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

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*Banco Central de la República Argentina*

April 2021



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# NON-TECHNICAL SUMMARY

## Research Question

The increasing use of inflation-targeting frameworks in developed and some emerging countries has influenced the literature to focus on monetary policy rules that use a short-term interest rate as the main instrument. However, this emphasis is not representative of the way monetary policy is implemented around the world. For example, according to IMF AREAER database, in 2018 only 21 % of a total of 192 countries had an inflation-targeting framework in place (using a short-term rate as the instrument). The others were divided between countries that use an exchange-rate anchor (41 %), those who target monetary aggregates (14 %), and the remainder 24 % use some hybrid framework. This distribution is largely determined by policies in low-income and emerging economies.

At the same time, most studies analyzing rules for interest rates assume rational expectations. Such a setup presumes a high degree of credibility, since it poses that agents know the policy rule and believe it holds not only in the present but in the future as well. However, many low-income and emerging countries face situations with limited credibility. The goal of this paper is to understand the extent to which instrument choice depends on the degree of credibility.

## Contribution

The comparison is performed by means of a small and open economy model with price and wage rigidities. To capture limits to credibility, we assume that inflation-related expectations are not rational. Instead, they are determined by econometric models that use past data to forecast the future (a framework named adaptive learning). In particular, the role that exchange rate movements may have in changing medium- and long-term inflation expectations is emphasized. In this context, three simple policy rules are compared: one for the interest rate (a Taylor rule), one for the growth rate of a monetary aggregate, and an exchange rate peg. The aim is to understand the pros and cons of using each of them when the economy is facing a shock to external borrowing costs.

## Results

The benefits and costs of these alternatives depend largely on the credibility framework. With high credibility (rational expectations) there is a trade-off between the dynamics of activity and inflation when a rule for the interest rate and one for money growth are compared, while maintaining a peg is costly. However, with limited credibility (adaptive learning), if exchange-rate surprises persistently change inflation expectations, the potential benefits of money-based rules are more limited. Conversely, reducing exchange-rate volatility may be desirable to limit the costs associated with un-anchored expectations.

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

Javier García-Cicco (BCRA)

## Abstract

We evaluate the dynamics of a small and open economy under alternative simple rules for different monetary-policy instruments, in a model with imperfectly anchored expectations. The inflation-targeting consensus is that interest-rate rules are preferred, instead of using either a monetary aggregate or the exchange rate; 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 instruments: 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 ranking is indeed influenced by how agents form inflation-related expectations.

## Resumen

Evaluamos las dinámicas de una economía pequeña y abierta bajo distintas reglas simples para instrumentos de política monetaria alternativos, en un modelo donde las expectativas de inflación no están ancladas. En esquemas de metas de inflación, el consenso se inclina por reglas para la tasa de interés, en lugar de utilizar agregados monetarios o el tipo de cambio, usando argumentos que generalmente asumen expectativas racionales y completa credibilidad. En cambio, asumimos aquí que los agentes usan modelos econométricos para formar expectativas de inflación, capturando así credibilidad limitada. En particular, enfatizamos el rol del tipo de cambio para determinar las expectativas de inflación de mediano y largo plazo. Comparamos los efectos de *shocks* al costo de endeudamiento externo (que tienen un papel relevante como determinante de ciclos en economías emergentes) bajo tres políticas alternativas: una regla de Taylor para la tasa de interés, una meta de crecimiento para agregados monetarios, y un tipo de cambio fijo. El análisis permite identificar costos y beneficios de los distintos instrumentos, enfatizando que la valoración relativa de las alternativas es sensible a la forma en que los agentes forman expectativas de inflación.

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# 1 Introduction

This paper presents an exploration of the trade-offs associated with choosing alternative monetary-policy instruments in small and open economies, in a context of imperfectly anchored expectations or 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 also in the future, a strong form of policy credibility).<sup>1</sup> Even those papers relaxing the rational-expectations assumption mostly focus on interest-rate rules.<sup>2</sup> 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.<sup>3</sup>

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 2018 only 21% of a total of 192 countries had an inflation-targeting framework (all of them using a policy rate as the main instrument), while 14% implemented a monetary-target setup, 41% had an exchange-rate anchor in place, and the remainder 24% implemented some other hybrid setup. This distribution is mostly influenced by the behavior of low-income and emerging countries (e.g. no developed economy has a monetary target in place). Moreover, 15% of those implementing inflation targeting choose to *de facto* manage the exchange rate to some extent, while close to 80% among those under a money-target also actively intervene in the foreign exchange market.

Our goal is to understand if limited credibility could be a determinant of instrument choice; for in many contexts credibility cannot be taken for granted. This has been historically the case at the initial stages of inflation-stabilization programs. Indeed, an earlier literature analyzes the dynamics of stabilization plans under alternative policy instruments; see, for instance, the surveys in [Calvo and Végh \(1994, 1999\)](#). More recently, [Calvo \(2018\)](#) presents concerns about implementing an interest-rate-based inflation targeting to generate a permanent reduction in inflation. [Taylor \(2019\)](#) also indicates that some type of monetary target might be desirable under lack of credibility even if the 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 that highlight how adaptive learning might limit the impact of monetary policy.<sup>4</sup> In particular, the forecasting model is a VAR with a time-varying mean, such that news can have a persistent impact if they modify the inference about long-run inflation.

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

<sup>2</sup>For instance, [Erceg and Levin \(2003\)](#), [Cogley et al. \(2015\)](#), [Gibbs and Kulish \(2017\)](#), among others.

<sup>3</sup>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](#)).

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

We emphasize two different components of the learning process. The first appears if long-run inflation expectations are shaped by past inflation only, 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 affect the real rate relevant for inter-temporal decisions, the power of the central bank to impact 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 measures seem to correlate with metrics of monetary-policy credibility (e.g. [Carriere-Swallow et al., 2016](#)). Moreover, in general equilibrium the exchange-rate-pass-through is influenced 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 one-year-ahead inflation expectations 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 the responses 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 of the external shock, while at the same time increases its 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 external shock, without a clear advantage in the inflationary front, and it is more costly in welfare terms.

In the 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 dynamics under different rules are modified. The dampening effect on activity obtained with a constant money growth is limited: the dynamics of GDP under interest-rate and money rules are closer to each other. At the same time, a money-based rule generates the worst outcomes in terms of inflation, as it induces more exchange-rate volatility. Finally, limiting exchange-rate fluctuations might be useful to prevent significant shifts in medium- and long-term expectations: 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 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. 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 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 if the aforementioned characteristics are added to the model. 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. Exports are not sensitive to real exchange rate fluctuations as in the dominant-currency-pricing paradigm. Households derive utility from consumption, leisure, and money holdings. They also have access to international borrowing and treasuries. The rest of this section describes the different agents in the model, the general equilibrium conditions, the assumptions regarding expectations formation, and the alternative policy rules considered.

## 2.1 Households

Households seek to maximize,<sup>5</sup>

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

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  $\Omega_t$  denotes profits from the ownership of firms.<sup>6</sup>

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

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

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

where  $U_{x,t} = \frac{\partial U_t}{\partial x_t}$ ,  $w_t \equiv \frac{W_t}{P_t}$ ,  $\pi_t \equiv \frac{P_t}{P_{t-1}}$ , and  $\pi_t^s \equiv \frac{S_t}{S_{t-1}}$ . The first relates the Lagrange multiplier with the marginal utility of consumption. The second and third characterize the inter-temporal trade-off in choosing domestic and foreign bonds, while the last represents the demand for money. Additionally, define the stochastic discount factor for claims in domestic currency as  $\chi_{t,t+s} = \beta^s \frac{\lambda_{t+s} P_t}{\lambda_t P_{t+s}}$ .

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

Wage setting is subject to a Calvo-type problem, whereby each period the union can set its

<sup>5</sup>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.

<sup>6</sup>Throughout, uppercase letters denote nominal variables containing a unit root in equilibrium (due to long-run inflation), while lowercase letters indicate stationary variables. Variables without time subscript denote non-stochastic steady-state values in the stationary model. Finally, we use the notation  $\hat{x}_t \equiv \ln(x_t/x)$  for a generic variable  $x_t$ .

nominal wage optimally in a fraction  $1 - \theta_W$  of randomly chosen labor markets, and in the other markets the past wage is indexed to a generic indexation variable  $\pi_t^{I,W} = (\pi_{t-1})^{\vartheta_W} (\pi)^{1-\vartheta_W}$ . In other words, wage indexation depends on past- and steady-state inflation.

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

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

where  $m c_t^W$  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

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

where  $\pi_t^W = \frac{W_t}{W_{t-1}}$ .

## 2.2 Final and Home Goods

Final goods are produced in two stages. At a wholesale level, a set of competitive firms combine home ( $x_t^H$ ) and foreign goods ( $x_t^F$ ) using the production function:

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

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:

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

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

The retail level features a monopolistic-competitive structure. The production  $y_t^C$  is a combination of a continuum of varieties indexed by  $j \in [0, 1]$  using the technology  $y_t^C = \left[ \int_0^1 (x_{jt}^C)^{1-\frac{1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}}$ , leading for the following demand for variety  $j$ ,

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

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

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

## 2.3 Home Goods

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

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

where  $z_t$  is an exogenous productivity shock. Profit maximization leads to the following input demands:

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

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

## 2.4 Capital Goods and Investment

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

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

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

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

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

In 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. Afterward, 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

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

where  $g_t$  is an exogenous process. In this setup,  $T_t$  adjust to satisfy this constraint (fiscal policy is passive) and thus Ricardian equivalence holds (only  $g_t$  matters for equilibrium determination). In turn, the monetary authority set its policy by choosing a rule for either instrument  $R_t$ ,  $M_t$ , or  $\pi_t^S$ ; which are discussed below.

## 2.6 Rest of the World

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

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

where  $R_t^W$  denotes the world interest rate and the second term is a debt elastic premium (with  $b_t^* \equiv B_t^*/P_t^*$ ) which serves as the ‘‘closing’’ device (see [Schmitt-Grohé and Uribe, 2003](#)). In the baseline model,  $\phi$  is calibrated to a small but positive number, while we explore other alternatives in Section 5. The main shock that we will analyze in the following sections is  $R_t^W$ .

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 (taken as given according to the small and open economy assumption). In particular, this implies that movements in the real exchange rate do not have a direct impact on exports (in line with the recent literature on dominant-currency pricing, e.g. [Gopinath et al., 2020](#)) which limits 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 equations relate inflation rates with relative prices:

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

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

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

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

where  $b_t^* = \frac{B_t^{*,H} - B_t^{*,T}}{P_t^*}$  denotes aggregate net-foreign assets. Define also the trade balance in real terms as  $tb_t \equiv x_t^{H*} - x_t^F$ .

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 includes the details regarding functional forms and calibration of the parameters described so far, which mostly follows related studies for

emerging countries. Finally, 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 using econometric models, as in the adaptive learning literature (e.g. [Evans and Honkapohja, 2001](#)). Many studies have used learning alternatives to capture limited credibility. For instance, [Gibbs and Kulish \(2017\)](#) assume that only a fraction of agents have rational expectations, analyzing how the real cost of alternative disinflation policies depends on this fraction. [Carvalho et al. \(2020\)](#) set up a model featuring endogenous changes in long-term inflation expectations of adaptive learners to study anchoring. A detailed survey on the importance of learning for monetary policy can be found, for instance, in [Eusepi and Preston \(2018b\)](#).

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

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

where  $\alpha_t$  is a scalar, i.e. a VAR model with a common time-varying long-run trend affecting all variables.<sup>8</sup> 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  $\sigma_\eta^2$ . Thus, the inference about  $\bar{\alpha}_t = E_t\{\alpha_t\}$  (the filtered value of  $\alpha_t$ ) can be represented by the Kalman-filter recursion under a constant gain,

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

where  $K \equiv [K_S, K_\pi, K_W]$  is a  $1 \times 3$  matrix containing the steady-state Kalman gains (obtained by solving the relevant Ricatti equation). In other words, surprises in either the nominal exchange rate, inflation and wages can in principle change the belief about the long-run values of these variables.<sup>9</sup> Lastly, belief parameters defining the forecast function in period  $t$  are assumed to be

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<sup>7</sup>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.

<sup>8</sup>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.

<sup>9</sup>The related literature assumes that each constant in the VAR is determined by a different process. In our

predetermined.<sup>10</sup> Thus, the one-period-ahead forecast is given by

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

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

This setup requires calibrating  $\Phi$  and  $K$ . We estimate the model in (3) using both Argentine and Chilean data. The former was the first country in Latin America to adopt an inflation targeting setup (the current framework started in 2001, but monetary policy was characterized by inflation targets since the early 90s) and since 2001 market expectations for one-year-ahead inflation was above the target range during only 9 months.<sup>11</sup> Argentina, in contrast, has experienced an increasing average inflation rate from 2004 to 2019, alternating several policy frameworks during this period. Thus, Argentina will taken as the case of limited credibility, while looking at Chilean data allows checking if the model can tell apart these two cases.

The set of observables includes the three variables in  $x_t$  (we use core inflation as the observable), plus one-year-ahead market expectations for inflation and exchange-rate depreciation (unfortunately, wage-related forecasts are not available in either country). The sample goes from 2004 to 2019, although for Argentina expectation variables are only available for the periods 2004-2007 and 2016-2019.<sup>12</sup> Table 1 report the results for both countries.<sup>13</sup>

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

In terms of Kalman gains, those related to inflation and nominal wage growth ( $K_\pi, K_W$ ) 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

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

<sup>10</sup>This avoids an analytically intractable simultaneity that would otherwise arise from the joint determination of beliefs and equilibrium outcomes.

<sup>11</sup>See [Arias and Kirchner \(2019\)](#) for a study of inflation anchoring in Chile.

<sup>12</sup>This gap in the data is handled by using the Kalman filter for missing observations. The model also includes a measurement error for the exchange-rate forecast, to avoid stochastic singularity. The Metropolis-Hastings algorithm was used to draw 200k random values from the likelihood function (equivalently, the posterior under flat priors). Quarterly data was used for the estimation, although all variables are available at a monthly frequency, to match the time period in the model. While not reported, the values of the Kalman gains  $K$  are similar with monthly data, although  $\Phi$  varies reflecting the different frequencies.

<sup>13</sup>The estimated values for  $\Phi$  are reported in Appendix B.

<sup>14</sup>The usual unconditional variance decomposition cannot be performed: variables are non-stationary according to the forecasting model.



Table 1: Estimated Learning Parameters

Parameter	Argentina			Chile		
	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
$K_S$	-0.02	-0.05	0.01	0.00	0.0	0.0
$K_\pi$	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

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

inflation is somehow smaller (around 0.15), while the influence of wage surprises is more limited.<sup>15</sup>

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

To explore this possibility, the first row in Figure 1 presents scatter plots of changes in one-year-ahead inflation expectations between two consecutive months (vertical axes), against the surprise in the exchange rate of that month (measured as the observed exchange rate minus the expected value from the previous month) for both countries.<sup>16</sup> Blue dots correspond to months when exchange-rate surprises were smaller than one standard deviation, while red dots are those for larger surprises.<sup>17</sup> As can be seen, under small movements, in both countries there is a positive but small relationship between these surprises and changes in inflation expectations. However, in periods with large surprises, one-year-ahead inflation expectations seem to shift significantly in Argentina, while that does not seem to be the case in Chile.<sup>18</sup>

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

Table 2 reports results from regressing the change in 12-month-ahead inflation expectations for each country, as a function of surprises (forecast errors) 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  $R^2$ ) 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).

In contrast, for Chile changes to inflation expectations are related with inflation rather than exchange rate surprises, although with a much smaller adjusted  $R^2$  (column 3). Large exchange rate forecast errors also produce a differential effect (column 4), but it only intensifies the relation-

<sup>15</sup>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)).

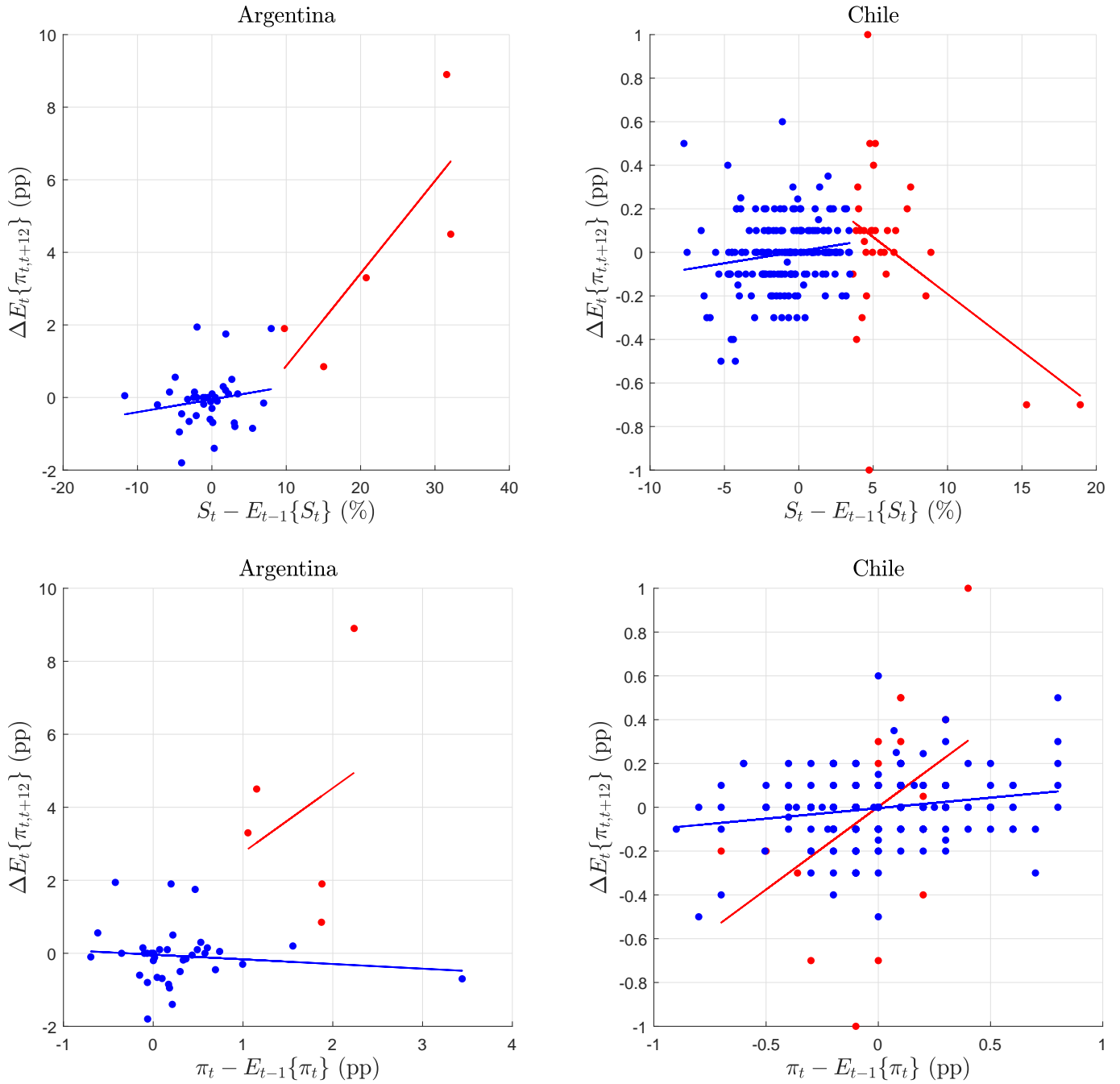
<sup>16</sup>The data for Argentina covers de 2016-2019 (constrained by availability of market-expectations surveys), while for Chile the sample goes from 2004-2019.

<sup>17</sup>The blue and red lines are simple OLS regressions for each set of observations.

<sup>18</sup>A simple regression with a dummy variable to account for different slopes shows a statistically-significant different coefficient for Argentina but not for Chile.



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



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

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.

ship with inflation surprises. Overall, this evidence suggests 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 enjoying 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  $K_S = K_\pi = K_W = 0.2$ .<sup>19</sup> The first tries to capture lack of credibility under normal-size shocks, while the latter is meant to capture situations where exchange rate volatility further hinders credibility.

## 2.9 Alternative policy rules

Our exploration of alternative simple rules considers the following:

1. Interest-rate rule:

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

where  $e_t^{MP}$  is an i.i.d. policy shock.<sup>20</sup> 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 rule:

$$\Delta M_t = \frac{M_t}{M_{t-1}} = \pi, \quad (7)$$

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

<sup>19</sup>The matrix  $\Phi$  is calibrated using the posterior mean for the case of Argentina (the first column in the table shown in [Appendix B](#)).

<sup>20</sup>We use this shock to understand the monetary transmission mechanism.

3. Nominal-exchange-rate rule:

$$\pi_t^S = \pi^S, \quad (8)$$

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, due to the interest rate parity, the nominal exchange rate depreciates. Both the rise in aggregate demand and the nominal depreciation increase inflation and, due to price stickiness, the real exchange rate also depreciates. We can also see that the path of inflation forecasts just equals that of actual inflation starting from period one (i.e. there is perfect foresight under rational expectations).

Next, we turn to the impact of a shock that increases the external interest rate by one standard deviation, displayed in Figure 3.<sup>21</sup> 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). It also reduces investment by increasing the real interest rate. This drop in aggregate absorption leads to a real depreciation, which in turn raises aggregate inflation (by the increase in the domestic price of foreign goods), outweighing the influence of aggregate-demand contraction. Also, due to sticky prices and wages, the required 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 quantities exported are no sensitive to the real depreciation.

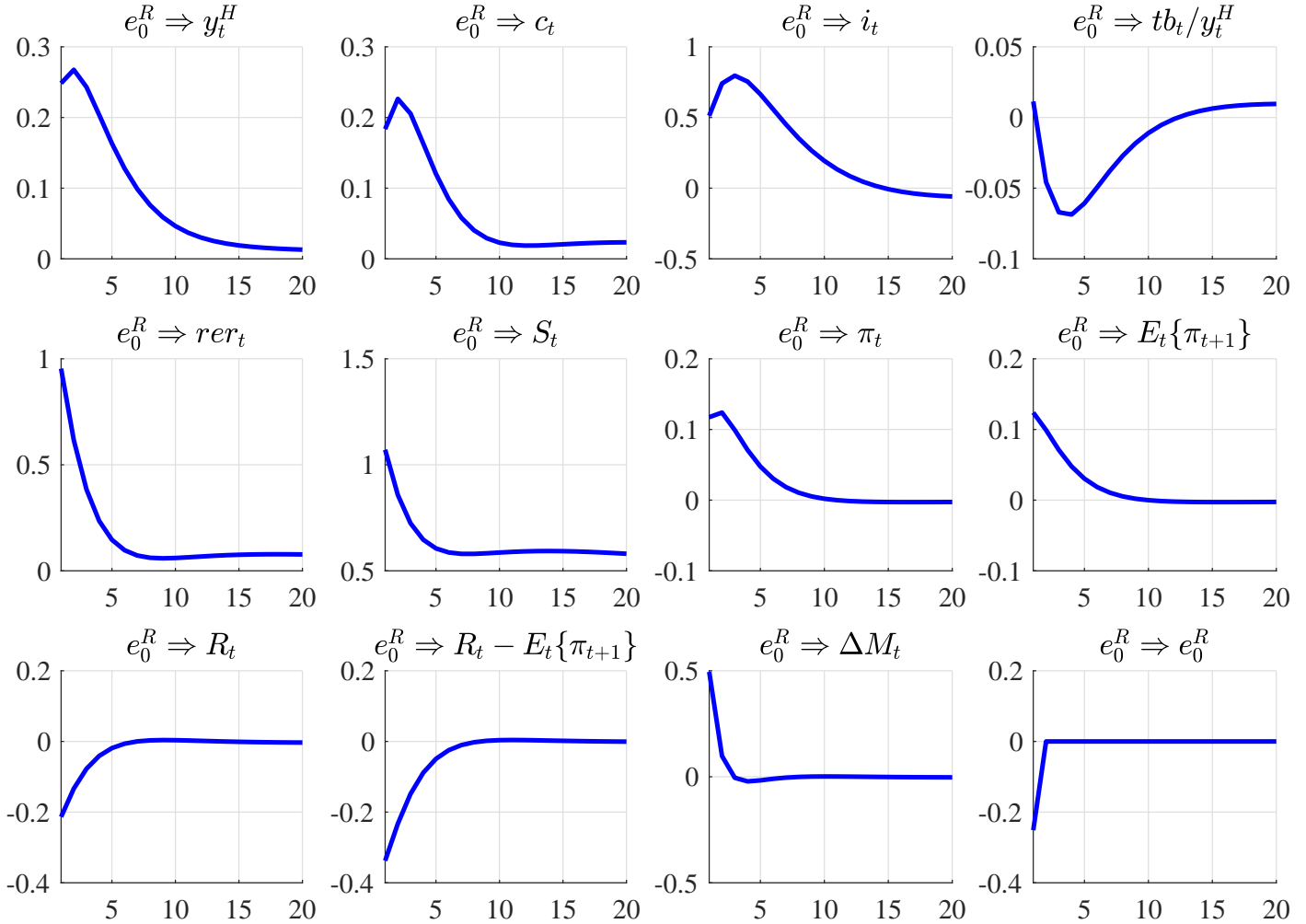
As inflation increases, the policy rate rises guided by the rule in equation (6). However, this increase is relatively mild, for the rise in inflation is not as large. Moreover, the rising policy rate somehow dampens the exchange rate dynamics, and therefore its impact on inflation. Along the same lines, money balance also falls, 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 of the shock on absorption also occur under this configuration. The exchange rate and inflation dynamics also go in the same direction. But the responses are quantitatively different. To understand the intuition, we can think of the responses under the interest-rate rule as a proxy of what would happen, *ceteris paribus*, if the policy rate remained constant. In such a case, money demand would fall due to the contraction in consumption. In a configuration with a constant-money-growth rule, the interest rates must fall to

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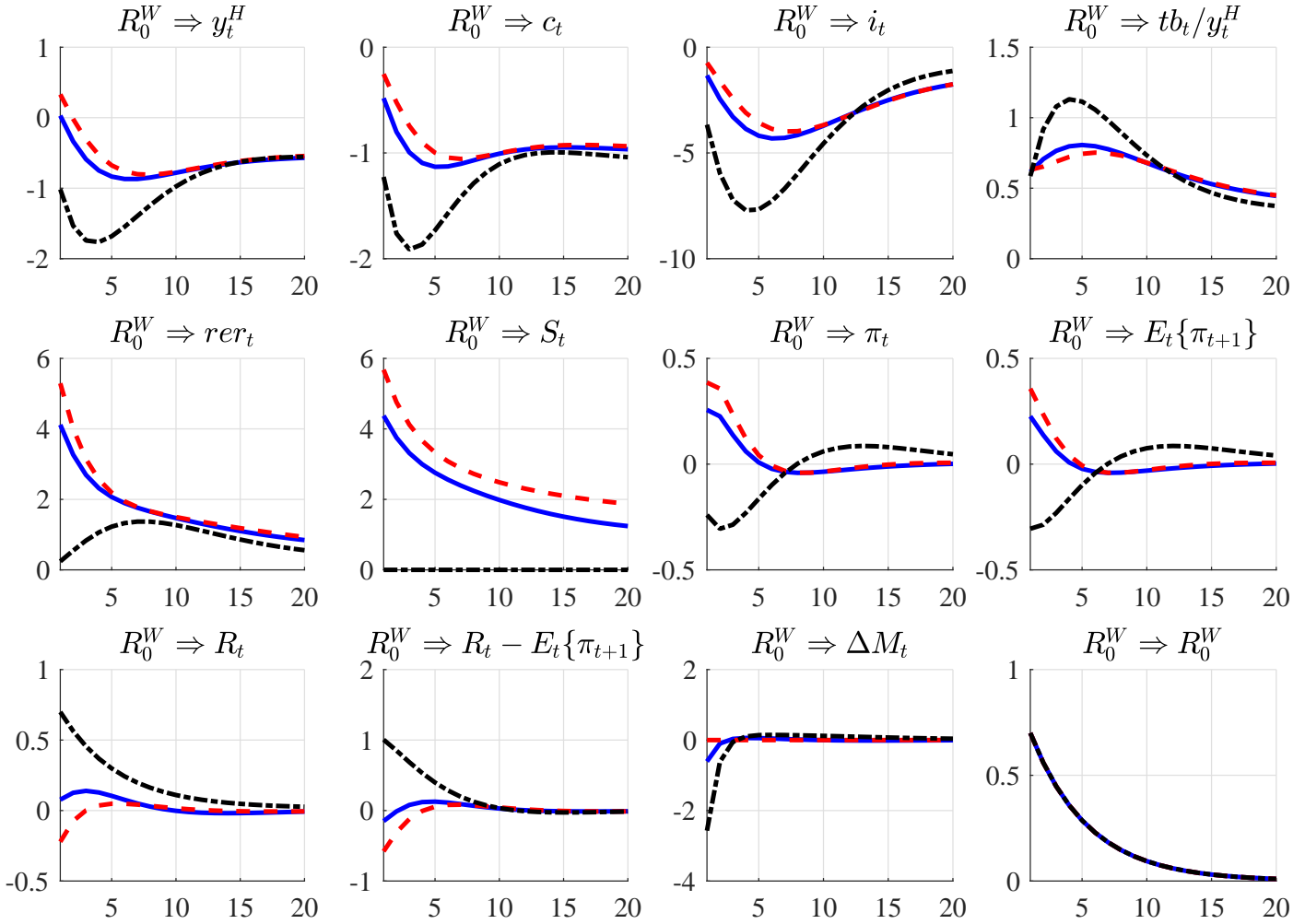
<sup>21</sup>As described in Appendix A, this is calibrated by estimating an AR(1) model to the sum of the LIBOR rate plus the J. P. Morgan EMBI Index for Argentina. The shock represents an increase of 280 annualized basis points in the cost of foreign borrowing.

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 ( $\pi$ ), 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. All 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.

clear the money market. This in turn leads to a larger nominal depreciation,<sup>22</sup> which puts upward pressure on inflation. At the same time, the real depreciation is larger (the addition nominal depreciation outweighs the higher inflation).

Given the path for the real interest rate, relative to the previous case the effect on consumption and investment is milder, which in turn implies an initially larger output expansion. Overall, we can see that a money-growth rule produces more limited activity effects, at the cost of higher inflation and a larger nominal and real depreciation.

Finally, the exchange-rate peg, equation (8), corresponds to the dashed-dotted-black line in Figure 3. The contraction in absorption is larger in this case: by eliminating the nominal-exchange-rate effect, domestic rates and spreads experience a larger increase.<sup>23</sup> In contrast, under this instrument inflation falls: as the nominal-exchange-rate channel disappears, prices are only driven by aggregate demand (as in a closed economy).

To further summarize the desirability of each alternative, we ranked them using two metrics. The first one is conditional welfare. For each model, with a given rule, we compute,<sup>24</sup>

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

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 compute the consumption compensation that makes households indifferent between alternatives. In particular, for a given reference equilibrium  $r$  and an alternative  $a$ , we define  $\Lambda$  implicitly such that

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

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

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

which is frequently used to characterize policy under an inflation-targeting framework (e.g. [Svensson, 2010](#)).

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<sup>22</sup>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.

<sup>23</sup>The interest rate parity under a peg forces the policy rate to replicate the expected path of the external rate.

<sup>24</sup>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 an relevant characteristic to rank outcomes. Additionally, 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).

Table 3 summarizes these comparisons, including also the volatilities of output, inflation and the real exchange rate to complement the analysis. The equivalence measure  $\Lambda$  is computed relative to the interest rate rule. In terms of welfare, the reduction in the volatility of aggregate demand brought about by the money rule improves welfare (even though inflation is more volatile). 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, and the consumption equivalent is more than five times higher than in the comparison between money and interest-rate rules. If we focus instead on the loss function, the  $M$  rule is slightly preferred to the  $R$  rule, while under the  $S$  rule the loss is much higher.

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

Rules	Relative Volatilities			Welfare	Relative
	$y_t^H$	$\pi_t$	$rer_t$	$\Lambda$	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.  $\Lambda$  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 while 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 changes in the presence of both limited-credibility configurations (which recall differ on the assumption about  $K_S$ ). Second, we compare how the propagation after the external-interest-rate shock differs depending on the expectations setup, assuming that policy follows an interest rate rule. Finally, we compare the three alternative rules under both deviations from rational expectations.

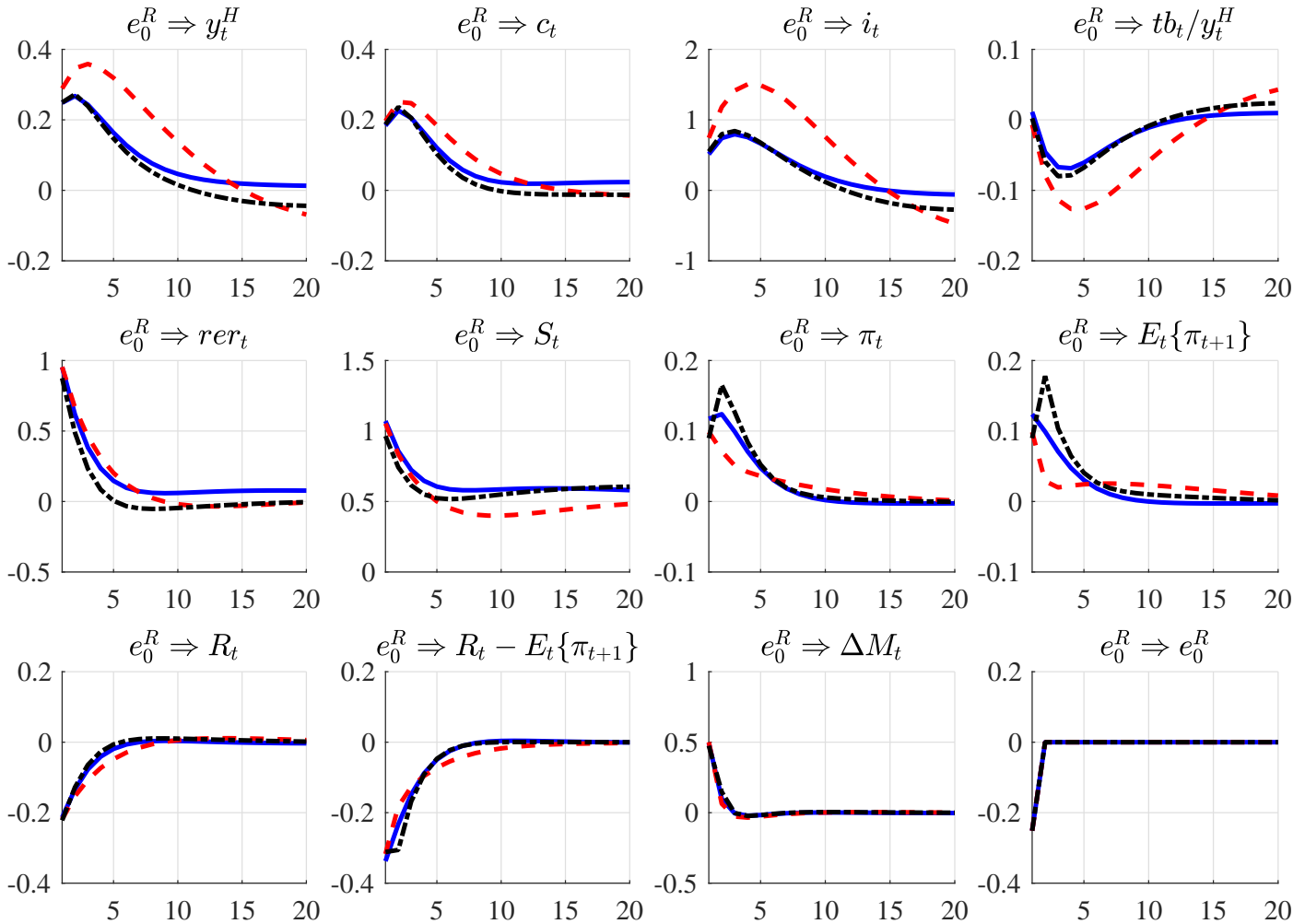
### 4.1 Transmission of Shocks Under Learning

In Figure 4 the effects of a negative policy shock in equation (6) under rational expectations are displayed in solid-blue lines, while the case of limited credibility with  $K_S = 0$  is displayed with dashed-red lines. The shock implies a larger and more persistent impact on activity when agents use the empirical model to forecast inflation, while prices are relatively less sensitive.

To understand this result consider the real rate that affects consumption and investment decisions:  $\widehat{R}_t - E_t\{\widehat{\pi}_{t+1}\}$ . 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.

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.

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 despite the higher path for aggregate demand because the forward-looking channel of the Phillips curve is muted under this type of learning. Thus, prices are less sensitive to the shock on impact, although more persistent than under rational expectations. We can also see that the path of expected inflation doesn't match that of realized inflation: instead of perfect foresight as in rational expectations, past inflation shapes agents' forecast.

A relevant corollary of this analysis is that, to achieve a given desired effect on inflation, the policy rate needs to move by more (and for a longer period) if expectations are not fully rational. This in turn generally 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  $\alpha_t$  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  $K_S > 0$ . As we will analyze next, this implies that the relevant policy trade-off could be exacerbated following a contractionary shock that induces a depreciation.

[Figure 5](#) compares the responses after an external interest rate increase, still assuming the interest-rate-policy rule. As can be seen, if learning features  $K_S = 0$  (dashed-red lines) the effects on consumption and investment are not as different in the initial quarters; for the impact comes mainly through a real channel and it is less related to inflation expectations. Afterward 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,  $\Phi$  in [equation \(3\)](#)) but, crucially, they remain above the steady-state for a longer period (generated by the impact of actual inflation in long-run expectations,  $\alpha_t$  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 affected by the exchange-rate surprises (dashed-dotted-black lines show the case with  $K_S > 0$ ) dynamics are further altered. Inflation increases by more as long-run expectations shift, and GDP also falls by more. This effect in activity comes from two channels. The policy rule dictates a more contractionary path, leading to a larger fall in demand. At the same time, 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. Therefore, if the exchange-rate jump feeds into expectations (as the evidence presented in [section 2.8](#) seems to suggest under limited credibility) policy will face a worse trade-off between inflation and activity after such this shock. In fact, in terms of conditional welfare and the loss function, [Table 4](#) shows that limited credibility is indeed costly.

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

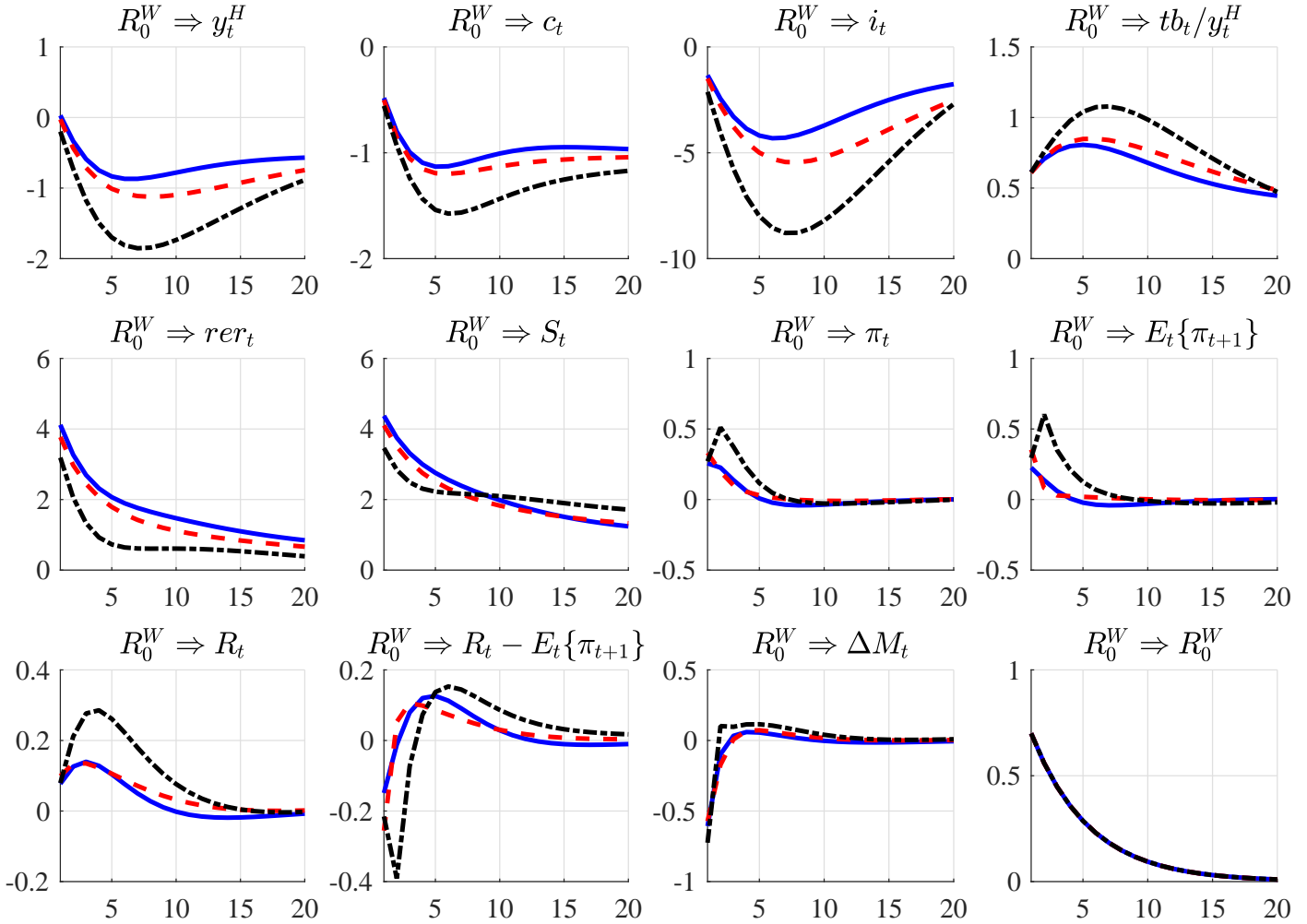
Alternatives	Relative Volatilities			Welfare	Relative
	$y_t^H$	$\pi_t$	$rer_t$	$\Lambda$	Loss
$LC, K_S = 0$ vs $RE$	1.05	1.06	0.86	0.13	0.83
$LC, K_S = 0.2$ vs $RE$	1.23	1.79	0.54	0.76	0.51

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

## 4.2 Alternative Policy Rules

[Figure 6](#) compares the three policy alternatives in the context of limited credibility if  $K_S = 0$ . Qualitatively, the differences between these rules are analogous to the analysis in [Section 3](#): a

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



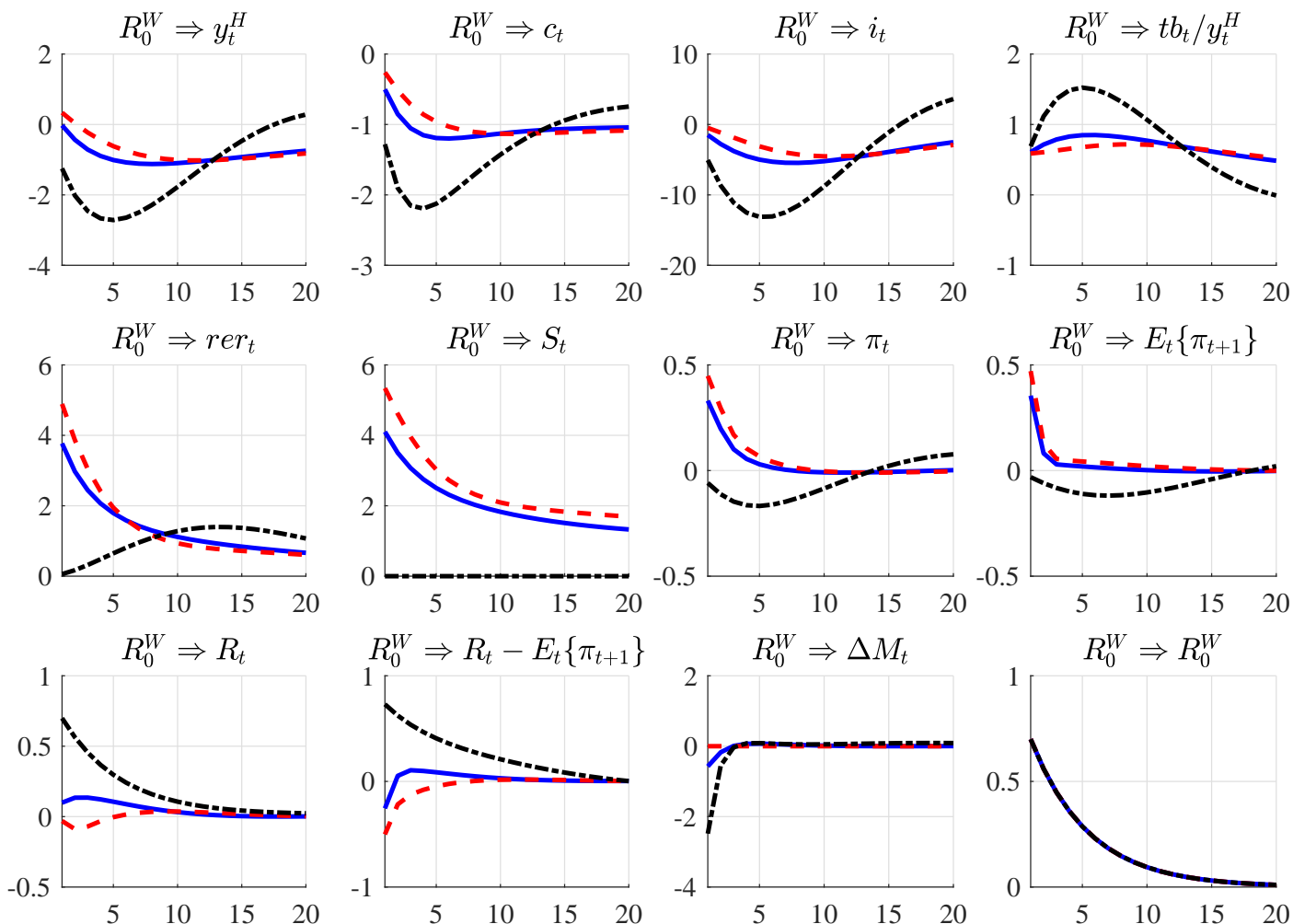
Notes: The solid-blue line is the version under rational expectations, the dashed-red line is the version of imperfect credibility with  $K_S = 0$ , and the dashed-dotted-black lines use  $K_S = 0.2$ . See the description in Figure 2 for variables' definitions.

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, due to 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 between instruments related to inflation dynamics gets amplified under lack of credibility. In particular, a constant-money-growth rule implies somehow higher and 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 values of inflation, the trade-off between interest-rate and money-based rules is

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.

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 leave agents marginally worse off under both metrics. Differences with the peg are similar in welfare terms, but not in terms of the loss function.

If expectations are also affected by exchange rate dynamics (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 results, the activity path is much similar under these two policies. Therefore the dampening effect in activity brought about by the money-growth rule is less significant. In contrast, the peak in inflation is still almost twice as large than with the

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

Rules	Relative Volatilities			Welfare	Relative
	$y_t^H$	$\pi_t$	$rer_t$	$\Lambda$	Loss
<i>Limited Credibility, <math>K_S = 0</math></i>					
$M$ 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
<i>Limited Credibility, <math>K_S = 0.2</math></i>					
$M$ 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.

interest rate rule.

The exchange rate peg induces similar dynamics regardless of the type of learning assumed. However, if  $K_S > 0$  the difference in activity with the other rules is somehow 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, although aggregate volatility is higher. The difference is that here, in relative terms the welfare cost of a peg is halved.

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

## 5 Sensitivity Analysis

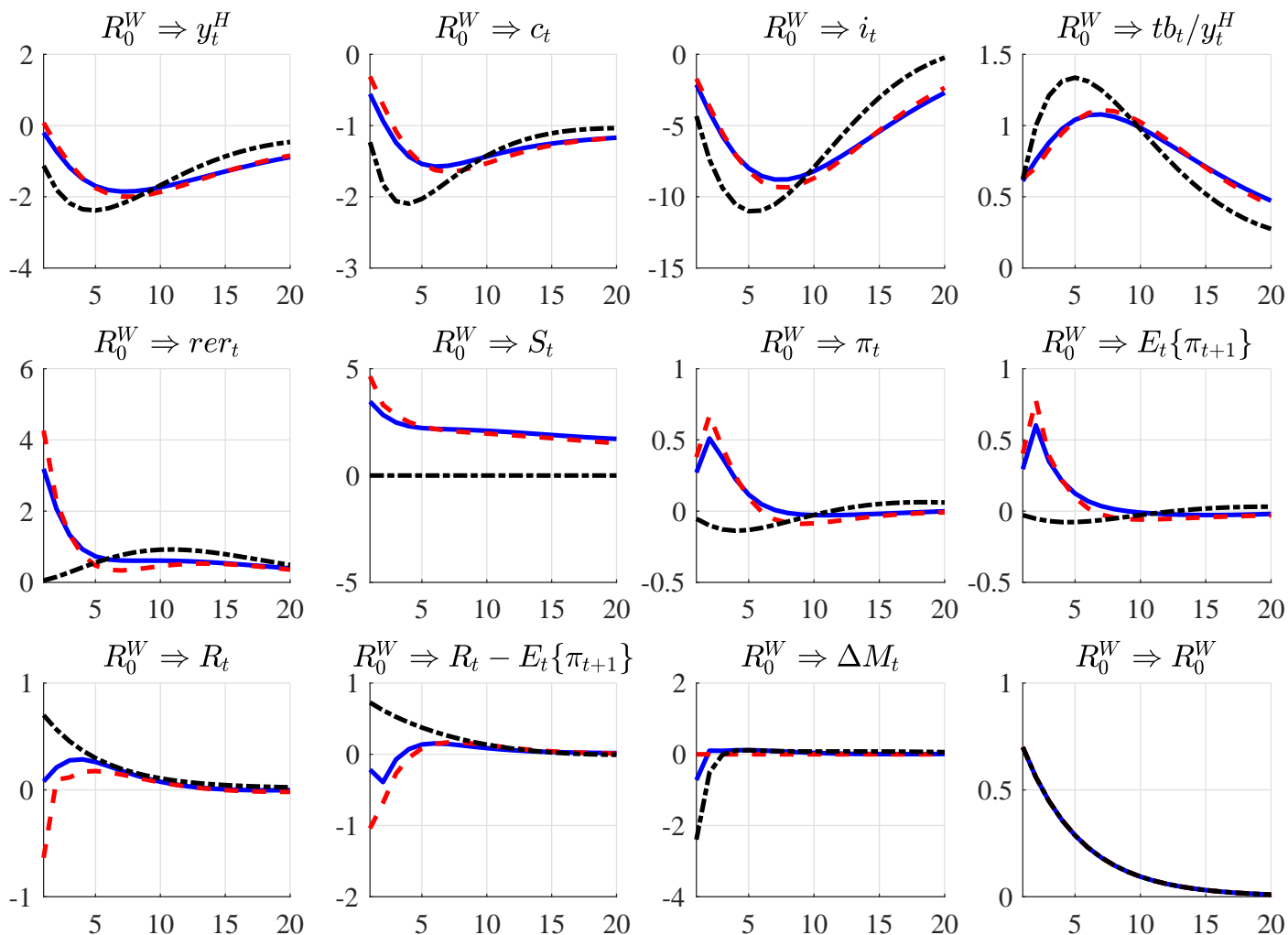
In this section, we compare the same policy rules under several model modifications: financial frictions in the form of an endogenous foreign-financing spread; habits at the good-level further limiting the expenditure-switching channel; a domestic banking sector that yields a richer structure for monetary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

### 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.<sup>25</sup> We explore how our results change if these concerns are present. To keep the model as simple as possible, we follow

<sup>25</sup>See, for instance, the survey by [Mendoza and Rojas \(2019\)](#).

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.

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:

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

Furthermore, we double the value of  $\phi$  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  $\phi$  increases, a larger depreciation is generated and inflation

further increases.<sup>26</sup> 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

Rules	Relative Volatilities			Welfare	Relative
	$y_t^H$	$\pi_t$	$rer_t$	$\Lambda$	Loss
<i>Rational Expectations</i>					
$R$ 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
<i>Limited Credibility, <math>K_S = 0</math></i>					
$M$ 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
<i>Limited Credibility, <math>K_S = 0.2</math></i>					
$M$ 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 each policy rule, considering each expectation-formation setup. Focusing first on rational expectations, we can see that the  $M$  rule further increases volatility relative to the  $R$  rule, particularly for inflation and the real exchange rate. Thus, the 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.<sup>27</sup>

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.

<sup>26</sup>If we just change the premium to (9) but maintain  $\phi = 0.001$ , the differences are small between models.

<sup>27</sup>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.

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.<sup>28</sup> 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,

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

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 because 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 mildly larger contraction originated by the negative shock.

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

Rules	Relative Volatilities			Welfare	Relative
	$y_t^H$	$\pi_t$	$rer_t$	$\Lambda$	Loss
<i>Rational Expectations</i>					
$R$ 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
<i>Limited Credibility, <math>K_S = 0</math></i>					
$M$ 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
<i>Limited Credibility, <math>K_S = 0.2</math></i>					
$M$ 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.

The rules comparison under rational expectations is similar than in the baseline, with the differences marginally exacerbated: as the dampening impact of the depreciation 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, both results analyzed in the baseline 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  $K_S > 0$ .

<sup>28</sup>The dominant-currency pricing assumption already contributes to this, by making exports insensitive to the real exchange rate. However, the expenditure-switching channel is still active in the substitution between  $H$  and  $F$  goods domestically.



### 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  $\alpha_K^L$  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  $\xi_t^B$  is an exogenous variable and  $\Psi$  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  $\tau_t$  per unit of deposit, remunerated at a rate  $R_t^\tau$ .

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

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

The goal is to maximize the net-present-value of dividends (i.e.  $E_t \{ \sum_{h=0}^{\infty} \chi_{t,t+h} \Omega_{t+h}^B \}$ ). The optimality conditions can be written in terms of two relevant spreads:

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

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

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, from this channel also, an increase in the policy rate widens both spreads.<sup>29</sup>

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, for inefficiency is generated by the presence of spreads to finance investment.

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 ( $K_S = 0.2$ ).

<sup>29</sup>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 Caribbean). 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.



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

Rules	Relative Volatilities			Welfare	Relative
	$y_t^H$	$\pi_t$	$rer_t$	$\Lambda$	Loss
<i>Rational Expectations</i>					
$R$ 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
<i>Limited Credibility, <math>K_S = 0</math></i>					
$M$ 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
<i>Limited Credibility, <math>K_S = 0.2</math></i>					
$M$ 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.

## 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  $\Gamma$ ) and Unconstrained (of mass  $1 - \Gamma$ ); as in, for instance, [Galí et al. \(2007\)](#) or [Colciago \(2011\)](#). The former just consumes its labor income, i.e.<sup>30</sup>

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

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.<sup>31</sup>

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

<sup>30</sup>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.

<sup>31</sup>In performing welfare comparisons with this model, we compute three consumption-equivalent measures: two of them compare the utility for each type of agents ( $\Lambda^C$  and  $\Lambda^U$ ), while we also compare welfare obtained using aggregate consumption ( $\Lambda$ ) as a measure of “average” welfare costs.

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

Alternatives	Relative Volatilities			Welfare			Relative Loss
	$y_t^H$	$\pi_t$	$rer_t$	$\Lambda$	$\Lambda^U$	$\Lambda^C$	
<i>Rational Expectations</i>							
$R$ 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
<i>Limited Credibility, <math>K_S = 0</math></i>							
$R$ 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
<i>Limited Credibility, <math>K_S = 0.2</math></i>							
$R$ 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.

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 world where a fraction of agents is cannot access financial markets.

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

Alternatives	Relative Volatilities			Welfare			Relative Loss
	$y_t^H$	$\pi_t$	$rer_t$	$\Lambda$	$\Lambda^U$	$\Lambda^C$	
<i>Rational Expectations</i>							
$R$ 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
<i>Limited Credibility, <math>K_S = 0</math></i>							
$R$ 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
<i>Limited Credibility, <math>K_S = 0.2</math></i>							
$R$ 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 of alternative simple rules for different monetary-policy instruments. The focus was on how these alternatives can help in smoothing the impact of shocks to external-borrowing costs depending on the policy configuration. Importantly, we explored how conclusions are altered in the presence of imperfect credibility, captured by departing from rational expectations (using instead simple time-series models to forecast inflation-related variables).

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

We also 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 due to both a more persistent inflation process and 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 role for limiting exchange rate volatility to prevent large 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. On one hand, a more thorough empirical analysis of the influence of exchange rate surprises in shaping inflation expectations could shed light on the relevant channels contributing to inflation anchoring. On the other, the rules analyzed here were relatively simple. One could also include other feedback variables in the rules (the exchange rate in particular) 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 should be desirable.

Finally, we have also abstracted from the presence of money-demand shocks that 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; although it should be included in a more complete quantitative assessment. We leave these considerations 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.<sup>32</sup> The other conditions generate dynamics

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<sup>32</sup>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.

for consumption, money and deposits decisions that are empirically plausible. The specification is,

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

where  $\tilde{c}_t, \tilde{m}_t, \tilde{d}_t$  denote habit-adjusted consumption as well as real cash and deposit.<sup>33</sup> The utility shifters (taken as given by individuals)  $\Xi_t^h, \Xi_t^M$  and  $\Xi_t^D$  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:

$$w_t m c_t^W = \xi^h h_t^\varphi$$

where  $\xi^h$  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.

- 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  $\xi^j$  are parameters. This generates the following demands for money and deposits:

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

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

which yield the desired properties.

The capital-adjustment-cost function is set to

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

with  $\phi_I > 0$ . 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  $\psi_{DL}$  determines the elasticity of the spread with respect to the deposits-to-loans ratio,  $\psi_D$  and  $\psi_L$  are related with the steady-state values of  $R^L$  and  $R^D$ , and  $\psi_0$  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 ( $\pi$ ), hours worked ( $h$ ), relative price of home goods ( $p^H$ ), the nominal interest rate ( $R$ ), nominal depreciation ( $\pi^S$ ), 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

<sup>33</sup>For a generic variable  $x_t$ , habit adjusted is given by  $\tilde{x}_t = x_t - \phi_X x_{t-1}^a$ , with  $x_t^a = x_t$  in equilibrium. We further assume that, individually, households take  $x_t^a$  as given (i.e. preferences exhibits external habits).



( $s^{dl} = d/l$ ), 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 ( $\varepsilon^M$  and  $\varepsilon^D$ ).

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  $\psi_{DL}$  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 almost 5 quarters.

Table 11: Calibrated parameters and targeted steady state values.

Parameter	Description	Value
$\sigma$	Coef. of relative risk aversion	2
$\varphi$	Inverse Frisch elasticity of labor supply	1
$\phi_C$	Habit in consumption	0.6
$\phi_M$	Habit in money demand	0.3
$\phi_D$	Habit in deposits demand	0.3
$\alpha$	Share of capital in production of $H$	0.33
$\delta$	Capital depreciation	0.015
$\phi_I$	Inv. adjustment cost	3
$\alpha_L^K$	Share of capital financed by loans	0.5
$\omega$	Share of home goods in consumption	0.7
$\eta$	Elast. of subst. between home and for. goods	0.5
$\eta^*$	Foreign demand elasticity	0.2
$\epsilon$	Elast. of subst. between varieties of goods	11
$\epsilon_W$	Elast. of subst. between varieties of labor	11
$\theta$	Calvo probability of no price adjustment	0.7
$\theta_W$	Calvo probability of no wage adjustment	0.9
$\vartheta$	Indexation to past inflation in prices	0.4
$\vartheta_W$	Indexation to past inflation in wages	0.8
$\phi_B$	Debt elasticity of foreign interest rate	0.001
$\psi_{DL}$	Elasticity of the spread to the deposit-to-loan ratio	0.01
$\rho_{RW}$	Autocorr. external interest rate	0.7
$\sigma_{RW}$	St.Dev. external interest rate shock	0.007
$\pi$	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	$1.06^{1/4}$
$\pi^S$	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	$R \times 1.05^{1/4}$
$\tau$	Required reserves	0.15
$R^\tau$	Interest rate on required reserves	1
$\epsilon^M$	Money demand elasticity	-1.5/4
$\epsilon^D$	Deposits demand elasticity	1/4

## B Learning Parameters

Table 12: Other Estimated Learning Parameters

Parameter	Argentina			Chile		
	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

# C Sensitivity Analysis

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

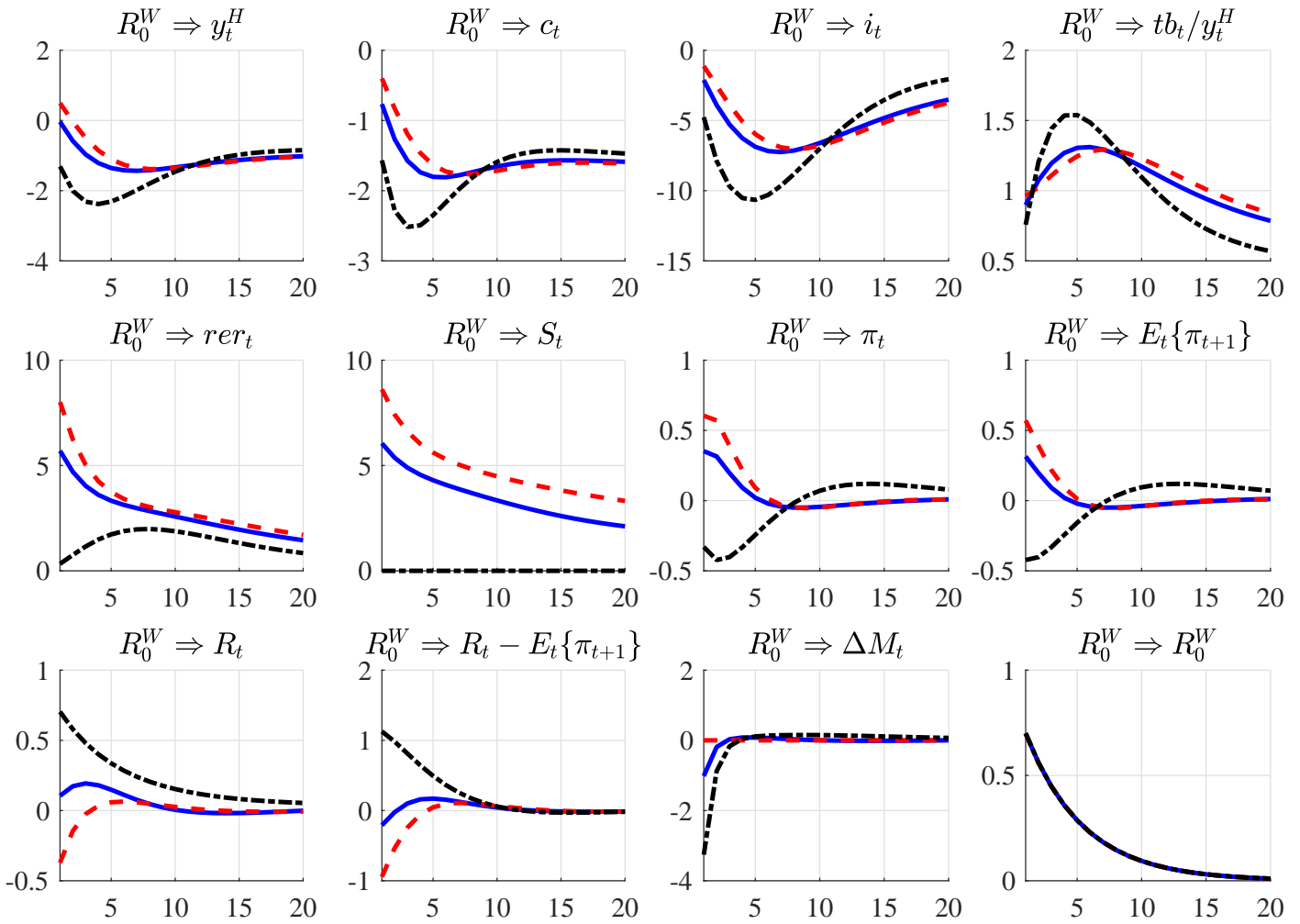


Figure 9: Alternative Instruments with Financial Frictions. Imperfect Credibility with  $K_S = 0$ .

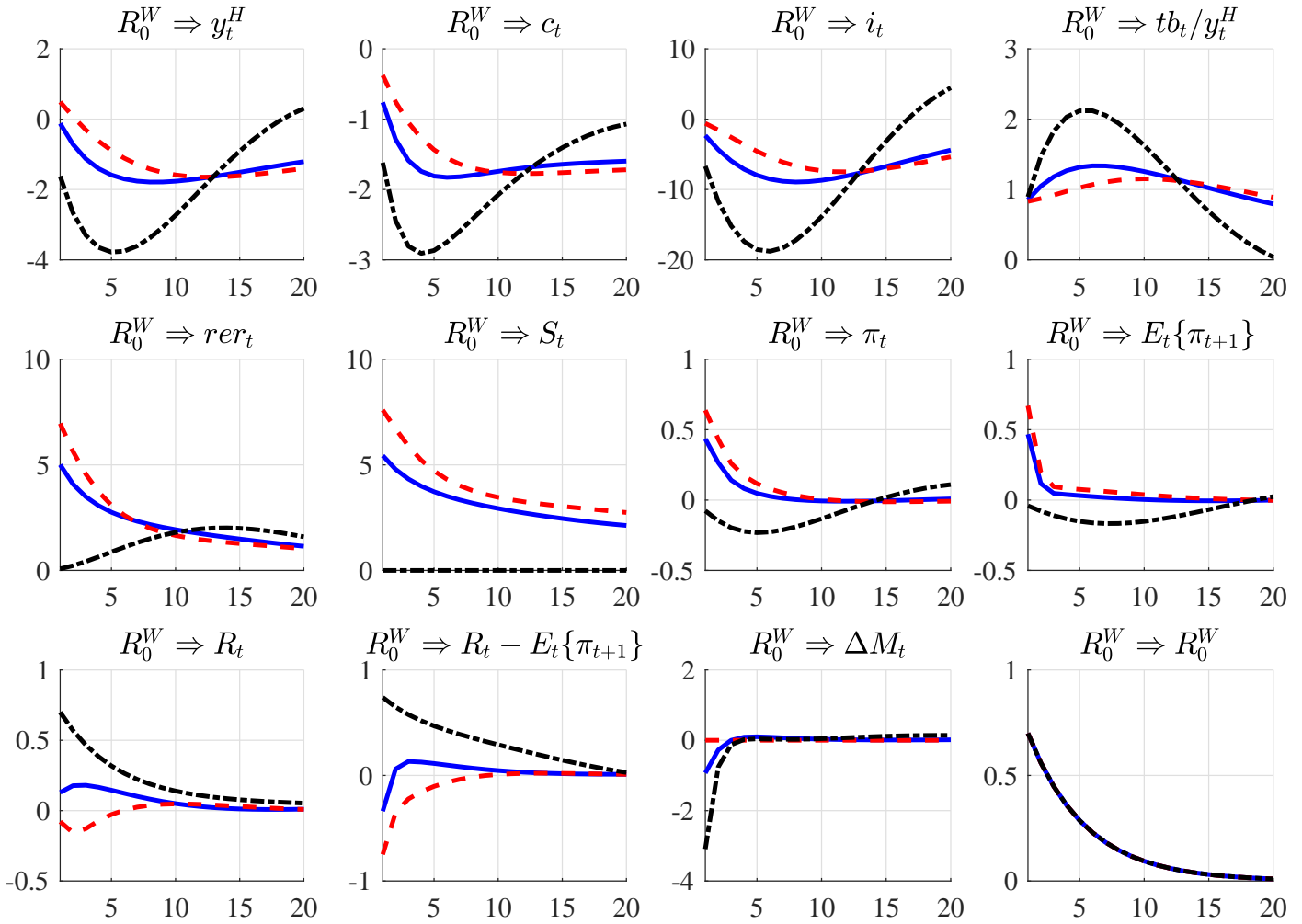


Figure 10: Alternative Instruments with Financial Frictions. Imperfect Credibility with  $K_S = 0.2$ .

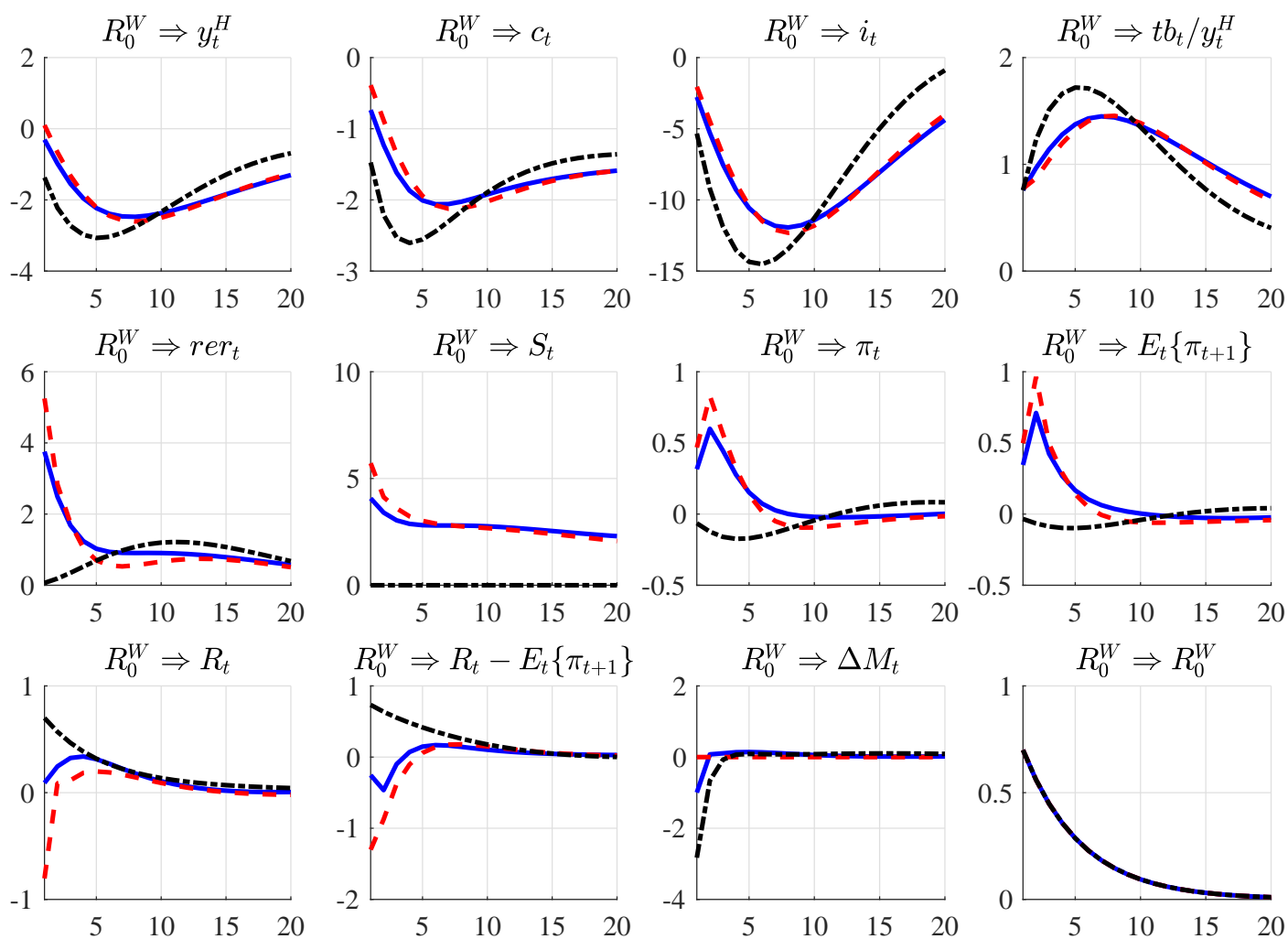


Figure 11: Alternative Instruments with Good-level Habits. Rational Expectations.

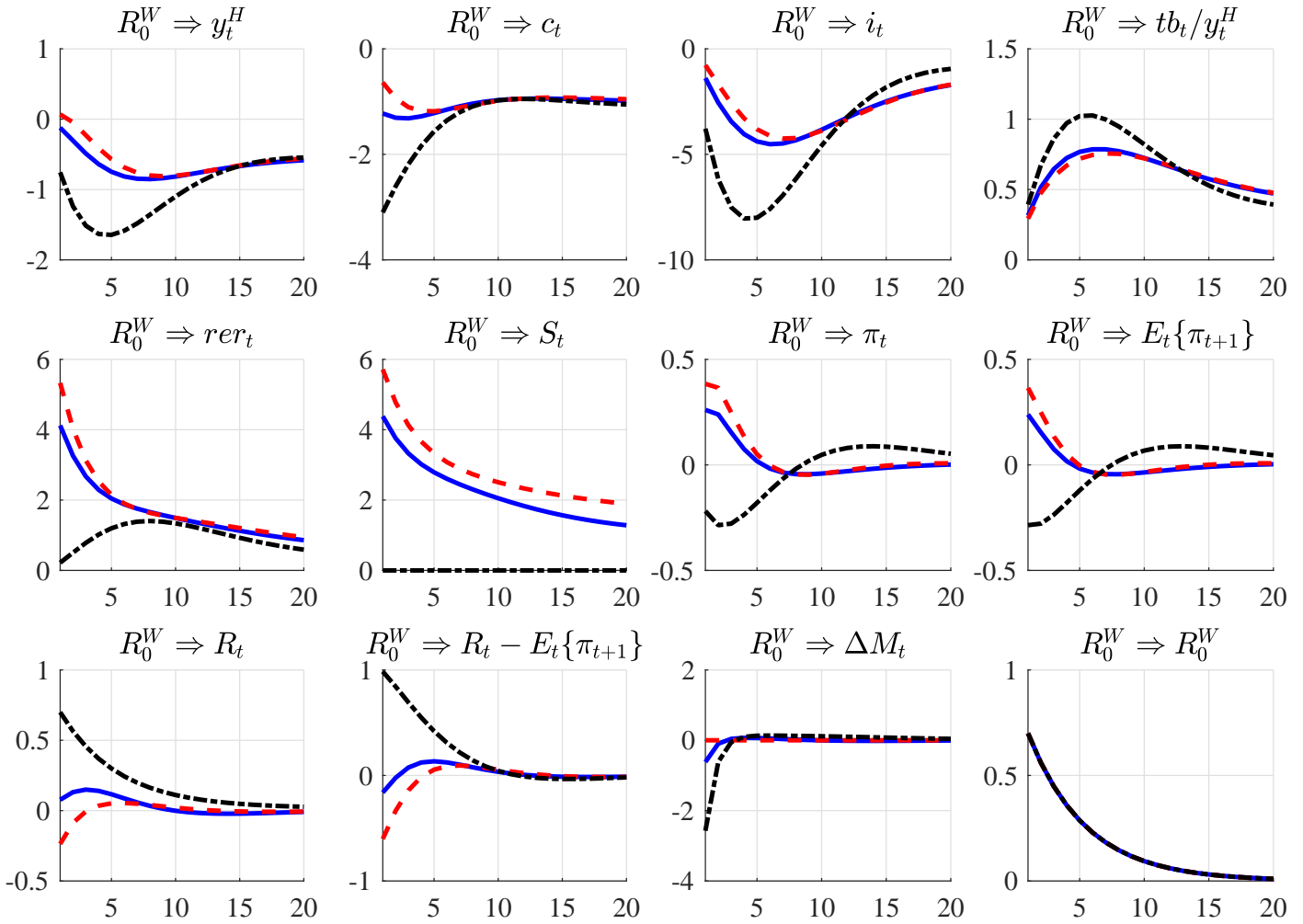


Figure 12: Alternative Instruments with Good-level Habits. Imperfect Credibility with  $K_S = 0$ .

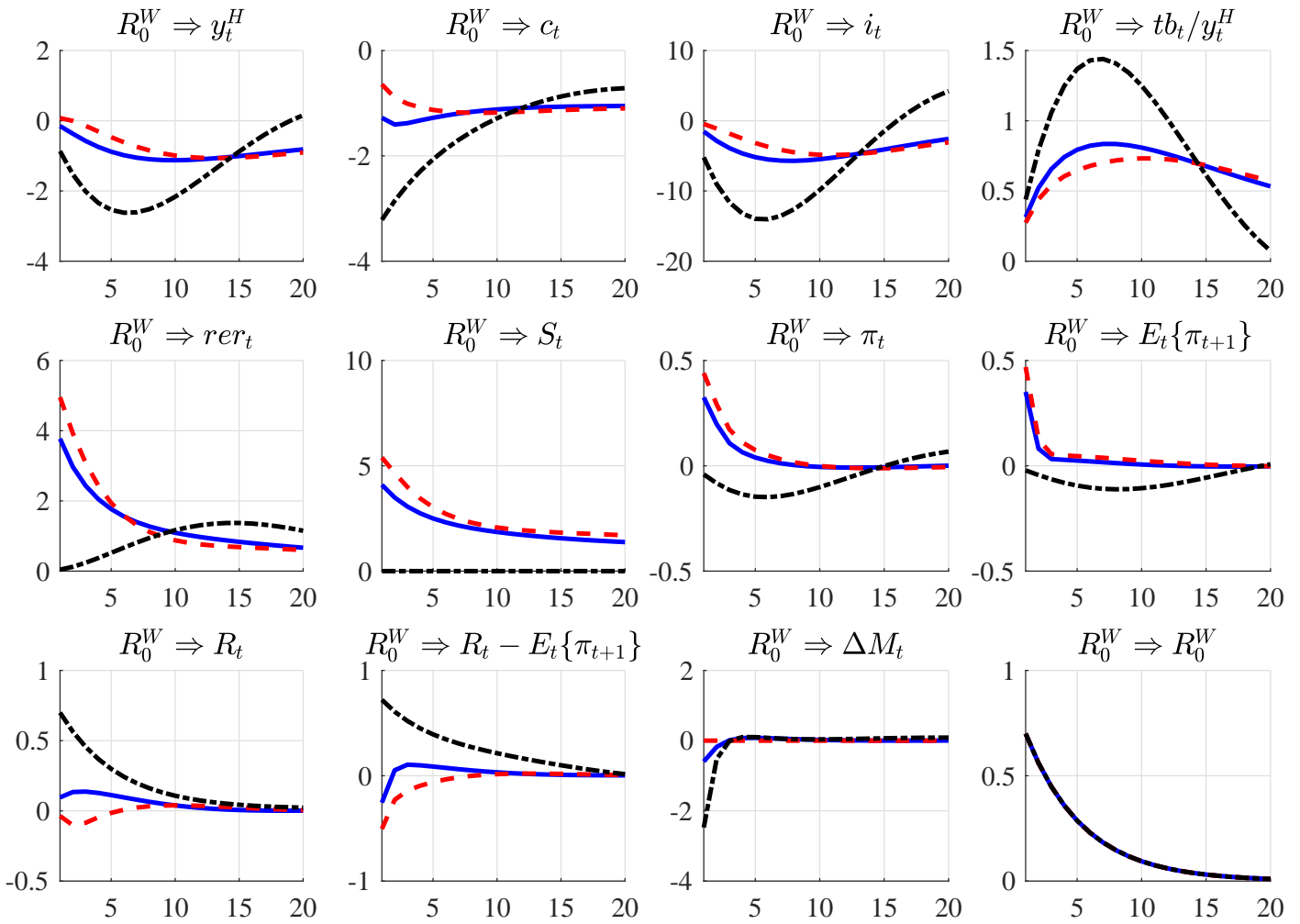




Figure 13: Alternative Instruments with Good-level Habits. Imperfect Credibility with  $K_S = 0.2$ .

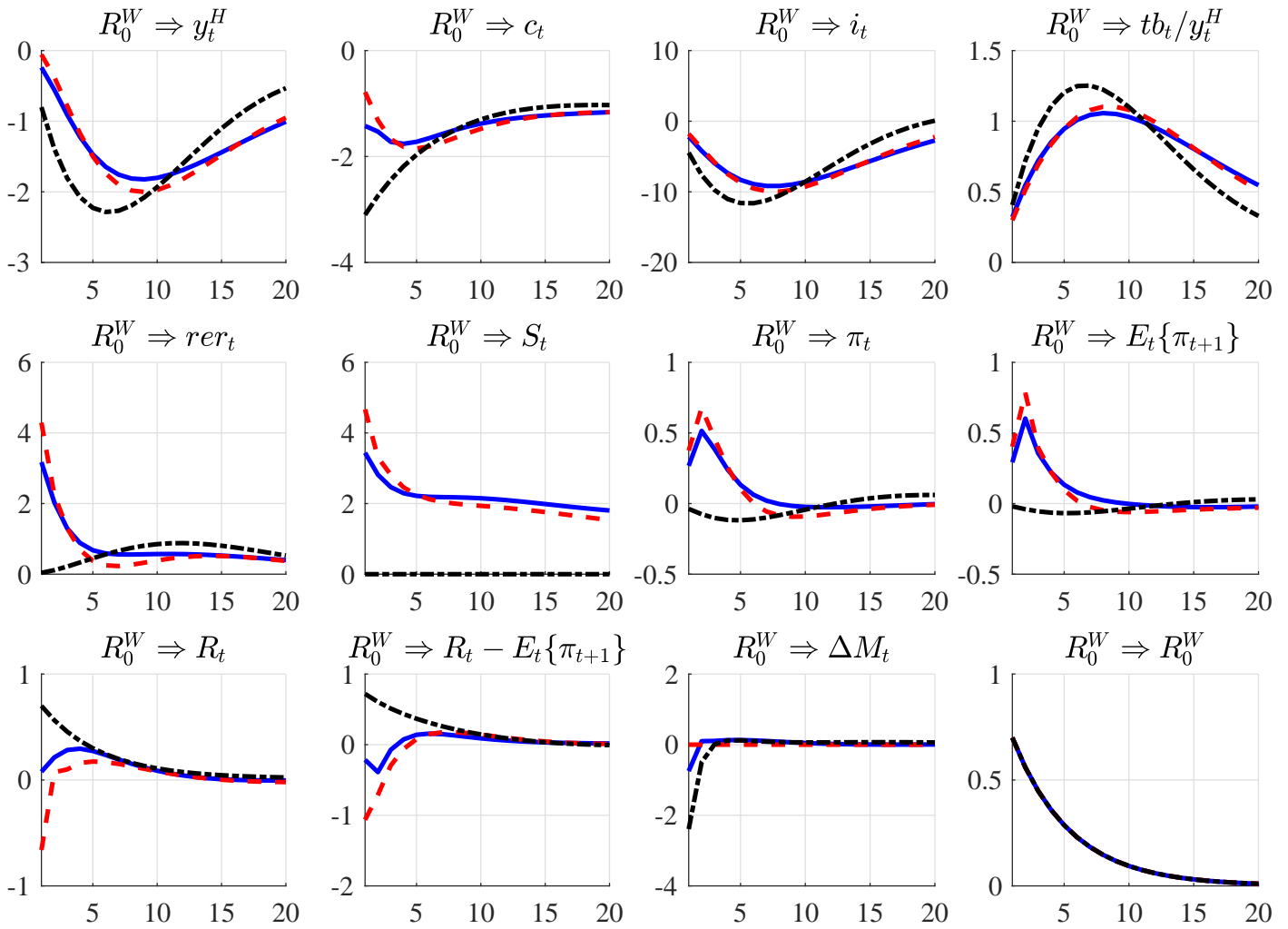


Figure 14: Alternative Instruments with Banks. Rational Expectations.

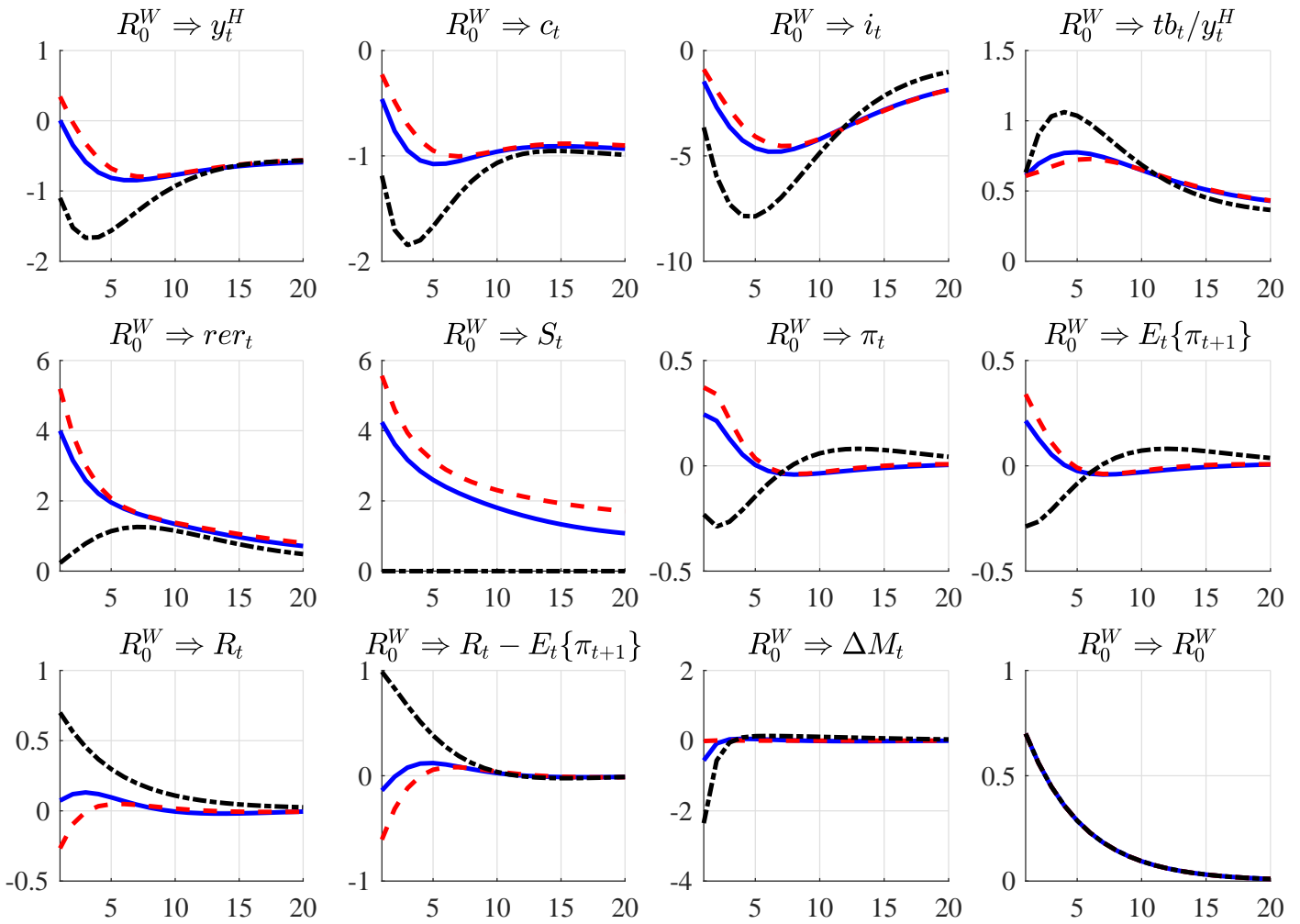


Figure 15: Alternative Instruments with Banks. Imperfect Credibility with  $K_S = 0$ .

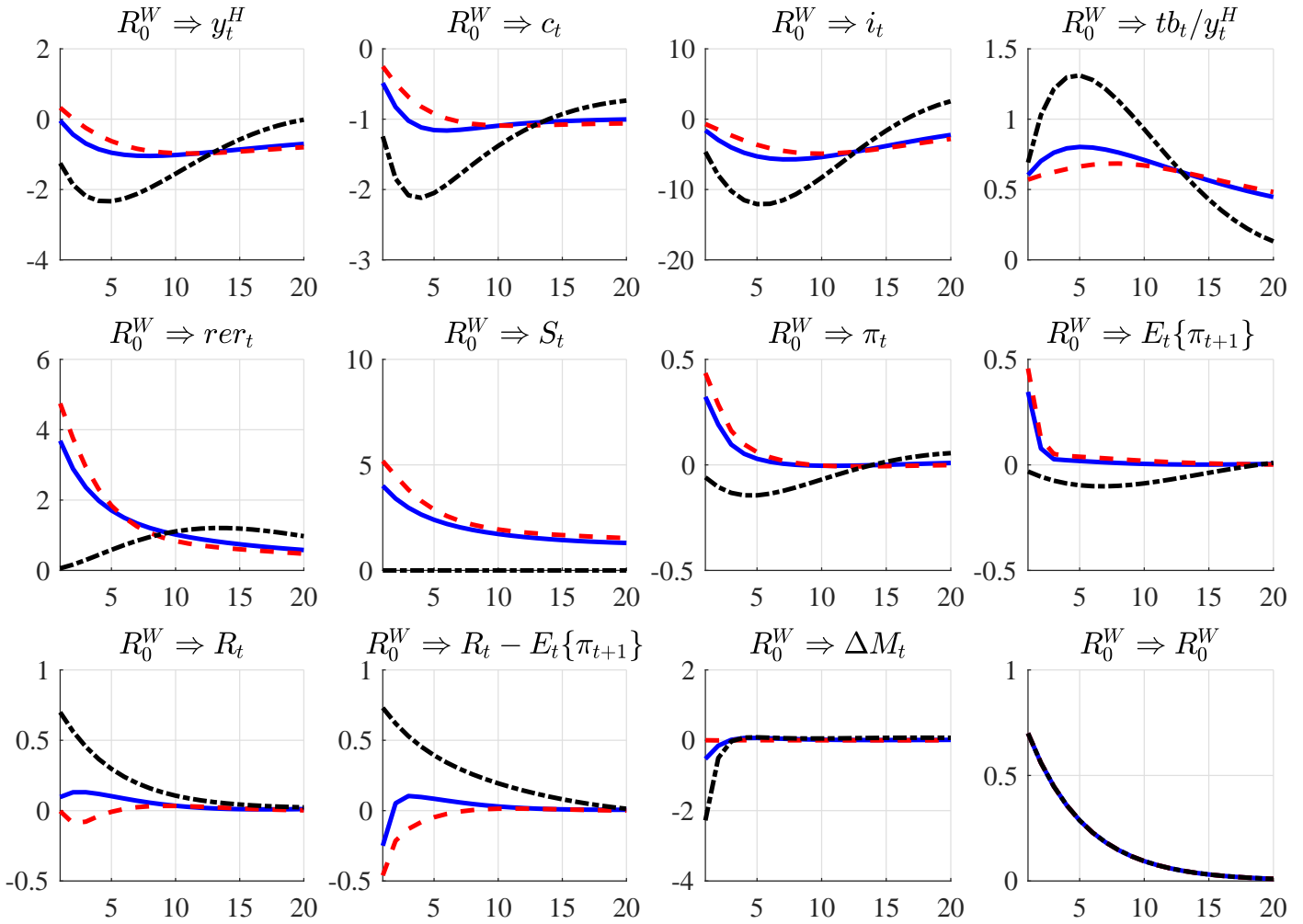


Figure 16: Alternative Instruments with Banks. Imperfect Credibility with  $K_S = 0.2$ .

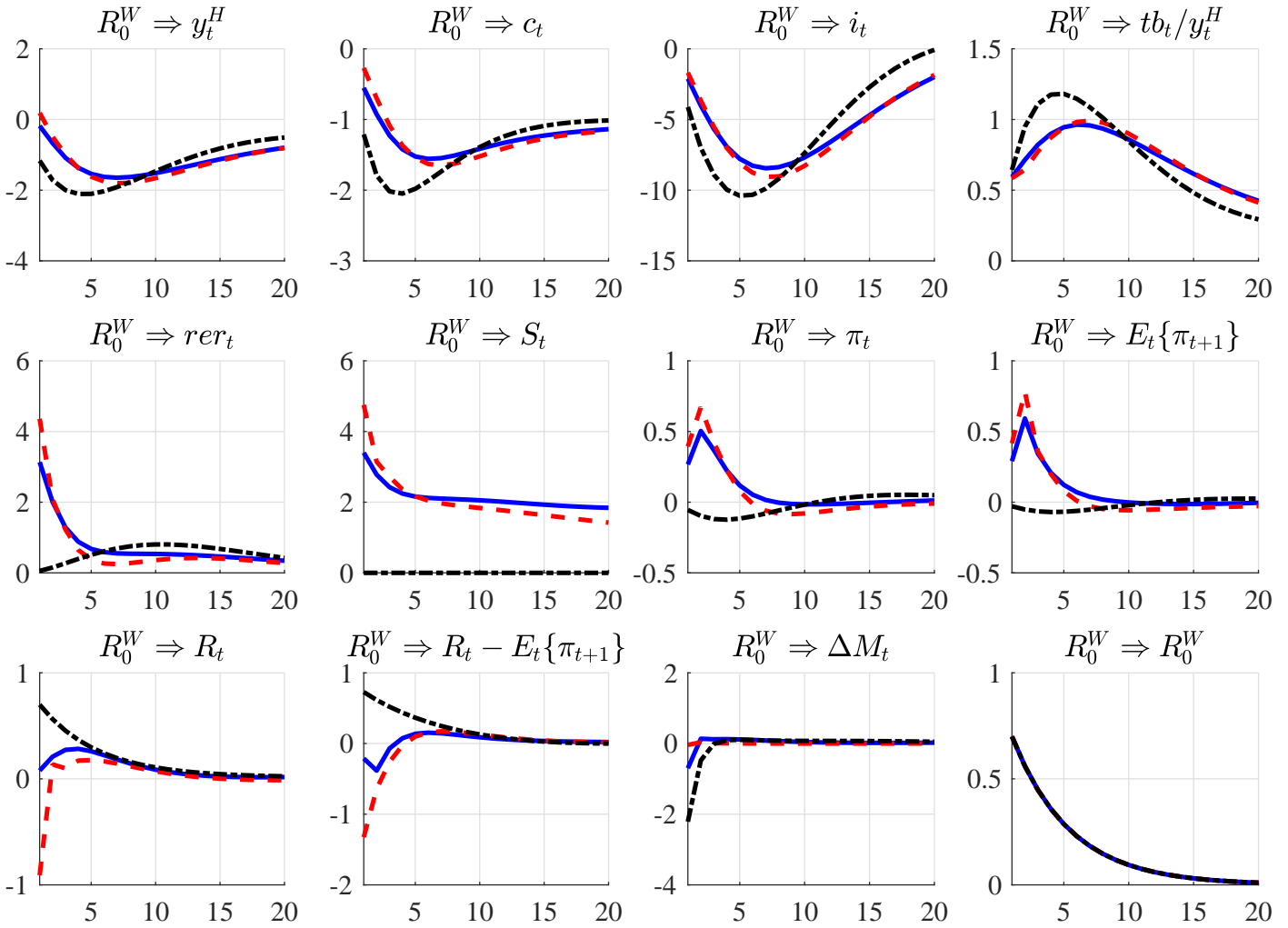


Figure 17: Alternative Instruments with Constrained Agents. Rational Expectations.

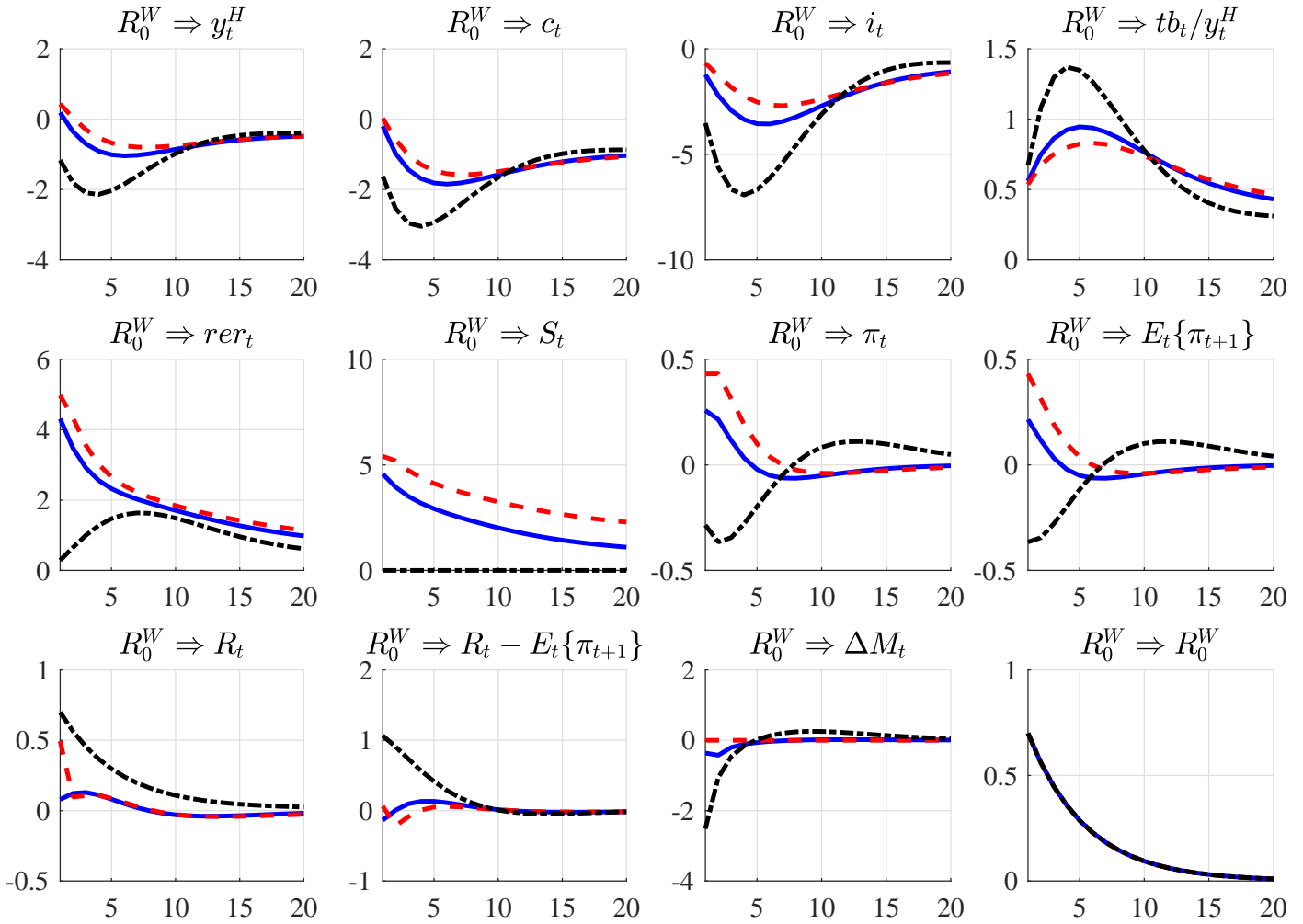


Figure 18: Alternative Instruments with Constrained Agents. Imperfect Credibility with  $K_S = 0$ .

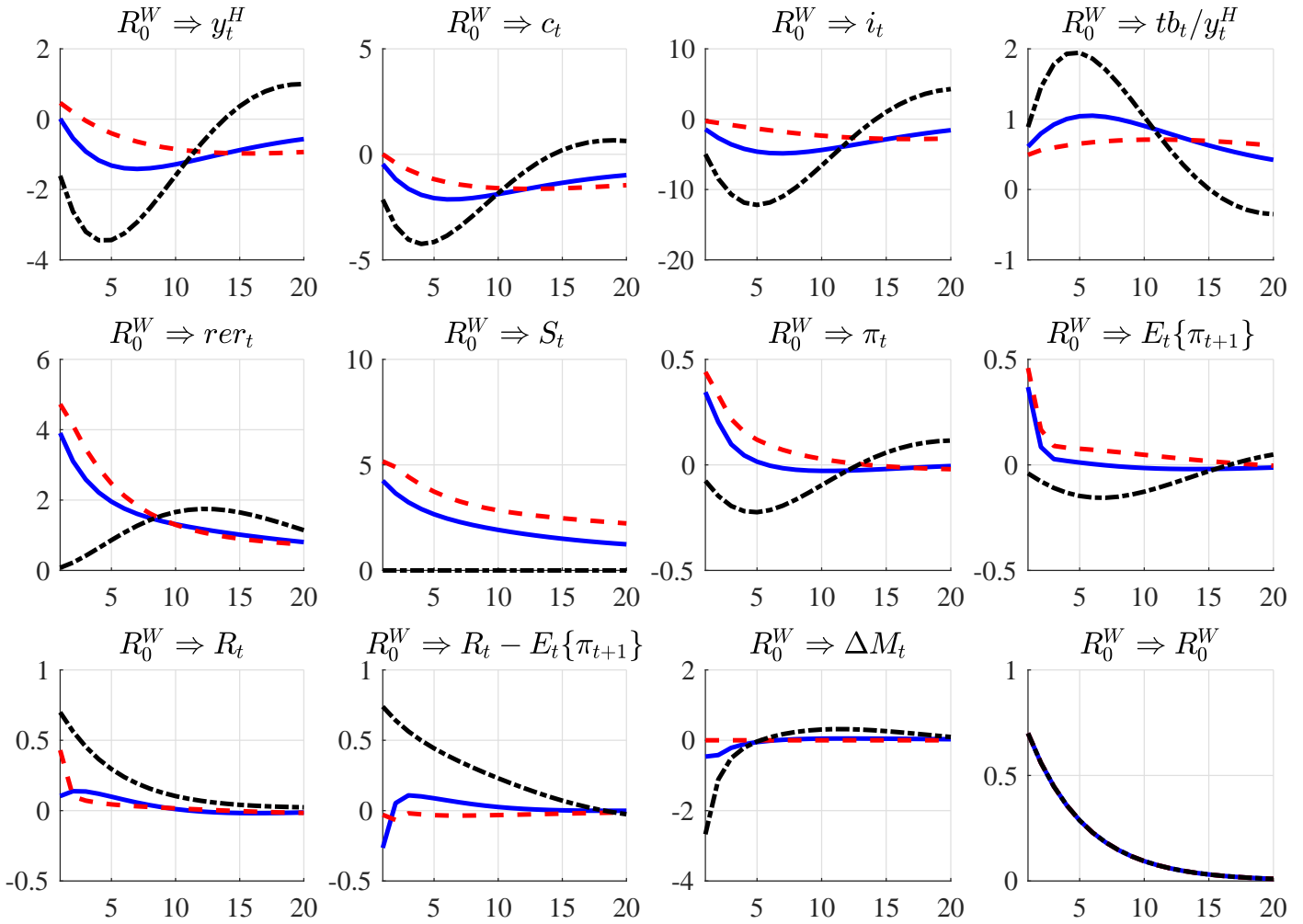


Figure 19: Alternative Instruments with Constrained Agents. Imperfect Credibility with  $K_S = 0.2$ .

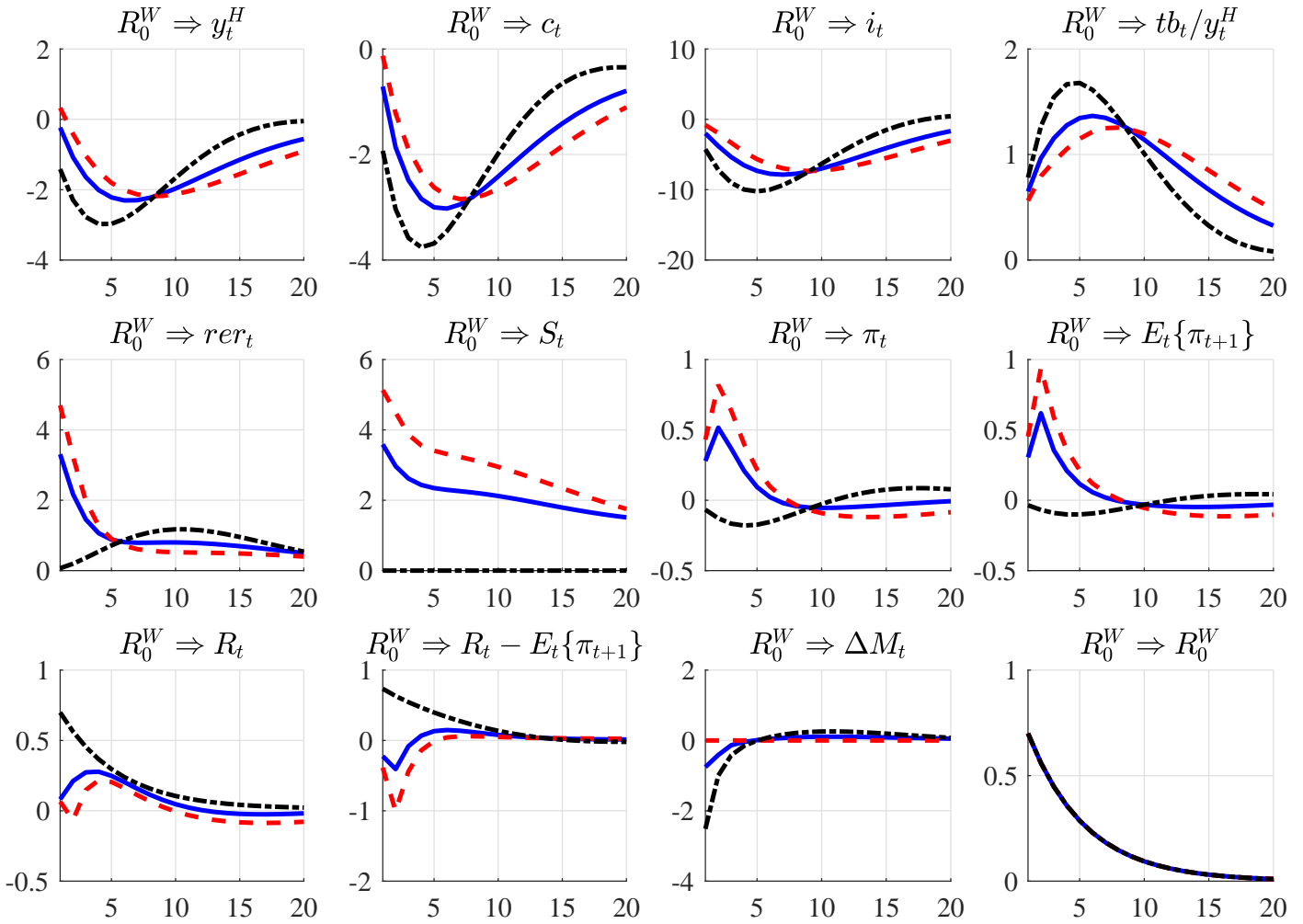


Figure 20: Alternative Instruments In Full Model. Rational Expectations.

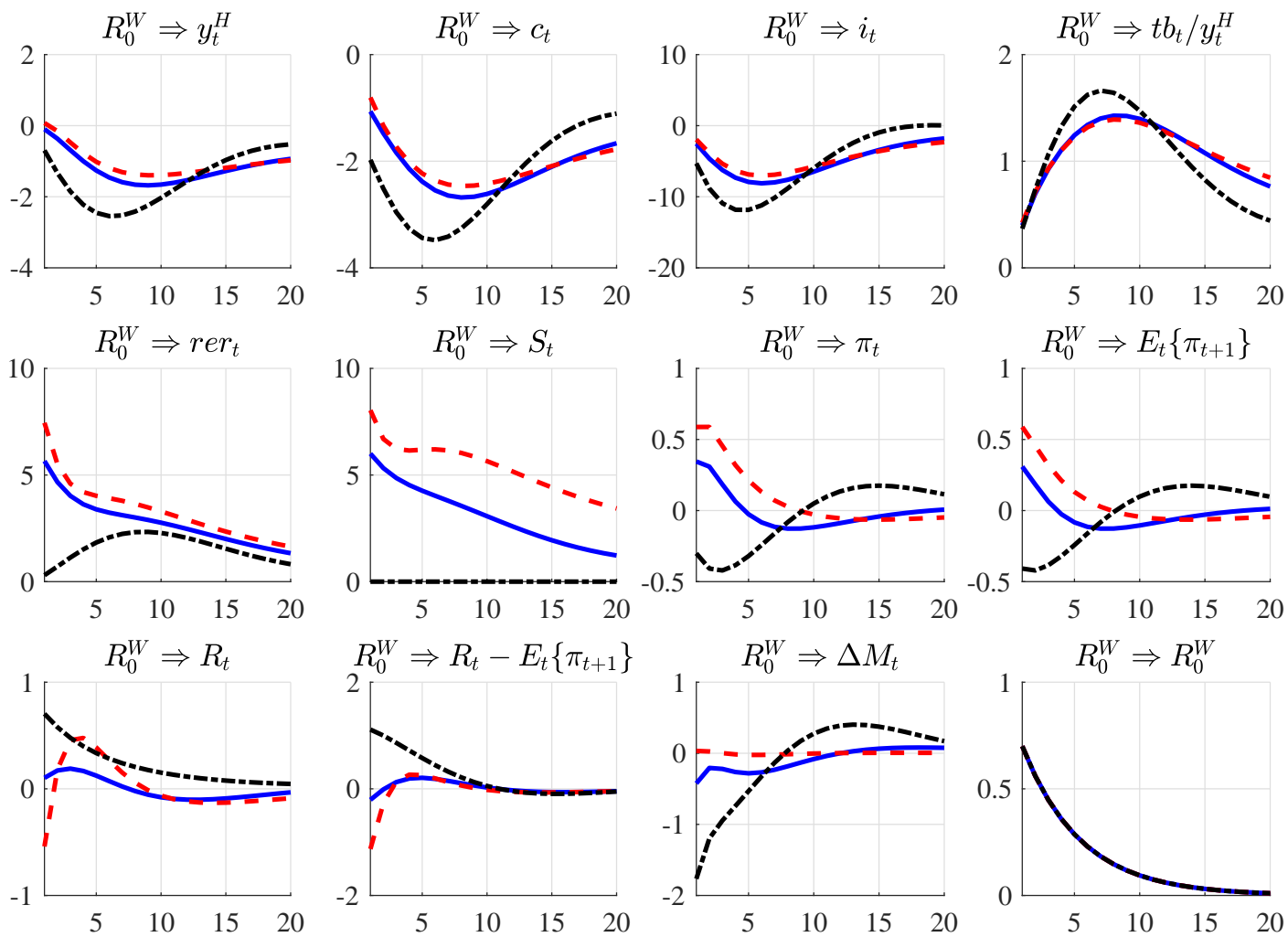




Figure 21: Alternative Instruments In Full Model. Imperfect Credibility with  $K_S = 0$ .

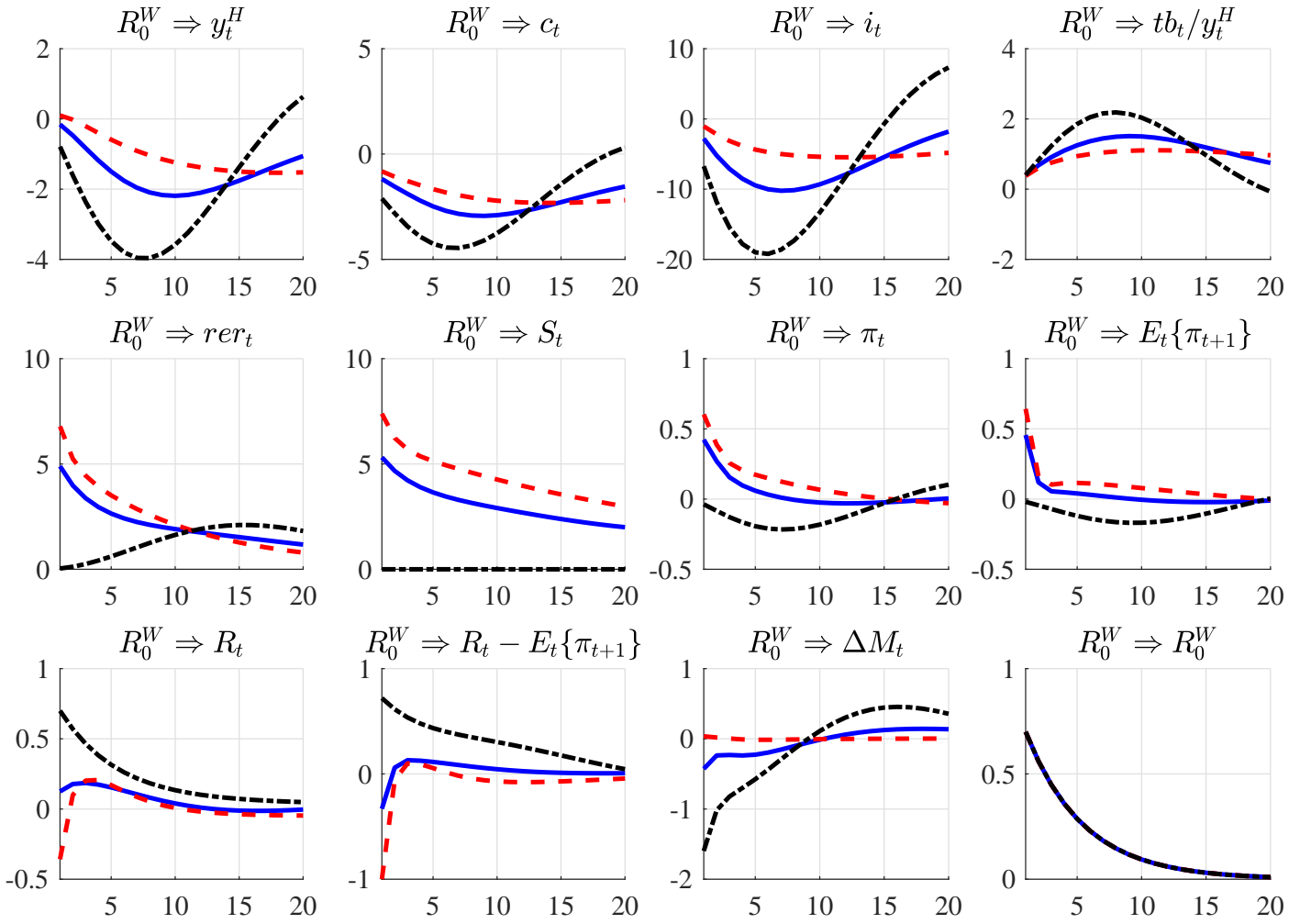


Figure 22: Alternative Instruments In Full Model. Imperfect Credibility with  $K_S = 0.2$ .

