

Demand Imbalances, Exchange Rate Misalignment and Monetary Policy¹

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Abstract

In standard open macro models with incomplete markets, monetary policy geared towards price stability may result in (rather than correcting) misalignments in important asset prices like the exchange rate, even when the latter only reflects fundamental-based valuation. We discuss instances in which optimal monetary policy redresses these inefficiencies, achieving significant welfare gains relative to price stability. These gains are obtained by leaning against an over- or under-valued exchange rate, associated with suboptimal cross-country demand and current account imbalances, consistent with flexible inflation targeting.

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1 Introduction

Concerns about real exchange rate misalignments and cross-country demand imbalances are recurrent in the policy debate on business cycle stabilization, reflecting the importance of exchange rates in their dual roles as relative price in the goods markets, and asset price in financial markets. Such concerns are often at the top of the policy agenda, motivating calls for redirecting monetary policy towards correcting exchange rate swings or excessive volatility — and raising analytical and quantitative issues in possible policy trade-offs between stabilizing output gap and prices, and stabilizing international prices. The literature has indeed addressed these issues stressing different distortions that may potentially lead to real exchange rate misalignments. However, the bulk of the recent monetary open-economy literature has focused on the role of nominal price distortions and emphasized the effects of exchange rate misalignment on the relative price of goods (see among others Benigno and Benigno [2003], Clarida, Gali and Gertler [2002], Devereux and Engel [2003], Corsetti and Pesenti [2005] and Gali and Monacelli [2005]). A comparatively small number of contributions have looked at the implications for monetary policy of misalignments that arise from the dual role of the exchange rate in goods and asset markets — a point recently stressed by Devereux and Engel [2006, 2007].²

The contribution of this paper is to study real exchange rate misalignments arising from this dual role in incomplete markets economies.³ This class of misalignments would lead to inefficiencies (relative to the first best allocation) even in an economy with flexible prices. Specifically, while the exchange rate acts as a “shock absorber” in response to fundamentals, it triggers inefficient adjustment in consumption and employment (see e.g. Devereux [2004]). Being related to frictions in financial markets, our class of misalignments also gives rise to cross-country (relative) demand imbalances, reflecting suboptimal wealth effects in the global allocation.⁴ Domestic and international inefficiencies potentially create trade-offs among different objectives relevant to the design of optimal stabilization policies.

To emphasize the relevance of incomplete markets distortions, we study a version of the economy analyzed by Devereux and Engel [2006, 2007] (henceforth DE), who consider real exchange rate misalignments in response to *anticipated* technology (news) shocks, thus high-

²An incomplete list of papers — further discussed below — includes Devereux [2004], Benigno [2008], Bergin and Tchakarov [2003], Kollmann [2003].

³In this respect, the gist of our analysis is similar to Allen and Gale [2000], who also look at the effects of financial markets distortions on misalignment of asset prices, and explore relevant policy trade-offs.

⁴In an efficient equilibrium, it is well known that the marginal utility of wealth should be equalized across agents in purchasing power terms (see Gravelle and Rees [1992]). Under standard assumptions on preferences, this implies that consumption should be higher for the agent whose basket’s price is lower. Therefore, as further discussed below, the gap between national marginal utilities in purchasing power parity terms provides a natural welfare-based measure of cross-country wealth and demand imbalances.

lighting the forward-looking nature of exchange rate determination.⁵ With a complete set of Arrow-Debreu securities — the case studied by DE — goods price stabilization, the same monetary policy that would be optimal in the face of standard, unanticipated technology shocks, is also optimal in response to news shocks. As already pointed out by Benigno [2007], this is true whether pricing decisions are staggered or not. With news shocks, however, optimal policy has the further implication of entailing complete exchange rate stabilization in the face of news, until the anticipated technology change materializes. Thus, in the DE economy, under the optimal policy there is no trade-off between exchange rate and price stabilization.

Drawing on our previous work (Corsetti et al. [2008], henceforth CDL), we analyze optimal cooperative monetary policy in bond economies parameterized with large home bias in consumption, for a trade elasticity sufficiently distant, on either side, from the unity case analyzed by DE, i.e., for a relatively high or a relatively low trade elasticity.⁶ This insures that, irrespective of nominal rigidities, misalignments materialize in (potentially large) real exchange rates responses to shocks that have the opposite sign relative to that in the efficient allocation.

These misalignments exacerbate cross-country demand imbalances, expressed in terms of the gap between marginal utility differentials and the real exchange rate — the relevant welfare measure of demand imbalances in multi-agent economies.⁷ Such a gap, which we dub “relative demand” gap, is identically equal to zero in an efficient allocation; however it becomes positive when Home consumption demand is excessive (relative to the efficient allocation) at the current real exchange rate, i.e. at the current relative price of consumption.

In our economies, as domestic consumption grows relative to the foreign one, the domestic currency appreciates in real terms, resulting in an inefficient trade balance deterioration. Notably, a positive association between good news on future output growth and dollar appreciation is consistent with the evidence provided by several studies documenting that positive surprises about the US business cycle tend to strengthen the US currency, negative ones to weaken it — e.g., see Andersen et al. [2003] and the recent survey by Engel et al. [2007].

We model nominal price rigidities with the Calvo mechanism — the standard way to capture forward-looking staggered pricing decisions — under alternative assumptions regarding

⁵The interest in anticipated shocks is based on the wealth of empirical evidence on the significant reaction of exchange rates to news (see e.g. the survey in Engel et al. [2007]). Here, we follow DE and do not attempt to fit the evidence on the effects of news shocks, as documented in Beaudry and Portier [2005] and Beaudry et al. [2008].

⁶In two-country models where national goods are imperfect substitutes for each other, and preferences have symmetric home bias, a unit elasticity of substitution implies that terms of trade movements ensure efficient risk sharing (see Cole and Obstfeld 1991).

⁷For the definition and analysis of this gap in the framework of a choice theoretic model of portfolio diversification in general equilibrium, see Viani [2009].

export pricing. Specifically, we assume that these prices are sticky either in the currency of the producer (producer currency pricing PCP) or in the currency of the market of destination (local currency pricing LCP).

Our main results are as follows. Starting with the case of a high trade elasticity economy, we find that the optimal monetary policy under cooperation brings about an allocation arbitrarily close to that prevailing under domestic production price stability in the case of PCP, and domestic CPI stability in the case of LCP. This finding appears in line with DE, but the reason is quite different: rather than resulting from the absence of trade-offs among competing objectives, price stabilization is optimally brought about at the cost of not redressing the exchange rate misalignment. In the high-elasticity economy, the welfare consequences of the misalignment and the associated demand gaps — both domestic and international — are not large enough to warrant significant deviations of optimal monetary policy from the objective of price stability.

However, this conclusion changes drastically when we look at the case of a low trade elasticity. Under price stability, misalignments are now sizable (in addition to having the wrong sign) and reflected in large deviations of consumption and employment from their efficient levels, both domestically and across countries. Ramsey monetary policy significantly improves over price stability, particularly under LCP, getting close to the first-best allocation. This outcome is achieved by a joint monetary policy stance across countries which leans against the real exchange rate misalignment, up to the point of restoring the right response — in terms of sign and magnitude — of international relative prices to news shocks. The optimal policy then results in a drastic reduction of domestic and cross-country demand imbalances, even improving upon the flex-price (but incomplete-market) allocation. Relative to such allocation, the optimal policy narrows the inefficiently large trade imbalances — it actually reverses the sign of net trade flows across countries.

Relative to the analysis in DE, our study provides examples of standard economies in which monetary policy geared towards price stability results in (rather than correcting) significant misalignments in important asset prices like the exchange rate, even when the latter only reflects fundamental-based valuations. Monetary policy can redress these inefficiencies and achieve large welfare gains relative to price stability, leaning against an over- or undervalued exchange rate, associated with suboptimal demand and current account imbalances. Remarkably, welfare gains remain appreciable even when the optimal cooperative policy is replaced by simple rules, relating the current interest rate to current inflation and the rate of exchange rate depreciation. In this respect, our results provide an argument in favor of flexible inflation targeting, with some weight placed on exchange rate movements.

Besides Devereux and Engel [2007], our paper is related to a number of contributions studying optimal monetary policy in two-country models with incomplete financial markets

and standard technology shocks.⁸ Devereux and Sutherland [2007] study a setting similar to ours but in which markets are effectively complete under flexible prices and no random element in monetary policy, finding that price stability also attains the efficient allocation. Kollmann [2003] and Bergin and Tchakarov [2003] both study optimized simple rules in economies with incomplete markets distortions which are independent of nominal frictions. In the former paper, as exchange rate volatility is driven by exogenous shocks to the model’s UIP relation, a policy of complete currency stabilization that eliminates these shocks would be optimal for very open economies, but not for the kind of relatively less open economies we study. In the latter paper, optimized cooperative rules would virtually eliminate exchange rate fluctuations when the only internationally traded asset is a bond denominated in either country’s currency, reflecting asymmetries in net foreign asset holdings in the *stochastic* steady state.

Finally, most closely related to our work are papers by Devereux [2004] and Benigno [2001,2008]. The former provides an example of economies under financial autarky in which, although the exchange rate acts as a perfect ‘shock absorber’ in face of demand shocks, it may in fact be better to prevent exchange rate adjustment altogether. This is because, with incomplete international financial markets, the flexible price allocation is inefficient. Benigno [2008] finds large gains accruing from Ramsey cooperative policies, relative to price stability under PCP, in economies with assumed asymmetries in net foreign asset holdings in the non-stochastic steady state. In addition, the unpublished version of this paper, Benigno [2001], characterizes welfare differences between Ramsey cooperative policies and price stability in economies with no steady state asymmetries. In contrast to our work, however, the focus is on economies in which PPP deviations are ruled out, thus limiting by construction the analysis of real misalignments at the core of our framework.

The rest of the paper is organized as follows. The next section presents our stylized 2-country economy, while Section 3 describes the parameterization we use throughout our exercises. The latter are reported in Section 4 and 5. In Section 4 we set the stage of our analysis looking at allocations without nominal rigidities. In Section 5 we introduce sticky price and sharply focus on monetary policy. Concluding observations are offered in Section 5.

2 The model economy

The world economy consists of two countries of equal size, H and F . Each country specializes in one type of tradable good, produced in a number of varieties or brands defined over a

⁸Other contributions have looked at similar issues in a small open economy framework — see e.g. De Paoli [2009].

continuum of unit mass. Brands of tradable goods are indexed by $h \in [0, 1]$ in the Home country and $f \in [0, 1]$ in the Foreign country. Firms producing the goods are monopolistic supplier of one brand only and use labor as the only input to production. These firms set prices either in local or producer currency units and in a staggered fashion as in Calvo [1983]. Assets markets are complete at the national level, but incomplete internationally.

In what follows, we describe our set up focusing on the Home country, with the understanding that similar expressions also characterize the Foreign economy — variables referred to Foreign firms and households are marked with an asterisk.

2.1 The Household's Problem

2.1.1 Preferences

We consider a cashless economy in which the representative Home agent maximizes the expected value of her lifetime utility given by:

$$\mathbb{W}_0 = E \left\{ \sum_{t=0}^{\infty} U [C_t, L_t] \exp \left[\sum_{\tau=0}^{t-1} -\nu (C_t, L_t) \right] \right\} \quad (1)$$

where instantaneous utility U is a function of a consumption index, C , and leisure, $(1 - L)$. Following Schmitt-Grohé and Uribe [2003], we assume an endogenous discount factor $\nu (C_t, L_t)$ which is a function of the average per capita level of consumption, C_t , and hours worked, L_t . Foreign agents' preferences are symmetrically defined. It can be shown that, for all parameter values used in the quantitative analysis below, these preferences guarantee the presence of a locally unique symmetric steady state, independent of initial conditions.⁹

Households consume both domestically produced and imported goods. We define $C_t(h)$ as the Home agent's consumption as of time t of the Home good h ; similarly, $C_t(f)$ is the Home agent's consumption of the imported good f . We assume that each good h (or f) is an imperfect substitute for all other goods' varieties, with constant elasticity of substitution $\eta > 1$:

$$C_{H,t} \equiv \left[\int_0^1 C_t(h)^{\frac{\eta-1}{\eta}} dh \right]^{\frac{\eta}{\eta-1}}, \quad C_{F,t} \equiv \left[\int_0^1 C_t(f)^{\frac{\eta-1}{\eta}} df \right]^{\frac{\eta}{\eta-1}},$$

The full consumption basket, C_t , in each country, aggregates Home and Foreign goods according to the following standard CES function:

$$C_t \equiv \left[a_H^{1-\phi} C_{H,t}^\phi + a_F^{1-\phi} C_{F,t}^\phi \right]^{\frac{1}{\phi}}, \quad \phi < 1, \quad (2)$$

⁹A unique invariant distribution of wealth under these preferences will allow us to use standard numerical techniques to solve the model around a stable nonstochastic steady state when only a non-contingent bond is traded internationally (see Obstfeld [1990], Mendoza [1991], and Schmitt-Grohe and Uribe [2003]).

where a_H and a_F are the weights on the consumption of Home and Foreign traded goods, respectively and $\omega = \frac{1}{1-\phi}$ is the constant (trade) elasticity of substitution between $C_{H,t}$ and $C_{F,t}$.

The price index of the Home goods is given by:

$$P_{H,t} = \left[\int_0^1 P_t(h)^{1-\eta} dh \right]^{\frac{1}{1-\eta}},$$

and the price index associated with the consumption basket, C_t , is:

$$\mathbb{P}_t = \left[a_H P_{H,t}^{\frac{\phi}{\phi-1}} + a_F P_{F,t}^{\frac{\phi}{\phi-1}} \right]^{\frac{\phi-1}{\phi}}.$$

Let \mathcal{E}_t denote the Home nominal exchange rate, expressed in units of Home currency per unit of Foreign currency. The real exchange rate (RER) is customarily defined as the ratio of CPIs' expressed in the same currency, i.e. $\frac{\mathcal{E}_t \mathbb{P}_t^*}{\mathbb{P}_t}$. The terms of trade (TOT) are instead defined as the relative price of domestic imports in terms of exports: $\frac{P_{F,t}}{\mathcal{E}_t P_{H,t}^*}$ if firms set prices in local currency and $\frac{\mathcal{E}_t P_{F,t}^*}{P_{H,t}}$ under producer currency pricing. .

2.1.2 Budget constraints and asset markets

Home and Foreign agents trade an international bond, B_H , which pays in units of Home currency and is zero in net supply. Households derive income from working, $W_t L_t$, from domestic firms' profits, $\Pi(h)$, and from interest payments, $(1+i_t)B_{H,t}$, where i_t is the nominal bond's yield, paid at the beginning of period t but known at time $t-1$. Households use their disposable income to consume and invest in state-contingent assets. The individual flow budget constraint for the representative agent j in the Home country is therefore:

$$P_{H,t} C_{H,t} + P_{F,t} C_{F,t} + B_{H,t+1} \leq W_t L_t + (1+i_t) B_{H,t} + \int_0^1 \Pi(h) dh. \quad (3)$$

The household's problem thus consists of maximizing lifetime utility, defined by (1), subject to the constraint (3).

The above asset market structure — although restrictive — still implies that exchange rate determination is forward-looking, reflecting equilibrium in financial markets, while capturing the notion that international financial markets do not provide efficient risk insurance against all shocks.¹⁰

¹⁰Obviously, in a standard setting of only two-agents and two shocks, asset markets could be effectively

2.2 Firms

Firms employ domestic labor to produce a differentiated product h according to the following linear production function:

$$Y(h) = ZL(h),$$

where $L(h)$ is the demand for labor by the producer of the good h and Z is a technology shock common to all producers in the Home country, which follows a statistical process to be specified below.

We first assume that firms can set prices in local currencies. Firms are subject to nominal rigidities à la Calvo so that, at any time t , they keep their price fixed with probability θ . We assume that when firms update their prices, they do so simultaneously in the Home and in the Foreign market, in the respective currencies. The maximization problem is then as follows:

$$\text{Max}_{\mathcal{P}(h), \mathcal{P}^*(h)} E_t \left\{ \sum_{k=0}^{\infty} p_{bt,t+k} \theta^k \left(\frac{[\mathcal{P}_t(h)D_{t+k}(h) + \mathcal{E}_t \mathcal{P}_t^*(h)D_{t+k}^*(h)] - MC_{t+k}(h) [D_{t+k}(h) + D_{t+k}^*(h)]}{MC_{t+k}(h) [D_{t+k}(h) + D_{t+k}^*(h)]} \right) \right\} \quad (4)$$

where $p_{bt,t+k}$ is the firm's stochastic nominal discount factor between t and $t+k$ and the firm's demand at Home and abroad is given by:

$$\begin{aligned} D_t(h) &= \int \left(\frac{\mathcal{P}_t(h)}{P_{H,t}} \right)^{-\eta} C_{H,t} dh \\ D_t^*(h) &= \int \left(\frac{\mathcal{P}_t^*(h)}{P_{H,t}^*} \right)^{-\eta} C_{H,t}^* dh \end{aligned}$$

In these expressions, $P_{H,t}$ and $P_{H,t}^*$ denote the price index of industry h and of Home goods, respectively, in the Foreign country, expressed in Foreign currency.

By the first order condition of the producer's problem, the optimal price $\mathcal{P}_t(h)$ in domestic currency charged to domestic customers is:

$$\mathcal{P}_t(h) = \frac{\eta}{\eta - 1} \frac{E_t \sum_{k=0}^{\infty} \theta^k p_{bt,t+k} D_{t+k}(h) MC_{t+k}(h)}{E_t \sum_{k=0}^{\infty} \theta^k p_{bt,t+k} D_{t+k}(h)}; \quad (5)$$

but counterfactually completed with a marginal increase in the number of internationally traded securities. Indeed, developing less stark theoretical frameworks for modelling open economies with incomplete markets amenable to study monetary policy design is a key direction for future research (see e.g. Dedola and Lombardo [2009]).

while the price (in foreign currency) charged to customers in the foreign country is:

$$\mathcal{P}_t^*(h) = \frac{\eta}{\eta - 1} \frac{E_t \sum_{k=0}^{\infty} \theta^k p_{bt,t+k} D_{t+k}^*(h) MC_{t+k}(h)}{E_t \sum_{k=0}^{\infty} \theta^k p_{bt,t+k} \mathcal{E}_{t+k} D_{t+k}^*(h)}.$$

Alternatively, we also posit that firms set prices in producer currency, so that the price charged to foreign consumers is a function of the optimal Home price and the exchange rate via the law of one price: $\mathcal{P}_t^*(h) = \frac{P_t(h)}{\mathcal{E}_t}$.

Since all the producers that can choose their price set it to the same value, we obtain the following equations for $P_{H,t}$ and $P_{H,t}^*$

$$\begin{aligned} P_{H,t}^{1-\eta} &= \alpha P_{H,t-1}^{1-\eta} + (1 - \theta) \mathcal{P}_t(h)^{1-\eta}, \\ P_{H,t}^{*1-\eta} &= \alpha P_{H,t-1}^{*1-\eta} + (1 - \theta) \mathcal{P}_t^*(h)^{1-\eta}. \end{aligned}$$

Similar relations hold for the Foreign firms.

3 Calibration and solution methods

This section describes the parameterization for our numerical experiments, which we assume symmetric across countries. Table 1 below presents a summary of the parameters values we pick.

Preferences and production We posit that the period-by-period utility function has the following form:

$$U[C_t, L_t] = \frac{C_t^{1-\sigma}}{1-\sigma} + \kappa \frac{(1-L_t)^{1-v}}{1-v}, \quad \sigma > 0. \quad (6)$$

where κ is set so that in steady state, one third of the time endowment is spent working. In our benchmark calibration, we assume v equal to σ (risk aversion), which we in turn set to 2. Following Schmitt-Grohe and Uribe [2003], the endogenous discount factor depends on the average per capita level of consumption, C_t , and hours worked, L_t , and has the following form:

$$\nu(C_t, L) = \ln(1 + \psi [C_t + \kappa(1 - L)]), \quad (7)$$

whereas ψ is chosen such that the steady-state real interest rate is 1 percent per quarter, i.e. equal to 0.006. This parameter also pins down the (very low) speed of convergence to the nonstochastic steady state.

The weights of domestic and foreign tradables in the consumption basket, a_H and a_F (normalized $a_H + a_F = 1$) are set such that imports are 10 percent of aggregate output in steady state, roughly in line with the average ratio for the U.S. in the last 30 years. As benchmark, we set the average frequency with which firms update their prices to 4 quarters. We set the constant elasticity of substitution across brands η equal to 6, so that the markup of downstream firms in steady state is 20 percent.

In our analysis of policy trade-offs, the sign and size of misalignments arising from incomplete markets relative to other inefficiencies in the economy will be crucial for our results. Drawing on CDL, we know that the response of international relative price to productivity shocks has the wrong sign — relative to the efficient allocation — when shocks are fairly persistent, and the trade elasticity is sufficiently different from unity (the Cobb-Douglas case). In light of these results, we either calibrate the elasticity of substitution ω to .45, corresponding to estimates from the macro literature, if only towards the low end, or equal to 6, based on estimates in the trade literature. These different values for the elasticity of substitution between Home and Foreign goods imply different magnitudes in the response of relative prices — movements in the real exchange rate and the terms of trade will be larger in the economy where the trade elasticity is lower.

Shocks Let the vector $\mathbf{Z} \equiv \{Z, Z^*\}$ represent the level of productivity in the domestic and foreign economies. Following Ferrero et al [2008], we assume that technology is composed of two processes, \mathbf{U}_t and \mathbf{V}_t :

$$\mathbf{Z}_t = \mathbf{U}_t - \mathbf{V}_t, \tag{8}$$

with

$$\mathbf{U}_t = \rho_u \mathbf{U}_{t-1} + \xi_t + \xi_{u,t}$$

$$\mathbf{V}_t = \rho_v \mathbf{V}_{t-1} + \xi_t$$

where $\rho_u > \rho_v$ and where ξ_t and $\xi_{u,t}$ are zero mean *i.i.d.* shocks. The process U with innovations ξ_u captures standard autoregressive technology shocks. In line with most of the international business cycle literature, we assume that this process is quite persistent, and set its autocorrelation $\rho_u = 0.95$. The standard deviation of the innovations $\xi_{u,t}$ is normalized to 0.01. The process V_t with innovation ξ_t is instead introduced to capture the idea of “news shocks.” To wit: starting at a steady state with $U_{t-1} = V_{t-1} = 0$, a positive innovation in ξ_t has no direct effect on the level of productivity Z_t in the first period. However, with $\rho_u > \rho_v$, the shock will affect its expected growth rate, as Z_t will grow steadily for some time. We model a relatively slow diffusion of news shocks, setting $\rho_v = 0.9$. The standard deviation of ξ_t is set to $\sqrt{.02}$, so that the unconditional variance of Z_t would be equal to that emerging with only the standard technology shock $\xi_{u,t}$. Figure 1 contrasts the one standard deviation

shocks for the conventional autoregressive shock and for our news shock. Observe that, in the latter, productivity peaks after over four years, and rises above its counterpart under the conventional process after full 6 years.

In our experiments, we will focus on the case in which $\xi_{u,t}$ is set always to zero, yielding an economy with only news shocks. Since we assume a symmetric economic structure across countries, we also impose symmetry on the autocorrelation and variance-covariance matrices of the above process across countries. For simplicity, we set the shock correlation and the spillovers across countries to zero.

As emphasized by DE, an important reason to focus on news shocks is that of highlighting the forward-looking nature of exchange rate determination. In our incomplete market setting, an additional reason is that, with news shock, the underlying change in productivity is naturally thought as being quite persistent. As already mentioned, this is a well-known necessary condition to make allocations with incomplete markets sufficiently different from their complete markets counterparts.

Monetary policy and welfare comparisons To characterize the optimal monetary policy, we let the planner choose allocations in the Home and Foreign economies, to maximize the world welfare subject to the first-order conditions for households and firms and the economy-wide resource constraints. We assume that the planner places equal weights on the discounted sum of Home and Foreign expected utilities, so that world welfare is given by the following expression:

$$Welfare = \frac{W_0 + W_0^*}{2}.$$

Our welfare measure is conditional, in the sense that it takes into account the transition dynamics from the initial non-stochastic steady state. Note that in our welfare calculations, we assume that the discount factor is constant in the above world welfare function. As it is standard in the literature (see Woodford [2003]), we follow an approach similar to that in Khan, King, and Wolman [2003] and consider an optimal policy that has been in place for a long enough time that initial conditions do not matter. In describing our results, we also compare the optimal policy to other well-known policy rules. To compute a first and second order approximation to such a policy we used the “*Get Ramsey*” algorithm developed by Levine and Lopez-Salido [200x]. To find the welfare cost of following suboptimal monetary policies, we compute the percent loss of steady-state consumption the Home and Foreign agents suffer. Appendix A provides a detailed explanation of welfare costs are computed.

4 Misalignments, demand imbalances and incomplete risk insurance

Our analysis reconsiders misalignments in the standard incomplete-market, intertemporal-trade model, where in reaction to news shocks agents have an incentive to smooth consumption by borrowing and lending in international markets. Under incomplete markets, inefficiencies relative to the first-best allocation are inherent in the dynamics of intertemporal trade, independently of price rigidities. As Home agents react to positive news shocks by borrowing in international markets, an inefficient wedge between domestic and foreign consumption emerges. In addition, with home bias in preferences and a trade elasticity sufficiently different from unity, the surge in domestic demand appreciates the Home currency in real terms, in stark deviations from basic efficiency conditions.

In this section, we set the stage of our analysis by accounting for the implications of exchange rate misalignments due to incomplete markets in economies with no nominal rigidities. Namely, we contrast the complete-markets, flex-prices allocation — our welfare benchmark — with a flex-price allocation where agents can only trade a single short-term bond — our natural-rate benchmark. The responses of selected variables to a news shock in the Home country are shown in Figures 2 and 3 for a high and a low trade elasticity, respectively.

4.1 The efficient allocation benchmark

In the *efficient economy* (complete-market, flex-prices), positive news regarding future home productivity make both home and foreign households feel richer. However, since in the short run there is no change in productivity, labor effort and consumption should not change anywhere in the world economy: the real interest rate must rise in both countries to induce households to postpone their spending plans to the future (when the higher productivity materializes) and prevent a fall in hours worked. Apart from real rates, no other variable, including the real exchange rate and the terms of trade, moves, until home productivity actually increases. This is shown in Figure 2 and 3.

As productivity starts to rise gradually over time, peaking at around 0.4 per cent after 15 quarters, all variables follow the well-known pattern under full risk sharing. Irrespective of the trade elasticities, consumption increases in both countries, with goods flowing from the more to the less productive one. International relative prices of Home goods depreciate; real interest rates are positive but falling, mirroring the rising profile of consumption. An interesting difference between Figure 2 and 3 emerges as regards hours worked. In the case of high elasticity, Hours worked increase in the more productive Home country but fall in the Foreign one; with a low elasticity, instead, because of the implied complementarity

between Home and Foreign goods in consumption, hours fall in the Home economy but remain approximately constant in Foreign country.

The efficient allocation provides the benchmark for defining welfare-relevant gaps in key variables of interest, such as the output gap — a standard measure in monetary theory. For the purpose of our analysis, it is convenient to assess economic inefficiencies defining gaps that are specific to the external dimensions of the economy, specifically the real exchange rate gap, and the relative demand gap, discussed below.

Exchange rates are misaligned when they deviate from the value they would take in the efficient allocation. Thus, we define the real exchange rate gap or RER-gap as follows:

$$RER\text{-gap} = RER - \widetilde{RER}$$

where a tilde denotes the complete-markets, flex price allocation. Analogously, it is useful to define also the terms of trade gap, or TOT-gap:

$$TOT\text{-gap} = TOT - \widetilde{TOT}$$

Because of home-bias in preferences and deviations from the law of one price, the two gaps above can move differently in response to shocks. In addition, the second gap is well defined even in models where PPP holds.

Inefficiencies giving rise to exchange rate misalignments have possible implications for all macroeconomic quantities, at both domestic and international levels. In other words, misalignments are bound to be associated with welfare-relevant gaps in output and demand within each country, as well as in demand across countries. Now, welfare-relevant demand imbalances across countries could be expressed in terms of gaps (relative to the efficient allocation) in the trade balance and the current account. However, theory suggests a measure of imbalances which is more directly and naturally relevant for welfare. This is the Relative Demand Gap, or RD-gap, defined as follows:

$$RD\text{-gap} = \sigma(C - C^*) - RER,$$

where σ is relative risk aversion which we have assumed identical across countries. As is well known (see, e.g., Gravelle and Rees [1992]), the RD-gap is zero in an efficient allocation: across any two (national representative) individuals the marginal utility of consumption should be lower for the one whose consumption is cheaper. This implies that, in a decentralized equilibrium with full consumption risk sharing, the ratio of national consumption across two countries should be proportional to the bilateral CPI-based real exchange rate — see e.g., Backus and Smith [1993] and Obstfeld and Rogoff [2001]. A relative demand imbalance

occurs when this efficiency condition is violated, and the (marginal utility of) consumption ratio is too high (or low) given its relative price.

4.2 The incomplete market natural-rate allocation

The competitive equilibrium with *flexible prices but incomplete markets* defines the natural-rate benchmark for our analysis. The dynamic response to a news shock is determined according to the prescription of the intertemporal trade model of the current account. Home households raise their demand and borrow to smooth consumption in anticipation of future domestic productivity growth, while decreasing labor supply. Due to incomplete markets, however, suboptimal wealth effects across border create a wedge relative to the efficient allocation, also shown in Figures 2 and 3. Specifically, such wedge is positive for Home consumption and Foreign hours — negative for Foreign consumption and Home hours. In addition, as traded goods are not homogeneous, the rise in home demand leads to a lasting appreciation of the home currency in real terms — at the roots of the negative wealth effects abroad.

The misalignment in relative prices is apparent. The real exchange rate not only moves, instead of remaining unchanged, on impact; it also appreciates (for a few quarters with the high elasticity, persistently so with a low elasticity), in sharp contrast with the efficient allocation. Intertemporal trade thus results in a suboptimal current account deficit for the Home country, reflecting the cross-country demand imbalance in consumption.

Observe that, under either calibration of trade elasticities, the response of the real exchange rate to asymmetric news shocks under incomplete markets has the wrong sign relative to the efficient allocation.¹¹ Namely, a rise in Home relative consumption will correspond to an appreciation of the real exchange rate (and an improvement in the terms of trade). Hence the misalignment will tend to magnify the size of the relative demand gap.

Yet, the magnitude of the RER-gap and RD-gap, and therefore the importance of misalignments in policy making, varies across our experiments. Specifically, the value of the trade elasticity has an important quantitative effect on the inefficiencies, affecting the size of the wedges due to wealth effects. As shown in the Figures 2 and 3, both domestic and international wedges relative to the efficient allocation are typically an order of magnitude larger in the case of the low trade elasticity. Correspondingly, the welfare loss, relative to the efficient allocation, amounts to 0.09 percent of steady state consumption in the low elasticity case, against 0.004 percent in the high elasticity case.

¹¹As discussed in CDL, this result would disappear for intermediate values of the trade elasticity, or even for a high elasticity if shocks are not persistent enough.

5 Misalignments and monetary policy trade-offs

Our main interest is to understand whether monetary policy could redress the real exchange rate misalignment and correct the cross-country demand imbalances that arise under incomplete markets. A related question is whether policies geared towards price stability may actually exacerbate misalignments, thus reducing welfare.

In this section, we sharply focus on the policy trade-offs between maintaining price stability, narrowly defined in terms of a constant price index, and correcting domestic and international inefficiencies deriving from misalignments. To this end, we construct economies with nominal frictions in which export prices are sticky either in the currency of producers (PCP), or in the currency of the market of destination (LCP). Following the literature, the target of the central bank when pursuing price stability will be either the GDP deflator, in the case of PCP, or the domestic CPI, in the case of LCP.

In what follows, we will first consider economies with a high trade elasticity, with either PCP or LCP. Then we will repeat the analysis for economies with a low trade elasticity. In each case, we will contrast the equilibrium allocation under a target of strict price-stability and under the optimal policy, both against the benchmark allocation with complete markets and flexible prices.

5.1 A case of near optimality of price stability: High trade elasticity

We begin our analysis with an assessment of the policy trade-offs under incomplete markets for economies characterized by a high trade elasticity, i.e. in which Home and Foreign goods are close substitutes. For the case of PCP, Figure 4 (panel a and b) shows the allocations under product price stability and optimal monetary policy to a news shock in the Home country. All the gaps in panel b of this figure are relative to the efficient allocation. Figure 5, panel a and b, repeats the analysis for the case of LCP.

Economies with high trade elasticity and Producer Currency Pricing. As discussed above, with incomplete markets news shocks create the desire for Home households to raise their consumption and reduce their labor supply on impact, as shown in Figure 4. Consumption smoothing by Home households thus create inflationary pressure at Home and abroad. When policymakers pursue *price stability*, both the Home and the Foreign real interest rate must then rise to stem the pressure on production prices. At an unchanged productivity, the larger demand by home households initially appreciates the Home currency in real terms, as well as the Home terms of trade. Thus, the larger consumption at Home

corresponds, on impact, to less consumption and more hours worked by Foreign households, reflecting the negative wealth effects from terms of trade movements. Initially, the Home country runs an external deficit: inefficiently, goods flow to the country with the higher relative wealth reflecting the better productivity prospects. A few quarters after the shock, nonetheless, higher productivity at home starts to produce benefits also for foreign households: the international price of Home goods fall, consumption is up and hours are down everywhere in the world economy.

Figure 4 highlights striking differences relative to the efficient allocation: Home consumption is too high, and Home hours too low (vice versa for Foreign households), corresponding to the overvaluation of the Home country’s international relative prices. Price stability also implies a negative welfare-relevant output gap at Home, a positive welfare-relevant output gap abroad.

What is the scope for the *optimal policy* to improve upon the price-stability allocation? The inefficiency with price stability consists of the fact that, by targeting domestic product inflation, monetary authorities do not internalize the detrimental wealth effects from exchange rate misalignments on consumption and labor, and let both the real exchange rate gap and the RD-gap grow too large. A policy that intended to improve over such an allocation would trade off price stability for a reduction in the cross-country demand gap, i.e. less consumption at Home, more consumption abroad, and a smaller Home exchange rate appreciation. However, as shown by Figure 4, there is hardly any difference between allocations under the optimal policy and under price stability. As shown in Table 1, the relevant gaps remain substantially unaffected when moving from the latter to the former.

Economies with high trade elasticity and Local Currency Pricing. The case of *LCP* — in which monetary policy is assumed to stabilize CPI inflation rather than producer price inflation — is shown in Figure 5. The response of many variables follow the same pattern discussed for the case of PCP. Under *price stability*, the real interest rates initially increase in both countries, again resulting into a positive differential in favor of the Home country — keep in mind that, with sticky import prices, the rise in Home demand for foreign goods is less attenuated by the depreciation of the exchange rate overtime, as it is the case under PCP. Compared to price stability, the *optimal policy* widens somewhat the interest-rate differential: Home rates increase by more, foreign rates by less. The contained increase in the Foreign interest rate redresses, if only marginally so, the inefficient fall in Foreign consumption. Yet, the optimal policy does not close the misalignments in any meaningful way so that the allocation remains inefficient: Home households consume too much and work too few hours, with the opposite occurring abroad, and the Home real exchange rate is too strong.

As for the case of PCP, a high trade elasticity implies that the scope for monetary policy to improve upon the price stability allocation is very limited. The relevant welfare gaps, shown in Table 2, are the same across policies.

Summing up: in a high trade-elasticity economy with nominal rigidities, under either PCP or LCP the price stability allocation is nearly identical to the corresponding allocation with incomplete markets and flexible prices — away from the efficient allocation. The optimal policy does not significantly redress any of the macroeconomic inefficiencies. The main reason for this result is not the absence, but the size of welfare-relevant trade-offs raised by misalignments and demand imbalances. The inefficiency in these dimensions is small, relative to inefficiencies induced by nominal rigidities. Under the optimal policy, the deviations from price stability are therefore negligible. In terms of the percent loss of steady-state consumption for the Home and Foreign agents, the gains from adopting the optimal policy rather than price stability (shown in Table 1 and 2) are essentially zero.

5.2 A case of large misalignments under price stability: Low trade elasticity

We have seen above that, when home and foreign goods are close substitutes, the inefficiency created by news shocks with incomplete markets should hardly be redressed by monetary policy, which, at the optimum, essentially coincides with one pursuing price stability. In this subsection, we turn to economies in which policy trade-offs are much more relevant, and optimal policy can actually improve upon price stability, supporting an allocation which moves the economy quite close to the first best. This is shown in Figures 6 and 7, depicting the case of economies with a low trade elasticity.

Economies with low trade elasticity and Producer Currency Pricing. Focus first on the case of *PCP*, corresponding to Figure 6. Under *price stability* home policy makers again react to the news shock with an interest rate hike, to counteract the inflationary pressures on domestic prices. Because of the low elasticity, the real appreciation associated with the rise in demand by Home households is now quite sizable — so is the real trade deficit. As a result of the large negative wealth spillovers in the foreign country, Foreign consumption falls and hours worked increases substantially.

Observe that, in contrast with the case with a high trade elasticity, the negative implications of the shock for the Foreign economy are persistent. Namely, the materialization of the anticipated increase in Home productivity does not benefit the Foreign country at all over time: the drop in Foreign consumption is never reversed. The reason is that, because of the low elasticity, domestic and foreign goods are complements in preferences, implying

that substitution effects of price changes are small relative to income effects: following an increase in productivity in the Home country, relative price movements have limited power in redirecting world demand from the foreign to the home goods. In the presence of home bias in preferences, if the trade elasticity is sufficiently away from the Cobb-Douglas case (as is the case under our calibration), strong income effects from price changes on the demand by Home consumers may actually prevent a lower price of Home tradables from clearing the world market: foreign demand would not increase enough to compensate for the large drop in domestic demand for Home tradables (see CDL for a thorough analysis). On the contrary, in the incomplete market allocation, Home real appreciation is required to raise the level of Home and global demand, at the cost of a large negative spillover on Foreign consumption and hours. Differences between the market and the efficient allocation are therefore much starker than in the economy with a high elasticity discussed in the previous subsection: a policy of price stability ignores the strong adverse effects from the real exchange rate misalignment on Foreign consumption and hours, leading to a large positive international demand gap.

With a low trade elasticity, the scope for the *optimal policy* to redress these inefficiencies is less limited. Indeed, as shown by Figure 6, the optimal policy initially redirects world demand from Home to Foreign consumers. Relative to price stability, monetary authorities are required to implement a larger interest rate hike at Home, and a more expansionary policy abroad — the response of the Foreign interest rate to the shock actually changes sign relative to price stability. However, the reduction in the relative demand gap comes at the cost of larger (inefficient) movements in hours worked and output gaps. By the same token, the increase in the interest-rate differential in favor of the Home country amplifies the appreciation of the real exchange rate, increasing the size of the RER-gap. Thus, under PCP, the optimal policy reduces the RD-gap by designing policies that focus on realigning consumption, but with little emphasis on currency misalignments, an issue to which we will return shortly below. Overall, the welfare cost of adopting inflation targeting instead of the optimal policy remains modest, as shown in Table 1.

Economies with low trade elasticity and Local Currency Pricing. Results are quite different when the news shock hit economies with a low trade-elasticity and LCP, illustrated in Figure 7 and Table 2. In sharp contrast with the previous cases, optimal monetary policy is now able to get remarkably close to the efficient allocation in terms of both domestic and cross-country imbalances — this is apparent from the responses of the RD-gap and RER-gap, as well as the output gaps, in Figure 7. Under the optimal policy, the real exchange rate actually depreciates as is prescribed under the efficient allocation — such currency reaction largely eliminates the suboptimal movements in wealth across countries, associated with

the inefficiently large trade deficit under price stability. Observe that the realignment of domestic consumptions and the real exchange rate toward their efficient paths is achieved by a combination of a looser monetary stance at Home (relative to price stability), and a tighter monetary stance abroad, up to engineering a real currency depreciation.

To understand the difference in the optimal policy under PCP and LCP, it is instructive to look at the behavior of our economies under financial autarky. This comparison provides an important key to understanding our results, making it clear that under LCP the terms of trade, the real exchange rate and relative consumption are not strictly proportional to relative output, as it is the case under PCP.

With no trade in assets, the trade balance equation under LCP can be expressed as a simple function of aggregate consumption in either countries:

$$\begin{aligned} P_{F,t}C_{F,t} &= \mathcal{E}_t P_{H,t}^* C_{H,t}^* \\ (1 - a_H) \frac{P_{F,t}}{\mathcal{E}_t P_{H,t}^*} \left(\frac{P_{F,t}}{P_t} \right)^{-\phi} C_t &= a_H^* \left(\frac{P_{H,t}^*}{P_t^*} \right)^{-\phi} C_t^*. \end{aligned}$$

When log-linearized, this expression becomes:

$$\widehat{\mathcal{T}}_t + \widehat{C}_t - \phi a_H \frac{\widehat{P}_{F,t}}{\widehat{P}_{H,t}} = \widehat{C}_t^* + a_H \phi \frac{\widehat{P}_{F,t}^*}{\widehat{P}_{H,t}^*}.$$

Contrary to the PCP case, the domestic relative prices $\frac{\widehat{P}_{H,t}}{\widehat{P}_{F,t}}$ and $\frac{\widehat{P}_{F,t}^*}{\widehat{P}_{H,t}^*}$ are generally different from the terms of trade $\widehat{\mathcal{T}}_t$, because of the deviations from the law of one price for tradables induced by currency movements. Specifically, we can rewrite these relative prices as the sum of the terms of trade and deviations in the law of one price at the individual good level — deviations which by assumption are entirely due to nominal rigidities in local currency:

$$\begin{aligned} \frac{\widehat{P}_{F,t}}{\widehat{P}_{H,t}} &= \widehat{\mathcal{T}}_t + \frac{\widehat{\mathcal{E}_t P_{H,t}^*}}{\widehat{P}_{H,t}} = \widehat{\mathcal{T}}_t + \widehat{\Delta}_{H,t} \\ \frac{\widehat{P}_{F,t}^*}{\widehat{P}_{H,t}^*} &= \widehat{\mathcal{T}}_t + \frac{\widehat{\mathcal{E}_t P_{F,t}^*}}{\widehat{P}_{F,t}} = \widehat{\mathcal{T}}_t + \widehat{\Delta}_{F,t}, \end{aligned}$$

where it can be shown that $\widehat{\Delta}_{H,t} = \widehat{\Delta}_{F,t}$. Similarly, we can also write the real exchange rate as a function of the same arguments:

$$\widehat{\Theta}_t = a_H \left(\frac{\widehat{P}_{F,t}}{\widehat{P}_{H,t}} + \frac{\widehat{P}_{F,t}^*}{\widehat{P}_{H,t}^*} \right) - \widehat{\mathcal{T}}_t = (2a_H - 1) \widehat{\mathcal{T}}_t + 2a_H \widehat{\Delta}_t.$$

Observe that the difference between $\widehat{\Theta}_t$ and $\widehat{\mathcal{T}}_t$ is proportional to total deviations from the law of one price $\widehat{\Delta}_t$. These LOP deviations also enter the relationships between terms of trade, relative output and relative consumption:

$$\begin{aligned}\widehat{\mathcal{T}}_t &= \frac{\widehat{Y}_{H,t} - \widehat{Y}_{F,t} - 2a_H\phi\widehat{\Delta}_t}{1 - 2a_H(1 - \phi)} \\ \widehat{C}_t - \widehat{C}_t^* &= \frac{2a_H\phi - 1}{1 - 2a_H(1 - \phi)} \left(\widehat{Y}_{H,t} - \widehat{Y}_{F,t} \right) + \frac{2(1 - a_H)a_H\phi}{1 - 2a_H(1 - \phi)} \widehat{\Delta}_t,\end{aligned}$$

Finally, the condition for efficient risk sharing then becomes

$$\begin{aligned}0 &= \sigma \left(\widehat{C}_t - \widehat{C}_t^* \right) - \widehat{\Theta}_t \\ &= \frac{\sigma(2a_H\phi - 1) - (2a_H - 1)}{1 - 2a_H(1 - \phi)} \left(\widehat{Y}_{H,t} - \widehat{Y}_{F,t} \right) + \\ &\quad a_H \left[\frac{2a_H - 1 + \phi(2\sigma(1 - a_H) - 1)}{1 - 2a_H(1 - \phi)} \right] \widehat{\Delta}_t,\end{aligned}$$

which will necessarily be satisfied for $\sigma = \phi = 1$.

Deviations from the law of one price have sharp implications for the design of optimal monetary policy. Policymakers now have the possibility to act on $\widehat{\Delta}_t$ in trying to redress the inefficiencies of the incomplete market allocation. In particular, they may try to make them move in the opposite direction of relative output, as a way to contain inefficient movements in the terms of trade and relative consumption. The price, of course, is that deviations from the law of one price are relative price misalignment, hence are costly in terms of welfare. In contrast, under PCP, eliminating the cross-country inefficiencies in consumption and the currency misalignment would necessitate large movements in output gaps that are costly in terms of welfare.

While the analytics and the exposition above has been facilitated by using a financial autarky example, the main results is very general. Specifically, the main message is that, with LCP and incomplete markets, it is possible for monetary policy to redress both domestic and cross-country inefficiencies in consumption and employment at once — yet, this can only be achieved by deviating from price stability. Therefore, the allocation remains inefficient, since the optimal policy results into some price dispersion.

As a final observation, we stress that in our experiments, monetary policy geared towards price stability does not prevent significant misalignments in important asset prices like the exchange rate, even when the latter only reflects fundamental-based valuations. However, our results also suggest that there is scope for monetary policy to redress these inefficiencies and achieve significant welfare gains relative to price stability, by leaning against an over- or under-valued exchange rate, associated with suboptimal demand and current account

imbalances. In our calibration, the gains under LCP from adopting the optimal monetary policy rather than targeting inflation reach 0.36 percent of steady state consumption.

5.3 News versus autoregressive productivity shocks

While news shocks provide a particularly intriguing framework of developing our arguments, it is important to keep in mind that our results do not critically hinge on them. The key is the lack of efficient risk insurance, which opens up the possibility of strong asymmetric wealth and demand effects in response to shock. To stress this point, we redo our exercise assuming standard AR(1) shocks for productivity, instead of news shocks, as captured by the process U_t defined above — see equation (8). Shutting down the news component of our process, we just run our model conditional on the standard productivity process.

We find that our findings are robust to this new specification of the productivity process. Specifically, under a high trade elasticity, the welfare cost of adopting price stability instead of the optimal policy is negligible: $2 \times e^{-6}$ and 0.0002 percent of steady state consumption under PCP and LCP, respectively. As with news shocks, the welfare costs rise substantially when the trade elasticity is low. These costs reach 0.5 percent of steady state consumption when firms adopt PCP, and get as large as 1 percent under LCP. Since the impulse-response analysis is quite similar to that with news shocks, we do not report it here. The intuitive discussion of the various cases with news shocks in this section can be applied to the new process as well.

5.4 Issues in implementation

We have seen above that optimal monetary policy leans against exchange rate fluctuations and tolerates some deviations from price stability — this is apparent in a world with relatively low trade elasticities. In this section, we ask whether it is possible to approximate the allocation under the optimal monetary policy, assuming that domestic and foreign authorities adopt standard interest-rate rules.

A key issue in implementation is how to quantify the exchange rate misalignment to which policy should react. To clarify this point, we write down standard simple rules allowing for an interest rate response to misalignment:

$$i_t = \rho_i i_{t-1} + (1 - \rho_i) (i_{ss} + \Psi(\pi_t - \pi^{ss}) + \zeta(RER_t - \Theta_t))$$

and

$$i_t^* = \rho_i i_{t-1}^* + (1 - \rho_i) (i_{ss}^* + \Psi E(\pi_t^* - \pi^{*ss}) - \zeta(RER_t - \Theta_t)),$$

where i_{ss} is the steady-state level of the nominal interest rate and the coefficients ρ_i , Ψ , and

ζ measure interest smoothing, the reaction to inflation in excess of target, and the degree of exchange rate stabilization around its desired level, Θ_t respectively — note that for simplicity, but without loss of generality, we abstract from changes in the output gap. Specifically, for $\zeta > 0$, central banks would set interest rates in reaction not only to movements in inflation, but also in response to movements in the value of the currency away from its efficient level.

5.4.1 Assessing misalignments

The performance of the rule crucially depends on Θ_t . Suppose that, counterfactually, monetary authorities could estimate the efficient exchange rate at each point in time with a good degree of approximation, i.e. $\Theta_t = \widetilde{RER}_t$. In this case, we can find the optimal interest-rate rule, by searching for the combination of coefficients that minimize the distance between world welfare under the rules and that under the optimal policy (under a second-order approximation of the equilibrium conditions) For an economy with PCP and low trade elasticities, for instance, we find that the coefficients of the optimal rule are $\rho_i = 0$, $\Psi = 5$, and $\zeta = 0$, so that the central bank focuses on stabilizing inflation. The gain from adopting the optimal policy rather than the rule above is only 0.012 percent of steady state consumption.

In contrast, under LCP and low trade elasticities, the coefficients of the optimized rule becomes: $\rho_i = 0.17$, $\Psi = 5$, and $\zeta = 1.48$. While the optimal interest-rate rule assigns a lot of weight to inflation, it also reacts significantly to currency misalignments. Consistent with our analysis so far, central banks in our environment lean against the wind of misalignment. As a result, the response of the economy under this rule is closely in line with the allocation under the optimal policy, and differs markedly from that under price stability. Indeed, conditional on knowing \widetilde{RER}_t , implementing the optimized rule leads to an allocation that is quite close to the efficient one: The welfare differential between the two policy regimes is a mere 0.0008 percent of steady state consumption.

The main issue however is that the performance of the rule crucially depends on the quality of the estimation of the efficient level the exchange rate in real time. We stress that this is not necessarily (and in general will not be) identical to the ‘equilibrium exchange rate’, traditionally studied by international and public institutions, as a guide to policy making. Estimates of the ‘equilibrium exchange rates’ typically refer to some notion of long-term external balance, against which to assess short run movements in currency values possibly reflecting nominal rigidities and all kind of real and financial frictions. On the contrary, the efficient exchange rate is theoretically and conceptually defined at any time horizon, in relation to a hypothetical economy in which all prices are flexible and markets are complete.

In fact, our measure of misalignment (as the difference between current exchange rates and the efficient one) is constructed in strict analogy to the notion of a welfare relevant output gap, as the difference between current output and the efficient level of output, which does not coincide with the natural rate (i.e. the level of output with flexible prices). In either case, the assessment of efficient prices and quantities, at both domestic and international level, posits a formidable challenges to researchers.

5.4.2 Simple rules

How would simple rules written in reference to observables only work? As a first natural experiment, we set Θ_t equal to the lagged value of the real exchange rate, as to let monetary policy respond to the exchange rate changes within the period. Remarkably, even leaving the parameter coefficients identical to the one optimized above, the simple rules achieve a significant improvement over price stability. Under LCP, for instance, implementing the simple rule augmented with the rate of real depreciation improve welfare by 0.15 percent compared to price stability under LCP. Not surprisingly, however, the rule doesn't come close to the optimal allocation, namely, it does not prevent RER appreciation. Yet, removing the growth rate of RER from the rule makes the welfare benefit fall by an order of magnitude.¹²

Monetary rules with some sensitivity of the interest rate to exchange rate depreciation have often been discussed and proposed by the literature, but based on perhaps sensible but typically ad-hoc considerations. The difference here is that we can motivate these rules from a theoretical framework, bridging monetary stabilization theory and international business cycle models. Moreover, there are potential important payoffs from a rigorous theoretical analysis, as this can provide guidance in the search for efficient implementation strategies, including the identification of simple rules based on observables. Namely, in Section 4.1 we noted that theory suggests a welfare-relevant measure combining exchange rate depreciations, and the differential in consumption (growth) across border — the RD-gap. Both terms can be easily quantified, although the construction of the RD-gap requires a conjecture on the degree of relative risk aversion characterizing the economy. Preliminary work suggests that a Taylor rule augmented with a simple average of the exchange rate and the consumption differential growth appears to improve considerably welfare relative to the performance of rules relying on exchange rate depreciation only. Although much more is to be done in this area, these

¹²It is important to stress, however, that leaning against the wind of misalignment is not an argument for limiting exchange rate flexibility tout-court. The optimal policy derived in the previous sections generates significant exchange rate movements, which bring about efficient relative price adjustment in both the goods and the assets markets. To emphasize this point, we estimate the welfare cost of adopting a fixed exchange rate — or a monetary union — under a low trade elasticity. In an economy characterized by PCP, a currency union entails of welfare cost of 0.28 percent of permanent consumption compared to a policy of price stability, which is even more sizeable than the welfare cost of price stability compared to the optimal policy.

preliminary results point to a promising and exciting research direction, to sharpen our understanding of stabilization policy in an environment with external imbalances.

6 Conclusion

A key question in the policy debate is whether misalignments in asset prices can create relevant trade-offs with other policy objectives — in particular, whether they could motivate deviations from price stability. This question is particularly pressing for the exchange rate, as this price plays a unique role in multiple markets — for consumption and investment goods, as well as for bonds, equities and other assets. When this issue is addressed in the context of models positing complete asset markets, it is hardly surprising that answers tend to be tilted towards price stability as the right strategy to minimize inefficiencies both domestically, and across borders. In some cases, as the one stressed by Devereux and Engel [2006, 2007], leaning against the wind of inflationary excess-demand in the domestic market (to preserve price stability) is the same as leaning against the wind of inefficient exchange rate appreciation.

In this paper we have explored different possibilities arising with incomplete asset markets, in line with the notion that misalignments can arise independently of nominal and monetary distortions, and indeed they can be expected to arise per effects of distortions and frictions in financial markets. Our analysis shows that standard open economy models where agents are restricted to trade in one bond only — one of the workhorse models in international economics — can already generate misalignments and demand imbalances that are quite consequential for welfare and the market allocation.

When in some of our experiments price stability still emerges as the optimal strategy, this happens not because such strategy succeeds in correcting also exchange rate misalignment and demand imbalances (as in DE) but because these inefficiencies is relatively inconsequential in terms of welfare. Price stability is the overwhelming concern for policymakers, who optimally choose not to address ‘external imbalances.’ But we also show instances in which a narrow implementation of inflation targeting results in inefficient level of consumption and hours, associated with relatively large misalignments and external imbalances, thus justifying significant deviations from price stability at an optimum. In these cases, indeed, optimal policy substantially reduce over- and under-appreciation of exchange rates, and correct imbalances in cross-border demand.

Previous work of ours suggests that misalignment and inefficient demand imbalances also emerge in economies with capital accumulation and non-traded goods (see CDL). While in this paper we have adopted a baseline monetary model, our main results should generalize also to more complex model economies. An open issue concerns the improvement of our

understanding of financial distortions that, at domestic as well as international level, prevent financial markets from providing full insurance — a promising direction for research on international policy interaction.

Finally, the Ramsey optimal policy we characterize as welfare benchmark implies cooperation and full commitment on the part of national policymakers. The detection of potentially sizeable welfare gains relative to price stability then raise intriguing but difficult issues in the design of the international policy environment in which countries could reap these gains most effectively.

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7 Appendix A

To find the welfare cost of adopting suboptimal monetary policies, we compute the percent loss of steady-state consumption the Home and Foreign agents experience in the following manner.

Let W^A be the world welfare under the suboptimal (alternative) policies and let W^R be the world welfare under the optimal policy. We compute the welfare cost, λ , of being in a world with suboptimal policies, by finding the drop in consumption that would equalized welfare under the two alternative policies:

$$W^A = \frac{1}{2}E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{(C^R(1-\lambda))^{1-\sigma}}{1-\sigma} + \psi \frac{(1-l)^{1-\sigma}}{1-\sigma} \right] + \frac{1}{2}E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{(C^{*R}(1-\lambda))^{1-\sigma}}{1-\sigma} + \psi \frac{(1-l^*)^{1-\sigma}}{1-\sigma} \right]$$

Define:

$$W^L = E_0 \sum_{t=0}^{\infty} \beta^t \psi \frac{(1-l)^{1-\sigma}}{1-\sigma}$$

and

$$W^{L^*} = E_0 \sum_{t=0}^{\infty} \beta^t \psi \frac{(1-l^*)^{1-\sigma}}{1-\sigma}.$$

This we have

$$W^A - \frac{1}{2} [W^L + W^{L^*}] = (1-\lambda)^{1-\sigma} \frac{1}{2} \left[E_0 \sum_{t=0}^{\infty} \beta^t \frac{(C^R)^{1-\sigma}}{1-\sigma} + E_0 \sum_{t=0}^{\infty} \beta^t \frac{(C^{*R})^{1-\sigma}}{1-\sigma} \right],$$

so that the welfare cost is given by

$$\lambda = 1 - \left[\frac{W^A - \frac{1}{2} [W^L + W^{L^*}]}{W^R - \frac{1}{2} [W^L + W^{L^*}]} \right]$$

Table 1.
Gap Volatility and Welfare with PCP under Optimal Policy and Domestic Price Stability

	Low Elasticity		High Elasticity	
	Optimal Policy	Domestic Price Stability	Optimal Policy	Domestic Price Stability
Standard Deviation				
Demand Gap	0.37	0.41	0.03	0.03
RER Gap	0.28	0.31	0.01	0.01
TOT Gap	0.35	0.39	0.01	0.01
Domestic Output Gap	0.01	0.01	0.01	0.01
Foreign Output Gap	0.01	0.01	0.01	0.01
Domestic Price Inflation	$2 \times e^{-5}$	0	$1 \times e^{-5}$	0
Welfare Cost ^a	–	0.009	–	$3 \times e^{-5}$

^a In percent of steady state consumption, relative to the price stability allocation.

Table 2.
Gap Volatility and Welfare with LCP under Optimal Policy and CPI Price Stability

	Low Elasticity		High Elasticity	
	Optimal Policy	Consumer Price Stability	Optimal Policy	Consumer Price Stability
Standard Deviation				
Demand Gap	0.02	0.76	0.03	0.03
RER Gap	0.02	0.58	0.01	0.01
TOT Gap	0.05	0.72	0.01	0.01
Domestic Output Gap	0.001	0.02	0.01	0.01
Foreign Output Gap	0.001	0.02	0.01	0.01
Consumer Price Inflation	0.003	0	0.001	0
Welfare Cost ^a	–	0.36	–	0.002

^a In percent of steady state consumption, relative to the price stability allocation.

Figure 1. News and Autoregressive Shocks

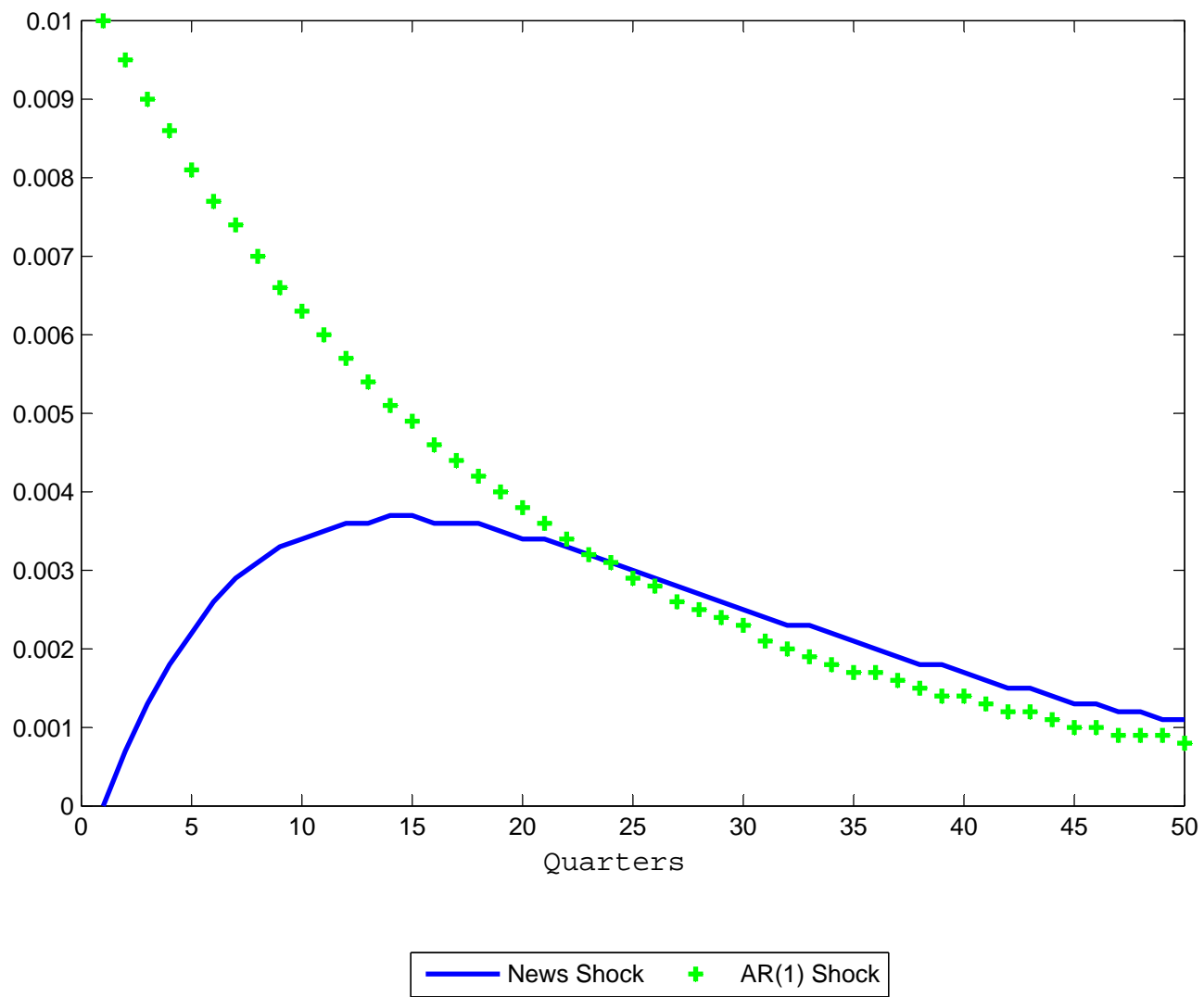


Figure 2. Macroeconomic Effects of News Shocks with Flexible Prices
 Complete versus Incomplete Markets Allocation under High Elasticity

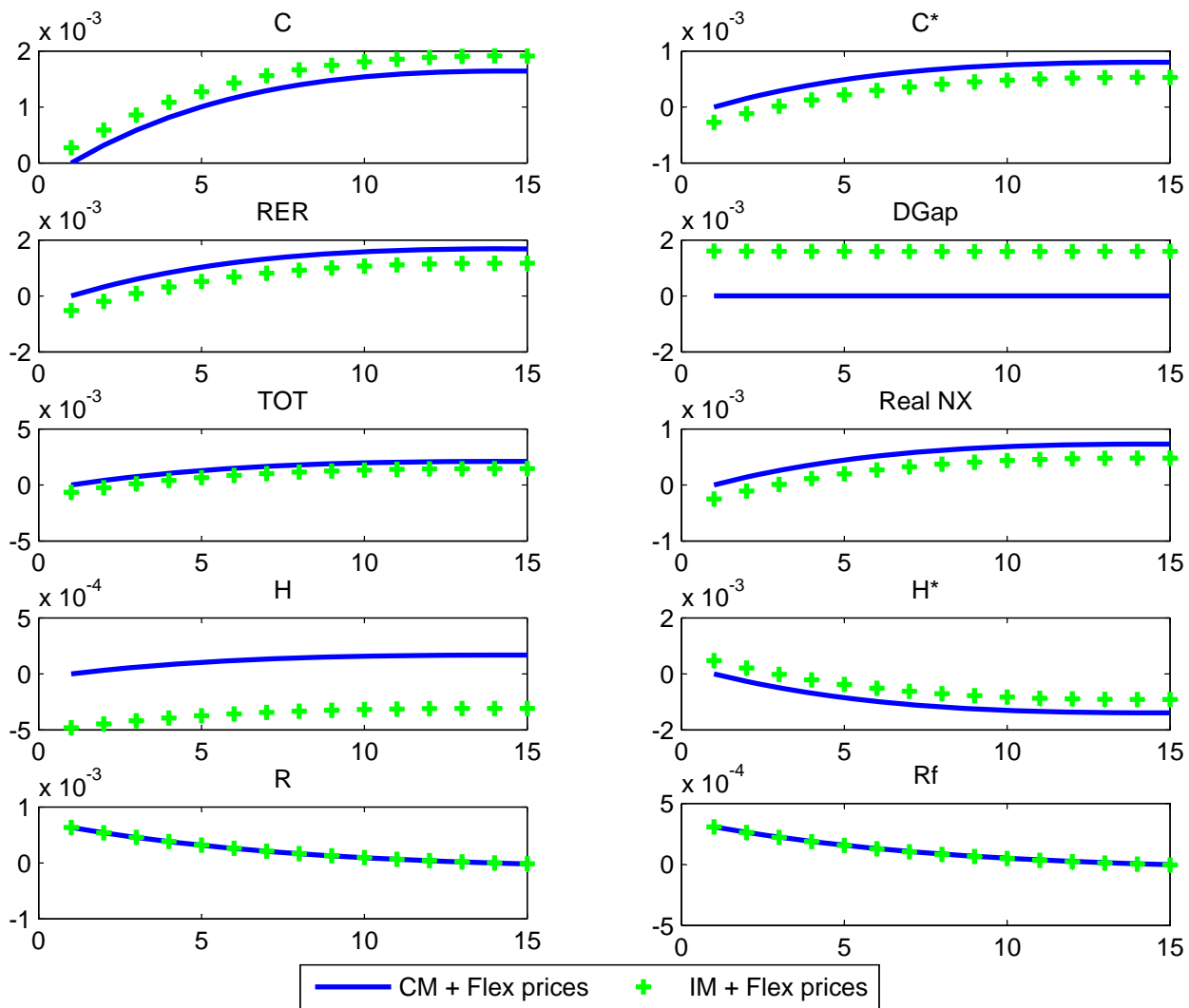


Figure 3. Macroeconomic Effects of News Shocks with Flexible Prices
 Complete versus Incomplete Markets Allocation under Low Elasticity

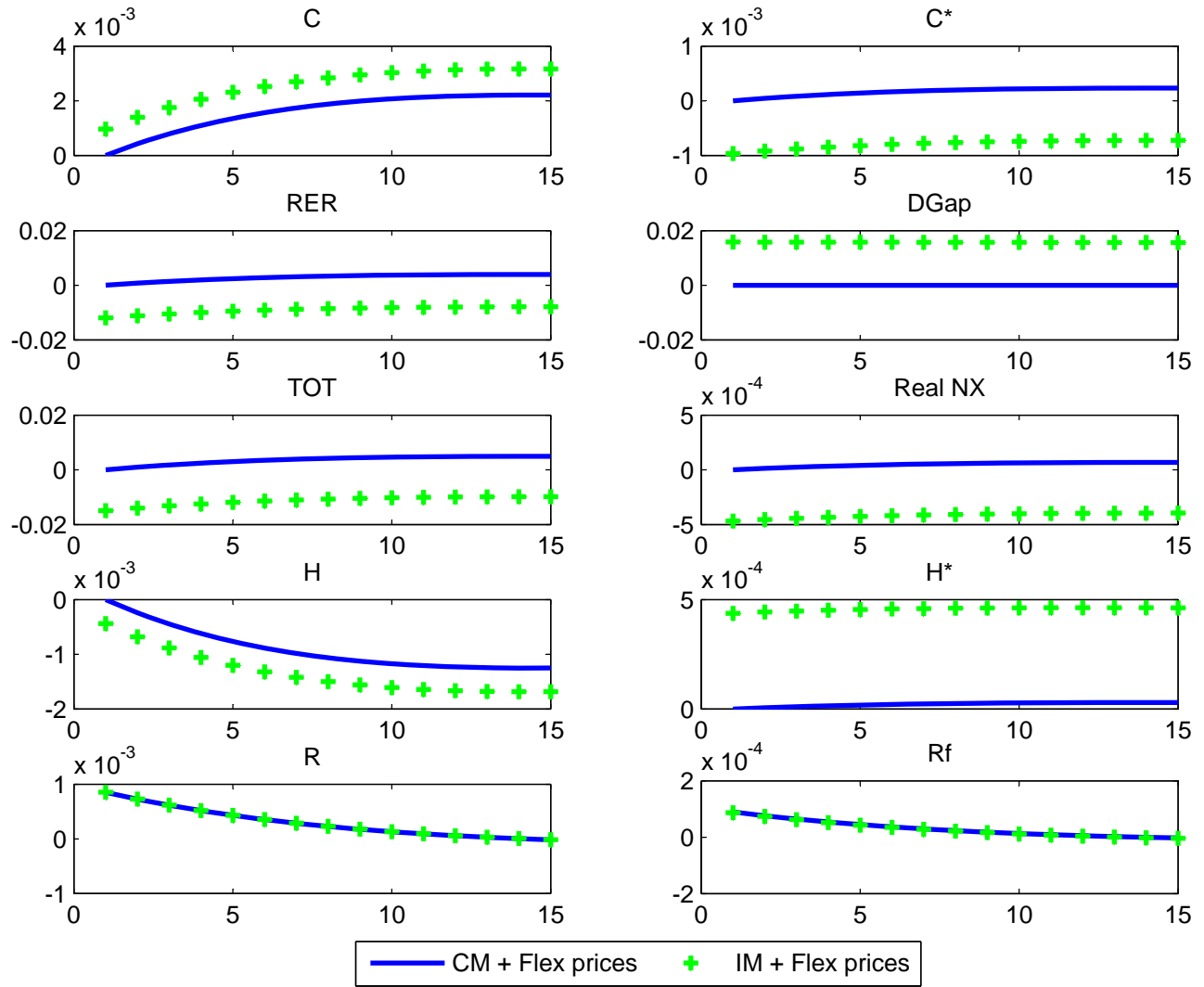


Figure 4a. News Shocks with High Elasticity and PCP:
 Domestic Price Stability and Optimal Policy

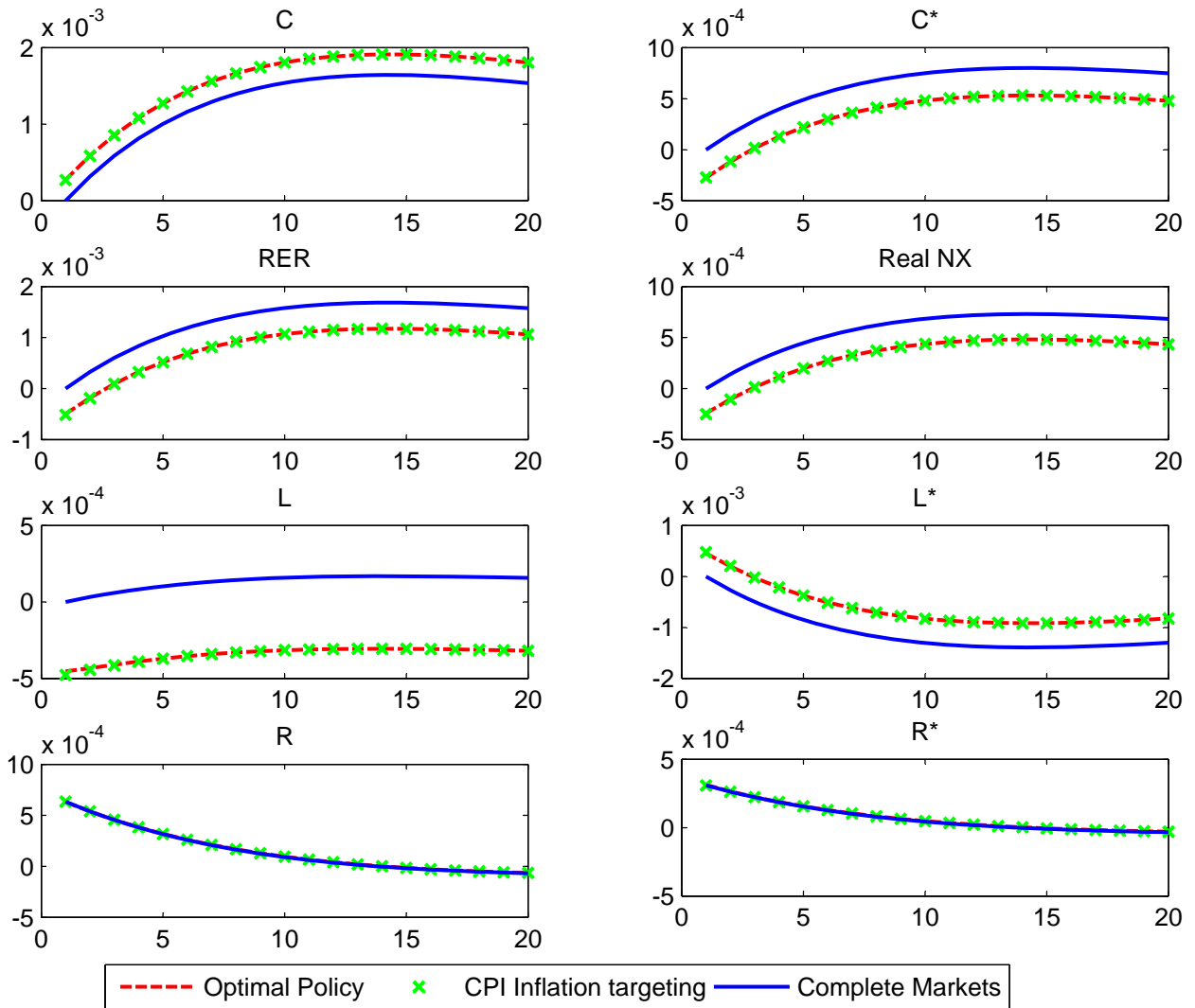


Figure 4b. News Shocks with High Elasticity and PCP:
 Domestic Price Stability and Optimal Policy

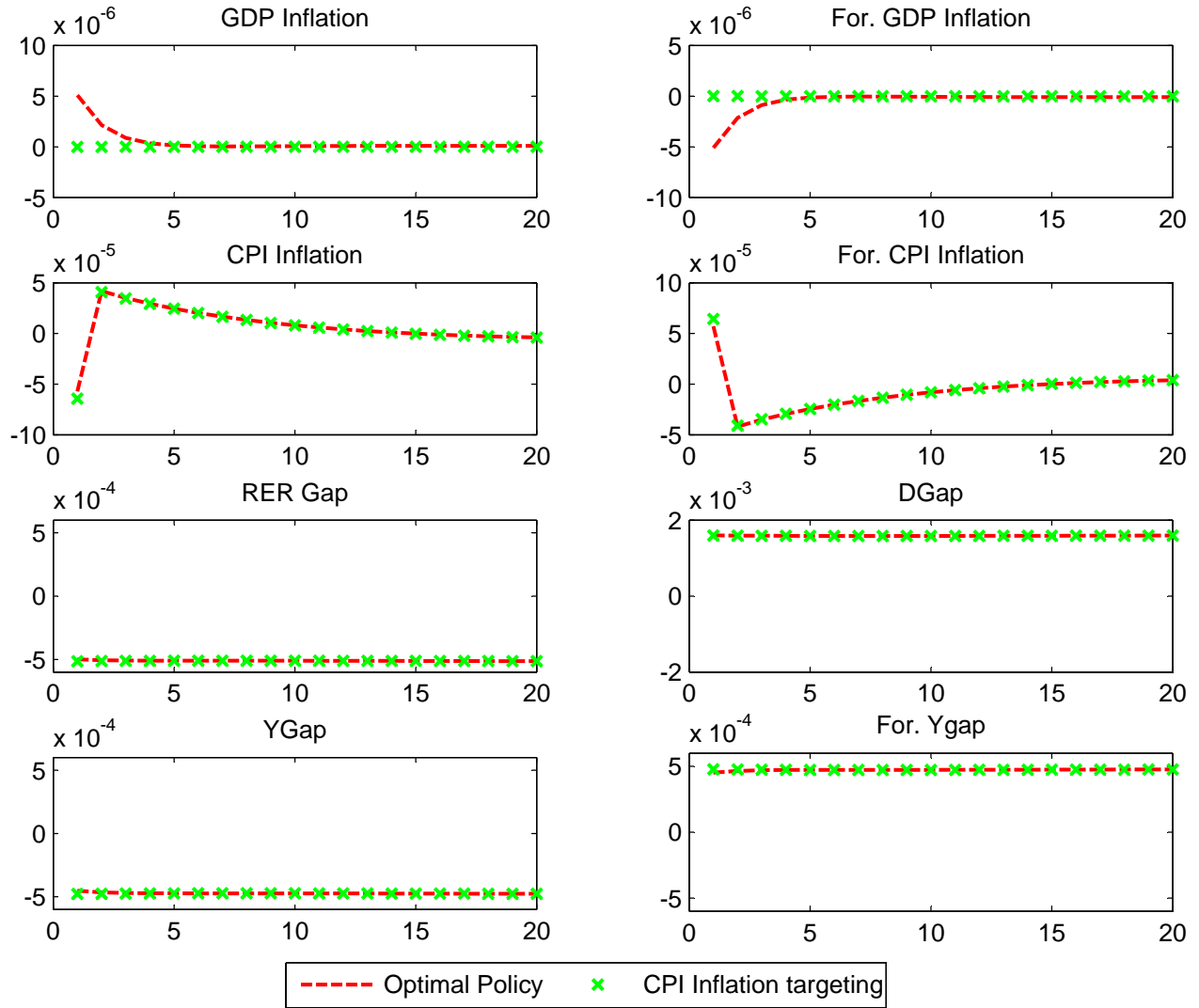


Figure 5a. News Shocks with High Elasticity and LCP:
Consumer Price Stability and Optimal Policy

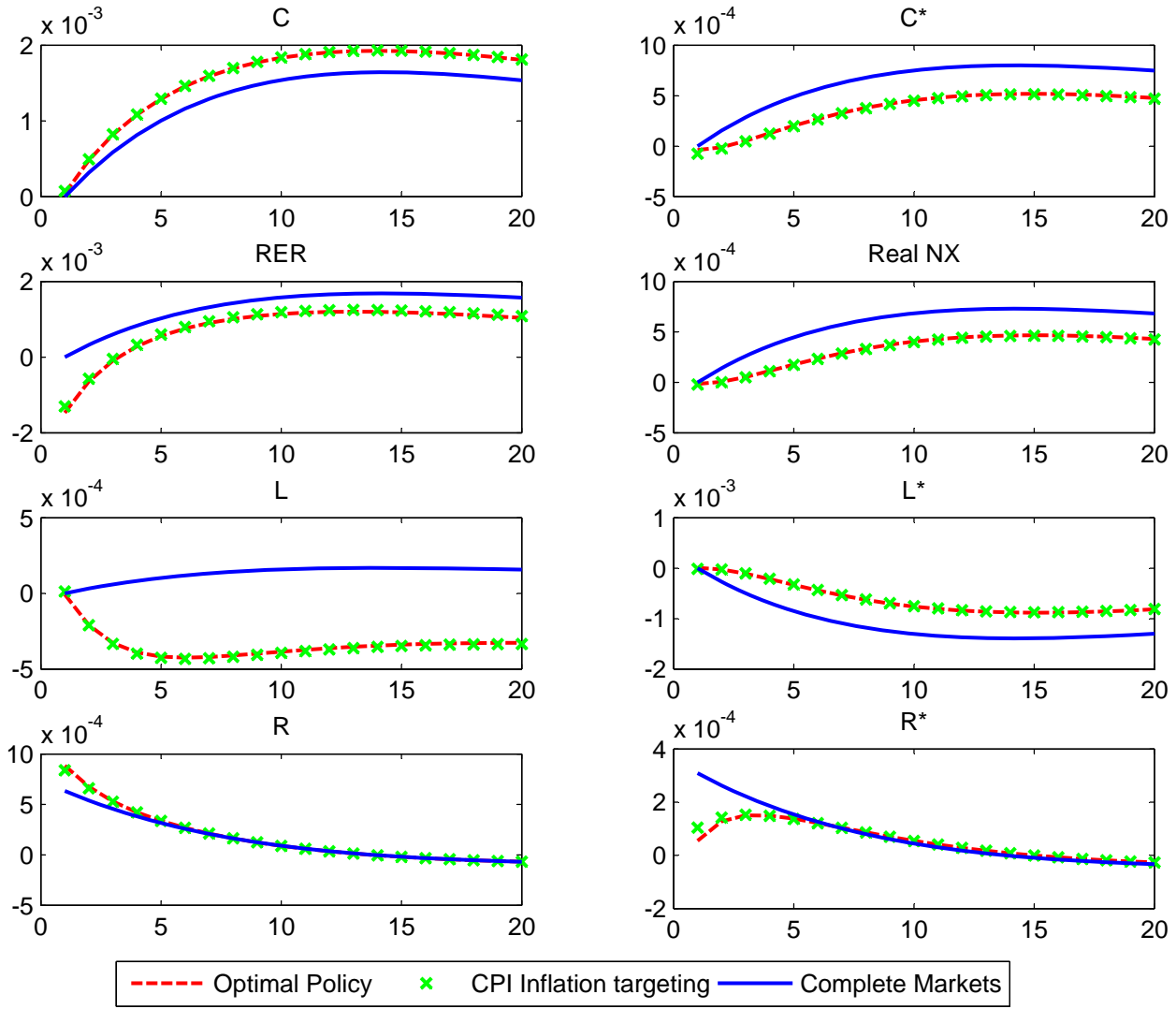


Figure 5b. News Shocks with High Elasticity and LCP:
Consumer Price Stability and Optimal Policy

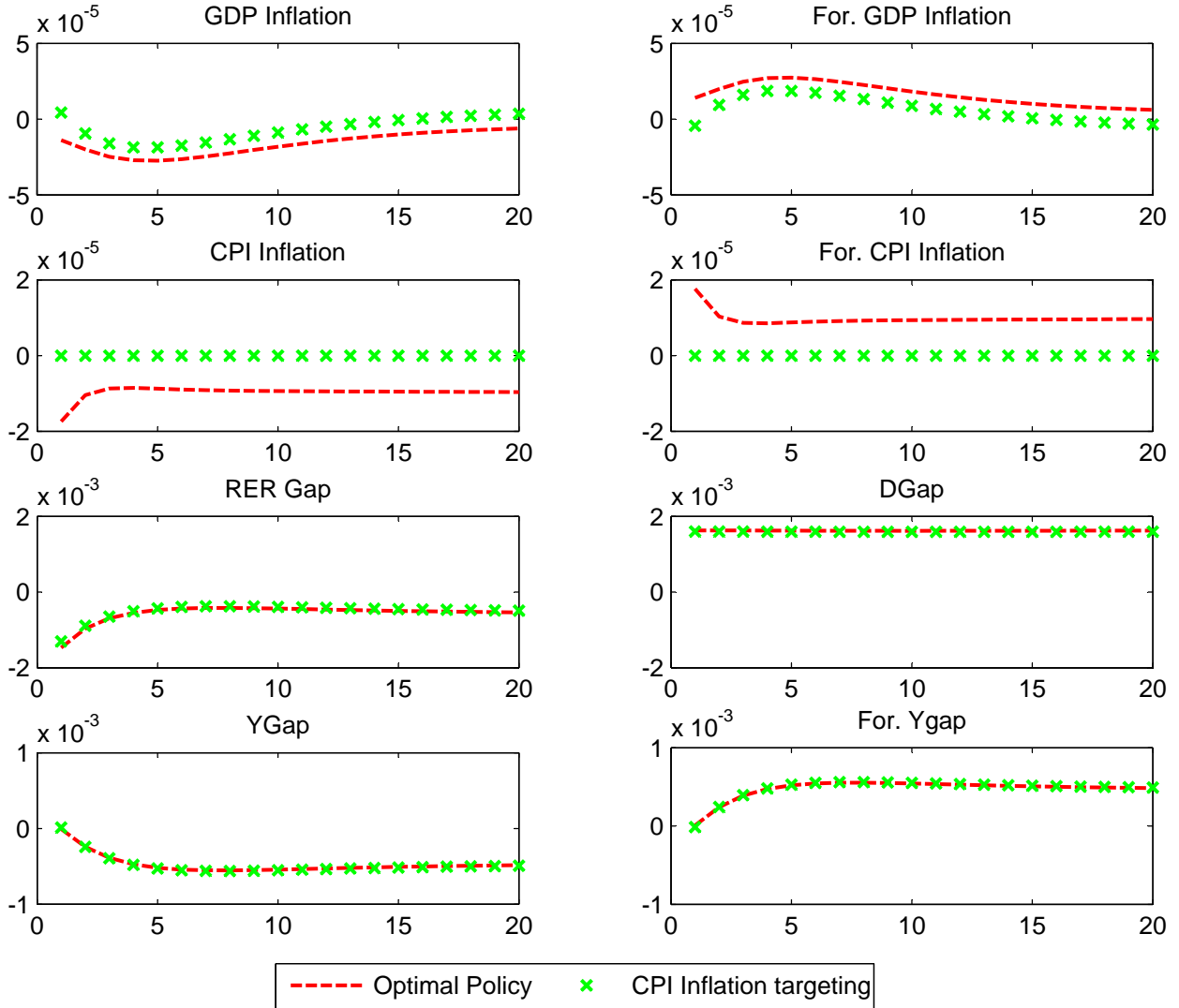


Figure 6a. News Shocks with Low Elasticity and PCP:
Domestic Price Stability and Optimal Policy

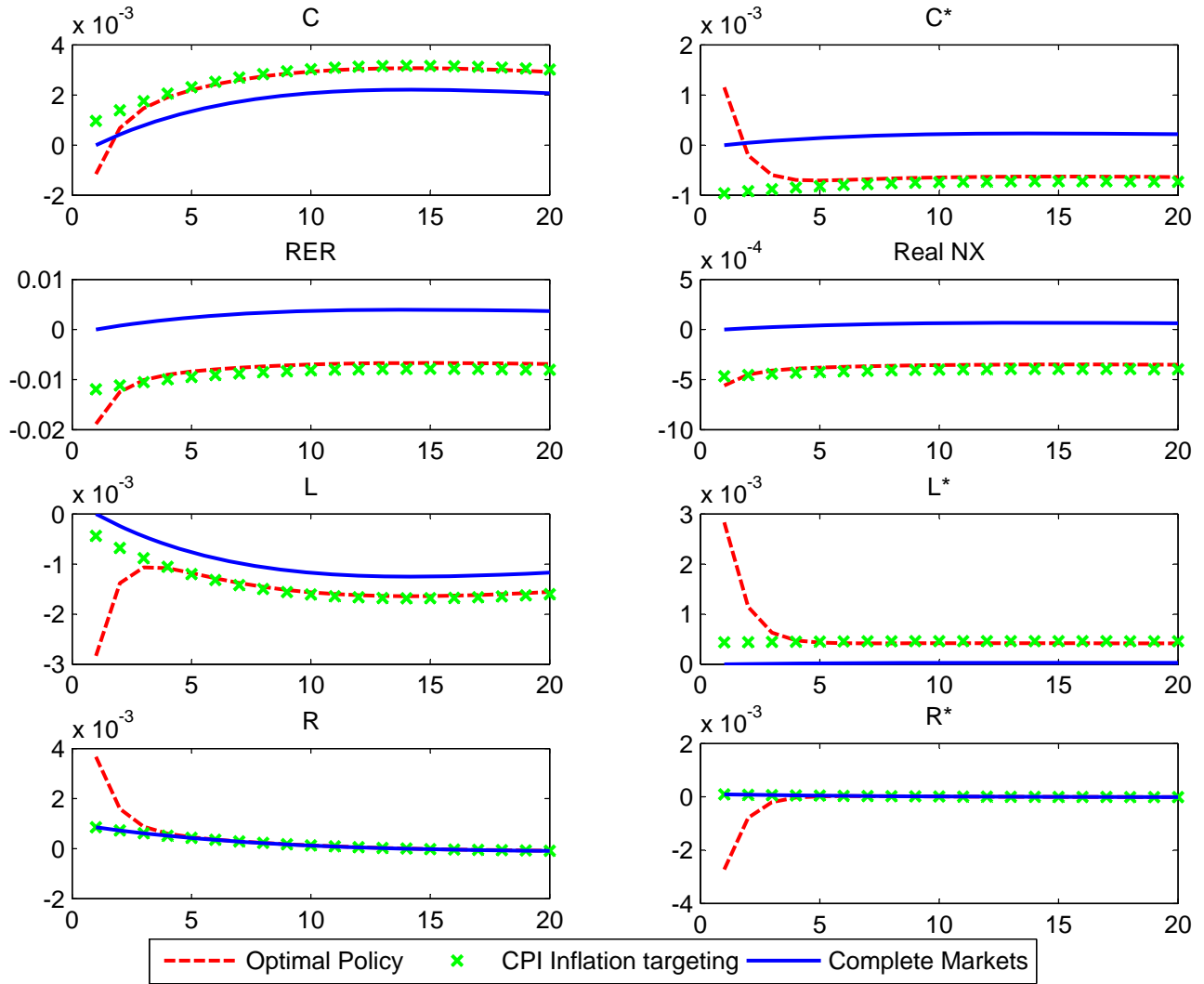


Figure 6b. News Shocks with Low Elasticity and PCP:
 Domestic Price Stability and Optimal Policy

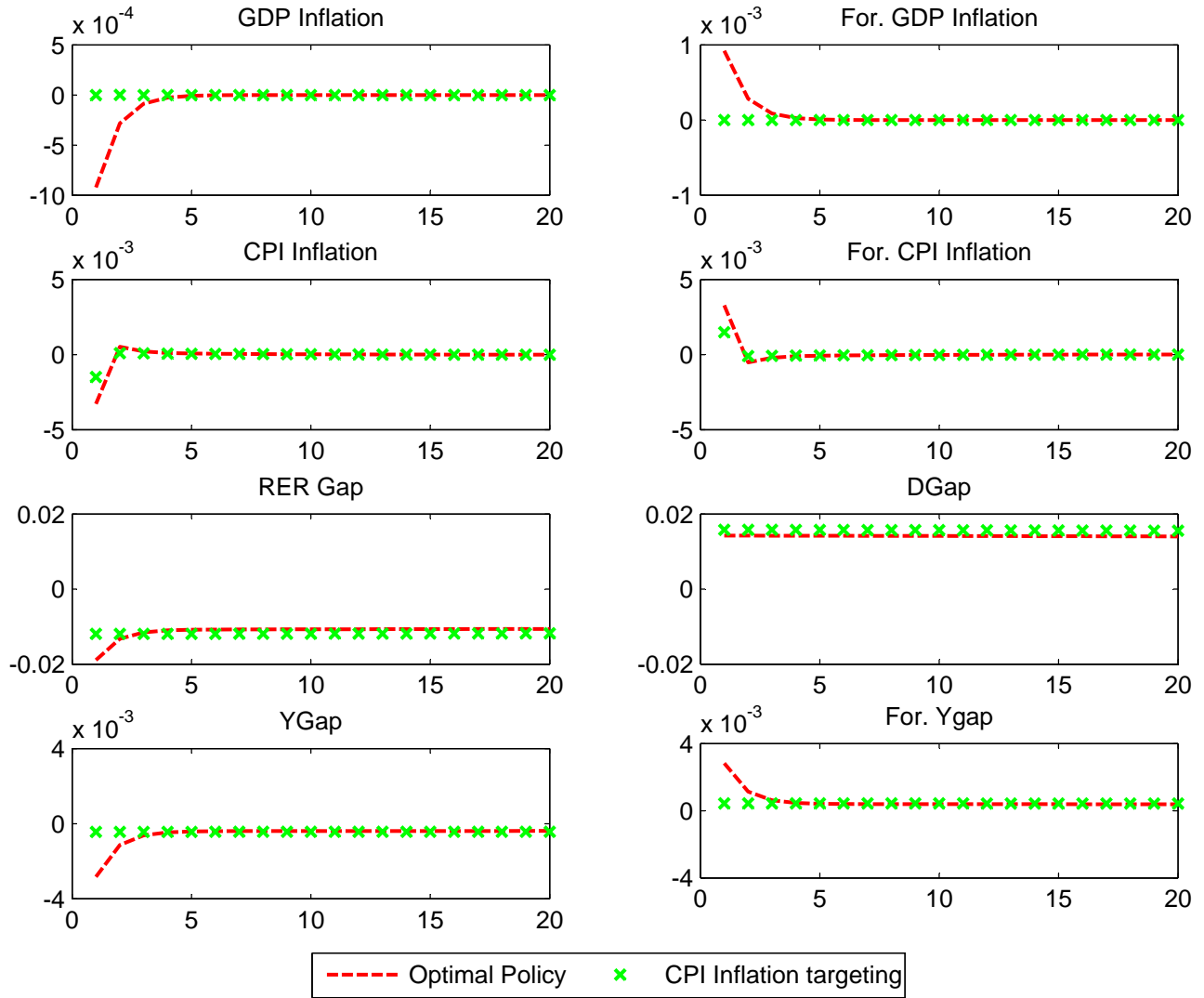


Figure 7a. News Shocks with Low Elasticity and LCP:
Consumer Price Stability and Optimal Policy

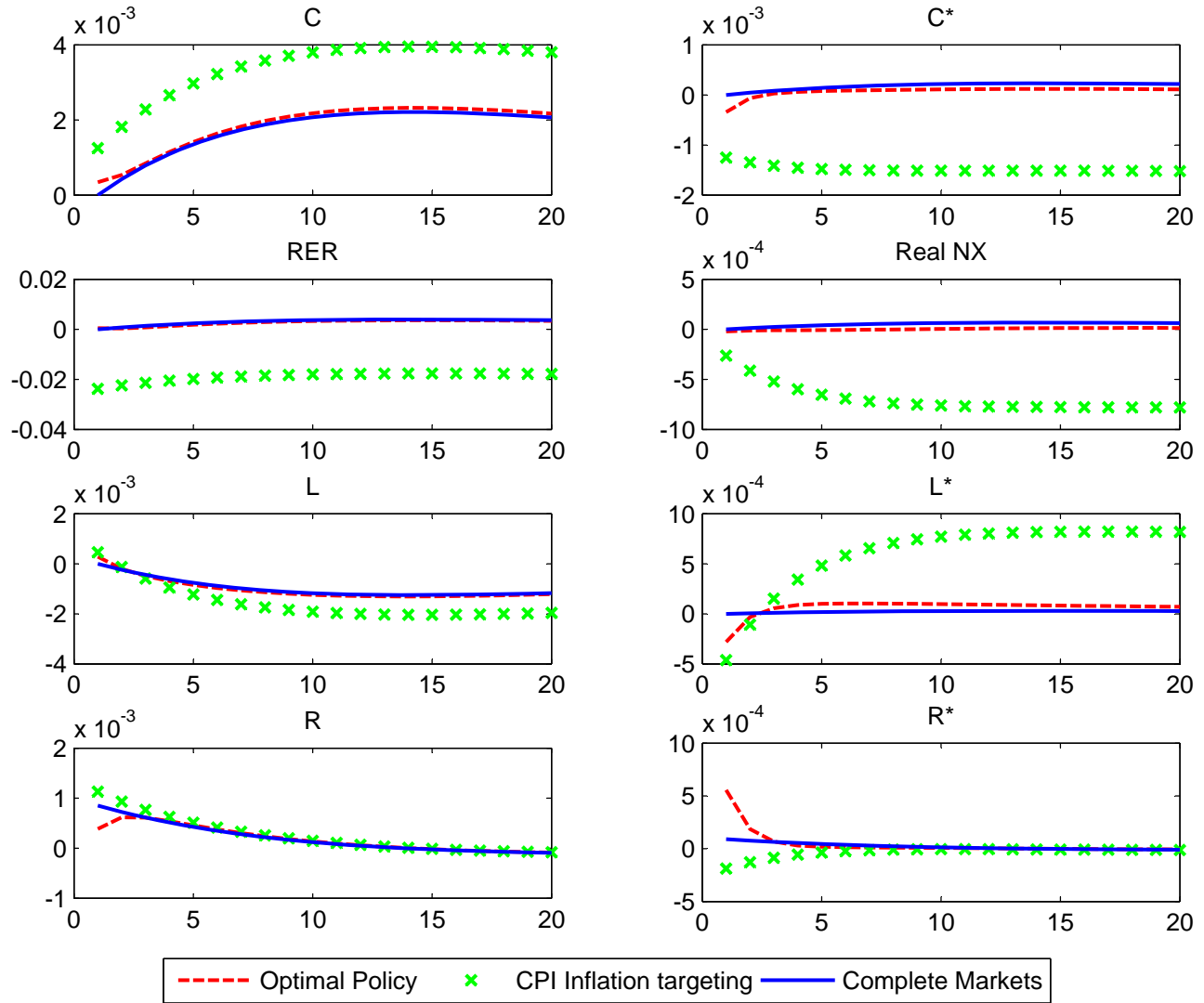


Figure 7b. News Shocks with Low Elasticity and LCP:
Consumer Price Stability and Optimal Policy

