Demand Imbalances, Exchange Rate Misalignment and Monetary Policy[1]

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Abstract

In standard open macro models with incomplete markets, inward-looking monetary policies like strict inflation targeting may result in (rather than correcting) misalignments in asset prices like the exchange rate, even when the latter only reflects fundamental-based valuation. We discuss conditions under which optimal monetary policy redresses these inefficiencies, achieving significant welfare gains relative to the flexible price allocation under incomplete markets. These gains are obtained by leaning against an over- or under-valued exchange rate, associated with suboptimal cross-country demand and trade imbalances, consistent with flexible inflation trageting placing non-zero weight on exchange rate misalignments.

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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 inflation, 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 distortions from nominal price rigidities and emphasized the effects of exchange rate misalignment on the relative price of goods (see among others Benigno and Benigno [2003], Clarida, Galí and Gertler [2002], Devereux and Engel [2003], Corsetti and Pesenti [2005], Engel [2009] and Galí 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 optimal policy when real misalignments arise from this dual role of the exchange rate 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-

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

[3] In 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.

[4] In 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 until the anticipated technology change materializes. Thus, in the DE economy, under the optimal policy there is no trade-off between external objectives such as exchange rate stabilization and domestic objectives such as product price inflation 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 ensures 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

[5] The 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 no attempt to fit the evidence on the effects of news shocks, as documented in Beaudry and Portier [2005] and Beaudry et al. [2008].

[6] In two-country models where national goods are imperfect substitute 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).

[7] For the definition and analysis of this gap in the framework of 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 incomplete markets and flexible prices — resulting in virtually complete 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, an inward-looking policy 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 domestic objectives.

However, this conclusion changes drastically when we look at the case of a low trade elasticity. Under a suboptimal policy micking the flexible price allocation, 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 such an allocation, 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 efficient 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, improving upon the flexible-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 strict inflation targeting 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 the flexible-price, incomplete-markets allocation, leaning against an over- or under-valued exchange rate, associated with suboptimal demand and current account imbalances. In this respect, our results provide an argument in favor of policies of flexible inflation targeting, including external objectives such as exchange rate misalignments. It should be stressed that the success of the optimal flexible inflation targeting strategy does not hinge on 'completing the market' by manipulating the ex-post value of nominal assets assets via fluctuation in the price level or in the exchange rate. Rather, the optimal policy acts as to avoid the inefficient relative wealth effects due to market incompletness.

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 the face of preference 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 nonstochastic steady state. In addition, the working paper 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 exchange rate 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 discusses analytically the policy trade-offs between domestic objectives and misalignment and demand imbalances. Section 4 describes the parameterization we use throughout our exercises. Our main results are reported in Section 5 and 6. In Section 5 we look at allocations without nominal rigidities. In Section 6 we introduce sticky price and sharply focus on optimal and suboptimal monetary policies. Concluding

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

observations are offered in Section 7.

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 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:

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

where instantaneous utility U is a function of a consumption index, C, and leisure, $(1-L)$, specialized as follows:

$$U\left[C_t, L_t\right] = \zeta_{C,t}\frac{C_t^{1-\sigma}}{1-\sigma} + \kappa\frac{(1-L_t)^{1-\eta}}{1-\eta}, \qquad \sigma > 0. \tag{2}$$

whereas the model also allows for shocks to marginal utilities of consumption $\zeta_{C,t}$.Following Schmitt-Grohé and Uribe [2003], for the numerical analysis below, we assume an endogenous discount factor $\nu\left(C_t, L_t\right)$ 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]

[9] A 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

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 an imperfect substitute for all other goods' varieties, with constant elasticity of substitution $\theta > 1$:

$$C_{\mathrm{H},t} \equiv \left[\int_0^1 C_t(h)^{\frac{\theta-1}{\theta}} dh\right]^{\frac{\theta}{\theta-1}}, \qquad C_{\mathrm{F},t} \equiv \left[\int_0^1 C_t(f)^{\frac{\theta-1}{\theta}} df\right]^{\frac{\theta}{\theta-1}}, \tag{3}$$

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

$$C_t \equiv \left[a_{\mathrm{H}}^{1/\phi} C_{\mathrm{H},t}{}^{\frac{\phi-1}{\phi}} + a_{\mathrm{F}}^{1/\phi} C_{\mathrm{F},t}{}^{\frac{\phi-1}{\phi}}\right]^{\frac{\phi}{\phi-1}}, \qquad \phi > 0, \tag{4}$$

where a_{H} and a_{F} are the weights on the consumption of Home and Foreign traded goods, respectively and ϕ is the constant (trade) elasticity of substitution between $C_{\mathrm{H},t}$ and $C_{\mathrm{F},t}$.

The price index of the Home goods is given by:

$$P_{\mathrm{H},t} = \left[\int_0^1 P_t(h)^{1-\theta} dh\right]^{\frac{1}{1-\theta}}, \tag{5}$$

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

$$\mathbb{P}_t = \left[a_{\mathrm{H}} P_{\mathrm{H},t}^{1-\phi} + a_{\mathrm{F}} P_{\mathrm{F},t}^{1-\phi}\right]^{\frac{1}{1-\phi}}. \tag{6}$$

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. $\Theta_t = \frac{\mathcal{E}_t \mathbb{P}_t^*}{\mathbb{P}_t}$. The terms of trade (TOT) are instead defined as the relative price of domestic imports in terms of exports: $\mathcal{T}_t = \frac{P_{\mathrm{F},t}}{\mathcal{E}_t P_{\mathrm{H},t}^*}$ if firms set prices in local currency and $\frac{\mathcal{E}_t P_{\mathrm{F},t}^*}{P_{\mathrm{H},t}}$ 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, $(1 + i_t)B_{\mathrm{H},t}$, 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

is traded internationally (see Obstfeld [1990], Mendoza [1991], and Schmitt-Grohe and Uribe [2003]).

flow budget constraint for the representative agent j in the Home country is therefore:

$$P_{\mathrm{H},t}C_{\mathrm{H},t} + P_{\mathrm{F},t}C_{\mathrm{F},t} + B_{\mathrm{H},t+1} \leq W_t L_t + (1+i_t)B_{\mathrm{H},t} + \int_0^1 \Pi(h)dh. \quad (7)$$

The household's problem thus consists of maximizing lifetime utility, defined by (1), subject to the constraint (7).

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]

2.2 Firms

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

$$Y(h) = ZL(h), \quad (8)$$

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.

Firms are subject to nominal rigidities à la Calvo so that, at any time t, they keep their price fixed with probability α. We assume that when firms update their prices, they do so simultaneously in the Home and in the Foreign market. Following the literature, we consider two models of nominal price distortions in the export markets. According to the first model, firms can set prices in local currencies — this is the LCP, or Local Currency Pricing hypothesis. The maximization problem is then as follows:

$$Max_{\mathcal{P}(h),\mathcal{P}^*(h)} \;\; E_t \left\{ \sum_{k=0}^{\infty} p_{bt,t+k}\alpha^k \begin{pmatrix} \left[\mathcal{P}_t(h)D_{t+k}(h) + \mathcal{E}_t\mathcal{P}_t^*(h)D_{t+k}^*(h)\right] - \\ MC_{t+k}(h)\left[D_{t+k}(h) + D_{t+k}^*(h)\right] \end{pmatrix} \right\} \quad (9)$$

where $p_{bt,t+k}$ is the firm's stochastic nominal discount factor between t and $t+k$ and the

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

firm's demand at Home and abroad is given by:

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

In these expressions, $P_{\mathrm{H},t}$ and $P^*_{\mathrm{H},t}$ 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:

$$\mathcal{P}_t(h) = \frac{\theta}{\theta - 1} \frac{E_t \sum_{k=0}^{\infty} \alpha^k p_{bt,t+k} D_{t+k}(h) MC_{t+k}(h)}{E_t \sum_{k=0}^{\infty} \theta^k p_{bt,t+k} D_{t+k}(h)}; \tag{10}$$

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

$$\mathcal{P}_t^*(h) = \frac{\theta}{\theta - 1} \frac{E_t \sum_{k=0}^{\infty} \theta^k p_{bt,t+k} D^*_{t+k}(h) MC_{t+k}(h)}{E_t \sum_{k=0}^{\infty} \theta^k p_{bt,t+k} \mathcal{E}_{t+k} D^*_{t+k}(h)}. \tag{11}$$

According to the alternative model, we posit that firms set prices in producer currency — this is the PCP, or Producer Currency Price hypothesis. In this case, exchange rate pass-through is complete. Given that demand elasticities are the same across markets, in domestic currency the price charged to foreign consumers is the same as the optimal price charged at Home: the law of one price holds: $\mathcal{P}_t^*(h) = \mathcal{P}_t(h)/\mathcal{E}_t$. The optimal price is similar to (10), whereas Home demand is replaced by global demand.

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

$$\begin{aligned} P_{\mathrm{H},t}^{1-\theta} &= \alpha P_{\mathrm{H},t-1}^{1-\theta} + (1-\theta)\,\mathcal{P}_t(h)^{1-\theta}, \\ P_{\mathrm{H},t}^{*1-\theta} &= \alpha P_{\mathrm{H},t-1}^{*1-\theta} + (1-\theta)\,\mathcal{P}_t^*(h)^{1-\theta}. \end{aligned} \tag{12}$$

Similar relations hold for the Foreign firms.

3 Monetary policy trade-offs in open economies

Our main interest is to understand the trade-offs facing monetary policymakers in open economies when asset markets can only support a decentralized allocation which is far from the efficient one, even when all prices are fully flexible. Given the focus on inefficiencies unrelated to nominal rigidities, a related question is thus whether policies geared toward purely domestic objectives, such as strict inflation targeting in production prices, may actually exacerbate misallocations in such an environment; or, conversely, whether the optimal monetary policy may actually improve welfare over the flexible-price benchmark allocation.

We carry out our analysis of these policy trade-offs defining welfare-relevant gaps in key variables of interest. As is customary in monetary theory, we define the welfare-relevant output gap as the deviation of output from its counterpart in the first-best allocation. In our study of inefficiencies specific to the international dimension of monetary policy, we also define three additional gaps, namely, the real exchange rate gap, the terms of trade gap and the relative demand gap, discussed below.

A first concern for policy design in open economy is the possibility that international relative prices are misaligned. Consistent with the definition of output gaps, misalignments occur when exchange rates deviate from the value they would take in the efficient allocation.[11] So, for the real exchange rate, we define the welfare-relevant gap or RER^{gap} as follows:

$$RER^{gap} = \ln \frac{\Theta}{\Theta^{fb}} \tag{13}$$

where fb denotes the variable in the benchmark first-best allocation. Analogously, the terms of trade gap, or TOT-gap is:

$$TOT^{gap} = \ln \frac{\mathcal{T}}{\mathcal{T}^{fb}} \tag{14}$$

While the two gaps above are a function of each other in equilibrium, because of home-bias in preferences and deviations from the law of one price, they 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

[11] We stress that, conceptually, the first-best exchange rate 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. '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.

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. In principle, 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, defined as follows:

$$\mathcal{D} = \ln \frac{MU^*}{MU}\Theta \tag{15}$$

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 Home consumption ratio is too low — Home consumption is too high given its relative price.

These newly defined gaps, together with output gaps and inflation, characterize monetary policy trade-offs in open economies. Quadratic welfare functions across the two national representative agents are particularly useful to illustrate this point (see CDL [2010]). Focusing on the two polar cases of complete markets (CM) and financial autarky (FA) under the assumption of PCP, what follows shows how these gaps enter both the policy welfare functions for benevolent policymakers with commitment, and the targeting rules characterizing the optimal policy.

Specifically, assuming a non-distorted steady state, PCP and a constant discount factor, it can be shown that the period-by-period loss function encompassing the polar cases of complete markets and financial autarky in our economy is

$$\propto -\frac{1}{2}\left\{\begin{array}{c} (\sigma+\eta)\left(\widetilde{Y}_{H,t}^{fb}-\widehat{Y}_{H,t}\right)^2+(\sigma+\eta)\left(\widetilde{Y}_{F,t}^{fb}-\widehat{Y}_{F,t}\right)^2+ \\ \frac{\theta\alpha}{(1-\alpha\beta)(1-\alpha)}\pi_{H,t}^2+\frac{\theta\alpha^*}{(1-\alpha^*\beta)(1-\alpha^*)}\pi_{F,t}^{*2}+ \\ -2a_{\mathrm{H}}(1-a_{\mathrm{H}})\frac{\sigma\phi-1}{\sigma}\left(4(1-a_{\mathrm{H}})a_{\mathrm{H}}\phi\sigma+(2a_{\mathrm{H}}-1)^2\right)\Psi\left(\widetilde{\mathcal{T}}_t^{fb}-\widehat{\mathcal{T}}_t\right)^2+ \\ \frac{2a_{\mathrm{H}}(1-a_{\mathrm{H}})(\phi-1)}{\sigma(2a_{\mathrm{H}}\phi-1)-(2a_{\mathrm{H}}-1)}\widehat{\mathcal{D}}_t^2 \end{array}\right\} \tag{16}$$

where all variables are in deviations from the steady state: a tilde denotes the allocation under flexible prices, a hat denotes the allocation under price rigidities, while the superscript

fb denotes the efficient allocation.[12] Under complete markets, the coefficient Ψ is equal to 1 and there are no relative demand imbalances, $\widehat{\mathcal{D}}_t = 0$. Under financial autarky, instead, $\Psi = \dfrac{\sigma\left(1 + 2a_{\mathrm{H}}\left(\phi - 1\right)\right)}{4\left(1 - a_{\mathrm{H}}\right) a_{\mathrm{H}}\phi\sigma + \left(2a_{\mathrm{H}} - 1\right)^2}$ and demand imbalances will generally be nonzero:

$$\widehat{\mathcal{D}}_t = \left(\sigma\left(2a_{\mathrm{H}}\phi - 1\right) - \left(2a_{\mathrm{H}} - 1\right)\right)\widehat{\mathcal{T}}_t - \left(\widehat{\zeta}_{C,t} - \widehat{\zeta}^{*}_{C,t}\right), \tag{17}$$

Observe that demand imbalances react to shocks to the differential in marginal utilities of consumption $\widehat{\zeta}_{C,t}$ and $\widehat{\zeta}^{*}_{C,t}$ independently of the terms of trade. More generally, when some assets are traded internationally, demand imbalances would also reflect the prices of these assets in addition to real exchange rates and terms of trade.

The optimal policy encompassing these two polar cases is fully characterized by targeting rules in sum (or global) and cross-country differences (or relative). The sum/global targeting rule is the same for the two market structures (CM and FA):

$$\begin{aligned} 0 \;=\; & \left[\left(\widehat{Y}_{H,t} - \widetilde{Y}^{fb}_{H,t}\right) - \left(\widehat{Y}_{H,t-1} - \widetilde{Y}^{fb}_{H,t-1}\right)\right] + \left[\left(\widehat{Y}_{F,t} - \widetilde{Y}^{fb}_{F,t}\right) - \left(\widehat{Y}_{F,t-1} - \widetilde{Y}^{fb}_{F,t-1}\right)\right] + \\ & +\theta\left(\pi_{H,t} + \pi^{*}_{F,t}\right) \end{aligned} \tag{18}$$

The relative targeting rule under complete markets (CM) is

$$\begin{aligned} 0 \;=\; & \left[\left(\widehat{Y}_{H,t} - \widetilde{Y}^{fb}_{H,t}\right) - \left(\widehat{Y}_{H,t-1} - \widetilde{Y}^{fb}_{H,t-1}\right)\right] - \left[\left(\widehat{Y}_{F,t} - \widetilde{Y}^{fb}_{F,t}\right) - \left(\widehat{Y}_{F,t-1} - \widetilde{Y}^{fb}_{F,t-1}\right)\right] + \\ & +\theta\left(\pi_{H,t} - \pi^{*}_{F,t}\right) + \frac{4a_{\mathrm{H}}\left(1 - a_{\mathrm{H}}\right)\left(\sigma\phi - 1\right)}{\sigma + \eta} \cdot \\ & \cdot\left\{ \begin{array}{c} \dfrac{4\left(1 - a_{\mathrm{H}}\right) a_{\mathrm{H}}\phi\sigma + \left(2a_{\mathrm{H}} - 1\right)^2}{\sigma}\left[\left(\widehat{\mathcal{T}}_t - \widetilde{\mathcal{T}}^{fb}_t\right) - \left(\widehat{\mathcal{T}}_{t-1} - \widetilde{\mathcal{T}}^{fb}_{t-1}\right)\right] + \\ +\theta\left(\pi_{H,t} - \pi^{*}_{F,t}\right) \end{array} \right\}. \end{aligned} \tag{19}$$

With financial autarky (FA), instead, the relative rule includes additional terms in the relative demand gap, and features different coefficients for inflation differentials and the TOT-

[12] In addition, to derive this expression we have slightly changed the expression for labor disutility to $-\dfrac{L^{1+\eta}}{1+\eta}$, as in Clarida et al. [2002]. Therefore the loss with PCP and complete markets is the same as in Engel [2009], but for a generic trade elasticity ϕ.

gap:

$$
\begin{aligned}
0 \;=\; & \left[\left(\widehat{Y}_{H,t}-\widetilde{Y}_{H,t}^{fb}\right)-\left(\widehat{Y}_{H,t-1}-\widetilde{Y}_{H,t-1}^{fb}\right)\right]-\left[\left(\widehat{Y}_{F,t}-\widetilde{Y}_{F,t}^{fb}\right)-\left(\widehat{Y}_{F,t-1}-\widetilde{Y}_{F,t-1}^{fb}\right)\right]+ \\
& +\theta\left(\pi_{H,t}-\pi_{F,t}^{*}\right)+ \\
& \frac{4a_{\mathrm{H}}\left(1-a_{\mathrm{H}}\right)(\sigma\phi-1)}{\sigma+\eta}\left\{\begin{array}{c}\left[\left(\widehat{\mathcal{T}}_t-\widetilde{\mathcal{T}}_t^{fb}\right)-\left(\widehat{\mathcal{T}}_{t-1}-\widetilde{\mathcal{T}}_{t-1}^{fb}\right)\right]+ \\ \frac{(1-\sigma)}{2a_{\mathrm{H}}(\sigma\phi-1)}\frac{\theta}{1+2a_{\mathrm{H}}(\phi-1)}\left(\pi_{H,t}-\pi_{F,t}^{*}\right)\end{array}\right\}+ \\
& +\frac{4a_{\mathrm{H}}\left(1-a_{\mathrm{H}}\right)(\phi-1)}{1-2a_{\mathrm{H}}(1-\phi)}\frac{1}{\sigma+\eta}\left(\widehat{\mathcal{D}}_t-\widehat{\mathcal{D}}_{t-1}\right)
\end{aligned} \tag{20}
$$

Consider first the two (sum and difference) rules in the complete market specification of the model. It is apparent that, as long as shocks affect both output and its first-best counterpart, the optimal policy consists of keeping national output gaps closed and inflation identically equal to zero. Under complete markets and PCP, this is indeed the optimal response to shocks to productivity and preferences, which by their nature affect the first-best allocation. The optimal policy prescription just described points to an open economy instance of what Blanchard and Galí have dubbed 'divine coincidence', characterizing economies in which different welfare-relevant gaps are proportional to each other, and there is no trade-off in their stabilization.

In open economies, a divine coincidence is possible by virtue of the fact that, with complete markets and holding the law of one price, closing output gaps automatically moves exchange rates towards their efficient level, in accord with the received wisdom of the international transmission as exemplified by, e.g., Friedman (1953). Indeed, assuming complete markets and PCP in our setting makes the terms of trade gap proportional to the differential in output gaps:

$$
\frac{4\left(1-a_{\mathrm{H}}\right)a_{\mathrm{H}}\phi\sigma+\left(2a_{\mathrm{H}}-1\right)^2}{\sigma}\left(\widehat{\mathcal{T}}_t-\widetilde{\mathcal{T}}_t^{fb}\right)=\left(\widehat{Y}_{H,t}-\widetilde{Y}_{H,t}^{fb}\right)-\left(\widehat{Y}_{F,t}-\widetilde{Y}_{F,t}^{fb}\right). \tag{21}
$$

Therefore, the relative target above reduces to one involving only output gap and inflation differentials, which further implies that optimal policy could be described in terms of purely domestic objectives, i.e. each country stabilize its own output gap and GDP-deflator inflation. This result establishes a well-known, though special, isomorphism of optimal policy in closed and open economies under PCP: strict inflation stabilization is the optimal response to all (*current and anticipated*) shocks affecting efficient output $\widetilde{Y}_{H,t}^{fb}$ and $\widetilde{Y}_{F,t}^{fb}$ — usually referred to as *efficient shocks* —, simultaneously closing the welfare-relevant output gaps. No role is assigned to external objectives such as real exchange rate misalignments.

The possibility of a divine coincidence is generally ruled out by incomplete markets, however. To start with, the terms of trade and the output gap are no longer proportional to each other. For the case of financial autarky, this can be seen combining the first-best and the financial autarky allocation:

$$(1 - 2a_{\mathrm{H}}(1-\phi))\,\widehat{\mathcal{T}}_t = \widehat{Y}_{H,t} - \widehat{Y}_{F,t} \tag{22}$$

$$\left[4(1-a_{\mathrm{H}})\,a_{\mathrm{H}}\phi + \frac{(2a_{\mathrm{H}}-1)^2}{\sigma}\right]\widetilde{\mathcal{T}}_t^{fb} = \widetilde{Y}_{H,t}^{fb} - \widetilde{Y}_{F,t}^{fb} - \frac{2a_{\mathrm{H}}-1}{\sigma}\left(\widehat{\zeta}_{C,t} - \widehat{\zeta}^*_{C,t}\right),$$

to obtain the following expression:

$$\begin{aligned}
\frac{4(1-a_{\mathrm{H}})\,a_{\mathrm{H}}\phi\sigma + (2a_{\mathrm{H}}-1)^2}{\sigma}\left(\widehat{\mathcal{T}}_t - \widetilde{\mathcal{T}}_t^{fb}\right) &= \left(\widehat{Y}_{H,t} - \widetilde{Y}_{H,t}^{fb}\right) - \left(\widehat{Y}_{F,t} - \widetilde{Y}_{F,t}^{fb}\right) + \frac{2a_{\mathrm{H}}-1}{\sigma}\left(\widehat{\zeta}_{C,t} - \widehat{\zeta}^*_{C,t}\right) \\
&\quad + \left[\begin{array}{c} 4(1-a_{\mathrm{H}})\,a_{\mathrm{H}}\phi + \dfrac{(2a_{\mathrm{H}}-1)^2}{\sigma} + \\ -(1-2a_{\mathrm{H}}(1-\phi)) \end{array}\right]\widehat{\mathcal{T}}_t \\
&= \left(\widehat{Y}_{H,t} - \widetilde{Y}_{H,t}^{fb}\right) - \left(\widehat{Y}_{F,t} - \widetilde{Y}_{F,t}^{fb}\right) - \frac{2a_{\mathrm{H}}-1}{\sigma}\widehat{\mathcal{D}}_t.
\end{aligned} \tag{23}$$

The equilibrium relation between terms of trade and relative output gaps coincides with the complete-market one only for $a_{\mathrm{H}} = 1/2$, i.e. when PPP holds. But even in this case, with the exception of some special parameterization, the relative targeting rule (20) will generally be different from the one under complete markets (19), reflecting both the presence of the demand imbalance term $\widehat{\mathcal{D}}_t$, and a weight on relative inflation different from θ.

One of these special cases often discussed in the literature consists of a specification where utility from consumption is in log form ($\sigma = 1$), and the trade elasticity between domestic and foreign goods is equal to one ($\phi = 1$), corresponding to a Cobb-Douglas aggregator of the two goods. Under this special yet amply studied specification, the welfare function and the targeting rules are identical under complete and incomplete markets. Yet it does not follow that the optimal policy coincides. The reason is that domestic welfare-relevant output gaps do not behave identically across the two specifications. Namely, with internationally incomplete markets the flexible price allocation is inefficient in response to preference shocks, prompting benevolent policymakers to react to these shocks in much the same way in which they react to markup shocks (see Devereux (2003) and CDL (2010)).

In general, the distortions created by incomplete markets combine with nominal rigidities as to prevent the economy from reaching a first-best allocation. However, nominal distortions also affect the ability of monetary policy to correct the allocation. In this respect, it is instructive to analyze the behavior of our economies under financial autarky, comparing PCP with LCP. Such a comparison provides an important key to understanding our numerical results showing that the optimal policy is much more effective under LCP than PCP. Under

PCP, indeed, the terms of trade, the real exchange rate and relative consumption are strictly proportional to relative output. This is not the case under LCP. .

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

$$
\begin{aligned}
P_{\mathrm{F},t}C_{\mathrm{F},t} &= \mathcal{E}_t P^*_{\mathrm{H},t}C^*_{\mathrm{H},t} \\
(1-a_{\mathrm{H}})\frac{P_{\mathrm{F},t}}{\mathcal{E}_t P^*_{\mathrm{H},t}}\left(\frac{P_{\mathrm{F},t}}{P_t}\right)^{-\phi} C_t &= a^*_{\mathrm{H}}\left(\frac{P^*_{\mathrm{H},t}}{P^*_t}\right)^{-\phi} C^*_t.
\end{aligned} \tag{24}
$$

When log-linearized, this expression becomes:

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

Contrary to the PCP case, the domestic relative prices $\widehat{\frac{P_{\mathrm{H},t}}{P_{\mathrm{F},t}}}$ and $\widehat{\frac{P^*_{\mathrm{F},t}}{P^*_{\mathrm{H},t}}}$ are generally different from the terms of trade $\widehat{\mathcal{T}}_t$ under LCP 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, $\widehat{\Delta}_{\mathrm{H},t}$ and $\widehat{\Delta}_{\mathrm{F},t}$ — deviations which by assumption are entirely due to nominal rigidities in local currency:

$$
\begin{aligned}
\widehat{\frac{P_{\mathrm{F},t}}{P_{\mathrm{H},t}}} &= \widehat{\mathcal{T}}_t + \widehat{\frac{\mathcal{E}_t P^*_{\mathrm{H},t}}{P_{\mathrm{H},t}}} = \widehat{\mathcal{T}}_t + \widehat{\Delta}_{\mathrm{H},t} \\
\widehat{\frac{P^*_{\mathrm{F},t}}{P^*_{\mathrm{H},t}}} &= \widehat{\mathcal{T}}_t + \widehat{\frac{\mathcal{E}_t P^*_{\mathrm{F},t}}{P_{\mathrm{F},t}}} = \widehat{\mathcal{T}}_t + \widehat{\Delta}_{\mathrm{F},t},
\end{aligned} \tag{25}
$$

Now, under symmetry in the Calvo probabilities, it can be shown that $\widehat{\Delta}_{\mathrm{H},t} = \widehat{\Delta}_{\mathrm{F},t} = \widehat{\Delta}_t$. With this simplification, we can write the real exchange rate as a function of the same arguments:

$$
\widehat{\Theta}_t = a_{\mathrm{H}}\left(\widehat{\frac{P_{\mathrm{F},t}}{P_{\mathrm{H},t}}} + \widehat{\frac{P^*_{\mathrm{F},t}}{P^*_{\mathrm{H},t}}}\right) - \widehat{\mathcal{T}}_t = (2a_{\mathrm{H}}-1)\widehat{\mathcal{T}}_t + 2a_{\mathrm{H}}\widehat{\Delta}_t. \tag{26}
$$

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:

$$\widehat{\mathcal{T}}_t = \frac{\widehat{Y}_{H,t} - \widehat{Y}_{F,t} - 2a_{\mathrm{H}}\phi\widehat{\Delta}_t}{1 - 2a_{\mathrm{H}}(1-\phi)} \tag{27}$$

$$\widehat{C}_t - \widehat{C}_t^* = \frac{2a_{\mathrm{H}}\phi - 1}{1 - 2a_{\mathrm{H}}(1-\phi)}\left(\widehat{Y}_{H,t} - \widehat{Y}_{F,t}\right) + \frac{2a_{\mathrm{H}}(1-a_{\mathrm{H}})\phi}{1 - 2a_{\mathrm{H}}(1-\phi)}\widehat{\Delta}_t.$$

Recall that allocations under PCP would have $\widehat{\Delta}_t = 0$. Finally, the condition for efficient risk sharing then becomes[13]

$$\begin{aligned} 0 &= \widehat{\mathcal{D}}_t = \sigma\left(\widehat{C}_t - \widehat{C}_t^*\right) - \widehat{\Theta}_t - \left(\widehat{\zeta}_{C,t} - \widehat{\zeta}_{C,t}^*\right) \\ &= \frac{\sigma(2a_{\mathrm{H}}\phi - 1) - (2a_{\mathrm{H}} - 1)}{1 - 2a_{\mathrm{H}}(1-\phi)}\left(\widehat{Y}_{H,t} - \widehat{Y}_{F,t}\right) + \\ &\quad + a_{\mathrm{H}}\left[\frac{2a_{\mathrm{H}} - 1 + \phi(2\sigma(1-a_{\mathrm{H}}) - 1)}{1 - 2a_{\mathrm{H}}(1-\phi)}\right]\widehat{\Delta}_t - \left(\widehat{\zeta}_{C,t} - \widehat{\zeta}_{C,t}^*\right), \end{aligned} \tag{28}$$

The presence of deviations from the law of one price due to nominal rigidities has 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 react as to offset movements in relative output, in such a way as to contain inefficient deviations in relative prices and demand. The trade-off, of course, is that deviations from the law of one price entail relative price misalignment, hence are costly in terms of welfare — indeed $\widehat{\Delta}_t$ would appear as an independent term in the counterpart, under LCP, of the loss functions derived above (see Engel [2009]). In contrast, under PCP, eliminating cross-country inefficiencies in demand and the currency misalignment could necessitate large movements in output gaps, which is also costly in terms of welfare.

While the analytic and the exposition above has been facilitated by focusing on the two polar case of complete markets and financial autarky, our main results provide insights on the economics of optimal monetary policy for more general specifications of the model, allowing for trade in some assets. The main lessons are straightforward. By making the flexible price allocation inefficient, incomplete markets induce policy trade-offs that motivate deviations from strictly targeting inflation and purely domestic objectives, as to account for international price misalignment and demand imbalances. The relative importance of these trade-offs of course depends on the structure of financial markets, the nature and number of the shocks hitting the economy, and specific economic features which jointly determine the distance of the incomplete market allocation from the first-best, in terms of macroeconomic activity and welfare. For any given 'distance' then, a key question is the extent to which the

[13] Note that, despite incomplete markets, $\widehat{\mathcal{D}}_t = 0$ again for the special case $\sigma = \phi = 1$.

optimal monetary policy is able to redress the underlying inefficiencies. Specifically, with LCP, monetary policy may be more effective in redressing both domestic and cross-country inefficiencies in consumption and employment at once, to such an extent that the resulting incomplete-market allocation may be better than the flexible price one. Yet, this will only be achieved by deviating from price stability. Therefore, the allocation will remain inefficient, since the optimal policy results in some price dispersion.

4 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 In our benchmark calibration, we assume that both η and σ (risk aversion) are equal to 2, and we set κ so that in steady state, one third of the time endowment is spent working. 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:

$$\nu\left(C_t, L\right) = \ln\left(1 + \psi\left[C_t + \kappa(1 - L_t)\right]\right), \tag{29}$$

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 $a_{\mathrm{H}} + a_{\mathrm{F}} = 1$) 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 θ 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 ϕ either to .45, corresponding to estimates from the macro literature, if only towards the low end, or 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 $\mathbf{V}_t$:

$$\mathbf{Z}_t = \mathbf{U}_t - \mathbf{V}_t, \tag{30}$$

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 baseline experiments, we will focus on the case in which $\xi_{u,t}$ is set equal 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:

$$Welfare = \frac{\mathbb{W}_0 + \mathbb{W}_0^*}{2}. \tag{31}$$

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 algorithm developed in Coenen et al [2010]. 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.

5 Misalignments and demand imbalances in the natural-rate allocation

Our analysis emphasizes 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.

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 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.[14] 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.

6 Optimal policy with incomplete-market distortions

This section analyzes the policy trade-offs between stabilizing domestic objectives narrowly defined in terms of a constant price index, and correcting both domestic and international inefficiencies deriving from misalignments. To this end, we compare the optimal policy against suboptimal rules targeting narrow domestic objectives in 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, we characterize suboptimal policies assuming that the central bank targets the GDP deflator in the PCP economy — so that the policy will support the flexible price allocation —, and the domestic CPI in the LCP economy.[15]

In what follows, we will present our analysis twice, first in economies with a high trade elasticity, then in economies with a low trade elasticity.

6.1 A case of 'near divine coincidence:' 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 (which is the same as the flexible price allocation) and optimal

[14] As 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.

[15] This policy would be optimal under complete markets with linear labor disutility (i.e. $\eta = 0$) — see Engel [2009].

monetary policy, following 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 have asymmetric effects on demand. On impact, Home households optimally raise their consumption and reduce their labor supply. Consumption smoothing by Home households create inflationary pressure at Home and abroad. As shown in Figure 4, when policymakers pursue a ***suboptimal policy*** of strict inflation targeting, 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. Observe that the Home country runs an external deficit for some time: 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.

Now, under strict inflation targeting the allocation is the same as with flexible prices and incomplete markets; hence its inefficiencies are the same as the one discussed in relation to Figure 2: 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, and an inefficient relative demand gap, mirrored by the Home external deficit. 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 upon 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. The relevant gaps, shown in Table 1, 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 the suboptimal 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 the ***suboptimal policy***, 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 depreciation of the Home exchange rate does not attenuate the rise in Home demand for foreign goods as much as with PCP. Compared to strict inflation targeting, 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: Home households consume too much and work too little, with the opposite occurring abroad, and the Home real exchange rate is too strong. Similarly to 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 optimal policy 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 relative size of the welfare relevant trade-offs raised by misalignments and demand imbalances. As the inefficiency in these dimensions is small, relative to inefficiencies induced by nominal rigidities, the optimal policy focuses on containing deviations from price stability, which are therefore negligible in equilibrium. 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.

6.2 Optimal trade-offs with large misalignments: 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 essentially faces an instance of divine coincidence. In this subsection, we turn to economies in which policy trade-offs are much more relevant, and in some cases 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 the ***suboptimal policy***, 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 2008a 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 somewhat less limited than in the cases discussed in the previous subsections. Indeed, as shown by Figure 6, the optimal policy initially redirects world demand from Home to Foreign consumers. Relative to a policy of strict inflation stabilization, 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 strict 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 output gaps, the RD-gap and RER-gap 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 strict inflation targeting. 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. As discussed in Section 3, optimal monetary policy thus trade-offs deviations from the law of one price with the other welfare objectives.

The key finding is that, with a low elasticity and incomplete markets, misalignment and demand imbalances are more consequential in terms of welfare, prompting monetary authorities to move as to correct them. The fact that, under LCP distortions, (as discussed in Section 3) deviations from the law of one price breaks the strict proportionality between relative output and the terms of trade, makes it possible for monetary policy to redress both domestic and cross-country inefficiencies in consumption and employment at once — although this can only by achieved by deviating from price stability. The allocation remains inefficient, since the optimal policy results into some costly price dispersion. Yet the dynamic path for aggregate variable is remarkably close to the first best.

In our experiments, monetary policy geared towards purely inward-looking objectives such as strict inflation targeting does not prevent significant misalignments in important asset prices like the exchange rate, even if the latter only reflects fundamental-based valuations. On the contrary, our results also suggest that there is scope for monetary policy to achieve significant welfare gains relative to strict inflation targeting, 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 a strict inflation target amount to 0.36 percent of steady state consumption.

An important, final observation is that leaning against the wind of misalignment is not an argument for limiting exchange rate flexibility tout-court. The optimal policy derived in the main text 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 strict inflation targeting, which further widens the welfare gap relative to the optimal policy.

6.3 News versus autoregressive productivity shocks

While news shocks provide a particularly interesting framework for developing our arguments, it is important to keep in mind that our results do not 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 fundamental shocks. 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 (30). 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. Actually, 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 autoregressive process as well.

7 Conclusion

A key question in the policy debate is whether misalignments in asset prices can create relevant trade-offs with other policy objectives. 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 and in which inefficiencies arise only because of nominal rigidities, it is hardly surprising that answers tend to be tilted in favor of purely inward-looking objectives such as strict inflation targeting, 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 asset 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 strict inflation targeting 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. Redressing price dispersion due to nominal rigidities is the overwhelming concern for policymakers, who optimally choose not to target 'external imbalances.' But we also show instances in which a narrow implementation of inflation targeting results in inefficient levels of consumption and hours, associated with relatively large misalignments and external imbalances, thus justifying flexible inflation targeting 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 misalignments and inefficient demand imbalances also emerge in economies with capital accumulation and non-traded goods (see CDL [2008a,b]). 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 distortions that, at domestic as well as international levels, 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 strict inflation targeting 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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8 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

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

so that the welfare cost is given by

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

Table 1.
Gap Volatility and Welfare under Optimal Policy and Strict GDP-deflator Inflation Targeting

	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.

Table 2.

Gap Volatility and Welfare with LCP under Optimal Policy and Strict CPI Inflation Targeting

	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.

Figure 1. News and Autoregressive Shocks

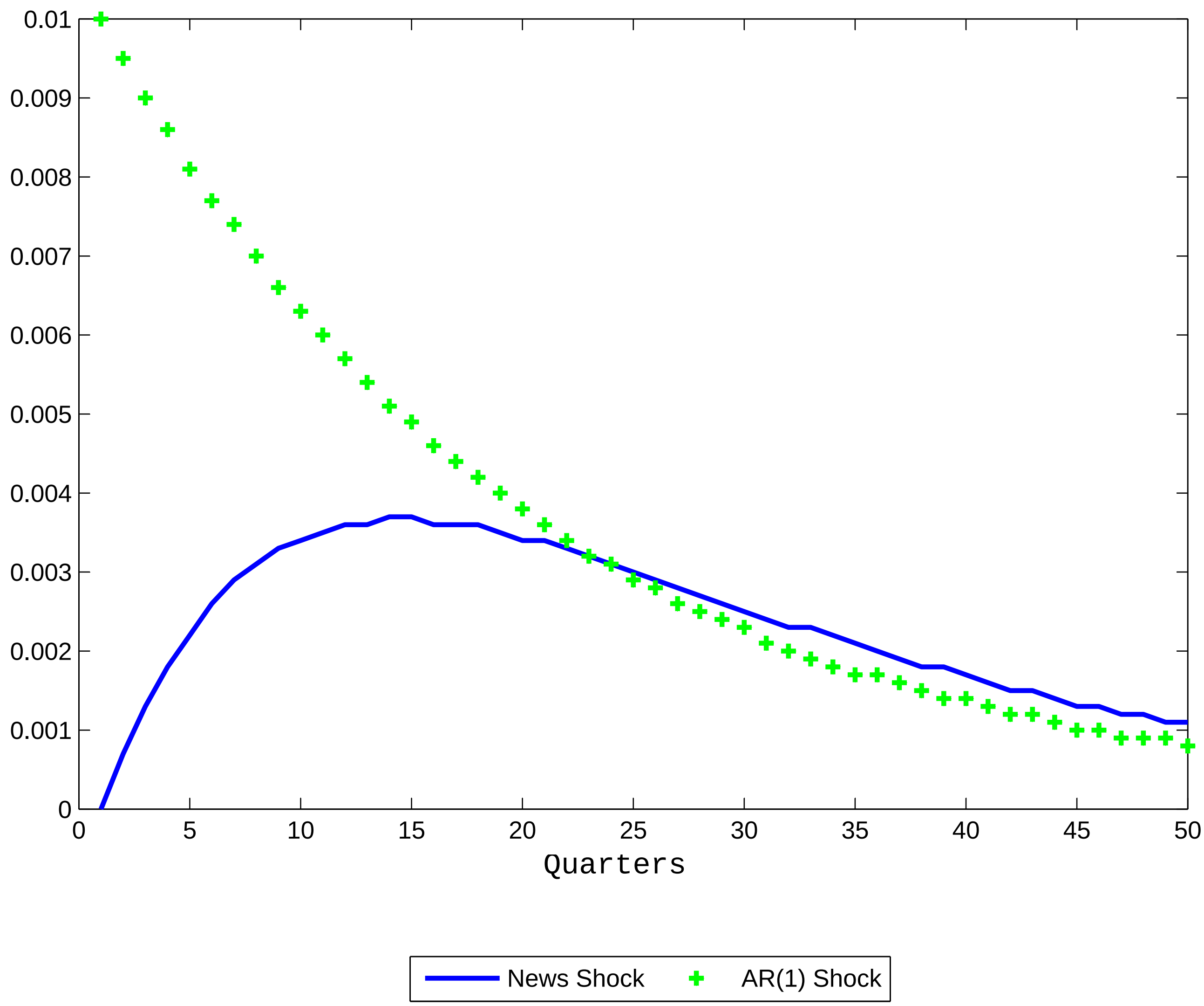

Figure 2. Macroeconomic Effects of News Shocks with Flexible Prices
Complete versus Incomplete Markets Allocation under High Elasticity

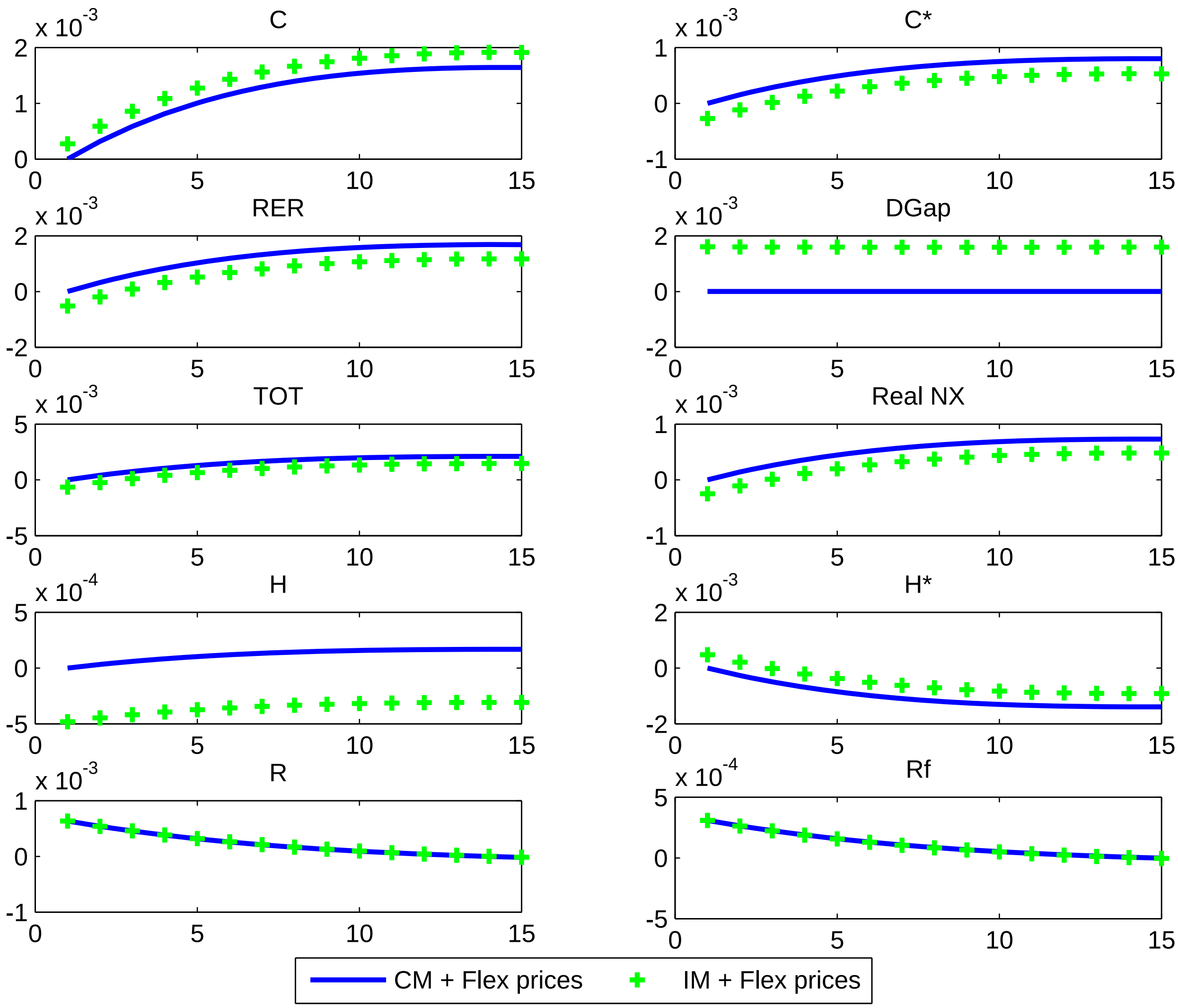

Figure 3. Macroeconomic Effects of News Shocks with Flexible Prices
Complete versus Incomplete Markets Allocation under Low Elasticity

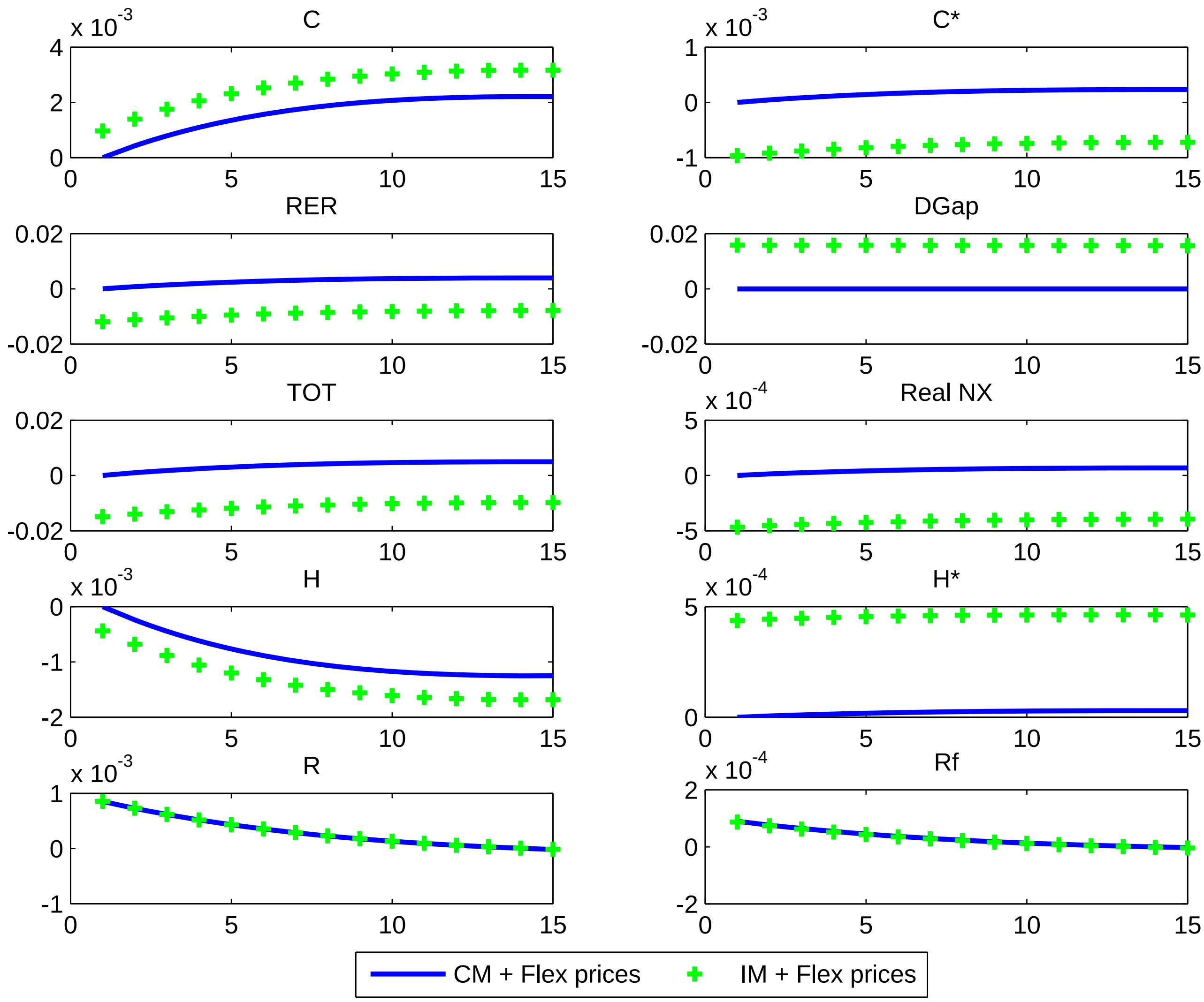

Figure 4a. News Shocks with High Elasticity and PCP:
Domestic Price Stability and Optimal Policy

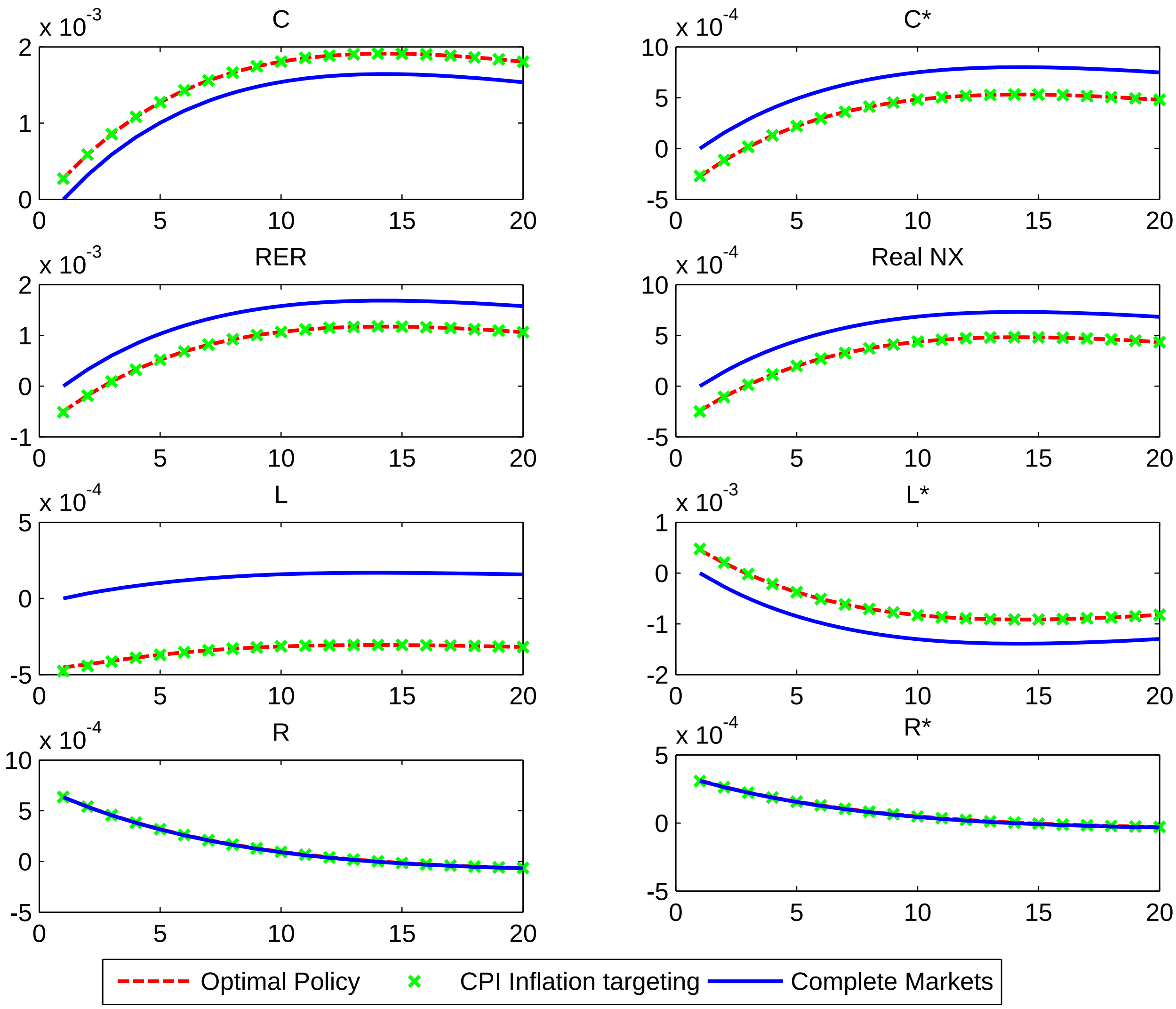

Figure 4b. News Shocks with High Elasticity and PCP:
Domestic Price Stability and Optimal Policy

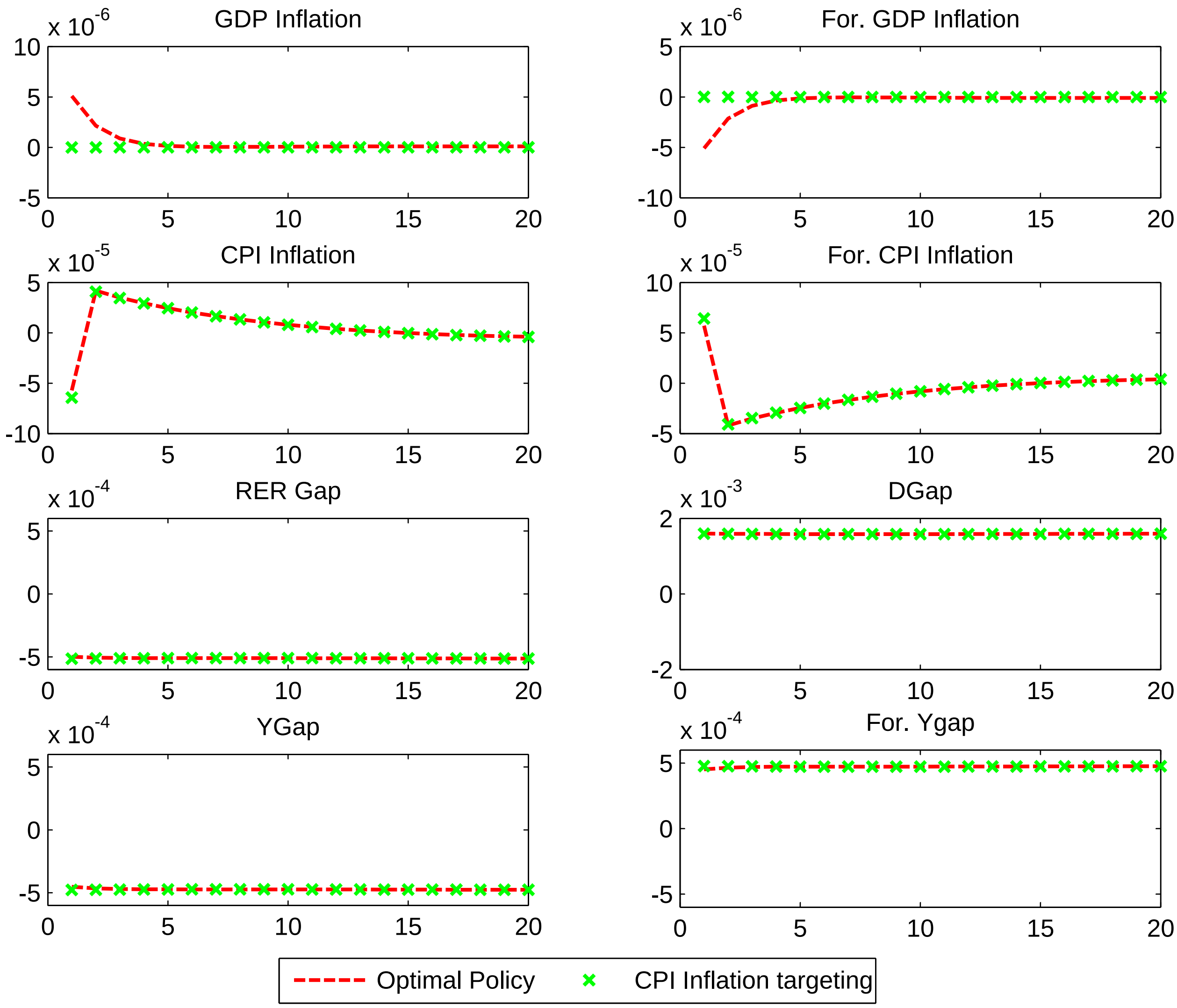

Figure 5a. News Shocks with High Elasticity and LCP:
Consumer Price Stability and Optimal Policy

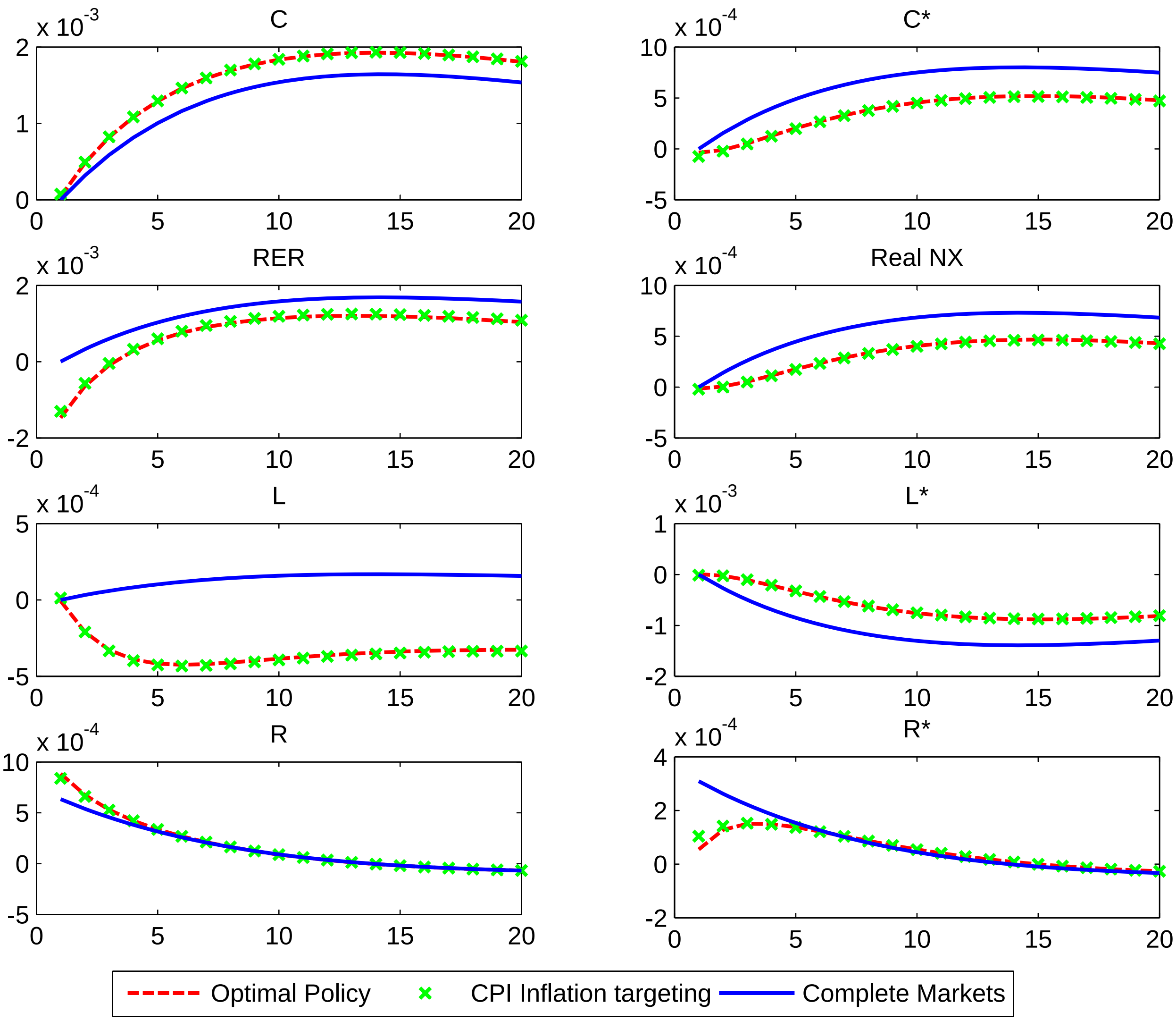

Figure 5b. News Shocks with High Elasticity and LCP: Consumer Price Stability and Optimal Policy

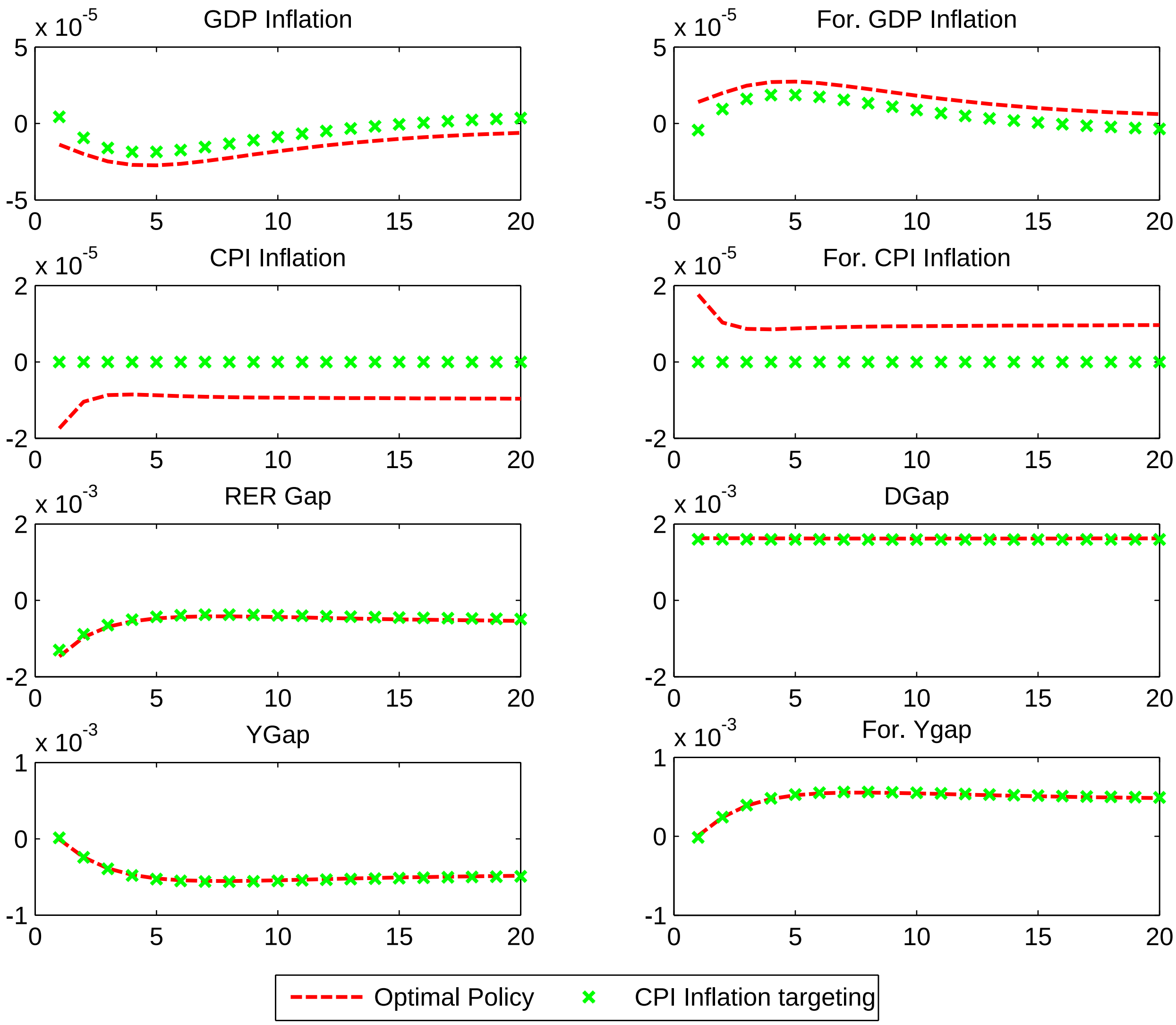

Figure 6a. News Shocks with Low Elasticity and PCP:
Domestic Price Stability and Optimal Policy

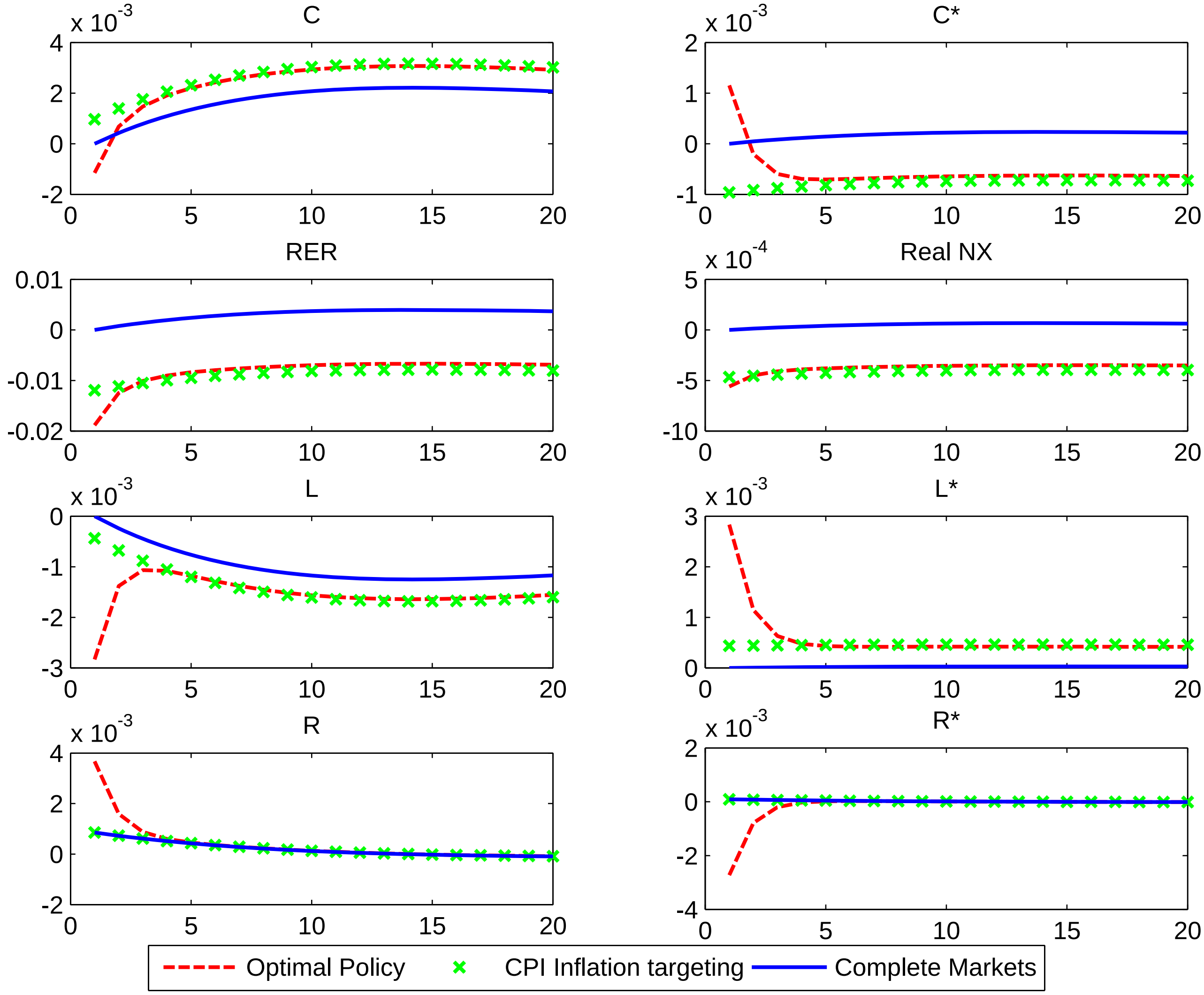

Figure 6b. News Shocks with Low Elasticity and PCP:
Domestic Price Stability and Optimal Policy

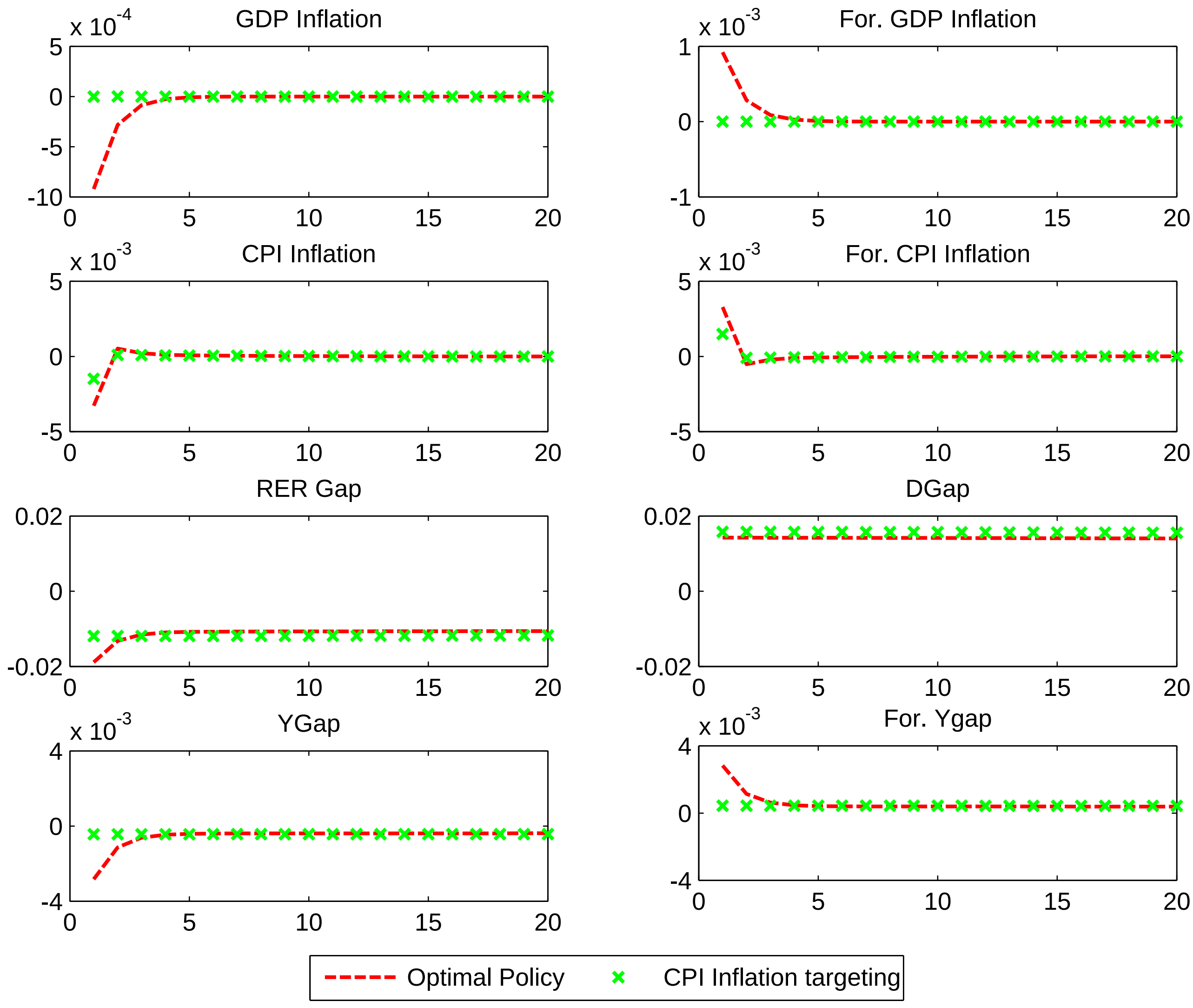

Figure 7a. News Shocks with Low Elasticity and LCP:
Consumer Price Stability and Optimal Policy

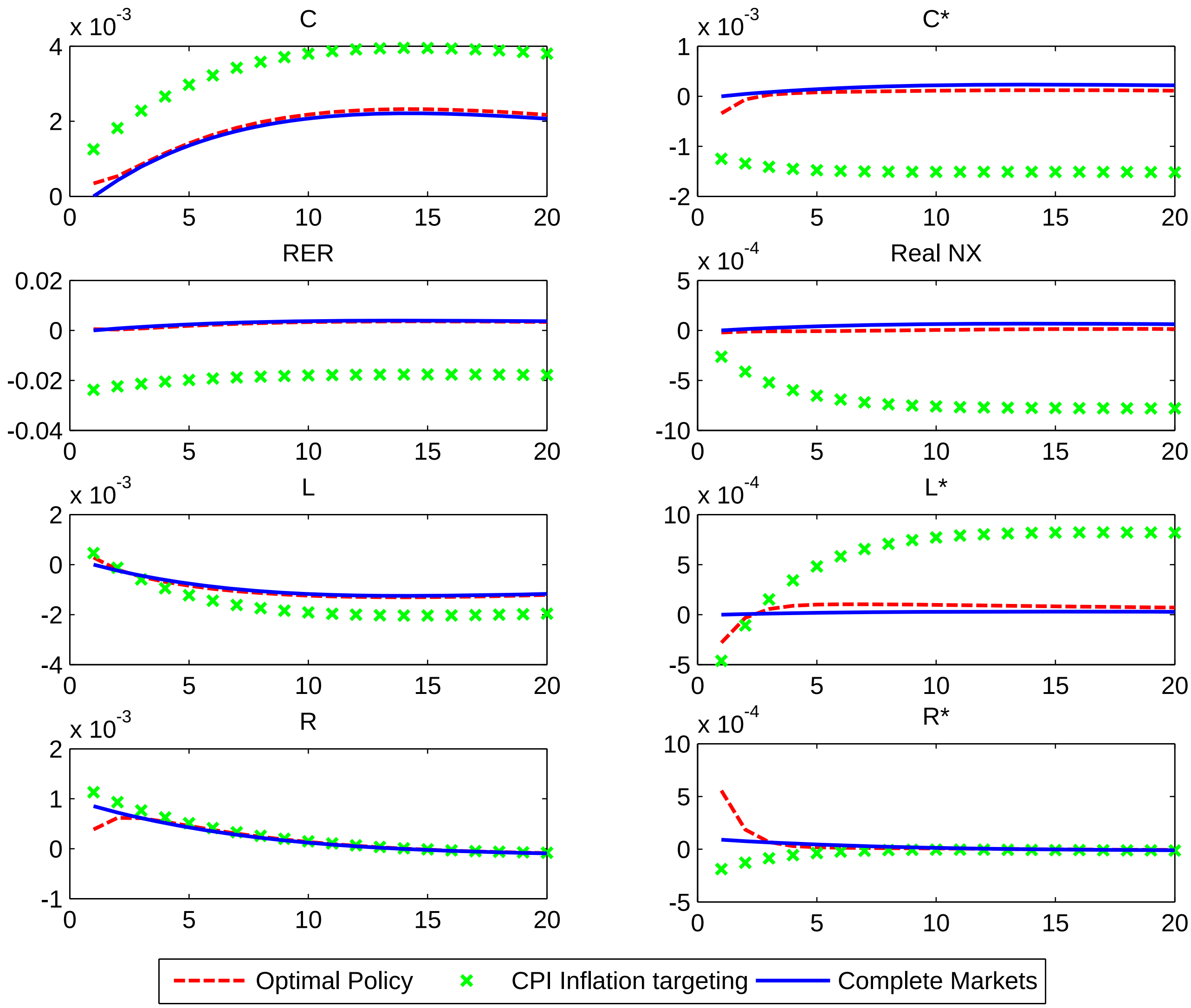

Figure 7b. News Shocks with Low Elasticity and LCP:
Consumer Price Stability and Optimal Policy