credibility; 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; while Taylor (2019) indicates that a monetary target might be desirable under lack of credibility even if the ultimate goal is to achieve an inflation target.

The analysis begins with a baseline model of a small and open economy with incomplete financial markets, nominal rigidities in prices and wages, dominant-currency pricing, and capital accumulation. To account for limited credibility, we deviate from rational expectations by assuming that agents use econometric models (based only on past data) to form inflation-related expectations. This choice is motivated by previous studies highlighting how adaptive learning might limit the impact of monetary policy.[4] In particular, the forecasting model is a VAR with a common time-varying mean, such that observed changes in the relevant variables can have a

[1]Some examples in closed economy models are Schmitt-Grohe and Uribe (2007), Faia (2008), and Faia and Monacelli (2007); while for open economies some relevant references are Faia and Monacelli (2008), De Paoli (2009), Corsetti et al. (2010), Devereux et al. (2006), Lama and Medina (2011). Notable exceptions are Berg et al. (2010) and Andrle et al. (2013), analyzing hybrid rules for low-income countries with a role for monetary aggregates.

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

[3]See, for instance, Ghosh et al. (2016) in the context of rational expectations and Adler et al. (2019) in a model where agents learn about possible changes in the inflation target (in the spirit of Erceg and Levin, 2003).

[4]Surveys of this literature can be found in Gaspar et al. (2010) and Eusepi and Preston (2018b), among others.

persistent impact if they modify the inference about long-run inflation.

We emphasize two different components of the learning process. The first appears if long-run inflation expectations are shaped only by past inflation data, which has been the main focus in most of the related literature (particularly in closed-economy setups). This has two main consequences: inflation is more persistent and, as inflation expectations also determine the real rate relevant for inter-temporal decisions, the central-bank's power to affect aggregate demand is limited.

The second component is specific to open economies and is related to exchange-rate volatility. The literature has extensively explored the role of exchange rates in shaping inflation dynamics (see, for instance, the survey in Burstein and Gopinath, 2014). Besides the several general-equilibrium channels emphasized elsewhere, here we consider the possibility that medium- and 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 suggestive evidence of such an effect. For instance, both the cross-country and time-variation of exchange-rate-pass-through (ERPT) measures seem to correlate with metrics of monetary-policy credibility (e.g. Carrière-Swallow et al., 2021). Moreover, in a general equilibrium context, the ERPT is in part determined by expected monetary policy (as stressed by García-Cicco and García-Schmidt, 2020). Finally, Adler et al. (2019) show that, among inflation targeters, countries with relatively low credibility tend to intervene more actively and frequently in the foreign exchange market.

To further explore this possibility, we analyze market-expectations data for both Argentina and Chile, two cases with arguably different degrees of credibility. We find reduced-form evidence that large exchange-rate surprises significantly change the one-year-ahead inflation expectation in Argentina but not in Chile. While additional evidence is required to study this link, our model-based analysis suggests that dynamics and policy prescriptions can significantly change if, due to limited credibility, agents adjust long-term inflation expectations after exchange-rate jumps.

We compare the dynamics in our model under different expectation-formation assumptions, contrasting three policy alternatives: a Taylor-type rule for the short-term interest rate, a constant growth rate for base money, and an exchange-rate peg. We focus on the role these rules have in smoothing fluctuations after an unexpected rise in foreign-financing costs; an important driving force behind fluctuations in emerging countries (e.g. Uribe and Yue, 2006, among many others). Moreover, external interest rates are also key drivers of exchange-rate movements, which in turn shape inflation dynamics.

The comparison under rational expectations shows that, qualitatively, there is a trade-off in choosing between an interest-rate and a constant-money-growth rule. Limiting fluctuations in the quantity of money partially insulates activity-related variables from the contractionary effects generated by the external shock, while at the same time increases inflation volatility. This is due to the different behavior of interest rates under both policy configurations. Moreover, welfare comparisons indicate that the money-growth rule is marginally preferred. Instead, a peg induces a larger contraction following the negative shock, without a clear advantage in the inflationary front, implying higher welfare costs.

In a limited-credibility setup where only past inflation influences long-run expectations, the qualitative trade-offs between the three rules are still present, but quantitatively the differences are exacerbated. This is a consequence of (i) a more persistent inflation and (ii) a magnified effect of interest-rate changes in activity if expectations are not fully rational. In welfare terms, the interest-rate rule is preferred to the other alternatives.

When exchange-rate movements can directly affect long-term inflation expectations, the consequences of external shocks under different rules change. The dampening effect on activity obtained with a constant money growth is limited and, at the same time, such a rule generates the worst outcome in terms of inflation, as it induces more exchange-rate volatility. In turn, limiting exchange-rate fluctuations might be useful to prevent significant shifts in medium- and long-term expectations. Indeed, the welfare cost of a peg is halved in this learning setup.

We also show that these results are maintained if we add several relevant features to the model. In particular, we consider financial frictions in the form of an endogenous foreign-financing spread; habits at the good-level that further limit the expenditure-switching channel; a domestic banking sector that yields a richer structure for monetary aggregates; a fraction of households with restricted access to financial markets; and a final version combining all of them. Among the main results, financial frictions further emphasize the potential gains from exchange-rate smoothing in situations where exchange-rate jumps can feed into long-term expectations. Also, the relative ranking of alternatives can be different for credit-constrained and unconstrained households, particularly under limited credibility.

The rest of the paper is organized as follows. Section 2 presents the baseline model, with a detailed discussion of the learning framework and its calibration. Section 3 compares the alternative policy instruments in the context of rational expectations. Section 4 performs the comparison under limited credibility. Section 5 explores the sensitivity to the aforementioned modifications. Finally, Section 6 concludes.

2 Baseline 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 and final goods, as well capital. The home good is produced by combining labor and capital. The final consumption good is composed of home and imported goods. The markets for final goods and labor have a monopolistic-competitive structure, where prices are subject to Calvo-style frictions. Following the dominant-currency-pricing paradigm, the demand for exports is insensitive to real exchange rate fluctuations. Households derive utility from consumption, leisure, and money holdings. They also have access to international bonds and domestic treasuries. The rest of this section describes the different agents in the model, the aggregation and market-clearing conditions, the assumptions regarding expectations formation, and the alternative policy rules considered.

2.1 Households

Households seek to maximize,[5]

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

subject to the constraint,

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

Here, c_t denotes consumption, h_t are hours worked, $B_t^{*,H}$ are holdings of foreign bonds (with interest rate R_t^*), B_t^T are holdings of domestic treasuries (with rate R_t), M_t denotes money holdings, T_t 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

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

where $U_{x,t} \equiv \frac{\partial U_t}{\partial x_t}$ for a generic variable x_t, $\pi_t \equiv \frac{P_t}{P_{t-1}}$, and $\pi_t^S \equiv \frac{S_t}{S_{t-1}}$. The first equation links the Lagrange multiplier with the marginal utility of consumption. The second and third characterize the inter-temporal trade-off related to the choices of foreign and domestic bonds, while the last represents the demand for money. For future references, let $\chi_{t,t+\tau} \equiv \beta^\tau \frac{\lambda_{t+\tau}}{\lambda_t} \frac{P_t}{P_{t+\tau}}$ be the stochastic discount factor for claims in domestic currency, τ periods ahead.

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 supplies all demanded labor. In addition, the total number of hours allocated to the different labor markets must satisfy the constraint $h_t = \int_0^1 h_{it} \mathrm{d}i$.

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

[5]While functional forms are presented in Appendix A, it is worth mentioning that we assume preferences feature no wealth-effects in labor supply, external habits in consumption and money holdings, and inter-temporal consumption decisions that are independent from labor and money.

[6]Throughout, uppercase letters denote nominal variables in levels, while lowercase letters indicate real variables, relative prices, or rates of change. Variables without time subscript denote non-stochastic steady-state values. Finally, we use the notation $\widehat{x}_t \equiv \ln(x_t/x)$ for a generic variable x_t.

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 $w_t \equiv \frac{W_t}{P_t}$ and 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 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 $\pi_t^W \equiv \frac{W_t}{W_{t-1}}$ denotes nominal wage inflation.

2.2 Final 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:

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

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

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 monopolist producing a given variety j internalizes this demand, and transforms wholesale final goods (purchased at price P_t^{Cw}) into the variety j using a linear technology ($y_{jt}^C = x_{jt}^{Cw}$). In setting prices, she faces a Calvo probability of not being able to optimally change its price given by θ. Whenever she is not able to choose optimally, the previous-period price is indexed by $(\pi_{t-1})^{\vartheta}(\pi)^{1-\vartheta}$. After a log-linearization we obtain the following Phillips curve

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

Notice that, as the exchange rate is part of the wholesales price P_t^{Cw}, the model feature imperfect exchange rate pass-trough to final-good prices.

2.3 Home Goods

These are produced competitively by combining labor (h_t) and capital (k_t^d) according to the production function

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

where z_t is an exogenous productivity shock. Profit maximization generate 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 $r_t^K \equiv \frac{R_t^K}{P_t}$ is the real rental rate of capital. 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, $(1-\delta)k_{t-1}$, which is combined with final goods (i_t) to produce new capital (k_t, sold at nominal price Q_t), using the technology

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

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

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

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

In the second stage, another set of competitive firms rent the stock of capital to firms and, after depreciation, sell the used capital to capital-goods producers. Afterwards, they buy new capital for the next period. The optimal choice of these firms is,

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

2.5 Fiscal and Monetary Policy

The consolidated balance sheet of the government is given by

$$P_t g_t = (M_t - M_{t-1}) + S_t\left(B_t^{*,T} - R_t^* B_{t-1}^{*,T}\right) + \left(B_t^T - R_{t-1}B_{t-1}^T\right) + T_t.$$

where g_t is an exogenous process. In this setup, T_t adjusts to satisfy this constraint (fiscal policy is passive) and thus Ricardian equivalence holds (only the path of g_t matters for equilibrium determination). In turn, the monetary authority set its policy by choosing a rule for either instrument R_t, M_t, or S_t; as discussed below.

2.6 Rest of the World

The economy has several interactions with the rest of the world. The interest rate is given by

$$R_t^* = R_t^W \exp\left\{\phi\left(-b_t^* + \bar{b}\right)\right\}. \tag{2}$$

where R_t^W denotes the world interest rate and the second term is a debt elastic premium (with $b_t^* \equiv (B_t^{*,H} - B_t^{*,T})/P_t^*$ denoting aggregate net-foreign assets in real terms) which serves as the "closing device" (see Schmitt-Grohé and Uribe, 2003). In the baseline model, ϕ is calibrated to a small but positive number, while we explore other alternatives in Section 5. In the following sections we focus on shocks to R_t^W.

The local price of foreign goods (P_t^F) satisfies the law of one price: $P_t^F = S_t P_t^*$. Additionally, defining the real exchange rate as $rer_t = S_t P_t^*/P_t$, it follows that $rer_t = p_t^F$. Finally, the world's demand for home goods is given by,

$$x_t^{H*} = \left(\frac{P_t^{*H}}{P_t^*}\right)^{-\eta^*} y_t^*$$

where y_t^* is GDP from trading partners and P_t^{*H} is the international price of Home goods (both taken as given according to the small economy assumption). Notice that movements in the real exchange rate do not have a direct impact on exports (in line with the dominant-currency pricing literature, e.g. Gopinath et al., 2020), limiting the expenditure-switching channel.

2.7 Aggregation and Market Clearing

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

$$y_t^H = x_t^H + x_t^{H*}, \quad y_t^C = c_t + g_t + i_t, \quad y_t^H = z_t(h_t)^\alpha (k_{t-1})^{(1-\alpha)}.$$

Real GDP in this model equals y_t^H. The following 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 for foreign inflation. The evolution of net foreign assets follows from the resource constraints of households, firms, and the government:

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

Finally, the trade balance in real terms is $tb_t \equiv x_t^{H*} - x_t^F$.

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 presents the functional forms and calibration of the parameters described so far, which follows related studies for Latinamerican countries. This calibration is not meant to fit the data of a particular country, but rather to provide reasonable parameter values (from the perspective of emerging countries) to study the dynamics implied by the model. In particular, while the model features many exogenous driving forces, we will only focus on shocks to R_t^W to keep the analysis as clean as possible; fixing all other exogenous variables to their respective steady-state values.

2.8 Limited Credibility

Under rational expectations, agents forecast future values using the equilibrium distribution of the variables in the model. In particular, they know and take as given the goals and policy rules implemented by the government. This will be our benchmark for full credibility. In contrast, imperfect credibility is captured by assuming that agents forecast inflation-related variables an econometric model, 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. Detailed surveys on the importance of learning for monetary policy can be found, for instance, in Gaspar et al. (2010) and Eusepi and Preston (2018b).

Specifically, we assume agents forecast price and wage inflation using an econometric model.[7] 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 $x_t = [\widehat{\pi}_t^S, \widehat{\pi}_t, \widehat{\pi}_t^W]'$, expectations are based on the following model,

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

where the eigenvalues of Φ are in modulus less than 1, and α_t is a scalar. In other words, this is a VAR model with a common time-varying long-run trend affecting all variables.[8] 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 $K \equiv [K_S, K_\pi, K_W]$ is a 1×3 matrix containing the steady-state Kalman gains (a function of Φ, Z, H and σ_η^2, obtained by solving the relevant Ricatti equation). In other words, surprises (i.e. observed values that differ from previous-period forecasts, the term in brackets in equation (4))

[7] 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.

[8] 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.

in either the nominal exchange rate, inflation or wages can in principle modify beliefs about the long-run values of these variables.[9] Finally, the parameters defining the forecast function in period t are assumed to be predetermined.[10] Under these assumptions the h-periods-ahead forecast is,

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

As can be seen, as $h \to \infty$, $E_t\{x_{t+h}\} \to Z\bar{\alpha}_{t-1}$ Therefore, $\bar{\alpha}$ captures long-run inflation expectations. Overall, the model with limited credibility replaces $E_t\{\widehat{\pi}_{t+1}\}$ and $E_t\{\widehat{\pi}^W_{t+1}\}$ in all relevant equations with the corresponding forecast from (5), adding also equation (4) to determine the evolution of $\bar{\alpha}_t$.

This setup requires calibrating Φ and K. We estimate the model in (3) for the cases of Argentina and Chile. The latter was the first country in Latin America to adopt an inflation targeting setup and, considering information from 2004 to 2019, one-year-ahead inflation expectations were above the target range during only 9 months (4% of the sample).[11] Argentina, in contrast, has experienced an increasing average inflation rate from 2004 to 2019, alternating several policy frameworks during this period. Thus, Argentina will be used as the limited-credibility case, while the Chilean data allows checking the extent to which the estimated model can tell these two cases apart. However, it is relevant to highlight that it is not our goal to account for the observed macro dynamics in any of these countries during this period. In turn, we see this comparison as providing suggestive evidence of a link between forecast surprises and inflation expectations, obtaining at the same time reasonable parameter values to calibrate the learning component of the DSGE model.

The set of observables includes the three variables in x_t (we use the core index as the inflation measure), 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.[12]

The first line in Table 1 displays the ratio between the sample variance of $\bar{\alpha}_t$ (obtained from the Kalman smoother) and that of observed inflation. In the case of Argentina, around 14%

[9]The related literature assumes that each constant in the VAR is determined by a different process. In our notation, this would correspond to a forecasting model as: $x_t = \gamma_t + \Phi x_{t-1} + \varepsilon_t$, $\gamma_t = \gamma_{t-1} + \upsilon_t$, where γ_t is 3×1, $\varepsilon_t \sim \mathcal{N}(0, H)$, and $\upsilon_t \sim \mathcal{N}(0, Q)$. Moreover, in this related literature it is assumed that the matrices H and Q are proportional to each other, which yields the updating equation $\bar{\gamma}_t = \bar{\gamma}_{t-1} + \kappa\,[x_t - \Phi x_{t-1} - \bar{\gamma}_{t-1}]$, where κ is a scalar. However, notice that such a framework prevents surprises in one variable to move the long-run expectation of another (e.g. in our case, this would prevent exchange-rate surprises 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).

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

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

[12]This gap is handled with the missing-observations Kalman filter. The model also includes a measurement error term for exchange-rate expectations, 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. The estimated values for Φ are reported in Appendix A.

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	0.20	0.1	0.3	0.14	0.1	0.2
K_W	0.23	0.1	0.4	0.04	0.0	0.1
K_S	-0.02	-0.05	0.01	0.00	0.0	0.0

Notes: The variance of α_t is computed from the smoothed series generated by the Kalman filter.

of inflation fluctuations can be explained by changes in this long-run trend, with a 90%-coverage credible set ranging from 8 to 22%. For Chile this ratio is close to 3%, with a much tighter credible set. Clearly, the estimated models capture the descriptive differences in the degree of expectations anchoring mentioned before.

In terms of Kalman gains, those related to inflation and nominal wage growth (K_π, K_W) 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.[13]

The influence of exchange rate surprises (K_S) is estimated to be near zero for both countries. This result, while somehow surprising, reflects the relationship among variables **on average**. However, we could be in the presence of conditional effects: large exchange-rate surprises could shift inflation expectations more than small ones. 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.[14] Blue dots correspond to months when exchange-rate surprises were smaller than one standard deviation, while red dots are those for larger surprises.[15]

As can be seen, in months with relatively small exchange-rate surprises, in both countries there is a positive but small relationship between these 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.

The bottom row in Figure 1 is analogous, but plotting inflation surprises in the horizontal axes instead, separating also the months of large exchange-rate surprises (i.e. red dots correspond to the same months in the top and bottom rows). 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.

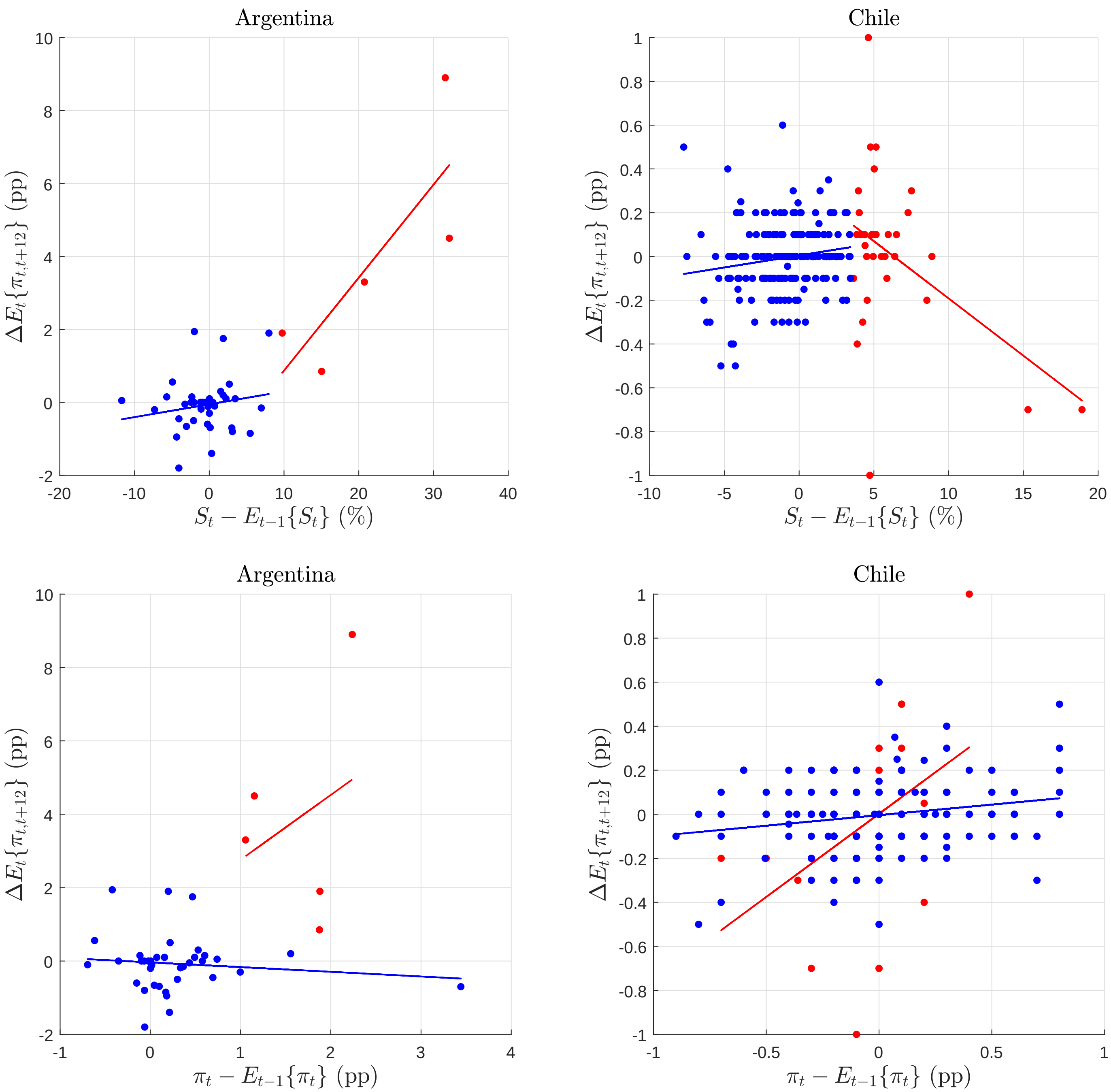
Table 2 reports results from regressing the change in 12-month-ahead inflation expectations

[13] 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).

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

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

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 ($\Delta E_t\{\pi_{t,t+12}\} \equiv E_t\{\pi_{t,t+12}\} - E_{t-1}\{\pi_{t-1,t-1+12}\}$). 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 $S_t - E_{t-1}\{S_t\}$. 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 ($\pi_t - E_{t-1}\{\pi_t\}$).

for each country, as a function of surprises (forecast errors according to the survey) in either the exchange rate or inflation. For Argentina, on average (column 1) these are mainly related with $S_t - E_{t-1}\{S_t\}$ (with a relatively high adjusted $R2$) but not with inflation surprises. Moreover, this effect seems to come mainly from observations in which the exchange rate surprise is high ($D_t = 1$, column 2).

Table 2: Changes in inflation expectation and surprises

	Argentina		Chile	
$S_t - E_{t-1}\{S_t\}$	0.16***	0.04	0.00	0.01
$\pi_t - E_{t-1}\{\pi_t\}$	-0.01	-0.14	0.15***	0.08**
$(S_t - E_{t-1}\{S_t\})\, D_t$		0.14**		-0.02
$(\pi_t - E_{t-1}\{\pi_t\})\, D_t$		0.30		0.65**
Const.	0.06	-0.05	0.00	0.01
Nobs	42	42	219	219
R2-adj	0.70	0.62	0.05	0.14

Notes: The dependent variable is the change in 12-month-ahead inflation expectations between month t and $t-1$. The regressors are one-month-ahead forecast errors. The variable D_t equals one if the exchange rate forecast error is higher than one standard deviation. *** and ** denotes significance at 99% and 95% level, respectively, computed with HAC standard errors.

In contrast, for Chile changes in inflation expectations are related with inflation surprises, rather than exchange rate forecast errors, although with a much smaller adjusted $R2$ (column 3). Large exchange rate suprises also produce a differential effect (column 4), but it only intensifies the relationship with inflation surprises.

Overall, this suggestive evidence seems to indicate that, in the country with more limited credibility, medium-term inflation expectations are significantly affected by large movements in the exchange rate; while this relationship is less evident in the country with a relatively higher degree of anchoring. Given these results, in what follows we will use two calibrations for limited credibility: one with $K_S = 0$, $K_\pi = K_W = 0.2$ and another where $K_S = K_\pi = K_W = 0.2$.[16] The first will be taken as representative of situations with lack of credibility but under normal-size shocks, while the latter is meant to capture situations where exchange-rate volatility further hinders credibility. This comparison will allow to understand the role played by these different channels that emerge once learning is considered.

2.9 Alternative policy rules

Our exploration of alternative simple rules considers the following:

1. Interest rate:

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

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

where e_t^{MP} is an i.i.d. policy shock.[17] 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 aggregate:

$$\Delta M_t \equiv \frac{M_t}{M_{t-1}} = \pi, \tag{7}$$

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

3. Nominal exchange rate:

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

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 in equation (6), displayed in Figure 2. As in most New-Keynesian models of small and open economies, a negative shock to the Taylor rule leads to a rise in consumption, investment and GDP. At the same time, by the interest rate parity, the nominal exchange rate depreciates. Both effects tend to increase inflation and, due to price stickiness, the real exchange rate also depreciates. Finally, under rational expectations the one-period-ahead inflation forecast mimics the path of actual inflation, one period after the shock.

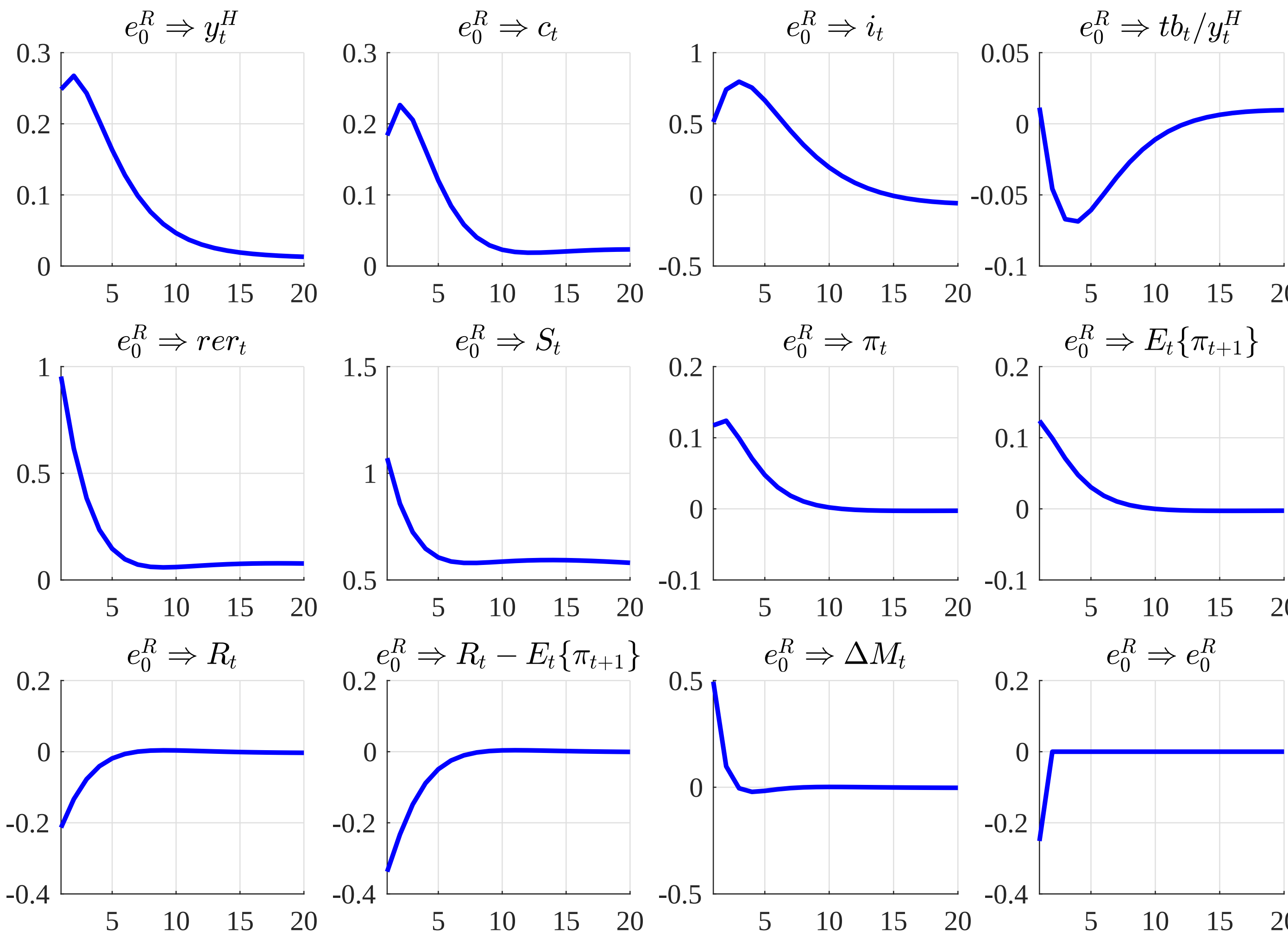
Next, we turn to the impact of a shock that increases the external interest rate by one standard deviation, displayed in Figure 3.[18] The solid-blue line depicts the responses under the interest-rate rule. This shock contracts consumption and investment. The former is reduced through both a negative wealth effect (as the country is a net-foreign borrower) and an intertemporal substitution effect (savings become relatively more attractive). Investment falls by the increase in 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 influence of the contraction in aggregate demand. Also, due to sticky prices and wages, the real depreciation is achieved by an increase in the nominal exchange rate. The trade balance improves driven by the drop in domestic absorption (which reduces imports), while the demand for exports is not sensitive to the real depreciation.

As inflation increases, the policy rate rises guided by the rule in equation (6). However, this increase is relatively mild, for the surge in inflation is limited, plus the part of the rule that responds to output is also limiting the interest-rate increase. In addition, this rise in the policy rate somehow dampens the nominal depreciation, and therefore its impact on inflation. Along

[17] Below, we use this shock only to understand the monetary transmission mechanism. However, it is not considered for the welfare analysis.

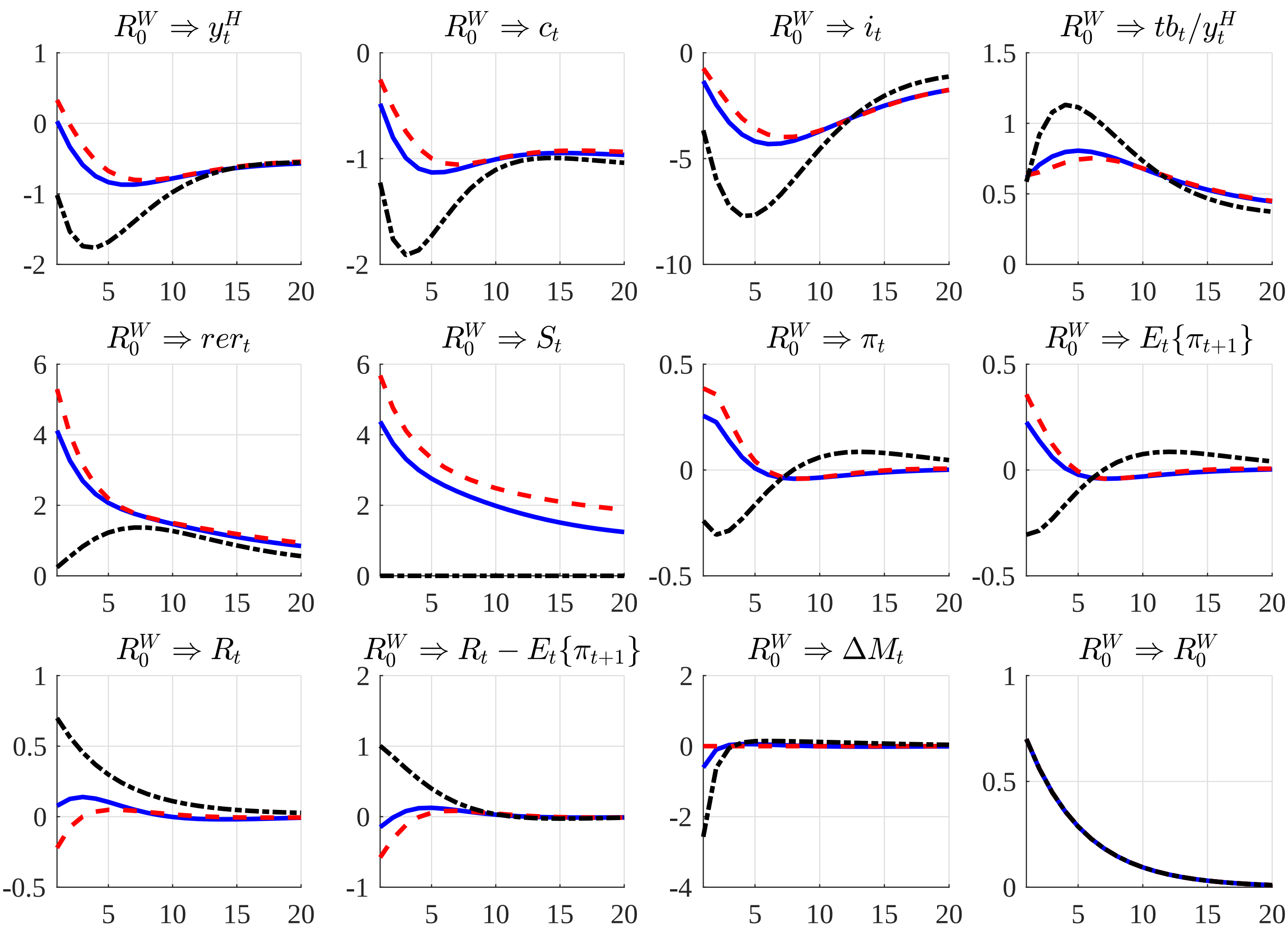
[18] As described in Appendix A, this is calibrated by estimating an AR(1) model to the sum of the LIBOR rate plus the J. P. Morgan EMBI Index for Argentina. The shock represents an increase of 280 annualized basis points in the cost of foreign borrowing.

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), the trade-balance-to-output ratio (tb_t/y_t^H), real exchange rate (rer), nominal exchange rate (S), inflation (π), expected inflation ($E_t\{\pi_{t+1}\}$), policy rate (R), ex-ante real rate ($R_t - E_t\{\pi_{t+1}\}$), money demand growth ($\Delta M1$) and the shock hitting the economy. Al variables are measured in percentage deviations relative to the steady state, except for tb_t/y_t^H which is expressed as percentage points relative to its steady state value.

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 lines use a money-growth rule, and the dashed-dotted-black lines correspond to the exchange-rate peg. See the description in Figure 2 for variables' definitions.

the same lines, nominal money balances fall despite the rise in inflation, reflecting both the fall in consumption and (to a lower degree) the interest rate increase.

The dashed-red lines in Figure 3 are the dynamics under the constant-money-growth rule in equation (7). Qualitatively, the contractionary effects on absorption are also observed under this configuration; and the exchange rate and inflation dynamics are similar as well. 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 would fall due to the contraction in consumption. In a configuration with a constant-money-growth rule, the interest rates must then fall to clear the money market. This in turn leads to a larger nominal depreciation,[19] placing an additional upward pressure on inflation. At the same time, the real depreciation is larger; as the addition nominal depreciation outweighs the higher inflation.

As the real interest rate drops slightly in this case, the negative direct effect on consumption and investment is relatively milder here, which in turn translates into a minor initial output expansion. Overall, we can see that a money-growth rule limits the negative consequences on activity, inducing instead more inflation and a larger depreciation.

Finally, the exchange-rate peg scenario is displayed with dashed-dotted-black lines in Figure 3. The contraction in absorption is larger: by eliminating the nominal-exchange-rate effect, domestic rates experience a larger increase.[20] In contrast, inflation falls under this configuration: in the absence of a nominal-exchange-rate channel, prices are only driven by aggregate demand.

To quantify the desirability of each alternative, we ranked them using two complementary metrics. The first one is conditional welfare. For each model, with a given rule, we compute,[21]

$$\mathcal{W} = E_{R_0^W}\left\{\sum_{t=0}^{\infty}\beta^t U\left(c_t, h_t\right)\right\},$$

i.e. the expected welfare conditional on having experienced a positive shock to R^W in period 0, starting from the steady state, computed by a second-order approximation.

We also calculate the consumption compensation that makes households indifferent between alternatives. In particular, for a given reference equilibrium r and an alternative a, Λ is implicitly defined as,

$$E_{R_0^W}\left\{\sum_{t=0}^{\infty}\beta^t U\left(c_t^a, h_t^a\right)\right\} = E_{R_0^W}\left\{\sum_{t=0}^{\infty}\beta^t U\left[\left(1-\Lambda\right)c_t^r, h_t^r\right]\right\},$$

i.e. the percentage of per-period consumption that households would be willing to sacrifice to live in the alternative a, relative to the equilibrium in r (if $\Lambda < 0$ agents prefer the situation a), both

[19] 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.

[20] Under a peg, the interest rate parity forces the domestic rate to replicate the path of the external rate.

[21] Notice that although the utility function in section 2 included also real money balances, we omit them here. We choose to do so because we consider this to be just a shortcut to model money demand, and not a relevant characteristic to rank outcomes. Notice also that expectations here are taken according to the equilibrium distribution. In cases where agents are adaptive learners, this implies that the welfare criteria is taking into account the implications of such learning for equilibrium outcomes (i.e. using the actual instead of the perceived law of motion to form expectations).

conditional on shocks to R^W only.

Finally, we also compare alternatives according to a loss function that weights equally deviations of output and inflation from steady state, i.e.

$$\mathcal{L} = E_{R_0^W} \left\{ \sum_{t=0}^{\infty} \beta^t \left[(\widehat{y}_t)^2 + (\widehat{\pi}_t)^2 \right] \right\},$$

which is some times used to characterize inflation-targeting frameworks (e.g. Svensson, 2010).

Table 3 summarizes these comparisons, including also the volatilities of output, inflation and the real exchange rate to complement the analysis. The measure Λ is computed relative to the R rule scenario. In terms of welfare, the smoother path for aggregate demand brought about by the M rule improves welfare (despite the additional inflation volatility). But the gain is relatively small: agents are willing to give up less than 0.2% of consumption to live in a world with a money rule. In contrast, welfare is the lowest under a peg: Λ is more than five times higher than in the comparison between money and interest-rate rules. If instead we focus on the loss function, the M rule is slightly preferred to the R alternative, with a larger loss under the S rule.

Table 3: Volatilities, Welfare and Loss Function:
Alternative Rules under Rational Expectations

Rules	Relative Volatilities y_t^H	π_t	rer_t	Welfare Λ	Relative Loss
M vs R	0.98	1.38	1.15	-0.17	-0.02
S vs R	1.16	1.44	0.54	0.94	0.22

Notes: The first three columns show the ratio of standard deviations of output, inflation and the real exchange rate, under either the M or the S rule, relative to those under the R rule. Λ is computed using the model with R rule as the reference in each case, expressed in percentage points. The last columns report the loss function under either the M or the S rule, minus that under the R rule (a positive number indicates R is preferred).

Overall, under rational expectations, the identified trade-off between the responses of inflation and output in comparing the M and the R rules is resolved slightly in favor of the money-growth rule with either ranking criteria. In contrast, the peg is clearly dominated.

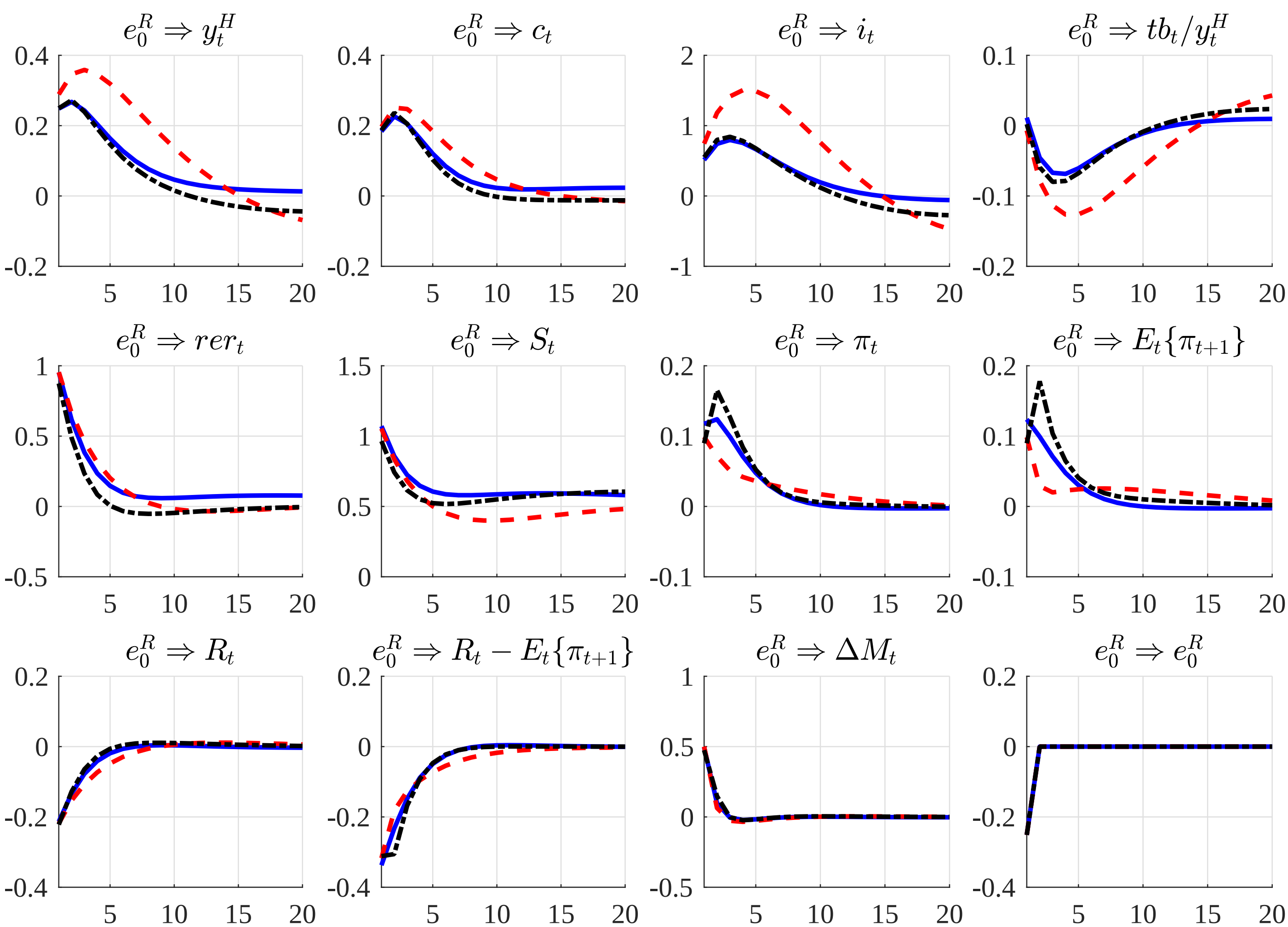
4 Comparing Instruments under Limited Credibility

We now turn to the analysis under limited credibility. We proceed in three steps. First, we study how the monetary transmission mechanism under an interest-rate rule changes in the presence of both limited-credibility configurations (which differ on the value assumed for K_S). Second, we compare how the propagation after the external-interest-rate shock differs depending on the expectations setup, still assuming that policy follows an interest-rate rule. Finally, we compare the three policy rules under each learning alternative.

4.1 The Transmission of Shocks Under Learning

In Figure 4 dashed-red lines display the effects of a negative policy shock in equation (6) in the case of limited credibility with $K_S = 0$, while the solid-blue lines replicates those under rational expectations to facilitate the comparison (i.e. the same as in Figure 2). 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.

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



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

To understand this result consider the real rate that affects consumption and investment decisions: $\widehat{R}_t - E_t\{\widehat{\pi}_{t+1}\}$. Under rational expectations, agents understand that the expansion generated by a more dovish policy stance will increase inflation in the future. Thus, the relevant real rate drops more than the nominal rate. If, instead, expectations incorporate inflation surprises only slowly, *ceteris paribus* the real rate remains at a low level for a longer period (as inflation expectations are more persistent). This leads to a somehow larger expansion in domestic absorption.

However, inflation does not increase under this type of learning, despite the higher path for aggregate demand, because the forward-looking channel of the Phillips curve is muted. 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; i.e. instead of perfect foresight, past inflation shapes agents' forecast.

A relevant corollary of this analysis is that, to achieve a given desired effect on inflation, the policy rate needs to change by more (and for a longer period) if expectations are not fully rational. This in turn leads to larger sacrifice ratios during disinflations, 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).

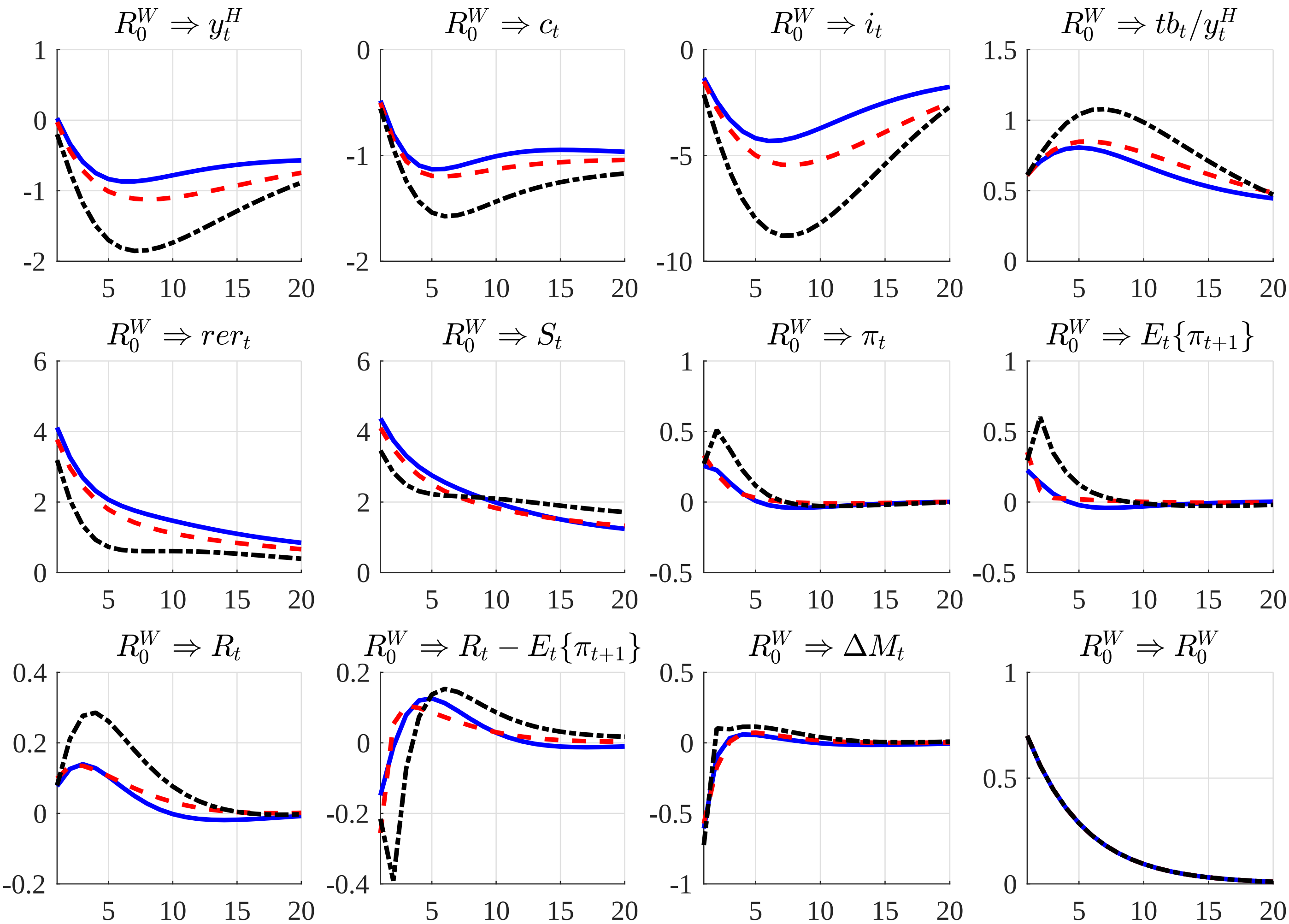
In the same figure, dashed-dotted-black lines show the case with $K_S = 0.2$. Here inflation expectations rise by more than when they are rational, with a one-period delay because the inference about α_t is predetermined on impact (recall the assumption discussed in Section 2.8). Under this setup, a more expansionary policy stance leads to more inflation than "intended" if $K_S > 0$. However, notice that the evolution of the real rate (and thus activity-related variables) is similar to the rational-expectations case, as $K_S > 0$ off-sets the milder response of inflation expectations that we observe in the dashed-red lines. Thus, the impact on activity is similar to rational expectations, but the more dovish policy induces more inflation. As we will analyze next, this implies that policy trade-offs could be exacerbated following a contractionary shock that induces a depreciation.

Figure 5 compares the responses after an external interest rate increase, still under the interest-rate rule. As can be seen, if learning features $K_S = 0$ (dashed-red lines) the effects on consumption and investment are not as different in the initial quarters; for the direct impact comes mainly through a real channel and it is less related to inflation expectations. Afterwards, the contraction is larger and more persistent, explained by the reaction of the policy rate. As can be seen, inflation and its expectation are marginally larger initially (due to the autoregressive component of the expectation model, Φ in equation (3)) but, crucially, they remain above the steady-state value for a longer period (generated by the impact of actual inflation in long-run expectations, α_t in the forecasting model). This implies a relatively more persistent policy-rate path (as implied by the R rule), explaining the additional contraction in activity.

If instead expectations are also affected by exchange-rate surprises (dashed-dotted-black lines show the case with $K_S > 0$) dynamics are further modified. Inflation increases by more as long-run expectations shift, and GDP also falls by more. This activity effect has two origins. First, the policy rule dictates a more contractionary path, leading to a larger fall in demand. Second, the real depreciation is smaller in this case (inflation increases by more, and the rise in domestic rates dampens the nominal depreciation), limiting any expenditure-switching effect. This is in contrast with the analysis after a policy shock in Figure 4, where part of the effect coming from the persistence channel of learning was offset by the exchange rate channel in the learning process. The difference arises because the shock to R^W is one that induces a contraction while at the same time generates a depreciation and more inflation, and therefore each of the learning layers under consideration generate additional amplification effects in activity-related variables.

To summarize, if the exchange-rate jump feeds into expectations (as the evidence in section 2.8 seems to suggest under limited credibility following a large shock) policy will face a worse trade-off

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, the dashed-red line is the version of imperfect credibility with $K_S = 0$, and the dashed-dotted-black lines use $K_S = 0.2$. See the description in Figure 2 for variables' definitions.

between inflation and activity after the R^W shock. In fact, in terms of conditional welfare and the loss function, Table 4 shows that limited credibility is indeed costly, specially if $K_S > 0$.

4.2 Alternative Policy Rules

Figure 6 compares the effects of the external shock under the three policy alternatives, in the learning setup with $K_S = 0$. 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 seem to alter the intuitive differences between the three alternatives.

Quantitatively the differences are exacerbated in this setup by two complementary effects. First, as previously identified, the presence of adaptive learners induces a more persistent response in nominal variables. Thus, the part of the trade-off related to inflation dynamics gets amplified under lack of credibility. In particular, a constant-money-growth rule implies somehow higher and

Table 4: Volatilities, Welfare and Loss Function:
Rational Expectations vs Limited Credibility under R Rule

Alternatives	Relative Volatilities y_t^H	π_t	rer_t	Welfare Λ	Relative Loss
LC, $K_S = 0$ vs RE	1.05	1.06	0.86	0.13	0.83
LC, $K_S = 0.2$ vs RE	1.23	1.79	0.54	0.76	0.51

Notes: All alternatives use the R rule, and the reference is the rational-expectations version. For more details, see notes in Table 3.

more persistent inflation and depreciation than with an interest-rate rule.

The differences in the behavior of interest rates are also amplified, yielding larger discrepancies between the three cases in terms of real variables. The contraction is milder with the constant money-growth rule while it is even larger under a peg. Overall, if long-term expectations are only affected by past 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 it is still not obvious that inflation volatility is reduced.

The top panel of Table 5 presents the comparison in welfare and loss-function terms. Relative to the results under rational expectations in Table 3, here the M rule leaves agents marginally worse off under both metrics (in this case the M rule induces more volatility in activity than the R rule, although only slightly). The differences with S rule are similar in welfare terms, but not in terms of the loss function.

Table 5: Volatilities, Welfare and Loss Function:
Alternative Rules under Limited Credibility

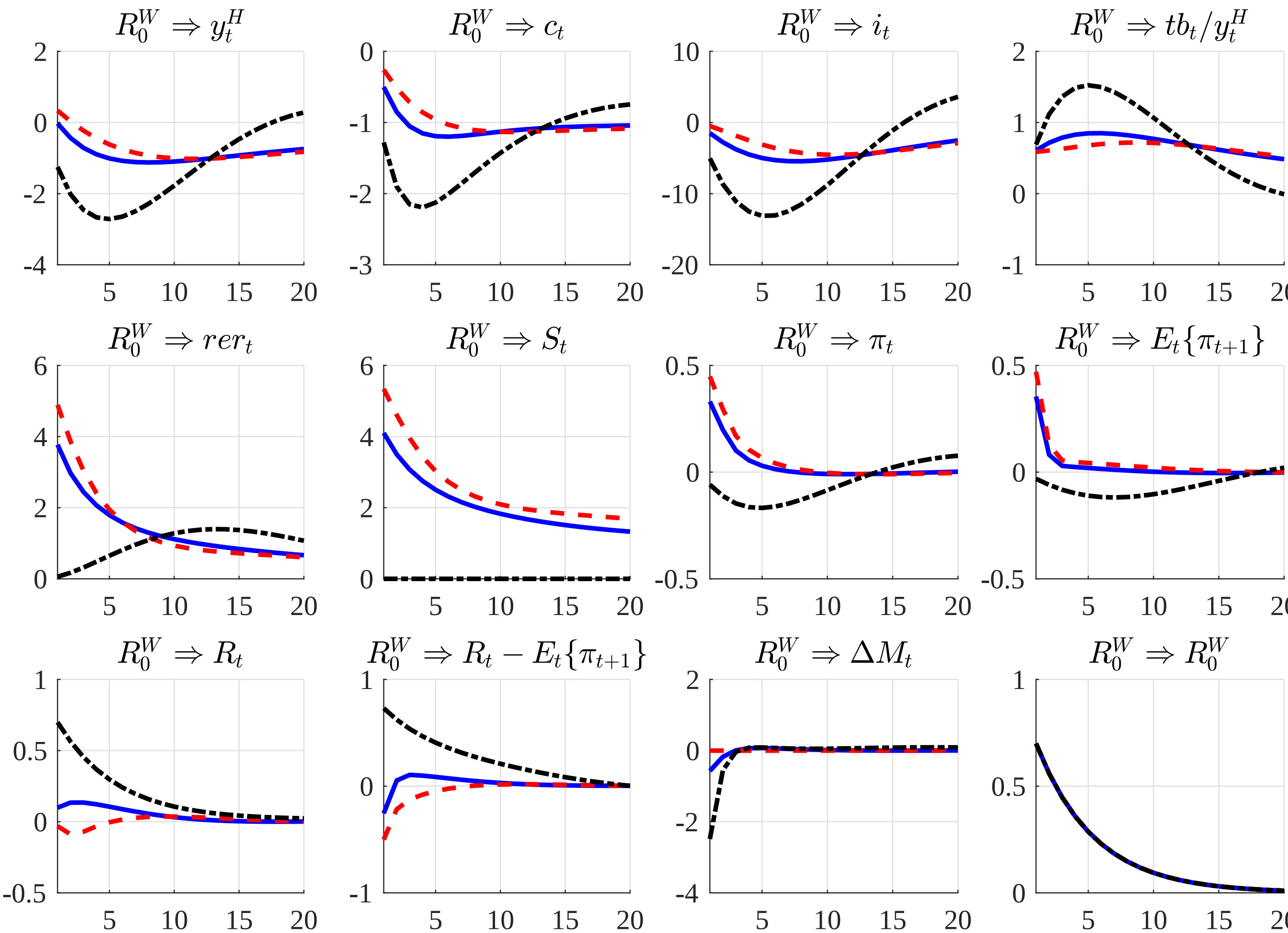
Rules	Relative Volatilities y_t^H	π_t	rer_t	Welfare Λ	Relative Loss
		Limited Credibility, $K_S = 0$			
M vs R	1.03	1.26	1.13	0.23	0.02
S vs R	1.32	1.10	0.74	0.95	0.53
		Limited Credibility, $K_S = 0.2$			
M vs R	1.03	1.23	1.12	0.19	0.06
S vs R	1.06	0.48	0.70	0.46	0.12

Notes: See the description in Table 3 for details.

If expectations are also affected by exchange rate dynamics ($K_S > 0$, shown in Figure 7), the comparison between rules is different. Under both money and interest-rate rules, inflation expectations are higher due to this additional learning channel. But here the real-rate path is relatively more contractionary with the M than with the R rule. As a result, the path of activity-related variables are similar in these two cases. Therefore the dampening effect in activity brought about by the M 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 qualitatively similar dynamics regardless of the type of learning assumed. However, if $K_S > 0$ the differences with the other rules in terms of activity are somehow

Figure 6: External-Interest-Rate Shock with Alternative Instruments. Imperfect Credibility with $K_S = 0$.

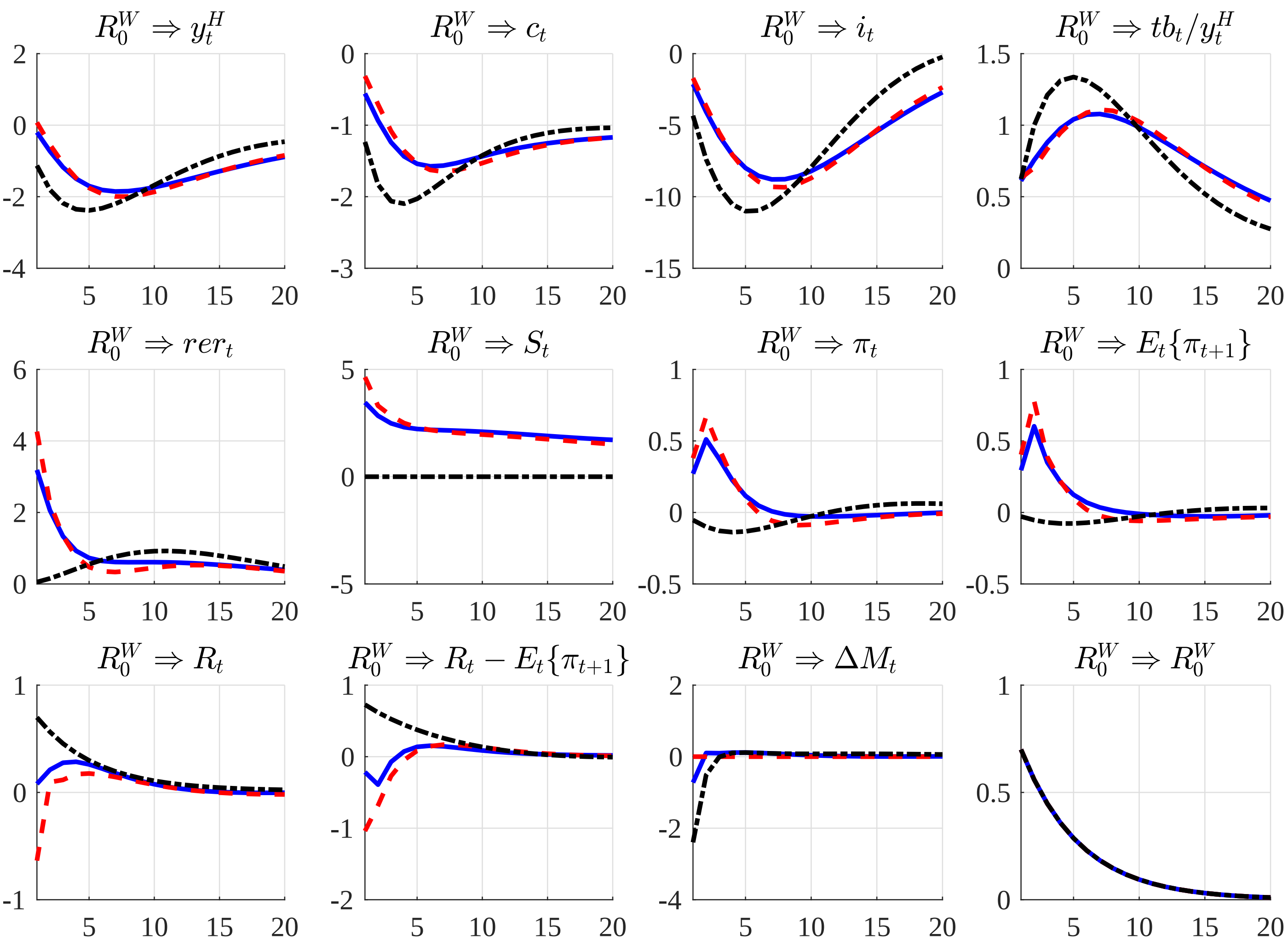


Notes: All responses correspond to the learning model with $K_S = 0$, the solid-blue lines are from the version with an interest-rate rule, the dashed-red lines use a money-growth rule, and dashed-dotted-black lines correspond to the exchange-rate peg. See the description in Figure 2 for variables' definitions.

smaller. Additionally, the path of inflation is now less volatile under the peg than with the other alternatives. These results are confirmed in the bottom panel of Table 5. The comparison between R and M rules is similar in both learning structures. The main difference is that the welfare cost of a peg is halved if $K_S > 0$.

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 induced by the external shock 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. This stresses the importance of accounting for the role that exchange rate in limited credibility environments.

Figure 7: External-Interest-Rate Shock with Alternative Instruments. Imperfect Credibility with $K_S = 0.2$.



Notes: All responses correspond to the learning model with $K_S = 0.2$, The solid-blue line are the version with an interest-rate rule, the dashed-red lines use a money-growth rule, and dashed-dotted-black lines correspond to the exchange-rate peg. See the description in Figure 2 for variables' definitions.

5 Sensitivity Analysis

In this section, we compare the same policy rules under several extensions to the baseline model: financial frictions in the form of an endogenous foreign-financing spread; habits at the good-level further limiting the expenditure-switching channel; a domestic banking sector that yields a richer structure for monetary aggregates; a fraction of households with restricted access to financial markets; and a final version combining all of them.[22]

[22] To save space, the analysis focuses only on volatilities, welfare and loss-function comparisons; while the impulse responses analogous to Figures 3, 6 and 7 for each case are included in the Appendix B.

5.1 Financial Frictions

A large literature highlights the role of financial frictions in propagating shocks in emerging countries, particularly those exposed to the liability dollarization phenomena.[23] We explore how our results change if these concerns are present. To keep the model as simple as possible, we follow García-Cicco and García-Schmidt (2020) and make the external premium elastic to the ratio of foreign debt to GDP. In particular, we change the external-interest-rate equation (2) to:

$$R_t^* = R_t^W \exp\left\{\phi\left(-\frac{rer_t b_t^*}{p_t^H y_t^H} + \bar{b}\right)\right\}. \tag{9}$$

Furthermore, we double the value of ϕ from 0.001 to 0.002.

To understand the effect of such a change, notice that in the baseline model the shock to R_t^W increases the debt ratio in (9); either because debt rises, activity falls, a real depreciation is induced, or a combination of them. As a consequence, under financial frictions, the shock is relatively more contractionary. If also ϕ increases, a larger depreciation is generated and inflation further increases.[24] This first line in Table 6 contrast this new setup under the R rule and the baseline model with the same rule, both under rational expectations. As can be seen, this modification rises volatility in the economy by around 50%, both for real and nominal variables. Moreover, the conditional welfare cost of suffering a negative shock to R^W in a world with this endogenous premium is significantly higher relative to the baseline.

Table 6: Volatilities, Welfare and Loss Function:
Alternative Rules with Financial Frictions

	Relative Volatilities			Welfare	Relative
Rules	y_t^H	π_t	rer_t	Λ	Loss
		Rational Expectations			
R vs Base R	1.54	1.48	1.55	5.50	0.38
M vs R	1.02	1.49	1.21	0.39	0.02
S vs R	1.01	1.39	0.51	-0.67	0.16
		Limited Credibility, $K_S = 0$			
M vs R	1.06	1.30	1.15	0.90	0.10
S vs R	1.25	1.12	0.69	0.23	0.90
		Limited Credibility, $K_S = 0.2$			
M vs R	1.02	1.26	1.12	0.20	0.06
S vs R	1.03	0.52	0.70	0.15	0.13

Notes: the first line compares the R rule under rational expectation in this alternative, using as reference the Baseline model under rational expectation with the R rule. The other lines compare each policy alternative with the R rule under this particular model, and each panel differs only by the expectation-formation assumption, as in Table 3.

Given the presence of financial frictions, we investigate the relative merits of the alternative rules, considering each expectation-formation setup. Focusing first on rational expectations, we

[23] See, for instance, the survey by Mendoza and Rojas (2019).

[24] If we just change the premium to (9) but maintain $\phi = 0.001$, the differences between models are minor.

can see that the M rule further increases volatility relative to the R rule, particularly for inflation and the real exchange rate. Thus, the potential advantages of the M rule identified in the baseline model are limited if financial frictions are relevant. In contrast, by limiting the real depreciation that would otherwise affect the endogenous premium, the peg has some advantages under rational expectations, and in terms of conditional welfare is even preferred to the other rules.[25]

Under limited credibility, the R rule seems to dominate the other alternatives in terms of both conditional welfare and the loss function. The relative merits of M rule are also diminished under learning, while the cost of a peg (which under learning is no longer preferred to the R rule) is milder, particularly if $K_S = 0.2$. Therefore, the potential advantages of reducing exchange rate volatility identified with the baseline model are strengthened if financial frictions are present.

5.2 Good-Level Habits

The expenditure-switching channel in isolation would imply an expansion after any shock that induces a real depreciation, as it implies (*ceteris paribus*) an improvement in the trade balance. As the evidence for emerging countries points to a contractionary effect of increases in foreign interest rates (e.g. Uribe and Yue, 2006), it seems appropriate to investigate the robustness of the result if the expenditure-switching channel is further limited.[26] To that end, we modify the assumption regarding habit formation in the model: we eliminate habits at the total-consumption level as in the baseline, and instead set the aggregation of final goods in equation (1) to,

$$y_t^{Cw} = \left[\omega^{1/\eta}\left(x_t^H - \phi_C x_{t-1}^{H,a}\right)^{1-1/\eta} + (1-\omega)^{1/\eta}\left(x_t^F - \phi_C x_{t-1}^{F,a}\right)^{1-1/\eta}\right]^{\frac{\eta}{\eta-1}}. \tag{10}$$

where $x_t^{H,a}$ and $x_t^{F,a}$ denote aggregate values of x_t^H and x_t^F and respectively (i.e. external habits). This alternative, inspired by the deep-habits setup of Ravn et al. (2012), limits the expenditure-switching channel: a given change in relative prices affects the relative demand for H and F only gradually. Table 7 reports the comparison in this case. Relative to the baseline under the R rule and rational expectations, the volatility of the economy is slightly greater, due to a somehow larger contraction originated by the negative shock.

The comparison between alternative rules under rational expectations is similar than in the baseline, with the differences marginally exacerbated: as the dampening impact of the deprecation on activity induced by expenditure-switching is reduced, both the potential benefits of a peg and the extra exchange-rate volatility induced by the M rule are less important in terms of welfare. Once we allow for limited credibility, the two main results discussed with the baseline model are maintained: the R rule is preferred to both alternatives (with only a small difference relative to the M rule), and there might be potential benefits to limit exchange-rate fluctuations if $K_S > 0$.

[25] This does not necessarily imply that the peg is the optimal rule under financial frictions, it just desirable among the three alternatives considered here. The optimal-policy analysis is beyond the scope of this paper.

[26] The dominant-currency pricing assumption already contributes to this, by making the demand for exports insensitive to the real exchange rate. However, the expenditure-switching channel is still active in the substitution between H and F goods domestically.

Table 7: Volatilities, Welfare and Loss Function:
Alternative Rules with Good-level Habits

Rules	Relative Volatilities y_t^H	π_t	rer_t	Welfare Λ	Relative Loss
Rational Expectations					
R vs Base R	1.01	1.05	1.00	0.26	0.99
M vs R	0.98	1.35	1.14	-0.21	-0.02
S vs R	1.14	1.37	0.56	1.39	0.20
Limited Credibility, $K_S = 0$					
M vs R	1.03	1.25	1.14	0.17	0.02
S vs R	1.34	1.06	0.73	1.53	0.57
Limited Credibility, $K_S = 0.2$					
M vs R	1.03	1.23	1.13	0.17	0.06
S vs R	1.06	0.44	0.68	0.91	0.12

Notes: See the description in Table 6 for details.

5.3 Domestic Banks

It might be argued that the baseline setup is somehow simple to study the M rule, as a variety of monetary aggregates exist in real life. To include this possibility, we add a banking sector to the model. We assume households derive utility from real holdings of both cash M_t/P_t and deposits D_t/P_t. In addition, the purchase of capital goods now requires to finance a fraction α_K^L with loans (L_t) from banks: $L_t \geq \alpha_L^K Q_t k_t$.

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. Following Edwards and Vegh (1997), this implies that loans and deposits are complements (e.g. due to economies of scale in monitoring borrowers). This sector is competitive and banks are required to hold 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. $E_t \left\{\sum_{h=0}^\infty \chi_{t,t+h} \Omega_{t+h}^B\right\}$). The optimality conditions can be written in terms of two relevant spreads:

$$R_t - R_t^D = (R_t - R_t^\tau)\, \tau_t + R_t \xi_t^B \Psi_{D,t}, \tag{11}$$

$$R_t^L - R_t^D = (R_t - R_t^\tau)\, \tau_t + R_t \xi_t^B \left(\Psi_{L,t} + \Psi_{D,t}\right), \tag{12}$$

Spreads arise for two different reasons. First, in the presence of required reserves, both spreads are positive as long as the policy rate is higher than that at which reserves are remunerated (usually the empirically relevant case). From this channel, a policy rate hike, *ceteris paribus*, increases both spreads. The second is related to marginal costs. In equation (11), the second term on the right-hand side can be shown to be increasing in the deposits-to-loans ratio. In equation (12), the second term on the right-hand side is also increasing in the deposits-to-loans ratio (given that the calibration assumes that deposits are larger than loans in steady state). Thus, also from this channel an increase in the policy rate widens both spreads.[27]

In this setup, we assume that the M rule targets nominal base-money growth, with $MB_t = M_t + \tau_t D_t$. The functional forms and calibration are detailed in Appendix A, and results are displayed in Table 8. Compared with the baseline under the R rule and rational expectations, this variant displays relatively milder volatility. However, in welfare terms agents are worse-off, due to the inefficiency generated by the presence of spreads to finance investment.

Table 8: Volatilities, Welfare and Loss Function: Alternative Rules with Banks

Rules	Relative Volatilities y_t^H	π_t	rer_t	Welfare Λ	Relative Loss
		Rational Expectations			
R vs Base R	0.95	0.96	0.94	2.24	1.06
M vs R	0.99	1.37	1.15	-0.13	-0.02
S vs R	1.14	1.39	0.55	0.78	0.18
		Limited Credibility, $K_S = 0$			
M vs R	1.04	1.25	1.11	0.25	0.03
S vs R	1.24	0.94	0.73	0.72	0.35
		Limited Credibility, $K_S = 0.2$			
M vs R	1.04	1.23	1.11	0.23	0.07
S vs R	1.06	0.42	0.73	0.37	0.10

Notes: See the description in Table 6 for details.

Conditional on living in a world with banks, the comparison between the different rules under alternative expectations setups is similar to that in the baseline model. If anything, the cost of a peg is somehow smaller with banks, particularly in the case in which exchange rate surprises feed into long-term expectations ($K_S = 0.2$).

5.4 Restricted Access to Financial Markets

Arguments against using the interest rate as the main policy instrument are many times related to the fact that, if a large part of the population does not have access to financial markets, the interest rate is not a relevant price for most agents in the economy; e.g. Berg et al. (2010), Andrle et al. (2013). To consider this possibility, we assume the presence of two types of households: Constrained (of mass Γ) and Unconstrained (of mass $1-\Gamma$); as in, for instance, Galí et al. (2007)

[27] Notice that this banking system operates fully in domestic-currency assets. While banks could be exposed to a currency-mismatch problem, evidence suggests that this phenomenon has significantly decreased over time (for instance, Tobal (2018) presents evidence for Latin America and the Caribean). Moreover potential liability dollarization issue could be relevant for the non-banking sector as well, which is addressed in the financial-frictions sensitivity analysis previously presented.

or Colciago (2011). The former just consumes its labor income, i.e.[28]

$$P_t c_t^C = W_t h_t,$$

and demands money to pay for a fraction of their consumption purchases (equal to the ratio of money to GDP in the baseline model). Changes in the policy rate will only affect consumption decisions for these agents to the extent that an equilibrium change in labor and/or wages is triggered. Instead, unconstrained households solve the same problem as the representative agents in the baseline. Therefore, in equilibrium,

$$c_t = \Gamma c_t^C + (1-\Gamma) c_t^U.$$

The rest of the model is analogous to the baseline. We calibrate $\Gamma = 0.7$. Results are displayed in Table 9.[29]

Table 9: Volatilities, Welfare and Loss Function:
Alternative Rules with Restricted Access to Financial Markets

	Relative Volatilities			Welfare			Relative
Alternatives	y_t^H	π_t	rer_t	Λ	Λ^U	Λ^C	Loss
Rational Expectations							
R vs Base R	0.99	1.03	1.12	0.24	–	–	1.13
R vs M	0.98	1.38	1.15	-0.39	-0.29	-0.99	0.050
R vs S	1.16	1.44	0.54	1.73	1.75	2.68	-0.294
Limited Credibility, $K_S = 0$							
R vs M	1.03	1.26	1.13	-0.04	-0.29	0.66	-0.031
R vs S	1.32	1.10	0.74	3.96	5.46	1.71	0.905
Limited Credibility, $K_S = 0.2$							
R vs M	1.03	1.23	1.12	0.10	0.07	0.52	0.047
R vs S	1.06	0.48	0.70	1.01	1.07	1.09	0.202

Notes: See the description in Table 6 for details.

Relative to the baseline model under rational expectations and the R rule, the world-interest-rate shock generates a similar volatility in activity and inflation, but a higher real-exchange-rate variance. While not shown in the table, aggregate consumption is more volatile in this model, as constrained agents cannot smooth the shock. This in turn explains the additional relative price volatility. In contrast, investment is relatively less affected by the external shock in this setup, for asset prices are determined by unrestricted consumption only (which is relatively less volatile). Overall, both in welfare and loss-function terms, the average household is worse off living in a word where a fraction of agents is excluded from financial markets.

[28]Given the preference setup featuring no wealth effect in labour supply, both types of households will optimally work the same amount of hours; i.e. $h_t^C = h_t^U = h_t$. Moreover, we assume labor productivity is the same for both types of households. Therefore, wages are also the same for both of them.

[29]In performing welfare comparisons with this model, we compute three consumption-equivalent measures: two of them compare the utility for each type of agents (Λ^C and Λ^U), while we also compare welfare obtained using aggregate consumption (Λ) as a measure of "average" welfare costs.

Comparing alternative rules with constrained households, under rational expectations both types of agents would prefer the money-based rule, particularly those that cannot access financial markets to smooth consumption. It is still the case (as in the baseline) that the M rule induces higher inflation and relative-price volatility, while smoothing activity. In fact, the R rule is marginally preferred according to the loss function. In contrast, the welfare cost of a peg under rational expectations is much larger in this model: the additional contraction is particularly costly for constrained households.

If limited credibility is in place, results change in the same direction as in the baseline. It is worth highlighting that the average welfare cost of a peg is much larger if $K_S = 0$ (in the baseline was similar to rational expectations), but this comes mainly from unconstrained households. The welfare-cost differences also appear with the M rule: if $K_S = 0$ constrained households now dislike this rule, while the comparison is the same for unconstrained ones. Finally, if $K_S = 0.2$, results are similar to those obtained in the baseline. Both households would prefer the R rule, while the relative cost of a peg is milder under this expectation assumption.

5.5 Full Model

Finally, we construct a model that features all the characteristics previously introduced to study the sensitivity of the result; labeled the Full model. Most characteristics can be easily combined in the model, as they refer to a different aspect of the economy. The only caveat worth mentioning is that we assume that constrained households only use cash, while only unconstrained agents use bank deposits. Results are reported in Table 10. Relative to the baseline, the volatility in all three variables reported is larger and the welfare cost of combining all features is significant.

Table 10: Volatilities, Welfare and Loss Function:
Alternative Rules in the Full Model

	Relative Volatilities			Welfare			Relative
Alternatives	y_t^H	π_t	rer_t	Λ	Λ^U	Λ^C	Loss
			Rational Expectations				
R vs Base R	1.40	1.66	1.55	7.47			0.45
R vs M	1.02	1.49	1.21	0.00	-0.03	-0.13	-0.059
R vs S	1.01	1.39	0.51	0.51	1.01	0.36	0.249
			Limited Credibility, $K_S = 0$				
R vs M	1.06	1.30	1.15	0.35	-0.51	2.29	-0.035
R vs S	1.25	1.12	0.69	3.46	5.36	1.09	1.222
			Limited Credibility, $K_S = 0.2$				
R vs M	1.02	1.26	1.12	-0.09	-0.56	1.02	-0.014
R vs S	1.03	0.52	0.70	0.61	0.78	0.91	0.201

Notes: See the description in Table 6 for details.

The rules comparison yields similar results under rational expectations. We can also see that the disagreement in terms of welfare regarding the M rule is exacerbated in the full model under learning. Instead, the relative merits of reducing exchange rate volatility if K_S is appreciated by both types of agents. Overall, none of the main results obtained under the baseline model are refuted with these model modifications.

6 Conclusions

This paper presented a model-based analysis of the relevant trade-offs in choosing alternative simple rules for different monetary-policy instruments. We focused on how these alternatives help to smooth the impact of shocks to external-borrowing costs. Importantly, we explored how the comparison might be affected by limited credibility, modeled as departures from rational expectations (using instead simple time-series models to forecast inflation-related variables).

We first documented that, under rational expectations, there is a trade-off between using a Taylor-type rule for the interest rate and 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 showed 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 in the related literature). This is generated by both a more persistent inflation process and by the different interest-rate behavior under this configuration.

Instead, if the exchange rate can directly influence medium- and long-term inflation expectations, the comparison among alternatives changes. In particular, the potential benefits of money-growth rules are reduced, and there might be a desirable role for limiting exchange-rate volatility, preventing larger shifts in inflation expectations. Moreover, we presented evidence suggesting that this additional exchange-rate channel in the learning process could be empirically relevant in cases with limited credibility.

While this exploration allows identifying relevant dimensions of the policy-instrument discussion, it also suggests that further work is needed to provide a more detailed evaluation. First, it is relevant to have a more comprehensive empirical analysis of the relationship between exchange rate fluctuations and inflation expectations, and its implication for optimal policy design.

We have also abstracted from other sources of fluctuations in the economy that are not only relevant to match the data of a particular country, but are also important for welfare comparisons. A particularly relevant set of shocks that should be consider in future work are those relate to money demand, which could *a priori* induce higher volatility under money-growth rules. In other words, the quote from former the Bank of Canada governor Bouey "We didn't abandon monetary aggregates, they abandoned us" was not considered in the analysis performed. This would be a relevant addition in order to have a complete quantitative assessment.

In addition, the rules analyzed here were relatively simple. One could also include other feedback variables in the rules or different parameters. A study of optimal simple rules (from a welfare perspective) for a given instrument, and a comparison between the best rule for each instrument, would be useful in extending th results of this paper.

Finally, it is relevant to highlight that in this paper credibility, in the form of adaptive learning, is taken as given. We think this is appropriate to capture situations where a policy maker must decide how to implement monetary policy, in contexts in which credibility is limited and there is little hope that this will change in the short or medium run. However, over time, one should expect some endogeneity between credibility and the way policy is implemented. How to properly capture this interplay in a model is not obvious. Moreover, in such a discussion, the interaction between fiscal and monetary policy is probably of a first order of importance. These important considerations are left for future research.

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A Functional Forms and Calibration

In the sake of space, we present the calibration of the version that also includes banks. The baseline model is obtained by simply setting $R_t^D = R_t^L = R_t$, $\tau_t = 0$ and $\xi_t^B = 0$.

The utility function is set in a way that yields the following characteristics: (i) labor supply has no wealth effect, (ii) the inter-temporal consumption trade-off is independent of 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 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:

- 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), who 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 in the utility.

[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 exhibit external habits).

– 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 yield the desired properties.

The capital-adjustment-cost function is set to

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

with $\phi_I > 0$. The bank's cost function is,

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

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 the rest of the economy.

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 11. Most macro-related parameters 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 are not discussed 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 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 280 basis points in a quarter. In turn, the calibrated persistence implies a half-life of

Table 11: Calibrated parameters and targeted steady state values.

Parameter	Description	Value
σ	Coef. of relative risk aversion	2
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	0.5
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	0.001
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	0.007
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	0.15
R^τ	Interest rate on required reserves	1
ε^M	Money demand elasticity	-1.5/4
ε^D	Deposits demand elasticity	1/4

almost 5 quarters.

Table 12: Other Estimated Parameters of the Learning Model

	Argentina			Chile		
Parameter	Mean	5 %	95 %	Mean	5 %	95 %
$\Phi_{1,1}$	0.039	-0.142	0.213	-0.321	-0.436	-0.204
$\Phi_{1,2}$	0.306	-0.293	0.951	0.286	-0.521	1.072
$\Phi_{1,3}$	0.015	-0.795	0.886	0.486	-0.748	1.683
$\Phi_{2,1}$	0.042	-0.019	0.100	0.005	-0.004	0.013
$\Phi_{2,2}$	0.532	0.341	0.710	0.215	0.143	0.287
$\Phi_{2,3}$	-0.126	-0.418	0.141	0.033	-0.056	0.131
$\Phi_{3,1}$	0.015	-0.033	0.063	0.003	-0.014	0.020
$\Phi_{3,2}$	0.414	0.252	0.573	0.094	-0.082	0.262
$\Phi_{3,3}$	0.083	-0.173	0.362	0.051	-0.162	0.279

B Sensitivity Analysis

Figure 8: Alternative Instruments with Financial Frictions. Rational Expectations.

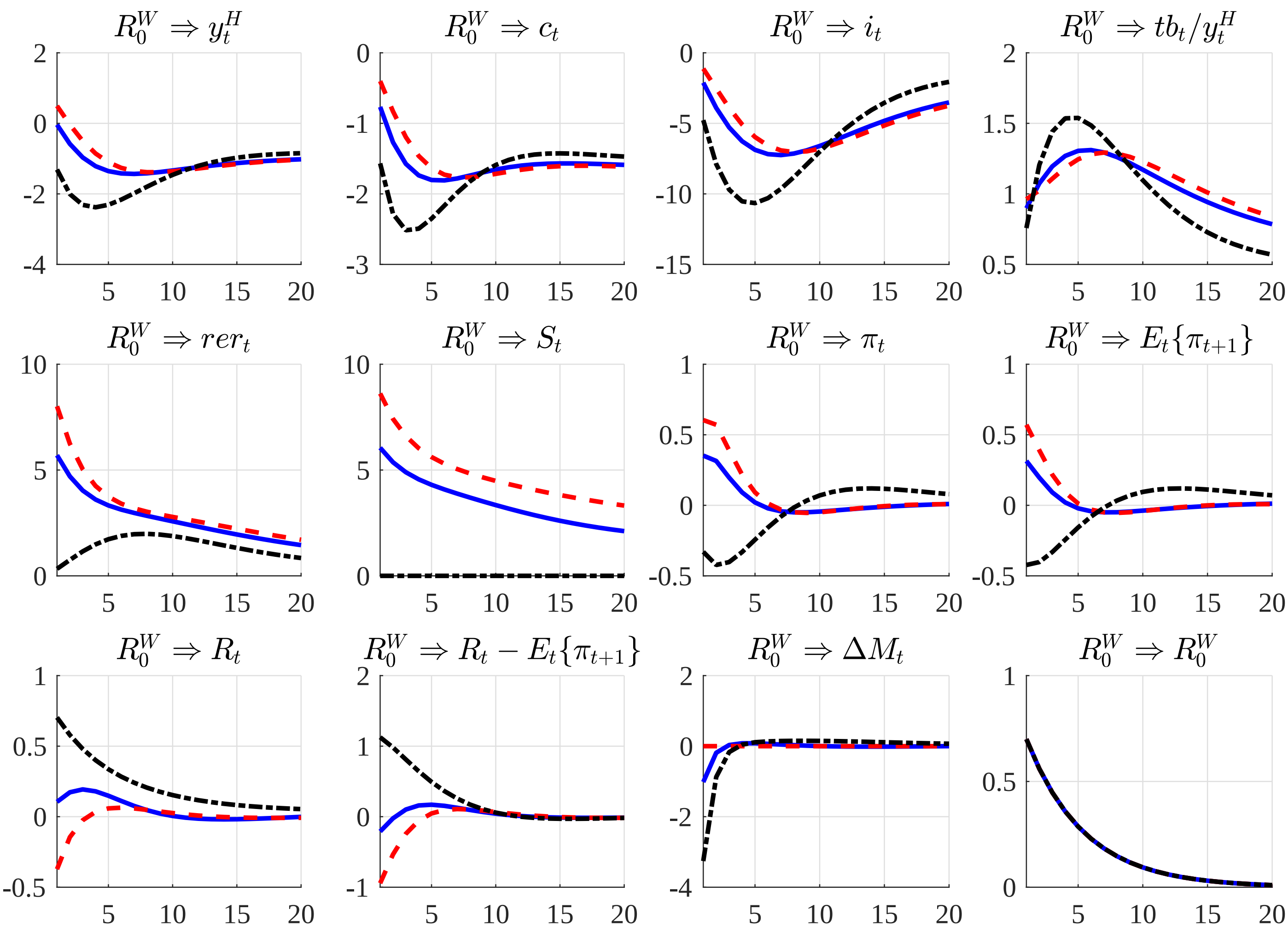

Figure 9: Alternative Instruments with Financial Frictions. Imperfect Credibility with $K_S = 0$.

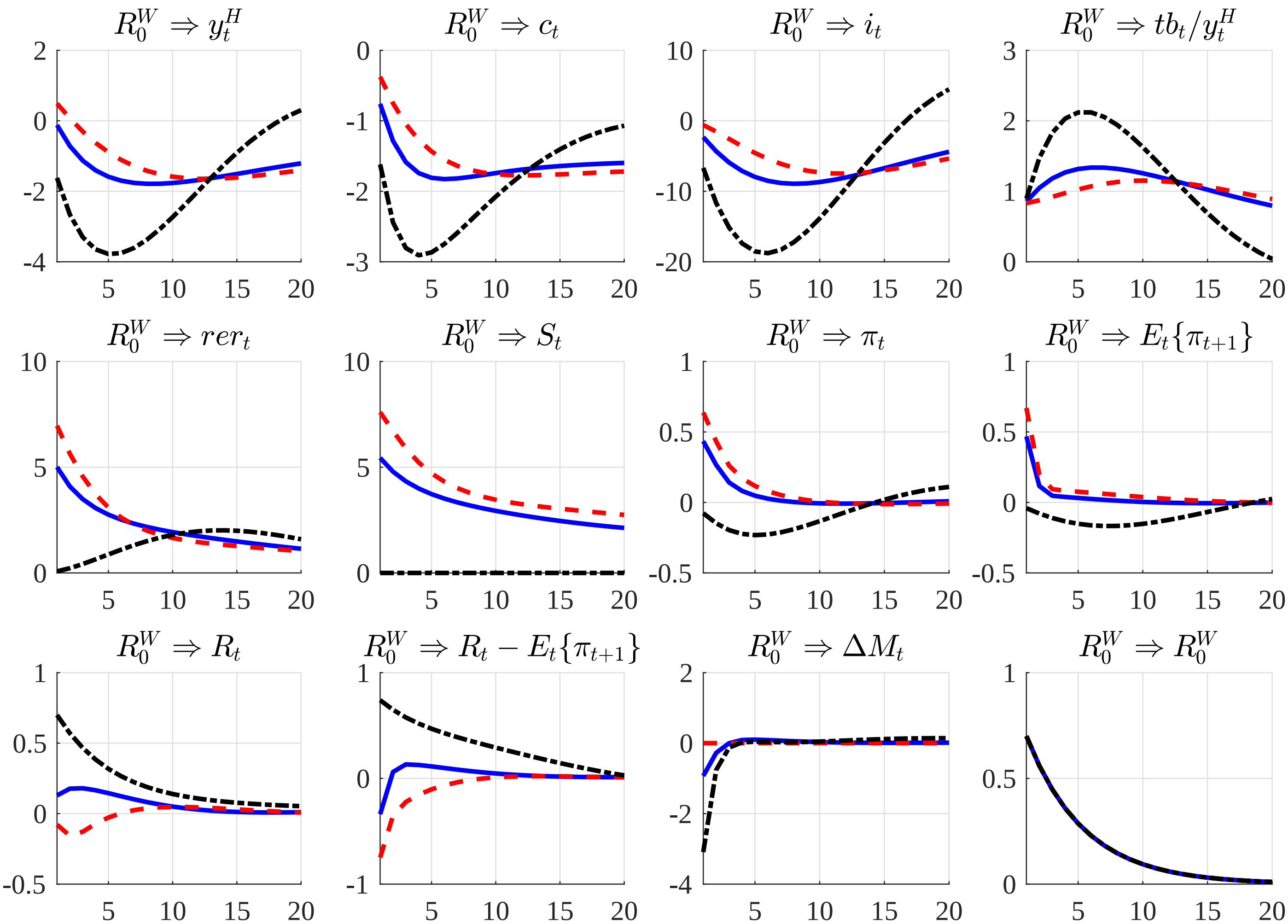

Figure 10: Alternative Instruments with Financial Frictions. Imperfect Credibility with $K_S = 0.2$.

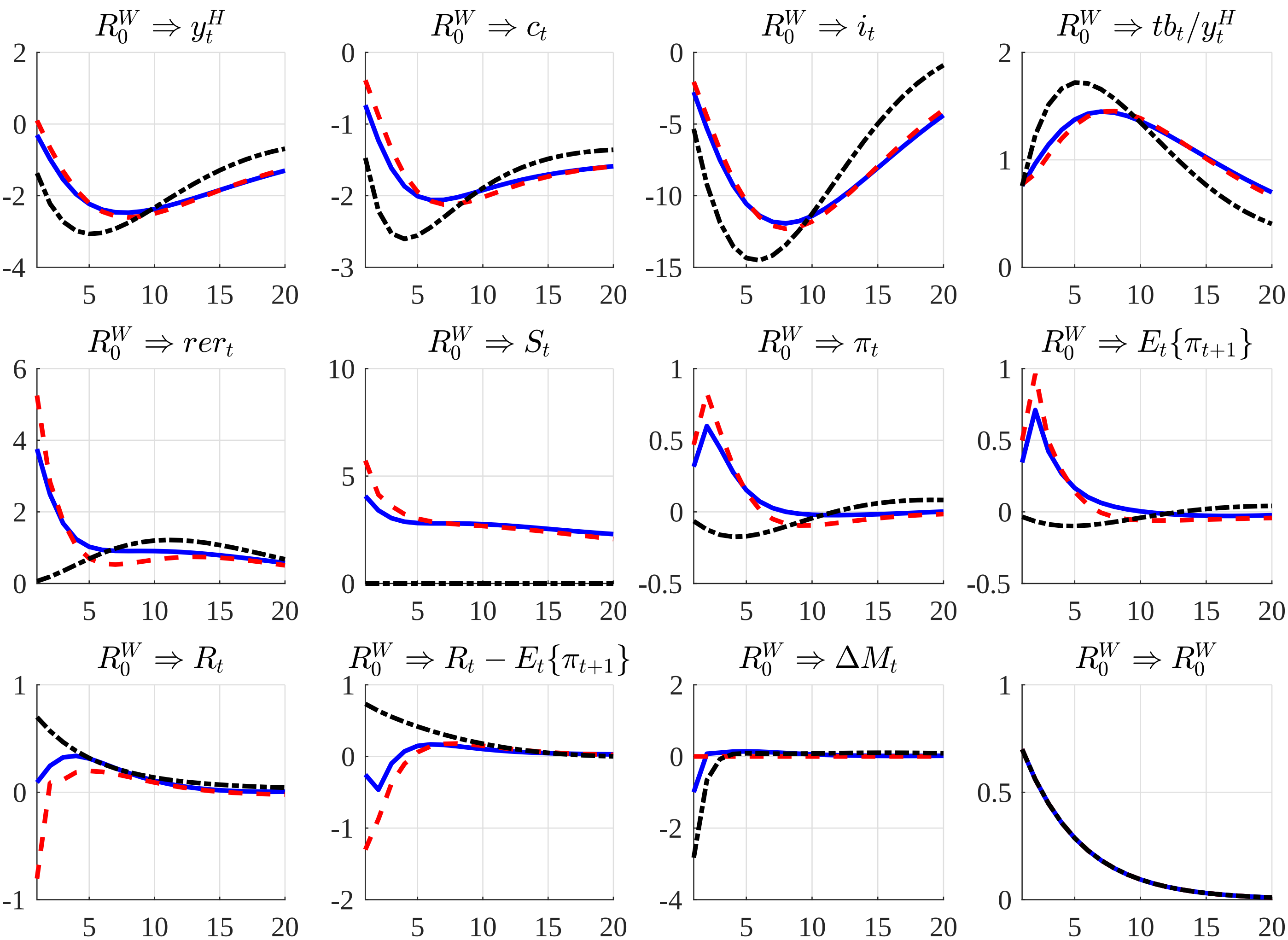

Figure 11: Alternative Instruments with Good-level Habits. Rational Expectations.

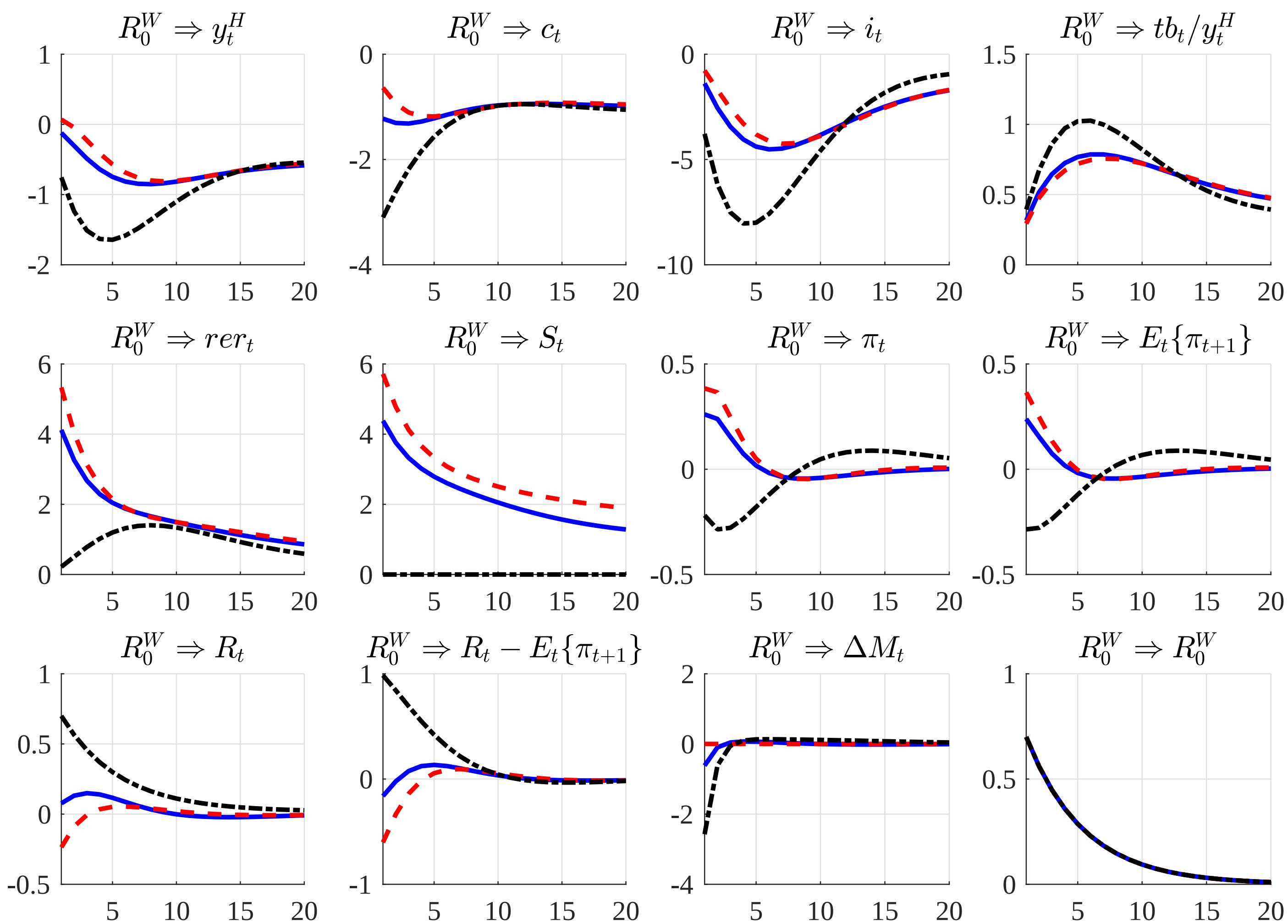

Figure 12: Alternative Instruments with Good-level Habits. Imperfect Credibility with $K_S = 0$.

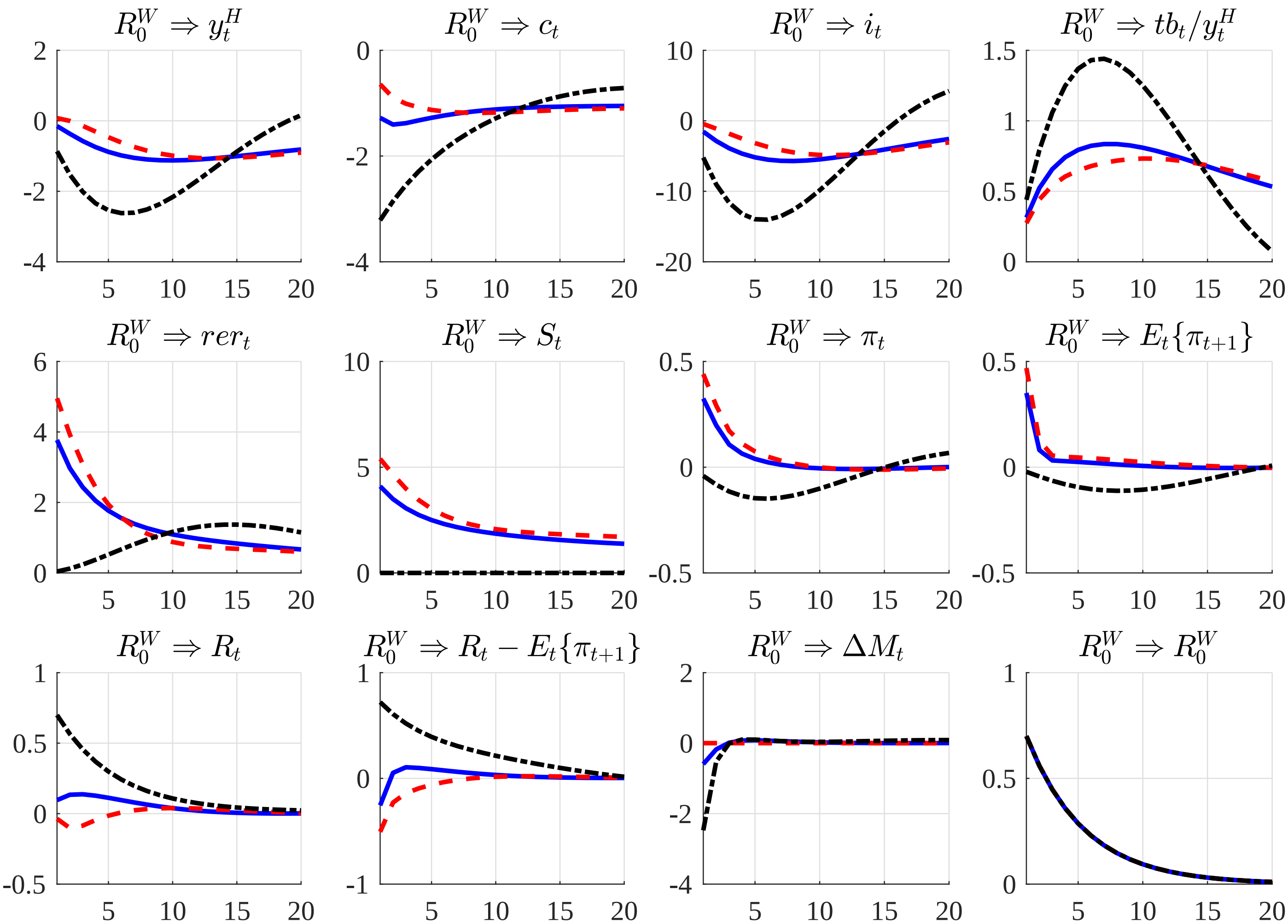

Figure 13: Alternative Instruments with Good-level Habits. Imperfect Credibility with $K_S = 0.2$.

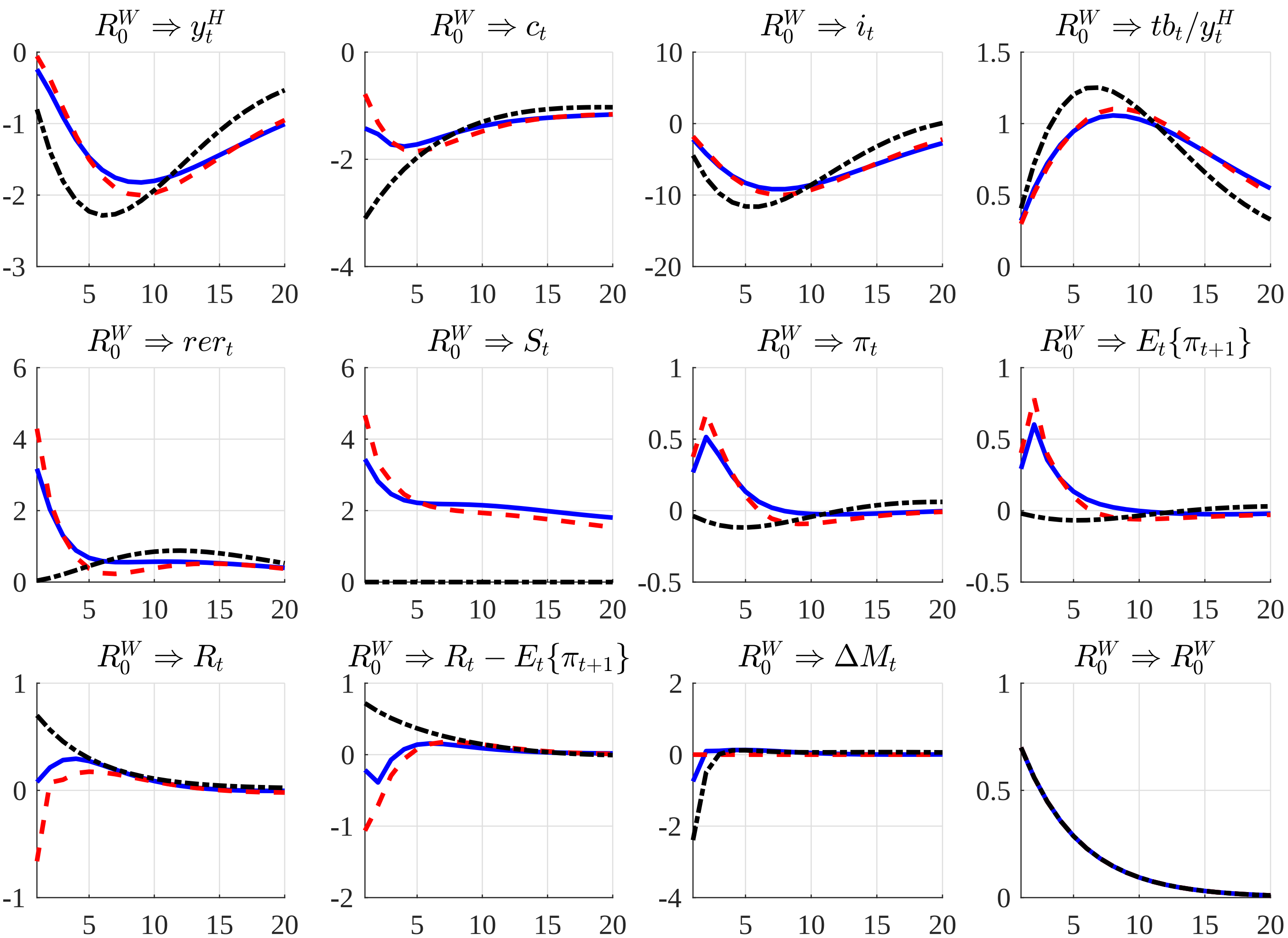

Figure 14: Alternative Instruments with Banks. Rational Expectations.

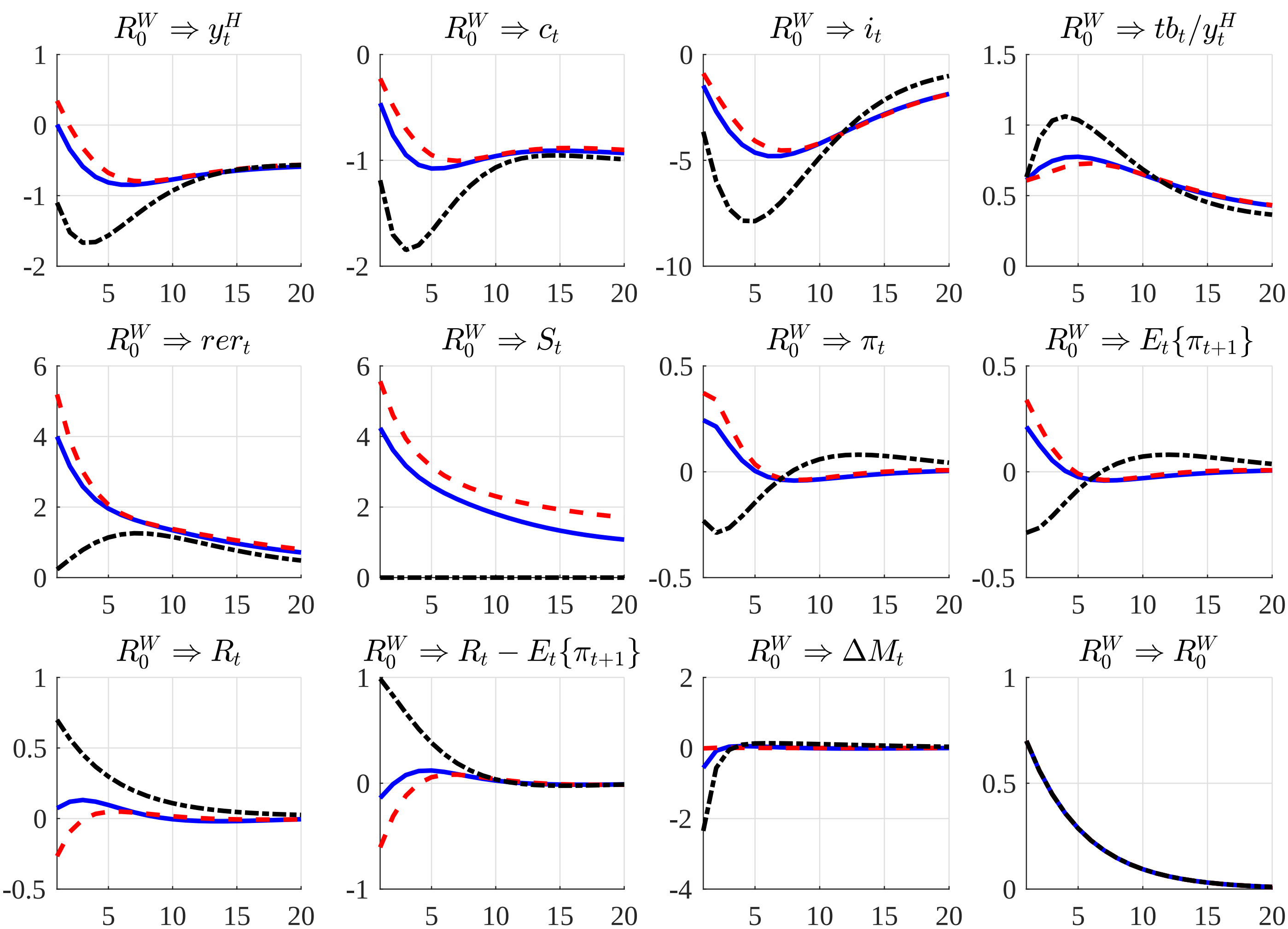

Figure 15: Alternative Instruments with Banks. Imperfect Credibility with $K_S = 0$.

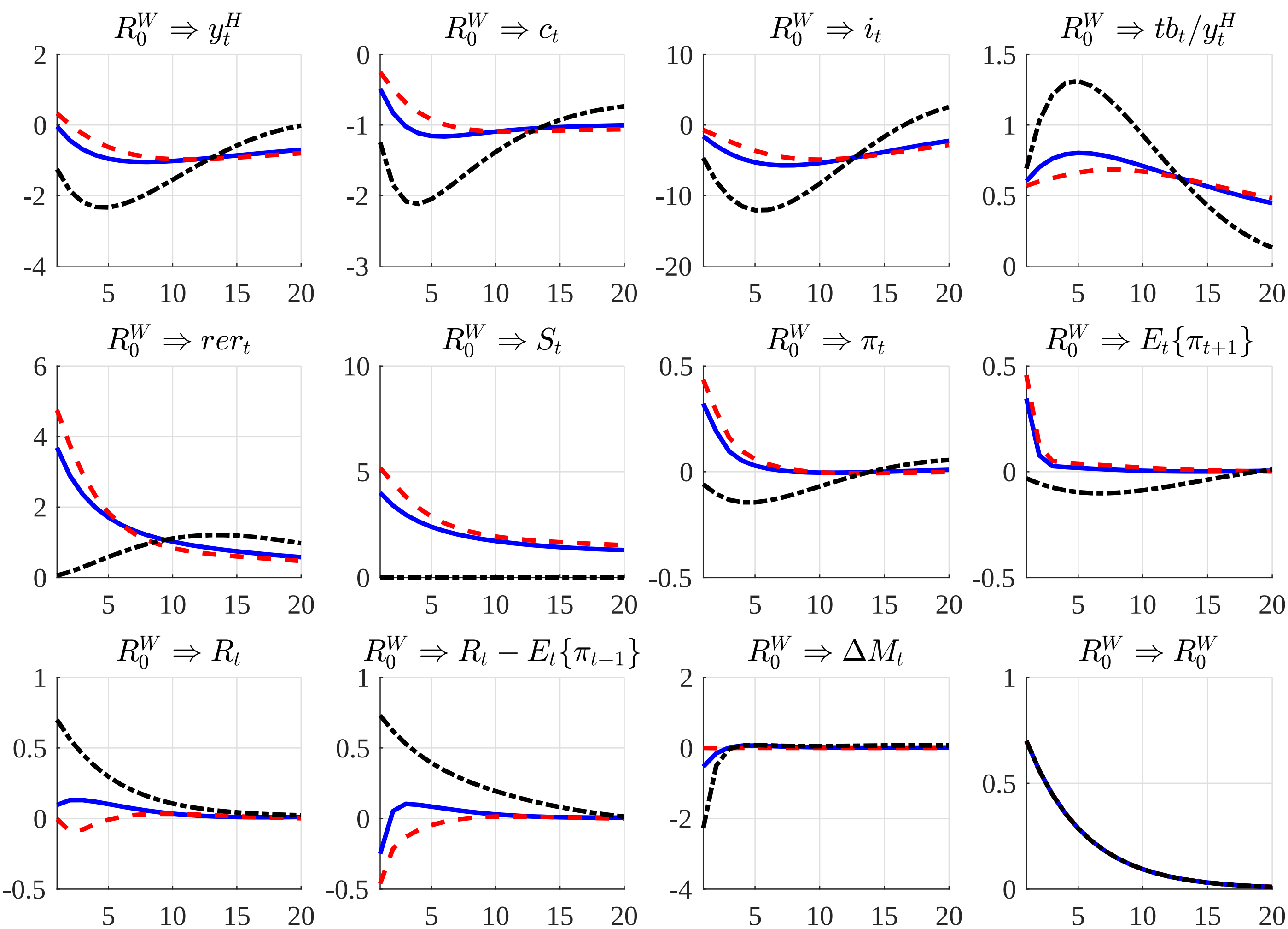

Figure 16: Alternative Instruments with Banks. Imperfect Credibility with $K_S = 0.2$.

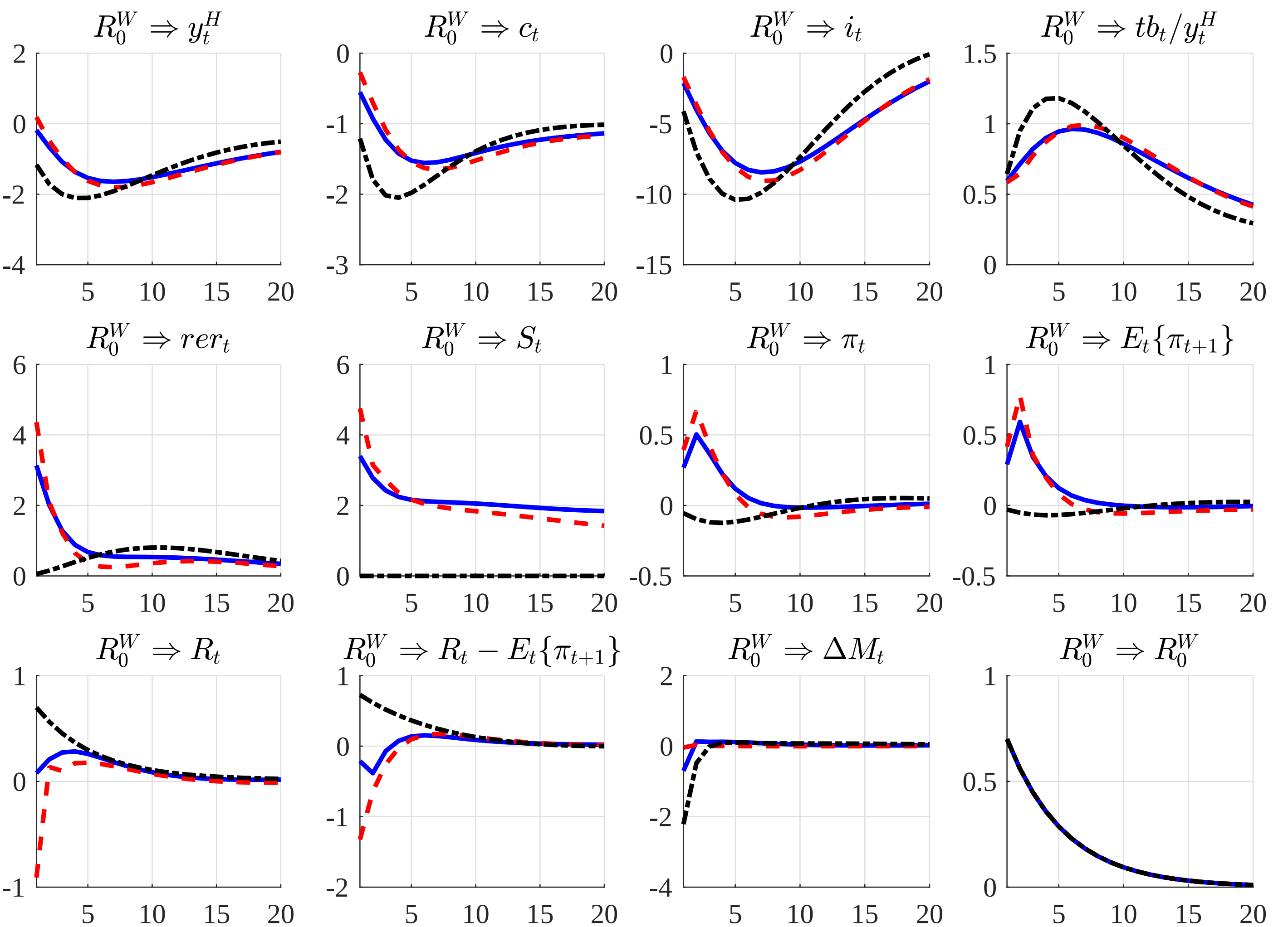

Figure 17: Alternative Instruments with Constrained Agents. Rational Expectations.

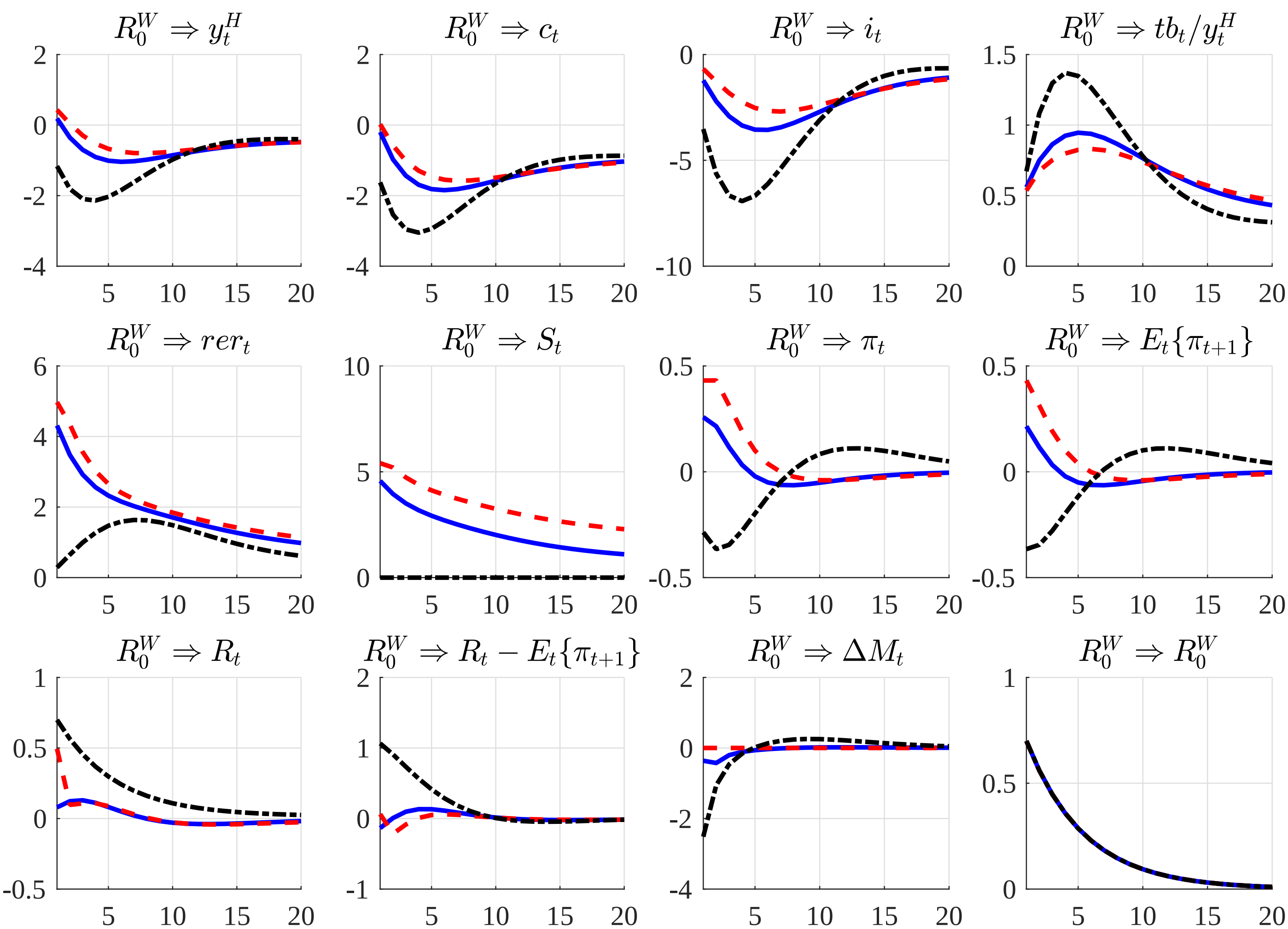

Figure 18: Alternative Instruments with Constrained Agents. Imperfect Credibility with $K_S = 0$.

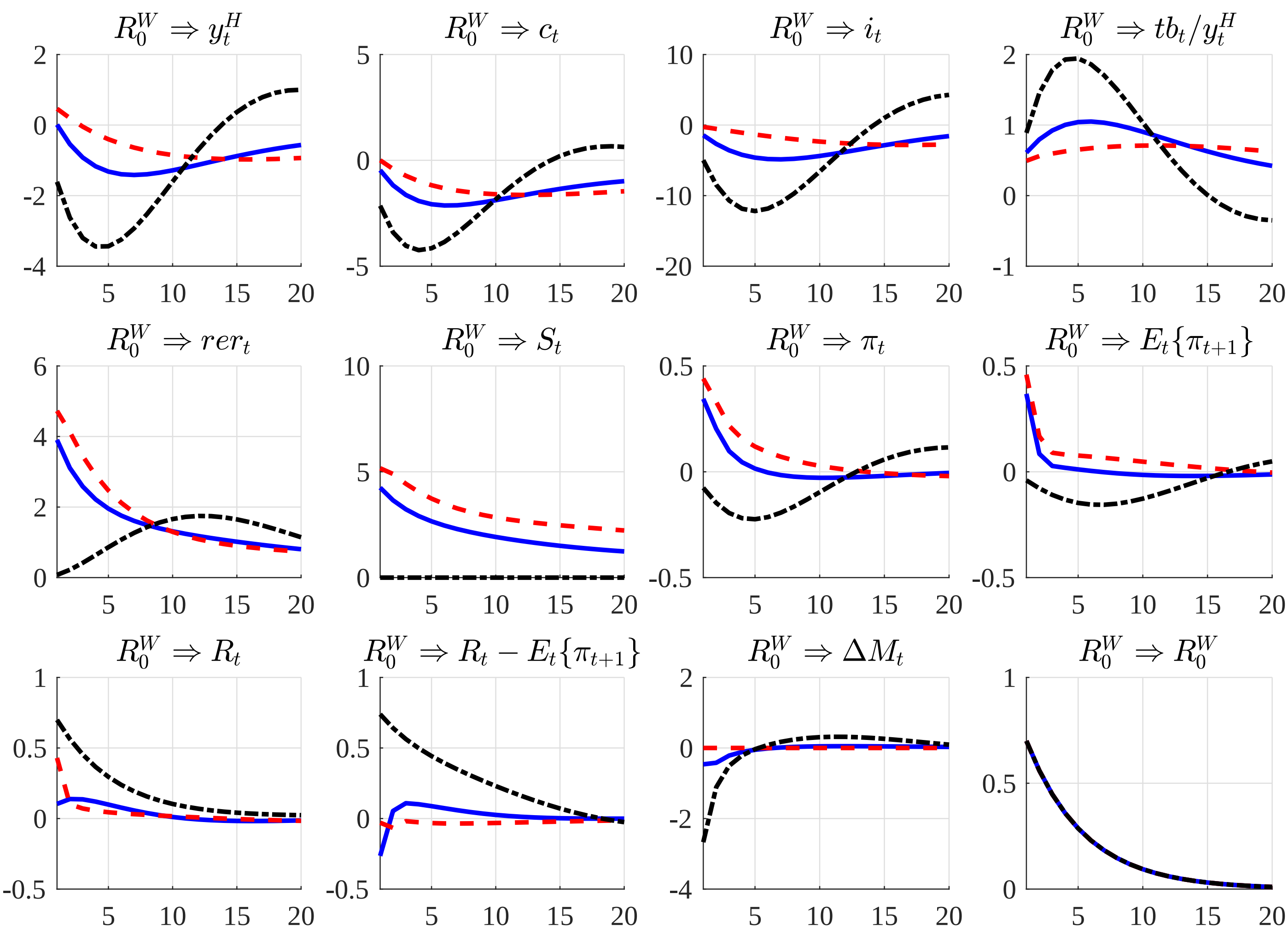

Figure 19: Alternative Instruments with Constrained Agents. Imperfect Credibility with $K_S = 0.2$.

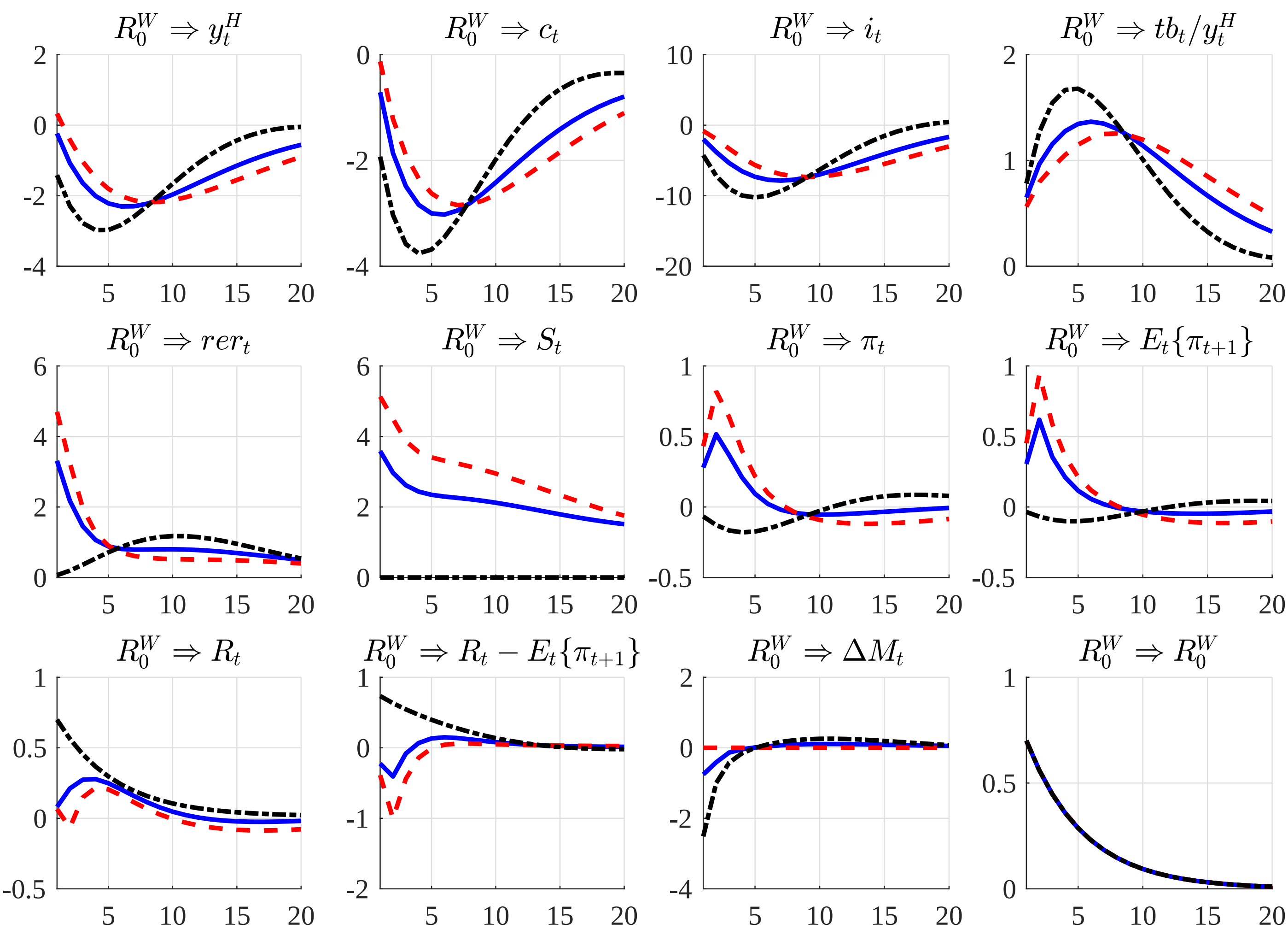

Figure 20: Alternative Instruments In Full Model. Rational Expectations.

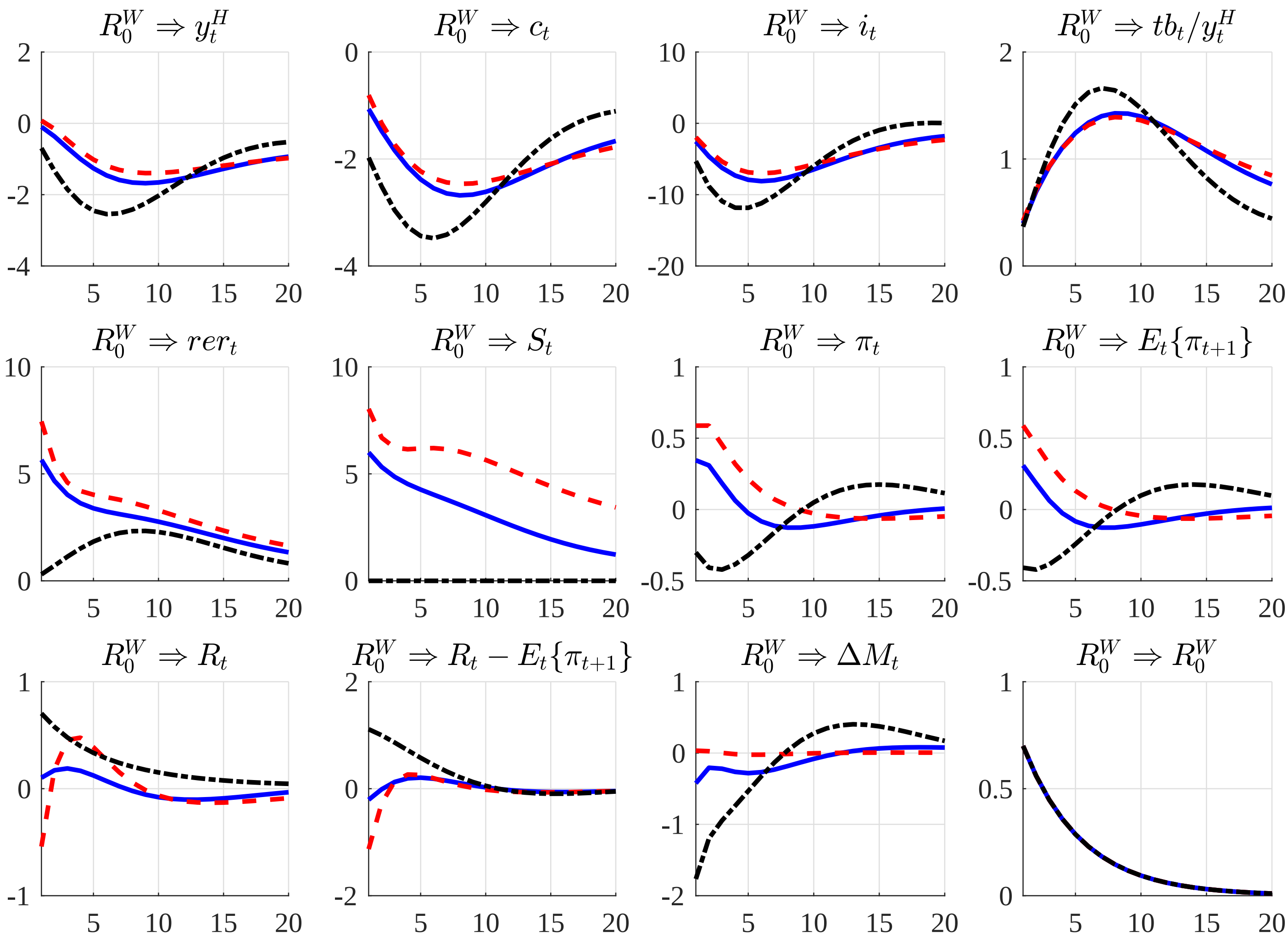

Figure 21: Alternative Instruments In Full Model. Imperfect Credibility with $K_S = 0$.

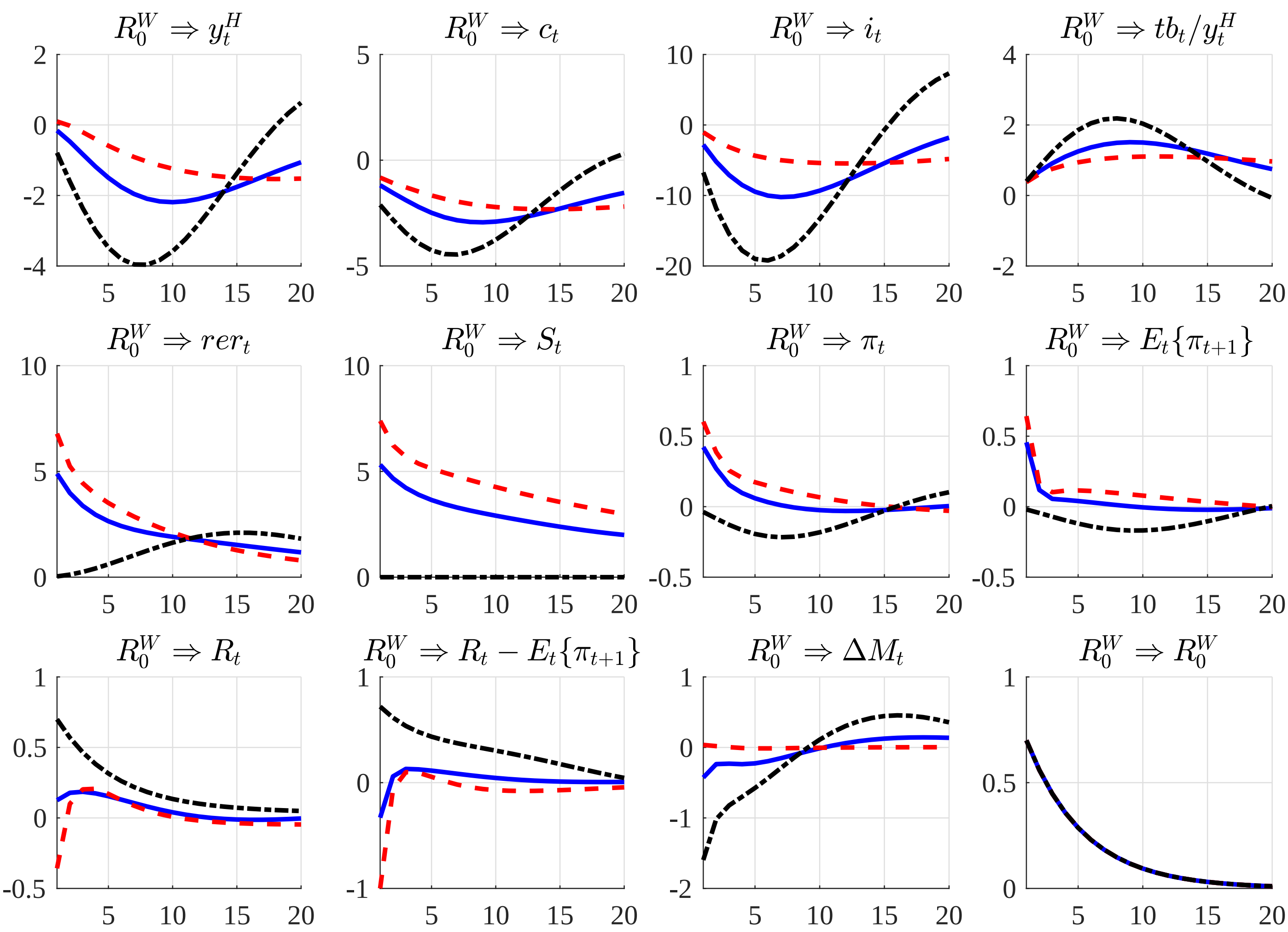

Figure 22: Alternative Instruments In Full Model. Imperfect Credibility with $K_S = 0.2$.