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

Giancarlo Corsetti
Cambridge University, University of Rome III and CEPR
Luca Dedola
European Central Bank and CEPR
Sylvain Leduc
Federal Reserve Bank of San Francisco

This version: September 2011

Abstract

Should monetary policy be concerned with real exchange rate misalignment and cross-country demand imbalances? This paper examines the trade-offs among external and internal objectives in standard open macro models with incomplete markets and nominal rigidities, both analytically and quantitatively. It derives quadratic welfare-based loss-functions for a general class of these NOEM models, providing a characterization of optimal monetary stabilization policy under cooperation. The latter is characterized by flexible inflation-targeting rules as a function of misalignment and cross-country demand imbalances. Focusing on 'news shocks' to emphasize the asset-price nature of the exchange rate, the paper shows that purely inward-looking monetary policies like strict inflation targeting may result in (rather than correcting) misalignments in the exchange rate, even when the latter only reflects fundamental-based valuation, leading to inefficient capital flows and current account imbalances across countries. Finally, conditions are discussed under which optimal monetary policy redresses these inefficiencies, achieving significant welfare gains relative to the flexible price allocation, by leaning against an over- or under-valued exchange rate, associated to cross-country demand imbalances and inefficient external borrowing.

[1]We thank our discussants Rodrigo Caputo, Charles Engel and Jordi Galì, Assaf Razin and participants in 2009 CEPR ESSIM, the 2009 BOC-ECB Workshop on Exchange Rates, the 2010 International Research Forum on Monetary Policy and World Congress of the Econometric Society, as well as seminar participants at the Reserve Bank of Australia, Banco Central de Chile, Cambridge University, EUI, Federal Reserve Bank of New York, HEC Lausanne and Montreal, Bank of Hungary, London School of Economics, University of California Santa Cruz, for comments. Financial support by the Pierre Werner Chair Programme at the Robert Schuman Centre of the European University Institute is gratefully acknowledged. The views expressed in this paper do not necessarily reflect those of the ECB or the Federal Reserve System.

1 Introduction

Concerns about real exchange rate over- or undervaluation, and inefficient capital inflows and outflows, resulting in cross-country imbalances are recurrent in the policy debate on business cycle stabilization, reflecting the importance of the exchange rate in its dual role 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 nominal distortions from 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 reconsidered by Devereux and Engel [2006, 2007].

The contribution of this paper is to study policy trade-offs between internal and external objective and characterize optimal monetary policy when real misalignments arise from this dual role of the exchange rate in incomplete markets economies.[2] This class of misalignments leads to inefficient market outcomes even in an economy with flexible prices.[3] Specifically, while the exchange rate acts as a "shock absorber" in response to fundamentals, it triggers suboptimal adjustment in consumption and employment and gives rise to cross-country (relative) demand imbalances, reflecting suboptimal capital flows and global wealth allocation.[4]

To emphasize the relevance of incomplete markets distortions, we consider real exchange rate misalignments in response to ***anticipated*** technology (news) shocks, thus highlighting the forward-looking nature of exchange rate determination, as in Devereux and Engel [2006, 2007] (henceforth DE).[5] When production risk is well diversified — the case studied by DE under a complete set of Arrow-Debreu securities — the optimal policy in response to news shock prescribes goods price stabilization, which in turn implies complete exchange rate stability until the anticipated technology

[2] 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. See also Kocherlakota [2010].

[3] As discussed below, these inefficiencies in the competitive equilibrium arise with respect to both the first-best allocation and the constrained-efficient allocation (see the seminal paper by Geanakoplos and Polemarchakis [1986] and Lorenzoni [2010] for a recent application).

[4] See e.g. Devereux [2004] for an analysis under financial autarky without capital flows and preference shocks, in which, although the exchange rate acts as a perfect 'shock absorber' it may in fact be better to prevent exchange rate adjustment altogether. Tille [2005] assesses the welfare impact of integrating international asset markets with nominal rigidities and monetary shocks.

[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].

change materializes.[6] Under the optimal policy, there is no trade-off between external and internal objectives.

Moving away from the case of frictionless financial markets, 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.[7] As shown in previous work of ours (Corsetti et al. [2008], henceforth CDL), we show that in this economies misalignments materialize in (potentially large) real exchange rates responses to shocks that have the opposite sign relative to that in the efficient allocation. Also, relative to DE, we model nominal price rigidities with the Calvo mechanism — the standard way to capture forward-looking staggered pricing decisions — under alternative assumptions regarding 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 contributions are as follow. First, abstracting from nominal rigidities, we show how financial imperfections result in real exchange rate misalignments and inefficient capital flows, which in turn exacerbate cross-country demand imbalances, expressed in terms of the gap between marginal utility differentials and the real exchange rate — the welfare-relevant measure of demand imbalances in multi-agent economies.[8] 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. Indeed, in our economies, as positive news shocks cause domestic consumption to grow relative to the foreign one fuelled by excessive borrowing, the domestic currency appreciates in real terms.[9]

Secondly, we characterize analytically the policy trade-offs faced by benevolent policymakers in open economy models, for the general case of incomplete markets and nominal rigidities. After deriving a quadratic approximation of the welfare function, we characterize the optimal policy under commitment and cooperation in terms of a pair of global and cross-country targeting rules. We show that both the loss and the targeting rules (as well as the Phillips curves), can be written as a function of real exchange rate misalignment and relative demand gap, in addition to inflation rates and output gaps. With incomplete markets, significant trade-offs between internal and external objectives prevent optimal monetary policy from closing any of the welfare-relevant gaps completely. These trade-offs, however, may differ markedly, depending on the structure of financial markets, trade elasticities and the type of nominal rigidities.

Our third contribution consists of providing a quantitative assessment of these policy trade-

[6] See also Benigno [2007].

[7] 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 in the face of productivity shocks (see Cole and Obstfeld [1991]).

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

[9] 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].

offs. In economies characterized by a relatively 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. But 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.

This conclusion changes drastically, however, when we look at low-trade elasticity economy. Under a suboptimal policy mimicking 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. Optimal cooperative 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. Relative to the flexible-price (but incomplete-market) allocation, the optimal policy results in a drastic reduction of domestic and cross-country demand imbalances, narrowing the inefficiently large Home trade deficits — it actually reverses the sign of net trade flows across countries.

Our analysis thus provides examples of standard open economies, in which monetary policy geared towards strict inflation targeting actually 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 findings provide an argument in favor of policies of flexible inflation targeting, including external objectives such as exchange rate misalignments. It should be stressed, however, 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 via fluctuation in the price level or in the exchange rate. Rather, the optimal policy acts as to correct inefficient relative wealth effects due to market incompleteness.

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.[10] 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.[11] Benigno [2009] finds large gains

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

[11] 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

accruing from cooperative policies, relative to price stability under PCP, in economies with (exogenously given) asymmetries in net foreign asset holdings in the nonstochastic steady state.[12] 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 which are at the core of our framework. Our study is also related to a recent literature which analyzes inefficient capital flows in small-open economies facing borrowing constraints, emphasizing pecuniary externalities and over- and under-borrowing relative to the (constrained-) efficient allocation (see Jeanne and Korinek [2010], Korinek [2010], Benigno et al. [2010], Bianchi [2010], Bianchi and Mendoza [2010]). Relative to these works, a distinct feature of our contribution is its specific focus on monetary policy in a global equilibrium.

The rest of the paper is organized as follows. The next section presents our stylized 2-country economy, while Section 3 and 4 discuss analytically the policy trade-offs between domestic objectives and misalignment and demand imbalances. Section 5 describes the parameterization we use throughout our exercises. Our main results with news shocks are reported in Section 6, comparing optimal and suboptimal monetary policies. Concluding observations are offered in Section 7.

2 The model economy

The analysis builds on the standard open-economy version of the workhorse model in monetary economics (see e.g. Clarida, Gali and Gertler (2002) and Engel (2009)). 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.

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.

[12] In addition, the working paper version of this paper, Benigno [2001], characterizes welfare differences between cooperative policies and price stability in economies with no steady state asymmetries.

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 (negatively) of labor effort L, specialized as follows:

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

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.[13]

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:

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

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

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. $\mathcal{Q}_t = \frac{\mathcal{E}_t \mathbb{P}_t^*}{\mathbb{P}_t}$. 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 flow budget constraint for the representative agent j in the Home country is therefore:

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

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.[14] Namely, consider the Euler equations for the Home

$$\frac{U_C\left(C_t, \zeta_{C,t}\right)}{\mathbb{P}_t} = (1 + i_t)\, E_t \left[\beta \frac{U_C\left(C_{t+1}, \zeta_{C,t+1}\right)}{\mathbb{P}_{t+1}} \right]$$

and Foreign households:

$$\begin{aligned} \frac{U_C\left(C_t^*, \zeta_{C,t}^*\right)}{\mathbb{P}_t^*} &= (1 + i_t^*)\, E_t \left[\beta \frac{U_C\left(C_{t+1}^*, \zeta_{C,t+1}^*\right)}{\mathbb{P}_{t+1}^*} \right], \\ \frac{U_C\left(C_t^*, \zeta_{C,t}^*\right)}{\mathcal{E}_t \mathbb{P}_t^*} &= (1 + i_t)\, E_t \left[\beta \frac{U_C\left(C_{t+1}^*, \zeta_{C,t+1}^*\right)}{\mathcal{E}_{t+1} \mathbb{P}_{t+1}^*} \right]; \end{aligned}$$

[14] Obviously, in a standard setting of only two-agents and a few 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]).

trade in the international bond will imply the following modified risk-sharing condition:

$$E_t\left[\beta\frac{U_C\left(C_{t+1},\zeta_{C,t+1}\right)}{U_C\left(C_t,\zeta_{C,t}\right)}\right]=E_t\left[\beta\frac{U_C\left(C^*_{t+1},\zeta^*_{C,t+1}\right)}{U_C\left(C^*_t,\zeta^*_{C,t}\right)}\frac{\mathcal{Q}_t}{\mathcal{Q}_{t+1}}\right]. \tag{8}$$

2.2 Firms

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

$$Y\left(h\right)=\zeta_Y L\left(h\right), \tag{9}$$

where $L\left(h\right)$ is the demand for labor by the producer of the good h and ζ_Y 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:

$$Max_{\mathcal{P}(h),\mathcal{P}^*(h)}\;\; E_t\left\{\sum_{k=0}^{\infty}p_{bt,t+k}\alpha^k\left(\begin{array}{c}\left[\mathcal{P}_t(h)D_{t+k}(h)+\mathcal{E}_t\mathcal{P}^*_t(h)D^*_{t+k}(h)\right]-\\ MC_{t+k}(h)\left[D_{t+k}(h)+D^*_{t+k}(h)\right]\end{array}\right)\right\} \tag{10}$$

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:

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

In these expressions, $P_{\mathrm{H},t}$ and $P^*_{\mathrm{H},t}$ denote the price index of Home goods in the Home and Foreign country — the latter 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:

$$\mathcal{P}_t(h)=\frac{\theta}{\theta-1}\frac{E_t\sum_{k=0}^{\infty}\alpha^k p_{bt,t+k}D_{t+k}(h)MC_{t+k}(h)}{E_t\sum_{k=0}^{\infty}\alpha^k p_{bt,t+k}D_{t+k}(h)}; \tag{11}$$

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

$$\mathcal{P}_t^*(h) = \frac{\theta}{\theta-1}\frac{E_t\sum_{k=0}^{\infty}\alpha^k p_{bt,t+k} D_{t+k}^*(h) MC_{t+k}(h)}{E_t\sum_{k=0}^{\infty}\alpha^k p_{bt,t+k}\mathcal{E}_{t+k} D_{t+k}^*(h)}. \tag{12}$$

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 (11), 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 $P_{\mathrm{H},t}^*$

$$\begin{aligned} P_{\mathrm{H},t}^{1-\theta} &= \alpha P_{\mathrm{H},t-1}^{1-\theta} + (1-\alpha)\,\mathcal{P}_t(h)^{1-\theta}, \\ P_{\mathrm{H},t}^{*1-\theta} &= \alpha P_{\mathrm{H},t-1}^{*1-\theta} + (1-\alpha)\,\mathcal{P}_t^*(h)^{1-\theta}. \end{aligned} \tag{13}$$

Similar relations hold for the Foreign firms.

Throughout the paper, the model's equilibrium conditions and constraints will be written out in log-deviations from steady-state — assuming a symmetric steady-state in which the net foreign asset position is zero. Denoting with an upper-bar steady-state values, $\widehat{x}_t = \ln x_t/\overline{x}$ will represent deviations under sticky prices, while $\widetilde{x}_t = \ln x_t/\overline{x}$ will denote deviations under flexible prices. When appropriate, a superscript fb will denote 'first best.' Details on the solution of the model are given in appendix.

3 Misalignments and demand imbalances in incomplete market economies

3.1 The natural rate and the first-best allocations

Misalignments in the standard incomplete-market, intertemporal-trade model, can be best illustrated by focusing on the case of news shock, raising agents' expectations about the future productivity of firms, and possibly their future income flows. According to the standard model, in reaction to news shocks agents have an incentive to smooth consumption by borrowing and lending in international markets. As Home agents react to positive news shocks by borrowing in international markets, domestic consumption rises relative to foreign consumption. With home bias in preferences and a trade elasticity sufficiently different from unity, the surge in domestic demand can appreciate the Home currency in real terms. The combined movements of relative consumption and relative prices corresponds to the emergence of an inefficient wealth wedge per effect of the shock. Under incomplete markets, inefficiencies relative to the first-best allocation are inherent in the dynamics of intertemporal trade, independently of price rigidities. It is well-known that in incomplete market economies there is scope for policy to improve on the competitive allocation even when facing the same constraints on asset trading and wealth dynamics as the agents in the market economy. As shown e.g. by Geanakoplos and Polemacharkis (1986), this results from the presence of pecuniary externalities, since private agents fail to internalize the effects of their actions on relative prices and asset valuations in the competitive equilibrium. Therefore, a benevolent policymaker, while facing the same constraints as the agents, could engineer a welfare-improving allocation — the constrained-efficient allocation.

In this section, we set the stage of our analysis by accounting for the inefficiencies due to incomplete markets in economies without nominal rigidities. Namely, we contrast the complete-markets, flex- prices allocation — which (with appropriate subsidies offsetting the steady state effects of firms' market power) defines the *first-best* allocation — with a flex-price allocation where agents can only trade a single short-term bond – which defines the *natural-rate* benchmark. Focusing on the case of an anticipated shock to productivity in the Home country, we first show the responses of selected variables for a trade elasticity below and above one, respectively — see Section 4 for exact parameter values. Moreover, we show that the competitive equilibrium in the bond economy with flexible prices (or natural-rate allocation) will generally imply a very different dynamics of international borrowing and lending, not only relative to the first-best allocation, but also the constrained-efficient allocation (that will be chosen by a benevolent planner facing the same kind of market incompleteness as the agents). This motivates our analysis of the ability of specific policies, such as monetary policy, to optimally redress these distortions.

The efficient, complete-market allocation Figure 2 and 3 report impulses responses to news about a persistent increase in Home productivity, that materializes for sure the following period, evolving as depicted by Figure 1. Starting first with the impulse responses characterizing the first-best *efficient economy* — with complete-market, and flex-prices — it is clear that on impact, the arrival of positive news regarding future home productivity moves neither consumption demand, nor employment. While the news makes both domestic and foreign households feel richer, in the short run there is no change in productivity: it would be inefficient to change production and consumption activities (in this economy without endogenous capital accumulation).[15] Indeed, the short-term (and implied long-term) real interest rate rises 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. Since production risk is well diversified through complete markets, the news creates no relative wealth wedge, driving Home consumption demand above the Foreign one.

Upon the arrival of the positive news, no variable reacts until the increase in Home productivity actually materializes. In particular, this applies to the real exchange rate and the terms of trade,

[15] Likewise, our model economy abstracts other sources of sluggish adjustment such has habits or adjustment costs. Introducing these features would change results only quantitatively.

which, in the first-best allocation, respond only to shocks to contemporaneous productivity and preferences — as shown by their equilibrium expressions below

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

where first-best output in the two countries, $\widetilde{Y}_{H,t}^{fb}$ and $\widetilde{Y}_{F,t}^{fb}$, is purely a function of *current* exogenous shocks to productivity and preferences (e.g. $\widehat{\zeta}_{Y,t}$ and $\widehat{\zeta}_{C,t}$, respectively, in the case of the Home country).

Likewise, this applies to net foreign assets dynamics, which, for the Home country, is characterized up to first-order by the following relation:

$$\widetilde{W}_t^{fb}=\beta^{-1}\widetilde{W}_t^{fb}+\left(1-a_{\mathrm{H}}\right)\sigma^{-1}\left[\left(2a_{\mathrm{H}}\left(\sigma\phi-1\right)+1-\sigma\right)\widetilde{\mathcal{T}}_t^{fb}-\left(\widehat{\zeta}_{C,t}-\widehat{\zeta}_{C,t}^{*}\right)\right], \tag{14}$$

where net foreign assets $W_t=\dfrac{B_{\mathrm{H},t+1}}{\mathbb{P}_t}$ are scaled with steady state output, $\widehat{W}_t\simeq\dfrac{W_t-W^{ss}}{Y}$, recalling that as a maintained assumption real net foreign assets are zero in steady state ($W^{ss}=0$). Clearly, there is no change in $\widehat{W}_t$ unless current productivity and preferences change.

As productivity starts to rise gradually over time, peaking at around 0.4 per cent after 15 quarters, all variables follow well-known patterns. Under full risk sharing, consumption increases in both countries, with goods flowing from the more to the less productive one (the Home country runs a trade surplus); international relative prices of Home goods depreciate. Note that these patterns are the same in both the high- and the low-elasticity economy in Figure 2 and 3, respectively.

An interesting difference between Figure 2 and 3 nonetheless 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 and slightly increase in the Foreign country (see e.g. Collard and Dellas [2007]).

The incomplete-market natural-rate allocation The allocation sharply differs for economies with *flexible prices but incomplete markets,* which define the natural-rate allocation benchmark for our analysis. The dynamic response to the news shock is now determined according to the prescription of the intertemporal trade model of the current account. More formally, it can be shown that the evolution of net foreign assets in this case can be approximated by the following equation:

$$\widehat{W}_t = \widehat{W}_{t-1} - (1-a_{\mathrm{H}})\,\sigma^{-1}\sum_{j=0}^{\infty}\beta^j \left[\begin{array}{c} (2a_{\mathrm{H}}(\sigma\phi-1)+1-\sigma)\,E_t\left(\widetilde{T}^{fb}_{t+1+j}-\widetilde{T}^{fb}_{t+j}\right)+ \\ -E_t\left(\left(\widehat{\zeta}_{C,t+1+j}-\widehat{\zeta}^{*}_{C,t+1+j}\right)-\left(\widehat{\zeta}_{C,t+j}-\widehat{\zeta}^{*}_{C,t+j}\right)\right) \end{array} \right] +$$

$$-(1-a_{\mathrm{H}})\,\sigma^{-1}\sum_{j=0}^{\infty}\beta^j\left[(2a_{\mathrm{H}}(\sigma\phi-1)+1-\sigma)\,E_t\left(\left(\widehat{T}_{t+1+j}-\widetilde{T}^{fb}_{t+1+j}\right)-\left(\widehat{T}_{t+1+j}-\widetilde{T}^{fb}_{t+j}\right)\right)\right]+$$

.

The inefficiency relative to the first-best case is apparent: Home country international borrowing suboptimally depends on expectations about the evolution of future fundamentals (as reflected by the change in efficient terms of trade $E_t\left(\widetilde{T}^{fb}_{t+1+j}-\widetilde{T}^{fb}_{t+j}\right)$, and preference shifts $E_t\left(\left(\widehat{\zeta}_{C,t+1+j}-\widehat{\zeta}^{*}_{C,t+1+j}\right)-\left(\widehat{\zeta}_{C,t+j}\right.\right.$ as well as expected terms of trade deviations from their efficient level (the last term on the right hand side).[16]

This is confirmed in Figures 2 and 3, whereby in anticipation of future domestic productivity growth, Home households raise their demand and borrow to smooth consumption, while decreasing labor supply. Relative to the efficient allocation, wealth effects across borders thus create an inefficient wedge. Specifically, such wedge is positive for Home consumption and Foreign hours — negative for Foreign consumption and Home hours. In addition, since traded goods are not homogeneous and there is home bias in consumption, the rise in home demand leads to a lasting appreciation of the home currency in real terms.

The misalignment in relative prices (relative to the first-best benchmark) is apparent. The real exchange rate not only jumps on impact, instead of remaining unchanged; 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: resources flow from the least to the most productive national economy.

It is worth stressing that, under either calibration of trade elasticities, the response of the real exchange rate to asymmetric news shocks has the wrong sign under incomplete markets, relative to the efficient allocation.[17] 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 deviations from the first-best, and therefore the potential importance of misalignments in policy making, varies across our experiments. Specifically, the value of the trade elasticity has important quantitative implications. As shown in the Figures 2 and 3, both domestic and international wedges relative to the first-best allocation are typically an order of

[16] A special case often discussed in the literature refers to a specification of utility from consumption in log form ($\sigma = 1$), with a unitary trade elasticity between domestic and foreign goods ($\phi = 1$), corresponding to a Cobb-Douglas aggregator of the two goods. Under this special yet amply studied specification, it is clear that any difference between the first-best and the natural rate allocations could be due only to preference shocks (see Devereux (2003) and CDL (2010)).

[17] 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.

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.

As already mentioned, the literature has long established that in incomplete market economies there could be scope for policy to improve on the competitive allocation because of pecuniary externalities. It is thus interesting to explicitly characterize the extent of misallocation in our economy, by looking at what a benevolent planner would achieve, when facing the same set of constraints as the agents in the market economy — specifically limiting cross-border financial trade to only one bond, and thus excluding the possibility of engineering state-contingent transfers.

In the constrained-efficient allocation, up to first order net foreign assets are approximated as follows:

$$\widehat{W}_t = \widehat{W}_{t-1} - (1 - a_{\mathrm{H}})\,\sigma^{-1} \sum_{j=0}^{\infty} \beta^j \left[\begin{array}{c} (2a_{\mathrm{H}}\,(\sigma\phi - 1) + 1 - \sigma)\, E_t \left(\widetilde{\mathcal{T}}^{fb}_{t+1+j} - \widetilde{\mathcal{T}}^{fb}_{t+j} \right) + \\ -E_t \left(\left(\widehat{\zeta}_{C,t+1+j} - \widehat{\zeta}^{*}_{C,t+1+j} \right) - \left(\widehat{\zeta}_{C,t+j} - \widehat{\zeta}^{*}_{C,t+j} \right) \right) \end{array} \right].$$

In contrast to the competitive equilibrium, net foreign assets respond to expectations about future fundamentals only (via anticipated movements in the efficient terms of trade), but not to expected deviations in the terms of trade from their efficient level. This does not mean that the planner is able to close these relative price misalignments at any point of time. What it means is that the planner takes into account the inefficient wealth effects of predictable relative price misalignments on saving choices, isolating the evolution of net foreign assets from these effects.

An immediate consequence is that, in the competitive allocation, even with flexible prices, international borrowing and lending will generally be different and thus suboptimal relative to both the first-best, and the constrained-efficient allocations, with either country displaying overborrowing, and the other country, correspondingly, oversaving. Moreover, the key driver of the discrepancy in cross-border capital flows between the competitive allocation and the constrained efficient allocation will be current and expected misalignment in international relative prices, reflecting the wealth effects of the pecuniary externality in the decentralized equilibrium.

3.2 Welfare-relevant gaps in open economy

Before turning to the analysis of the trade-offs faced by monetary policy, we find it useful to define welfare-relevant gaps in key variables of interest. As is customary in monetary stabilization analysis, 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 key concern for policy design in open economy is the possibility that international relative prices are misaligned. Consistently with the definition of welfare-relevant output gaps and inflation-related relative price gaps (due to the dispersion of prices charged for goods which are ex ante symmetric in production and preferences), misalignments occur when exchange rates deviate from the value they would take in the efficient allocation.[18] So, for the real exchange rate, we define the welfare-relevant gap or RER^{gap} as follows:

$$RER^{gap} = \ln \frac{\mathcal{Q}}{\mathcal{Q}^{fb}} \tag{15}$$

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

$$TOT^{gap} = \ln \frac{\mathcal{T}}{\mathcal{T}^{fb}} \tag{16}$$

Finally, inefficient relative prices may result when nominal rigidities in local currency translates into cross-border deviations from the law of one price (henceforth LOOP), whereby identical goods are sold at different prices at Home and abroad. For the basket of Home goods, these deviations are defined as

$$LOOP^{gap} = \ln \Delta_{\mathrm{H},t} = \ln \frac{\mathcal{E}_t P^*_{\mathrm{H},t}}{P_{\mathrm{H},t}}$$

where $\Delta_{\mathrm{H},t}$ is equal to one when the LOOP holds. To the extent that $P^*_{\mathrm{H},t}$ and $P_{\mathrm{H},t}$ are sticky, the law of one price is violated with any movement in the exchange rate. Specifically, domestic currency depreciation tends to increase the Home firms' receipts in Home currency from selling goods abroad, relative to the Home market: Home currency depreciation raises $\Delta_{\mathrm{H},t}$. Similar considerations apply to $\Delta_{\mathrm{F},t} = \mathcal{E}_t P^*_{\mathrm{F},t}/P_{\mathrm{F},t}$.

In our economies, up to a first order, the above gaps are related to each other as follows:

$$\begin{aligned} \widehat{\mathcal{Q}_t} - \widetilde{\mathcal{Q}}_t^{fb} &= (2a_{\mathrm{H}} - 1)\left(\widehat{\mathcal{T}}_t - \widetilde{\mathcal{T}}_t^{fb}\right) + 2a_{\mathrm{H}}\widehat{\Delta}_t, \\ \widehat{\mathcal{T}}_t - \widetilde{\mathcal{T}}_t^{fb} &= \frac{\sigma\left[\left(\widehat{Y}_{H,t} - \widetilde{Y}_{H,t}^{fb}\right) - \left(\widehat{Y}_{F,t} - \widetilde{Y}_{F,t}^{fb}\right)\right] - (2a_{\mathrm{H}} - 1)\left(\widehat{\mathcal{D}}_t + \widehat{\Delta}_t\right)}{4a_{\mathrm{H}}\left(1 - a_{\mathrm{H}}\right)(\sigma\phi - 1) + 1} - \widehat{\Delta}_t \end{aligned} \tag{17}$$

where $\widehat{\mathcal{D}}_t$ is the *relative demand gap*, to be defined below, and we have used the fact that under symmetry, $\widehat{\Delta}_{\mathrm{H},t} = \widehat{\Delta}_{\mathrm{F},t} = \widehat{\Delta}_t$ (see Engel 2009). These expressions show that, while the RER and the TOT 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, implying $\widehat{\mathcal{Q}_t} = 0$.

What underlies the concern with exchange rate misalignment is the fact that the inefficiencies giving rise to it also affect macroeconomic quantities and the inflation process, at both domestic

[18] 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.

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, or the dynamics of net foreign assets, e.g. using the expression above for $\widetilde{W}_t^{fb}$. However, theory suggests a measure of imbalances which is more directly and naturally relevant for welfare and has a natural counterpart in other setting with heterogenous agents and financial frictions (e.g. see Curdia and Woodford (2010)). This is the 'relative demand gap,' defined as follows:

$$RD^{gap} = \ln \mathcal{D} = \ln \frac{MU^*}{MU} \mathcal{Q} = \sigma \left(\ln C_t - \ln C_t^* \right) - \ln \mathcal{Q}_t - \left(\ln \zeta_{C,t} - \ln \zeta_{C,t}^* \right) \tag{18}$$

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. A relative demand imbalance occurs when, given the relative price of consumption, the marginal utility of Home consumption is too low relative to the Foreign marginal utility. Abstracting from preference shifts, 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].

In log-linearized form, taking the difference in budget constraints, the relative demand gap can be expressed as follows:

$$\begin{aligned} \widehat{\mathcal{D}}_t &= \sigma \left(\widehat{C}_t - \widehat{C}_t^* \right) - \widehat{\mathcal{Q}}_t - \left(\widehat{\zeta}_{C,t} - \widehat{\zeta}_{C,t}^* \right) \\ &= \sigma \left[\left(\widehat{Y}_{H,t} - \widetilde{Y}_{H,t}^{fb} \right) - \left(\widehat{Y}_{F,t} - \widetilde{Y}_{F,t}^{fb} \right) + 2 \left(\beta^{-1} \widehat{W}_{t-1} - \widehat{W}_t \right) \right] + \\ &\quad - \left[2 \left(1 - a_{\mathrm{H}} \right) \sigma + \left(2a_{\mathrm{H}} - 1 \right) \right] \left(\widehat{\mathcal{T}}_t - \widetilde{\mathcal{T}}_t^{fb} \right) - 2a_{\mathrm{H}} \widehat{\Delta}_t + \\ &\quad \left(1 - a_{\mathrm{H}} \right) \left[4a_{\mathrm{H}} \left(1 - a_{\mathrm{H}} \right) \left(\sigma\phi - 1 \right) + 1 \right] \sigma^{-1} \left[\left(2a_{\mathrm{H}} \left(\sigma\phi - 1 \right) + 1 - \sigma \right) \widetilde{\mathcal{T}}_t^{fb} - \left(\widehat{\zeta}_{C,t} - \widehat{\zeta}_{C,t}^* \right) \right], \end{aligned} \tag{19}$$

where under financial autarky, obviously, $\widehat{W}_t = 0$. The relative demand gap is of course related to the other welfare-relevant gaps; it is instructive to rewrite the above expression substituting out $\widehat{\mathcal{T}}_t - \widetilde{\mathcal{T}}_t^{fb}$ and emphasizing the misallocation in net foreign assets and capital flows $\widehat{W}_t - \widetilde{W}_t^{fb}$ as well:

$$\begin{aligned} \left(1 - a_{\mathrm{H}} \right) \left[2a_{\mathrm{H}} \left(\phi - 1 \right) + 1 \right] \widehat{\mathcal{D}}_t &= \left[4a_{\mathrm{H}} \left(1 - a_{\mathrm{H}} \right) \left(\sigma\phi - 1 \right) + 1 \right] \left(\beta^{-1} \left(\widehat{W}_{t-1} - \widetilde{W}_t^{fb} \right) - \left(\widehat{W}_t - \widetilde{W}_{t-1}^{fb} \right) \right) + \\ &\quad \left(1 - a_{\mathrm{H}} \right) \left[2a_{\mathrm{H}} \left(\sigma\phi - 1 \right) + 1 - \sigma \right] \left[\left(\widehat{Y}_{H,t} - \widetilde{Y}_{H,t}^{fb} \right) - \left(\widehat{Y}_{F,t} - \widetilde{Y}_{F,t}^{fb} \right) \right] + \\ &\quad 2a_{\mathrm{H}} \left(1 - a_{\mathrm{H}} \right) \left[2 \left(1 - a_{\mathrm{H}} \right) \left(\sigma\phi - 1 \right) + 1 - \phi \right] \widehat{\Delta}_t + t.i.p. \end{aligned} \tag{20}$$

where $t.i.p.$ denotes the remaining terms independent of policy.

This expression highlights three determinants of inefficient demand gaps. Two comprise misalignment in relative prices, reflecting deviations from the law of one price under LCP, and cross-country misallocation of output. A third one consists of the suboptimal dynamics of net foreign assets, pointing to inefficient cross-border capital flows as a potential source of demand misallocation. In this respect, it is important to note that, up to first order, $\widehat{\mathcal{D}}_t$ does not respond to the ex-post returns on internationally traded assets: real net foreign assets are capitalized at the steady state real interest rate β^{-1}. While this is not true for more general specifications of the model, allowing for a non-zero stock of foreign assets in steady state, it has notable implications for optimal monetary policy. Namely, starting from a symmetric steady state with zero foreign wealth, monetary policy cannot correct inefficient relative demand gaps $\widehat{\mathcal{D}}_t$ by manipulating ex-post the return on existing assets and thus the wealth distribution. It can however affect relative prices, output allocation and net foreign assets accumulation. It is through this latter channel that expectations and thus asset prices will still play a crucial role, given the forward-looking determination of the exchange rate.

4 Monetary policy trade-offs in open economies with incomplete markets

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 potentially far from the efficient one, independently of the presence of nominal rigidities. A related question is thus whether policies geared toward purely domestic objectives, such as strict inflation targeting in terms of 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.

To analyze in depth the monetary policy trade-offs created by currency misalignments and demand imbalances, in this section we discuss a general quadratic policy loss function obtained from a second order approximation of agents utility, and characterize the optimal cooperative policy under commitment, in terms of standard targeting rules including welfare-relevant gaps as arguments. Leaving the details of the derivation to the appendix, we can write a second order approximation of the sum of the utility of the Home and Foreign national representative agents in terms of purely quadratic internal and external objectives: the former include inflation and output gaps; the latter relative price misalignments and the relative demand gap. While the first two arguments have been extensively analyzed in the closed-economy counterpart of our model, the other gaps identify policy objectives due to heterogeneity among sectors and agents, in an economy distorted by financial imperfections, in addition to nominal rigidities (see e.g. Curdia and Woodford [2009] for the latter case in a closed economy setting).

Specifically, under the assumption of appropriate subsidies offsetting firms' markup to deliver a non-distorted steady state, the period-by-period quadratic welfare function for incomplete market economies, expressed in deviations from the first best allocation, is as follows:

$$
\begin{aligned}
&\mathcal{L}_t^W - \left(\mathcal{L}_t^W\right)^{fb} \ltimes \\
&-\frac{1}{2}\left\{
\begin{array}{c}
(\sigma+\eta)\left[\left(\widetilde{Y}_{H,t}^{fb}-\widehat{Y}_{H,t}\right)^2+\left(\widetilde{Y}_{F,t}^{fb}-\widehat{Y}_{F,t}\right)^2\right]+ \\
\frac{\alpha}{(1-\alpha\beta)(1-\alpha)}\theta\left[a_{\mathrm{H}}\pi_{H,t}^2+(1-a_{\mathrm{H}})\,\pi_{H,t}^{*2}+a_{\mathrm{H}}\pi_{F,t}^{*2}+(1-a_{\mathrm{H}})\,\pi_{F,t}^2\right]+ \\
-\frac{2a_{\mathrm{H}}(1-a_{\mathrm{H}})}{4a_{\mathrm{H}}(1-a_{\mathrm{H}})(\sigma\phi-1)+1}\left[\begin{array}{c}(\sigma\phi-1)\,\sigma\left(\left(\widehat{Y}_{H,t}-\widetilde{Y}_{H,t}^{fb}\right)-\left(\widehat{Y}_{F,t}-\widetilde{Y}_{F,t}^{fb}\right)\right)^2+ \\ -\phi\left(\widehat{\Delta}_t+\widehat{\mathcal{D}}_t\right)^2\end{array}\right]
\end{array}
\right\} \\
&+t.i.p., \qquad (21)
\end{aligned}
$$

whereas for simplicity we have substituted out terms of trade misalignments using their equilibrium relation with output gaps, deviations from the law of one price, and relative demand gaps. Moreover, for simplicity and clarity of exposition, we have abstracted from the endogenous discount factor specified in (1).

Three key properties of the above loss are worth stressing. First, the loss is written for the (more general) case of LCP, but its PCP counterpart can be readily obtained by setting LOOP deviations to zero ($\widehat{\Delta}_t = 0$), and by using the fact that, holding the law of one price the inflation term $a_{\mathrm{H}}\pi_{H,t}^2 + (1-a_{\mathrm{H}})\,\pi_{H,t}^{*2} + a_{\mathrm{H}}\pi_{F,t}^{*2} + (1-a_{\mathrm{H}})\,\pi_{F,t}^2$ reduces to $\pi_{H,t}^2 + \pi_{F,t}^{*2}$.[19] Second, the loss is derived from a generic budget constraint, encompassing the cases of financial autarky (no asset is traded internationally), international trade in one bond, or international trade in any number of assets, including complete markets (in which case obviously $\widehat{\mathcal{D}}_t = 0$). In this respect, the above generalizes and completes previous results in CDL [2010].

Lastly, the terms in the last line of the loss function, resulting from summing up the consumption side of (1) across agents, specifically characterize the heterogeneity typical of an open economy environment. In such an environment, agents may not be able to efficiently share risk due to incomplete markets, may have different preferences and may face different prices for similar goods. Heterogeneity may in turn shape equilibrium trade-offs among competing objectives.

To assess these trade-offs, we now derive targeting rules characterizing the optimal cooperative policy. In accord with the literature, these rules are derived by maximizing the above quadratic function subject to the log-linearized equilibrium conditions and constraints characterizing the competitive equilibrium allocation, including the Phillips Curves. It is worth noting that, together with output gaps and inflation, our newly defined gaps will be particularly useful in characterizing monetary policy trade-offs in open economies. As an important instance, the Phillips Curves, for

[19] Under complete markets ($\widehat{\mathcal{D}}_t = 0$), this loss function is directly comparable to the corresponding expressions in Engel [2009] for PCP and LCP — although in our analysis we allows for different values of the trade elasticity ϕ.

the more general case of LCP, can be written out in terms of these gaps:

$$\pi_{H,t} - \beta E_t \pi_{H,t+1} =$$
$$\frac{(1-\alpha\beta)(1-\alpha)}{\alpha}\left[\begin{array}{c}(\sigma+\eta)\left(\widehat{Y}_{H,t} - \widetilde{Y}^{fb}_{H,t}\right) + \widehat{\mu}_t + \\ -(1-a_{\rm H})\left[2a_{\rm H}(\sigma\phi - 1)\left(\widehat{\mathcal{T}}_t - \widetilde{\mathcal{T}}^{fb}_t + \widehat{\Delta}_t\right) - \widehat{\Delta}_t - \widehat{\mathcal{D}}_t\right]\end{array}\right]$$
$$= \pi^*_{H,t} - \beta E_t \pi^*_{H,t+1} - \frac{(1-\alpha\beta)(1-\alpha)}{\alpha}\widehat{\Delta}_t,$$

$$\pi^*_{F,t} - \beta E_t \pi^*_{F,t+1} =$$
$$\frac{(1-\alpha\beta)(1-\alpha)}{\alpha}\left[\begin{array}{c}(\sigma+\eta)\left(\widehat{Y}_{F,t} - \widetilde{Y}^{fb}_{F,t}\right) + \widehat{\mu}^*_t + \\ (1-a_{\rm H})\left[2a_{\rm H}(\sigma\phi - 1)\left(\widehat{\mathcal{T}}_t - \widetilde{\mathcal{T}}^{fb}_t + \widehat{\Delta}_t\right) - \widehat{\Delta}_t - \widehat{\mathcal{D}}_t\right]\end{array}\right]$$
$$= \pi_{F,t} - \beta E_t \pi_{F,t+1} + \frac{(1-\alpha\beta)(1-\alpha)}{\alpha}\widehat{\Delta}_t,$$

where $\widehat{\mu}_t$ and $\widehat{\mu}^*_t$ denote possible markup shocks. As emphasized by CDL (2010), it is apparent that price misalignments and a non-zero demand gap will generally be a source of trade-off with inflation stabilization.

Following the literature and assuming (timeless) commitment (see e.g. Woodford [2010]), the optimal cooperative policy can be synthesized by two rules, conveniently written (as customary in international economics) in terms of sums and differences across country — the derivations are in the appendix. A key property of our economies is that the sum rule is identical under complete and incomplete markets — and is invariant to the specific structure of financial market incompleteness. However, it will depend on whether PCP or LCP is assumed. Specifically, the global (sum) rules are

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

and

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

for the PCP and LCP case, respectively. Their implications are straightforward and well understood: policymakers should stabilize output gaps and inflation at the global level — as noted above under PCP world CPI and PPI inflation rates coincide. Absent markup-shocks the two objectives could be reached at the same time, as could be easily seen by appropriately summing up the Phillips curves.

The relative, cross-country, rules are instead specific to each form of both nominal rigidities and market incompleteness, as discussed below.

The PCP case We start from the benchmark case of a bond economy under PCP. It is worth stressing that, by virtue of intertemporal trade, the households' Euler equations can be combined as to derive the following key equilibrium condition:

$$E_t \widehat{\mathcal{D}}_{t+1} = \widehat{\mathcal{D}}_t.$$

In words, trade in one bond ensures that the expected cross-country demand gap in the future is identical to the ex-post demand gap today.

The cross-country targeting rule can be written as:

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

It is instructive to compare the above rule with its counterpart under complete markets (see CDL [2010]):

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

Clearly, the cross-country targeting rule in a bond economy implements a 'forward' version of the one under complete markets. On the one hand, monetary policy is characterized in both cases by conformity to a flexible inflation target. On the other hand, the notable difference is that, with incomplete risk sharing, policymakers optimally trade-off differences in output gap growth with inflation differentials in expectations, rather than state-by-state.[20]

To fully understand the implications of these rules, take the difference of the two Phillips curves:

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

[20] Under financial autarky, the cross-country rule already derived in Corsetti et al. [2010] can be written as follows:

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

whereas under PCP the relative price misalignment (17)) is given by:

$$\widehat{\mathcal{T}}_t - \widetilde{\mathcal{T}}_t^{fb} = \frac{\sigma\left[\left(\widehat{Y}_{H,t} - \widehat{Y}_{F,t}\right) - \left(\widetilde{Y}_{H,t}^{fb} - \widetilde{Y}_{F,t}^{fb}\right)\right] - (2a_{\rm H} - 1)\,\widehat{\mathcal{D}}_t}{4a_{\rm H}\,(1 - a_{\rm H})\,(\sigma\phi - 1) + 1}. \tag{22}$$

With complete markets, $\widehat{\mathcal{D}}_t = 0$ implies that the above terms of trade gap actually becomes strictly proportional to the differences in output gaps. It is then easy to verify that, consistent with the cross-country targeting rule above, a trade-off between inflation and output gap stabilization materializes only in the presence of markup shocks $\widehat{\mu}_t$ or $\widehat{\mu}_t^*$. In other words, as long as (*current* and *anticipated*) 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, usually referred to as *efficient* shocks. With news shocks, however, optimal policy has the further implication of entailing complete exchange rate stabilization until the anticipated technology change materializes.

As discussed in CDL [2010], the optimal policy prescription just described points to an open economy instance of what Blanchard and Galí [2007] 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 an open economy, the divine coincidence is possible by virtue of the fact that closing output gaps automatically moves relative prices towards their efficient level. So, the relative target reduces to one involving only output gaps and inflation differentials. Furthermore, optimal policy can be described in terms of purely domestic objectives, i.e. each country stabilizes its own output gap and GDP-deflator inflation, identifying a case of 'isomorphism' of optimal policy in closed and open economies — requiring PCP, complete market and cooperative policy making with commitment (in addition to flexible wages and absence of distortions in the labor market). Thus, in the case analyzed by Devereux and Engel [2006, 2007], under the optimal policy there is no trade-off between external objectives such as exchange rate stabilization and domestic objectives such as output gap and product price inflation stabilization even in the face of anticipated productivity shocks.

What makes incomplete markets different is that, with $\widehat{\mathcal{D}}_t \neq 0$, terms of trade gaps and output gaps are no longer proportional to each other in general. Most importantly, a non zero relative demand gap implies a meaningful policy trade-off between inflation and employment even in response to efficient shocks. To see this most clearly, combine the Phillips curves under PCP with the cross-country targeting rule as to substitute out expected inflation:

$$\theta\left(\pi_{H,t}-\pi^{*}_{F,t}\right)+\left[\left(\widehat{Y}_{H,t}-\widetilde{Y}^{fb}_{H,t}\right)-\left(\widehat{Y}_{F,t}-\widetilde{Y}^{fb}_{F,t}\right)\right]=$$
$$\left[1+\frac{(1-\alpha\beta)(1-\alpha)}{\alpha}\theta(\eta+\sigma)\right]\left[\left(\widehat{Y}_{H,t}-\widetilde{Y}^{fb}_{H,t}\right)-\left(\widehat{Y}_{F,t}-\widetilde{Y}^{fb}_{F,t}\right)\right]+$$
$$-\beta\left(E_t\left[\left(\widehat{Y}_{H,t+1}-\widetilde{Y}^{fb}_{H,t+1}\right)-\left(\widehat{Y}_{H,t}-\widetilde{Y}^{fb}_{H,t}\right)\right]-E_t\left[\left(\widehat{Y}_{F,t+1}-\widetilde{Y}^{fb}_{F,t+1}\right)-\left(\widehat{Y}_{F,t}-\widetilde{Y}^{fb}_{F,t}\right)\right]\right)$$
$$-\frac{(1-\alpha\beta)(1-\alpha)}{\alpha}\theta\left\{\begin{array}{c}2(1-a_{\mathrm{H}})\cdot\left[2a_{\mathrm{H}}(\sigma\phi-1)\left(\widehat{\mathcal{T}}_t-\widetilde{\mathcal{T}}^{fb}_t\right)-\widehat{\mathcal{D}}_t\right]+\\+\widehat{\mu}_t-\widehat{\mu}^{*}_t\end{array}\right\},$$

where the terms of trade gap is given by (22). It is apparent that under incomplete markets, whatever the shock, the optimal cooperative policy faces a trade-off not only between price and output gap stabilization, but also with respect to stabilizing misalignment in relative prices and cross-country demand imbalances. In this sense, financial imperfections indeed cause **(*endogenous*)** cross-country imbalances and misalignments to act like inefficient **(*exogenous*)** 'markup shocks' in shaping the optimal stabilization policy. The main lesson is that, in general, the distortions created by incomplete markets combine with nominal rigidities as to prevent the economy from reaching a first-best allocation.[21]

The LCP case Under LCP, the cross-country (difference) rule cannot be characterized analytically in a transparent way, as in general it involves solving a system of difference equations in the different Lagrange multipliers. However, a relatively simple solution exists for the case of $\sigma=1$ and $\eta=0$. In this case, regardless of the form of market incompleteness, the cross-country targeting criterion can be expressed as follows:

$$0=\theta\left[\left(a_{\mathrm{H}}\pi_{H,t}+(1-a_{\mathrm{H}})\pi_{F,t}\right)-\left(a_{\mathrm{H}}\pi^{*}_{F,t}+(1-a_{\mathrm{H}})\pi^{*}_{H,t}\right)\right]+$$
$$\left[\left(\widehat{\mathcal{D}}_t-\widehat{\mathcal{D}}_{t-1}\right)+\left(\widehat{\mathcal{Q}}_t-\widetilde{\mathcal{Q}}^{fb}_t\right)-\left(\widehat{\mathcal{Q}}_{t-1}-\widetilde{\mathcal{Q}}^{fb}_{t-1}\right)\right];$$

which, using the definition of $\widehat{\mathcal{D}}_t$, can be turned into an expression combining CPI-inflation and consumption differentials:

$$0=\theta\left[\left(a_{\mathrm{H}}\pi_{H,t}+(1-a_{\mathrm{H}})\pi_{F,t}\right)-\left(a_{\mathrm{H}}\pi^{*}_{H,t}+(1-a_{\mathrm{H}})\pi^{*}_{H,t}\right)\right]+$$
$$\left[\left(\widehat{C}_t-\widetilde{C}^{fb}_t\right)-\left(\widehat{C}^{*}_t-\widetilde{C}^{*fb}_t\right)\right]-\left[\left(\widehat{C}_{t-1}-\widetilde{C}^{fb}_{t-1}\right)-\left(\widehat{C}^{*}_{t-1}-\widetilde{C}^{*fb}_{t-1}\right)\right].$$

[21] A special case often discussed in the literature refers to a specification of utility from consumption in log form ($\sigma=1$), with a unitary trade elasticity between domestic and foreign goods ($\phi=1$), 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)).

Interestingly, it turns out that this targeting rule is the same as in an economy with LCP and complete markets ($\widehat{\mathcal{D}}_t = 0$). Under the optimal rules, however, the incomplete-market allocation will generally be quite different from the first-best one. This can be readily seen by taking the difference in CPI inflation rates, using the Phillips curves to get:

$$
\begin{aligned}
& a_{\mathrm{H}} \pi_{H,t} + (1 - a_{\mathrm{H}}) \pi_{F,t} - \left(a_{\mathrm{H}} \pi^*_{F,t} + (1 - a_{\mathrm{H}}) \pi^*_{H,t} \right) = \\
& \beta E_t \left(a_{\mathrm{H}} \pi_{H,t+1} + (1 - a_{\mathrm{H}}) \pi_{F,t+1} \right) - \beta E_t \left(a_{\mathrm{H}} \pi^*_{F,t+1} + (1 - a_{\mathrm{H}}) \pi^*_{H,t+1} \right) + \\
& \frac{(1 - \alpha\beta)(1 - \alpha)}{\alpha} \left[\widehat{\mathcal{Q}}_t - \widetilde{\mathcal{Q}}^{fb}_t + (2a_{\mathrm{H}} - 1) \left(\widehat{\mu}_t - \widehat{\mu}^*_t + \widehat{\mathcal{D}}_t \right) - 4 (1 - a_{\mathrm{H}}) \widehat{\Delta}_t \right].
\end{aligned}
$$

In response to efficient shocks ($\widehat{\mu}_t = \widehat{\mu}^*_t = 0$), under complete markets ($\widehat{\mathcal{D}}_t = 0$) the optimal policy sets CPI inflation rates and output gaps to zero, thus eliminating at the same time consumption differentials and LOOP deviations, the only source of inefficient real exchange rate fluctuations. With incomplete markets, however, there will exist a trade-off between these competing objectives, implying that the optimal policy will not close any of them in equilibrium.

5 Calibration and solution methods

This section describes the parameterization for our numerical experiments, which we assume symmetric across countries.

Preferences and production In our benchmark calibration, we assume that σ (risk aversion) and η are equal to 2, while 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:

$$
\nu (C_t, L) = \ln \left(1 + \psi \left[C_t + \kappa (1 - L_t) \right] \right), \tag{23}
$$

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

$$\mathbf{Z}_t = \mathbf{U}_t - \mathbf{V}_t, \tag{24}$$

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 vectors of zero mean *i.i.d.* shocks. The process $\mathbf{U}$ 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 $\mathbf{V}$ with innovation ξ_t is instead introduced to capture the idea of "news shocks." To wit: starting at a steady state with $\mathbf{U}_{t-1} = \mathbf{V}_{t-1} = 0$, a positive innovation in ξ_t in either country has no direct effect on the level of productivity $\mathbf{Z}_t$ in the first period. However, with $\rho_u > \rho_v$, the shock will affect its expected growth rate, as $\mathbf{Z}_t$ 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 $\mathbf{Z}_t$ 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.[22]

[22] Results are qualitatively unchanged when we instead model news shocks as signals perfectly correlated with productivity innovations four quarters out, i.e. with $\xi_{u,t+4}$.

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:

$$\textit{Welfare} = \frac{\mathbb{W}_0 + \mathbb{W}_0^*}{2}. \tag{25}$$

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.

6 Monetary policy trade-offs with misalignment and external imbalances

In this section, we focus on the 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. Specifically, we contrast the market allocation under the optimal policy, against the allocation under suboptimal rules targeting narrow domestic price objectives, in economies differing along two dimensions. The first one concerns trade elasticities, set below and above unity. The second concerns nominal frictions, whereas in our economies export prices are assumed to be sticky either in the currency of producers (PCP), or in the currency of the market of destination (LCP). In line with the literature, we characterize suboptimal policies assuming that the central bank targets the GDP deflator in the PCP economy— thus supporting the flexible price allocation — and the domestic CPI in the LCP economy.[23]

6.1 Small trade-offs: the case of high trade elasticity

We begin our assessment of the policy trade-offs under incomplete markets, looking at 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 allocation under product price stability (which is the same as the flexible price allocation) and optimal monetary policy, following a news

[23] This policy would be optimal under complete markets with linear labor disutility (i.e. $\eta = 0$) — see Engel [2009] and CDL [2010].

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.

High Trade Elasticity and Producer Currency Pricing. As discussed in Section 3, with incomplete markets news shocks have asymmetric effects on demand: upon the news, Home households feel richer, hence they optimally plan to raise their consumption and reduce their labor supply. Consumption smoothing by Home households then translates into inflationary pressure not only at Home, but also abroad, per effect of an increase in the Home demand for imports. 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 domestic households initially appreciates the Home currency in real terms, and strengthens the Home terms of trade. As a result, a larger consumption at Home corresponds, on impact, to less consumption and more hours worked by Foreign households, per effect of 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 due to the better productivity prospects. A few quarters after the shock, nonetheless, the increasing 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 with sticky prices is the same as with flexible prices. Hence, because of incomplete markets, its inefficiencies are the same as the one discussed in relation to Figure 2. Relative to the welfare benchmark, 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, as well as to 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 employment, 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.

High Trade Elasticity and Local Currency Pricing. The case of LCP is shown in Figure 5. In this case, drawing on the literature, we posit that suboptimal monetary policy targets CPI inflation, rather than producer price inflation (see the discussion in CDL [2010]). Observe that, despite these differences in nominal frictions and monetary policy, the response of most variables broadly follow the same pattern discussed for the case of PCP. Under the suboptimal policy, indeed, the real interest rates initially increase in both countries, again with a positive differential between the Home and the Foreign country, driving Home real appreciation. Because of sticky import prices, however, Home nominal exchange rate appreciation attenuates the switch in world demand from Home into Foreign goods, relative to the PCP case. In LCP economies, the muted expenditure switching effects of exchange rate movements creates, at the margin, some small room for policy correction of inefficiencies.

Compared to strict inflation targeting, indeed, the optimal policy widens somewhat the interest-rate differential: Home rates increase by more, Foreign rates by less, resulting in a modest correction of inefficient consumption movements. The widened interest differential exacerbates, if only marginally so, the inefficient appreciation of the Home exchange rate, however. Limited expenditure switching effects imply that the exchange rate movements do not redirect demand across goods, thus resulting also in a small short-run impact on output gaps. Hence, the optimal policy can act more decisively on relative demand.

Yet, while the distance between the two policies is larger under LCP than under PCP, as also apparent from larger deviations in CPI inflation under the former, once again 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 in the Foreign country. 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 virtually the same across policies.

Discussion. The main conclusion from this first set of exercises is that, in a high trade-elasticity economy with nominal rigidities, whether PCP or LCP, the optimal policy allocation is nearly identical to the corresponding allocation with incomplete markets and flexible prices — therefore 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 in our calibration 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 are hardly redressed by the optimal cooperative monetary policy. 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 one. The results from our second set of exercises are shown in Figures 6 and 7, for 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 of strict GDP inflation targeting, Home policy-makers again react to the news shock with an interest rate hike, to counteract the inflationary pressures on domestic prices. Because of a low trade 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, consumption falls and hours worked increase substantially abroad.

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, even at the time when the anticipated increase in Home productivity actually materializes, there are still no benefit for the Foreign country: the drop in Foreign consumption is never reversed. The reason is that, because of the low trade elasticity, domestic and foreign goods are complements, 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). Rather, 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 and PCP, 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 is successful in redirecting world demand from Home to Foreign consumers, if only for a few quarters. Relative to a policy of strict inflation targeting, 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. Furthermore, the increase in the interest-rate differential in favor of the Home country amplifies the appreciation of the real exchange rate, making the RER-gap larger. So, under PCP, the optimal policy reduces the RD-gap through policies that focus on realigning consumption, but with little emphasis on currency misalignments.

In fact, a mix of policy stances directed at counteracting the real appreciation would exacerbate the misallocation in consumption and employment across countries. Home policymakers can always bring about real depreciation and a deterioration of the terms of trade in line with the efficient allocation, by relaxing the Home monetary stance relative to strict inflation targeting. However, such a policy would result into large expenditure switching effects from Foreign into Home goods, and thus into a suboptimally high level of Home employment and a positive output gap. Overall, the welfare costs of adopting strict inflation targeting instead of pursuing the optimal policy are around 0.03 percent of steady state consumption, as shown in Table 1.

Economies with low trade elasticity and Local Currency Pricing. The welfare gains from adopting the optimal policy are however larger when the news shock hits 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 7b. Under the optimal policy, the real exchange rate not only depreciates, but is also much less volatile, as the efficient allocation would prescribe, relative to the allocation under the suboptimal policy of strict CPI inflation targeting. By preventing the inefficiently large and persistent currency appreciation under this rule, the optimal policy eliminates suboptimal movements in wealth across countries.

Relative to the allocation under strict CPI inflation targeting, the realignment of consumption and the real exchange rate toward their efficient path is achieved by a combination of a looser monetary stance at Home, and a tighter monetary stance abroad, up to engineering a *small* nominal and real currency depreciation. In a LCP economy, the reduced currency volatility is key to contain deviations from the law of one price. On the other hand, because of the stickiness of local prices, the depreciation under the optimal policy has limited expenditure switching effects in the short run, from Foreign in favor of Home goods. Therefore, monetary policy is able to lean against the large real appreciation — so as to counteract the wealth effect on consumption and realign demand to its efficient level while containing inefficient deviations from the law of one price —, without triggering an increase in the world demand for Home goods (as would be the case under PCP). An increase in the demand for Home goods would indeed translate into substantial movements in domestic and foreign labor supply, incompatible with the efficient distribution of domestic and foreign consumption.

With LCP and a low trade elasticity, the optimal policy is able to bring the dynamic path for most aggregate variables remarkably close to the first best. Yet, its apparent success in correcting cross-country wealth imbalance is not costless. Overall, the allocation remains inefficient, also to the extent that the optimal policy results into some inflation fluctuations and costly price dispersion.

Discussion. A key conclusion from our analysis is that 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. Our results also suggest that there is scope for monetary policy to go a long way in redressing the inefficiencies arising from incomplete markets and achieve significant welfare gains, 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 are large, amounting to 1.45 percent of steady state consumption (see Table 2).

An important observation is that leaning against the wind of misalignment is not an argument for limiting exchange rate flexibility *tout-court*. The optimal policy indeed generates significant exchange rate movements over time, which are necessary to 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 either PCP or LCP, a currency union entails a sizable 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, our results do not hinge on them. What our analysis emphasizes is the lack of efficient risk insurance, which opens up the possibility of strong asymmetric wealth and demand effects in response to all kinds of (fundamental) shocks. To stress this point, we redo our exercises assuming standard AR(1) shocks for productivity, instead of news shocks, as captured by the process U_t defined above — see equation (24). 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 essentially invariant 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. 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 Conclusions

A key question in the debate about stabilization policy is whether misalignments in asset prices and global imbalances create relevant trade-offs with other policy objectives. This question is particularly pressing for the exchange rate, as it plays a unique role in multiple markets — including the markets for consumption and investment goods as well as the markets for bonds, equities and other assets. When 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 to the question tend to be tilted in favor of the standard prescription that monetary policy should pursue 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] with anticipated technology shocks and complete markets, 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, 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 and cannot diversify risk — 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 even when exchange rates and other asset prices reflect only fundamental valuations. Our results stressing the role of news shocks are particularly important as they would readily generalize to the case in which expectation formation could instead deviate from full rationality.

When in some of our experiments strict inflation targeting still emerges as the optimal strategy, this happens not because such strategy succeeds in correcting misalignments and demand imbalances (as in DE), but because these are relatively inconsequential in terms of welfare relative to the costs associated with nominal rigidities. In this cases, redressing price dispersion due to nominal rigidities is the overwhelming concern for monetary policymakers, who optimally choose not to use the monetary tools 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. Lending support to strategies of flexible inflation targeting, the optimal policy substantially reduce over- and under-appreciation of exchange rates, and correct imbalances in cross-border demand. While the analysis here suggests that these external conditions should be taken into account in monetary policy deliberations, it hardly follows that the traditional goals of monetary stabilization policy should no longer be important. Moreover, even during instances when external imbalances concerns cannot be set aside, the proposed target criterion would continue to imply a clear medium-run target for the inflation rate; for a commitment to ensure that the economy's projected evolution is consistent with the target criterion at all horizons would necessarily imply that departures of the inflation rate from its optimal long-run level (zero, in the simple model presented here) were purely transitory.

Another ground for skepticism would assert that, even if one grants that monetary policy might be able to influence external imbalances, there are surely better tools available for this purpose, such as capital controls, perhaps as instruments of "macroprudential" policy. But the existence of these other instruments does not, in general, justify complete neglect of the problem in monetary policy deliberations. That would be true only if one could count on the other policy instruments to completely eliminate these distortions, and without other costs of having to resort to those instruments. This is unlikely, and at any rate, it is hardly the situation in which central banks already find themselves.

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 which distortions, at domestic as well as international levels, prevent financial markets from providing full insurance — a promising direction for research on international policy interaction.[24]

Finally, the 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.

References

[1] Allen, Franklin and Douglas Gale [2000], "Bubbles and Crises," Economic Journal 110, 236-255.

[2] Backus, David K., Patrick J. Kehoe, and Finn E. Kydland [1994]. "Dynamics of the Trade Balance and the Terms of Trade: The J Curve?" *American Economic Review 82,* pp. 864-88.

[3] Backus, David K., and Gregor W. Smith, [1993]. "Consumption and Real Exchange Rates in Dynamic Economies with Non-traded Goods," *Journal of International Economics* 35, pp. 297-316.

[4] Beaudry, Paul and Franck Portier, [2006]. "Stock Prices, News, and Economic Fluctuations," *American Economic Review*, 96, pp. 1293-1307.

[5] Beaudry, Paul, Martial Dupaigne, and Franck Portier [2008]. "The International Transmission of News Shocks", manuscript.

[6] Benigno, Pierpaolo [2009]. "Price Stability with Imperfect Financial Integration", *Journal of Money, Credit and Banking*, 41, pp.121-149.

[7] Benigno, Gianluca [2007]. Comments on Devereux, Michael B. and Charles Engel [2007]. "Expectations, Monetary Policy, and the Misalignment of Traded Goods Prices", *NBER International Seminar on Macroeconomics*

[8] Benigno, Pierpaolo [2001]. "Price Stability with Imperfect Financial Integration," CEPR Discussion Paper No. 2854.

[9] Benigno, Gianluca and Pierpaolo Benigno [2003]. "Price Stability in Open Economies," *Review of Economic Studies* 70, pp. 743-764.

[10] Benigno, Gianluca, Huigang Chen, Christopher Otrok, Alessandro Rebucci and Eric Young [2010]. "Revisiting Overborrowing and its Policy Implications,"CEPR DP. No. 7872.

[24] Likewise, the extreme lack of diversification we assume could be extended to a situation in which markets are segmented and most agents do not participate in international equity and bond markets, in line with the observed degree of high home bias.

[11] Bergin, Paul R., and Ivan Tchakarov [2003]. "Does Exchange Rate Risk Matter for Welfare?," NBER Working Paper No. 9900.

[12] Bianchi, Javier [2010]. "Overborrowing and Systemic Externalities in the Business Cycle," *American Economic Review,* forthcoming.

[13] Bianchi, Javier and Enrique Mendoza [2010]."Overborrowing, Financial Crises and .Macro-prudential.Taxes," NBER Working Papers 16091.

[14] Chari, V.V., Patrick J. Kehoe, and Ellen McGrattan [2002]. "Can Sticky Prices Generate Volatile and Persistent Real Exchange Rates?," *Review of Economic Studies* 69, pp. 633-63.

[15] Clarida, R., Galí J. and Gertler, M. [2002], "A simple framework for international policy analysis." *Journal of Monetary Economics* 49, 879–904.

[16] Coenen, G., G. Lombardo, F. Smets, and R. Straub [2010]. "International Transmission and Monetary Policy Cooperation," in International Dimensions of Monetary Policy, pp.157-192.

[17] Cole, Harold L., and Maurice Obstfeld [1991]. "Commodity Trade and International Risk Sharing: How Much Do Financial Markets Matter?" *Journal of Monetary Economics* 28, pp. 3-24.

[18] Collard, Fabrice and Harris Dellas [2007]. "Technology Shocks and Employment," *Economic Journal*.

[19] Corsetti, Giancarlo and Paolo Pesenti [2005]. "International Dimensions of Optimal Monetary Policy", *Journal of Monetary Economics* 52, pp. 281-305.

[20] Corsetti Giancarlo, Luca Dedola and Sylvain Leduc [2006]. "Productivity, External Balance and Exchange Rates: Evidence on the Transmission Mechanism Among G7 Countries," *NBER International Studies on Macroeconomics.*

[21] Corsetti Giancarlo, Luca Dedola and Sylvain Leduc [2008a]. "International Risk-Sharing and the Transmission of Productivity Shocks," *Review of Economic Studies* 75, pp. 443-473.

[22] Corsetti Giancarlo, Luca Dedola and Sylvain Leduc [2008b]. "High exchange rate volatility and low pass-through," *Journal of Monetary Economics* 55 , pp. 1113–1128.

[23] Corsetti Giancarlo, Luca Dedola and Sylvain Leduc [2010]. "Optimal Policy in Open Economies," forthcoming in the *Handbook of Monetary Economics.*

[24] Curdia, Vasco and Michael Woodford [2009]. "Credit Frictions and Optimal Monetary Policy," Federal Reserve Bank of New York.

[25] De Paoli, Bianca [2009]. "Monetary Policy under Alternative Asset Market Structures: The Case of a Small Open Economy," *Journal of Money, Credit and Banking* 41(7): 1301-1330 .

[26] Devereux, Michael B. [2004]."Should the exchange rate be a shock absorber?", *Journal of International Economics* 62, pp. 359– 377

[27] Devereux, Michael B. and Charles Engel [2003]. "Monetary policy in the open economy revisited: Price setting and exchange-rate flexibility", *Review of Economic Studies* 70, pp.765-783.

[28] Devereux, Michael B. and Charles Engel [2006]. "Expectations and Exchange Rate Policy", NBER Working Paper No. 12213.

[29] Devereux, Michael B. and Charles Engel [2007]. "Expectations, Monetary Policy, and the Misalignment of Traded Goods Prices", *NBER International Seminar on Macroeconomics*

[30] Devereux, Michael B. and Alan Sutherland [2008]. "Financial Globalization and Monetary Policy." *Journal of Monetary Economics* 55, pp.1363-1375.

[31] Engel, Charles, Mark, C. Nelson, and Kenneth D.West [2007], "Exchange Rate Models Are Not as Bad as You Think." *NBER Macroeconomics Annual*.

[32] Engel, Charles [2009]."Currency Misalignments and Optimal Monetary Policy: A Reexamination", NBER Working Paper No.14829, *American Economic Review,* forthcoming.

[33] Galí, Jordi and Tommaso Monacelli [2005]. "Monetary Policy and Exchange Rate Volatility in a Small Open Economy", *Review of Economic Studies* 72, pp.707–734.

[34] Geanakoplos, John and Herakles Polemarchakis [1986]. "Existence, regularity, and constrained suboptimality of competititve allocations when the asset market is incomplete," in: Essays in Honor of Kenneth J. Arrow; Uncertainty, Information and Communication, Vol. 3; Heller, W. P.; Starr, R. M.; Starrett, D. A., Eds.; Cambridge University press: Cambridge, pp. 65–96.

[35] Gravelle, Hugh, and Ray Rees [1992]. Microeconomics, London: Longman.

[36] Jeanne, Olivier and Anton Korinek [2010]. "Excessive Volatility in Capital Flows: A Pigouvian Taxation Approach," *American Economic Review*, vol. 100(2), pages 403-07.

[37] Kocherlakota, Narayana [2010]. "Two Models of Land Overvaluation and Their Implications," working paper, Federal Reserve Bank of Minneapolis.

[38] Kollmann, Robert [2002]. "Monetary policy rules in the open economy: effects on welfare and business cycles", *Journal of Monetary Economics* 49, pp. 989–1015.

[39] Kollmann, Robert [2003]. "Monetary Policy Rules in an Interdependent World", CEPR Discussion Paper No.4012 .

[40] Korinek, Anton [2010]. "Regulating Capital Flows to Emerging Markets: An Externality View," University of Maryland.

[41] Lorenzoni, Guido [2008]. "Inefficient Credit Booms," *Review of Economic Studies*, 75 (3), 809–833.

[42] Mendoza, Enrique [1991]. "Real Business Cycles in a Small Open Economy," *American Economic Review,* vol. 81(4), pages 797-818.

[43] Mountford, Andrew [2005]. “Leaning into the Wind: A Structural VAR Investigation of UK Monetary Policy,” *Oxford Bulletin of Economics and Statistics* 67, pp. 597-621.

[44] Obstfeld, Maurice, and Kenneth Rogoff [2001]. “The six major puzzles of international macroeconomics: Is there a common cause?” *NBER Macroeconomics Annual.*

[45] Obstfeld, Maurice [1990]. “Intertemporal dependence, impatience, and dynamics”. *Journal of Monetary Economics* 26, 45–75.

[46] Schmitt-Grohe and Uribe [2003]. “Closing small open economies.” *Journal of International Economics,* vol. 61, 163–185

[47] Sutherland, Alan [2004], "International Monetary Policy Coordination and Financial Market Integration", CEPR Discussion Paper No 4251.

[48] Tille, Cédric [2005]. "The welfare effect of international asset market integration under nominal rigidities." Journal of International Economics, Volume 65 (1), Pages 221-247

[49] Viani, Francesca [2009], "Why is the consumption correlation puzzle so important?", mimeo, European University Institute.

[50] Woodford, Michael [2010]. "Optimal Monetary Stabilization Policy" forthcoming in the *Handbook of Monetary Economics.*

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	0.54	0.614	0.036	0.035
Deviations from LOOP	0	0	0	0
RER Gap	0.398	0.450	0.009	0.009
Domestic Output Gap	0.013	0.013	0.006	0.006
Foreign Output Gap	0.013	0.013	0.006	0.006
Domestic Price Inflation	0.002	0	$4{\times}e^{-6}$	0
Welfare Cost[a]	–	0.028	–	0

[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	0.38	1.640	0.036	0.036
Deviations from LOOP	0.055	0.084	0.002	0.002
RER Gap	0.282	1.203	0.009	0.009
Domestic Output Gap	0.016	0.034	0.006	0.006
Foreign Output Gap	0.016	0.034	0.006	0.006
Consumer Price Inflation	0.010	0	$2 \times e^{-5}$	0
Welfare Cost[a]	–	1.45	–	0.0001

[a] In percent of steady state consumption.

Figure 1. News and Autoregressive Shocks

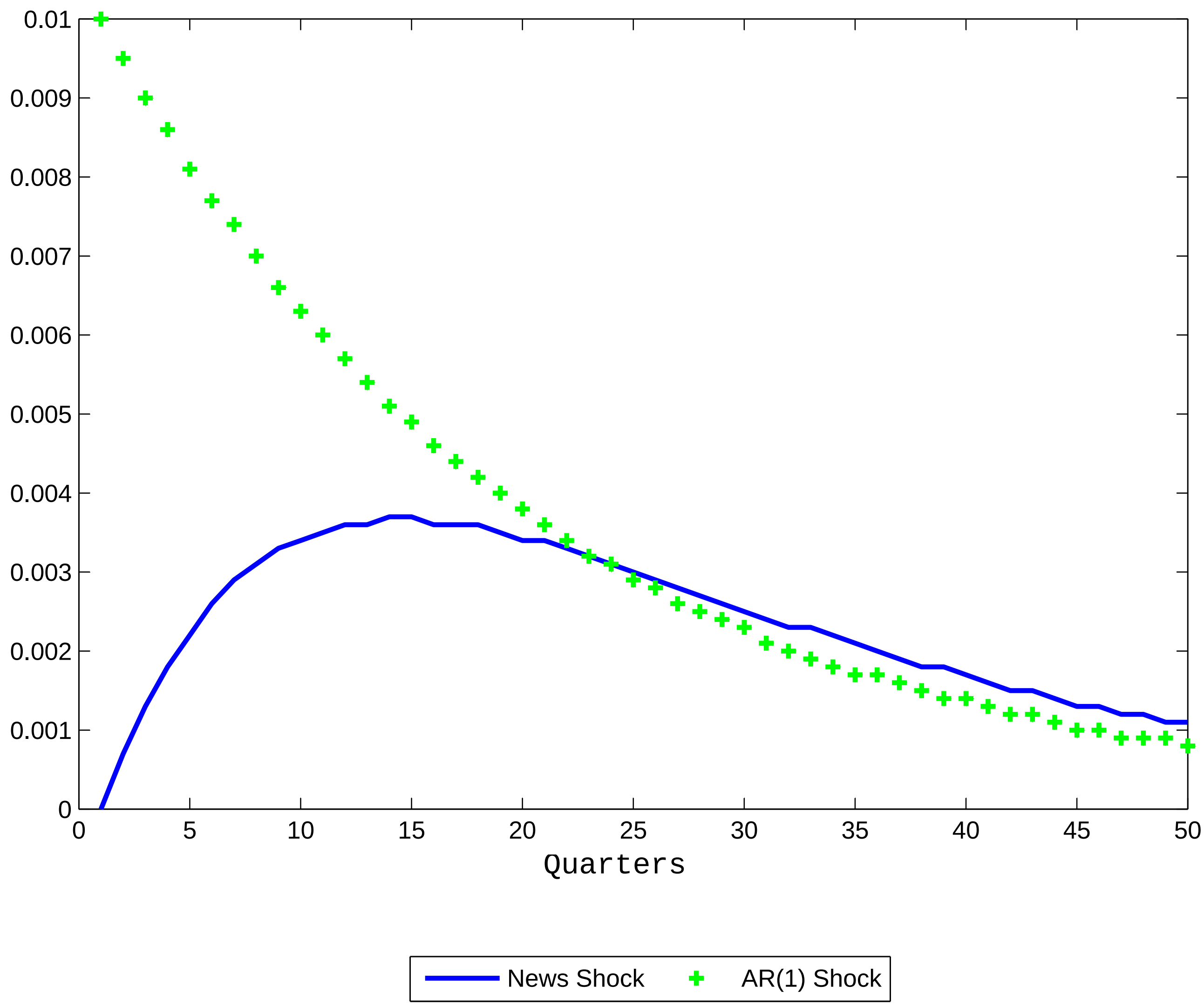


Figure 2. Macroeconomic Effects of News Shocks with Flexible Prices
Complete versus Incomplete Markets Allocation under High Elasticity

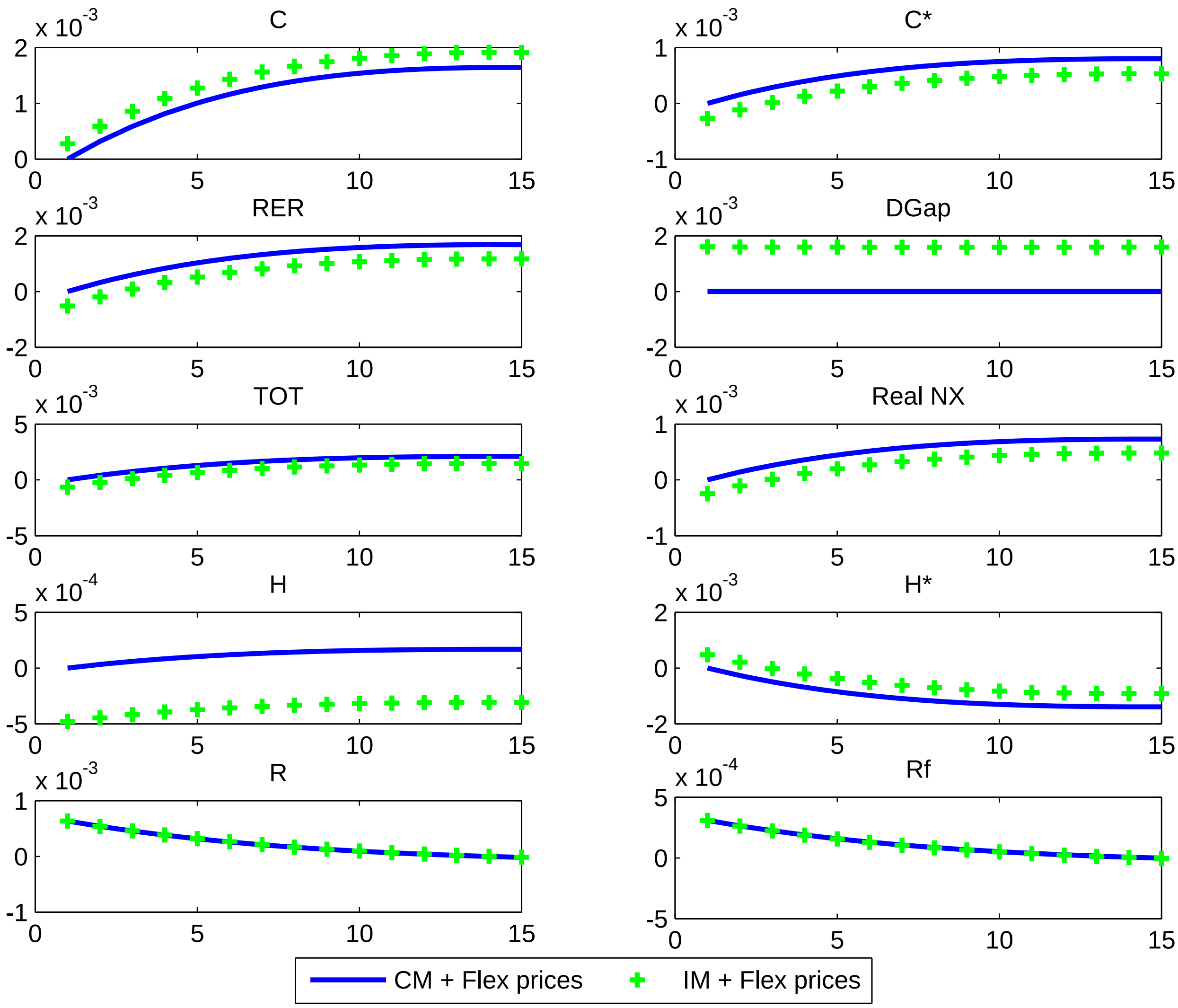


Figure 3. Macroeconomic Effects of News Shocks with Flexible Prices
Complete versus Incomplete Markets Allocation under Low Elasticity

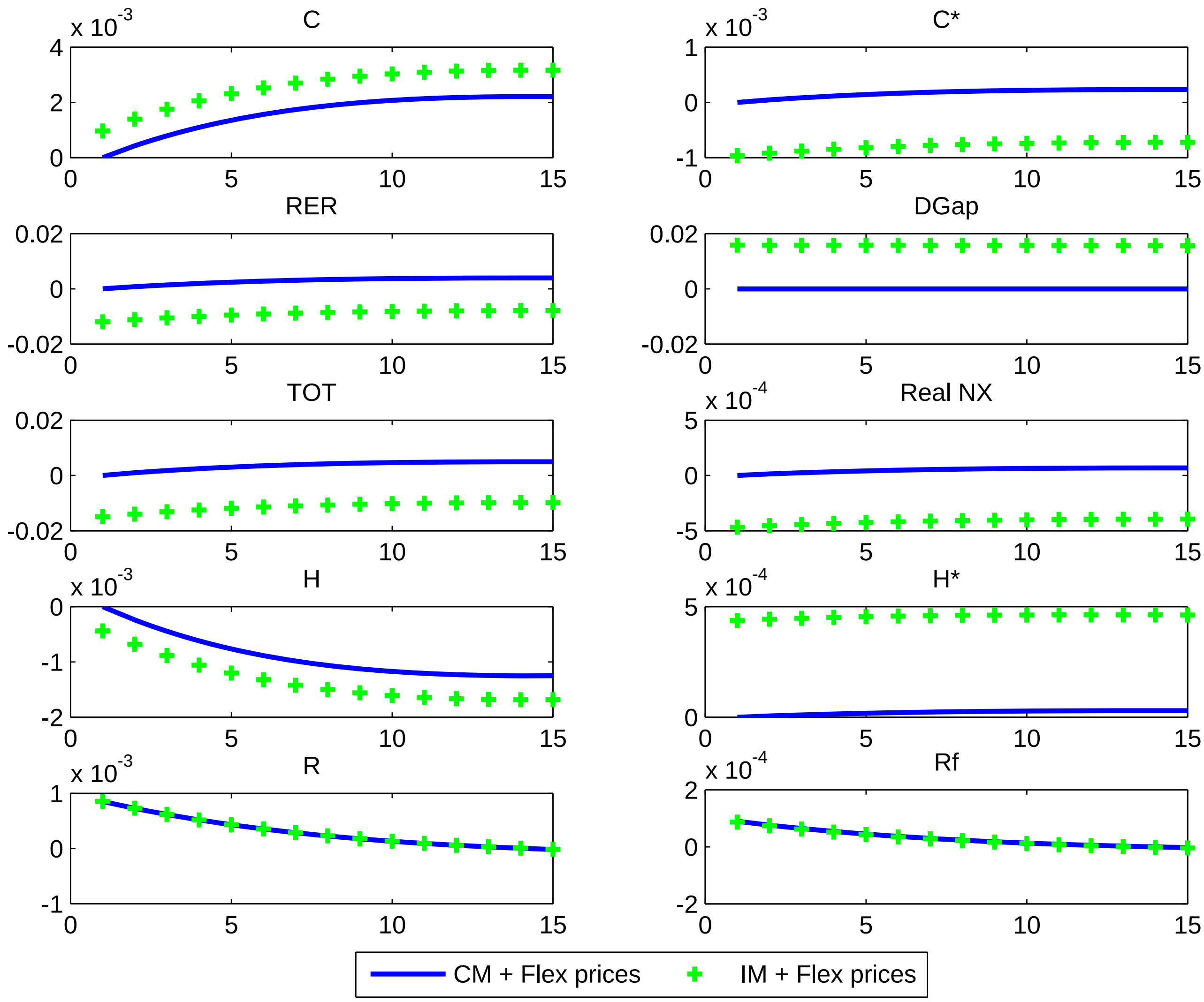


Figure 4a. News Shocks with High Elasticity and PCP:
Domestic Price Stability and Optimal Policy

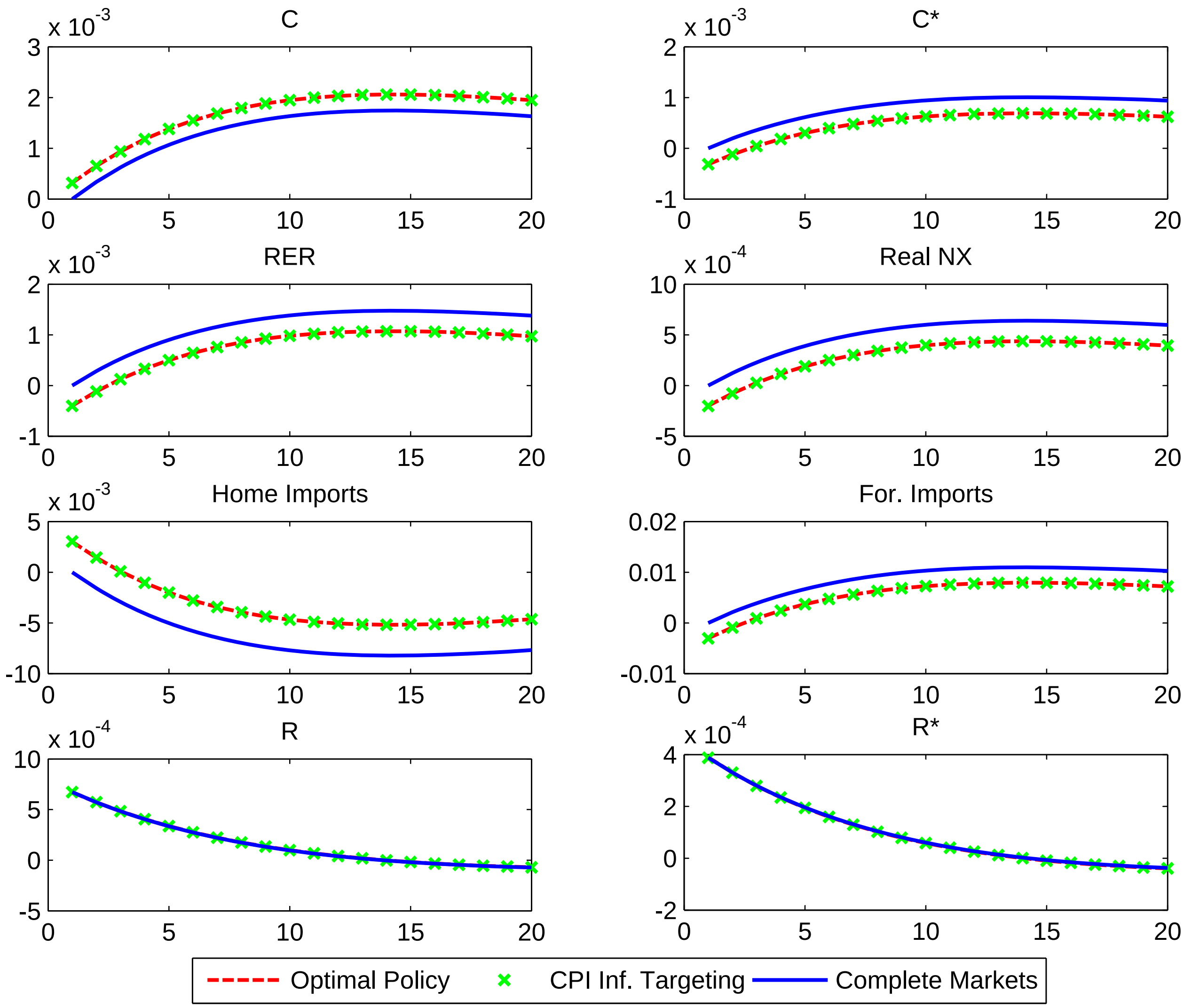


Figure 4b. News Shocks with High Elasticity and PCP:
Domestic Price Stability and Optimal Policy

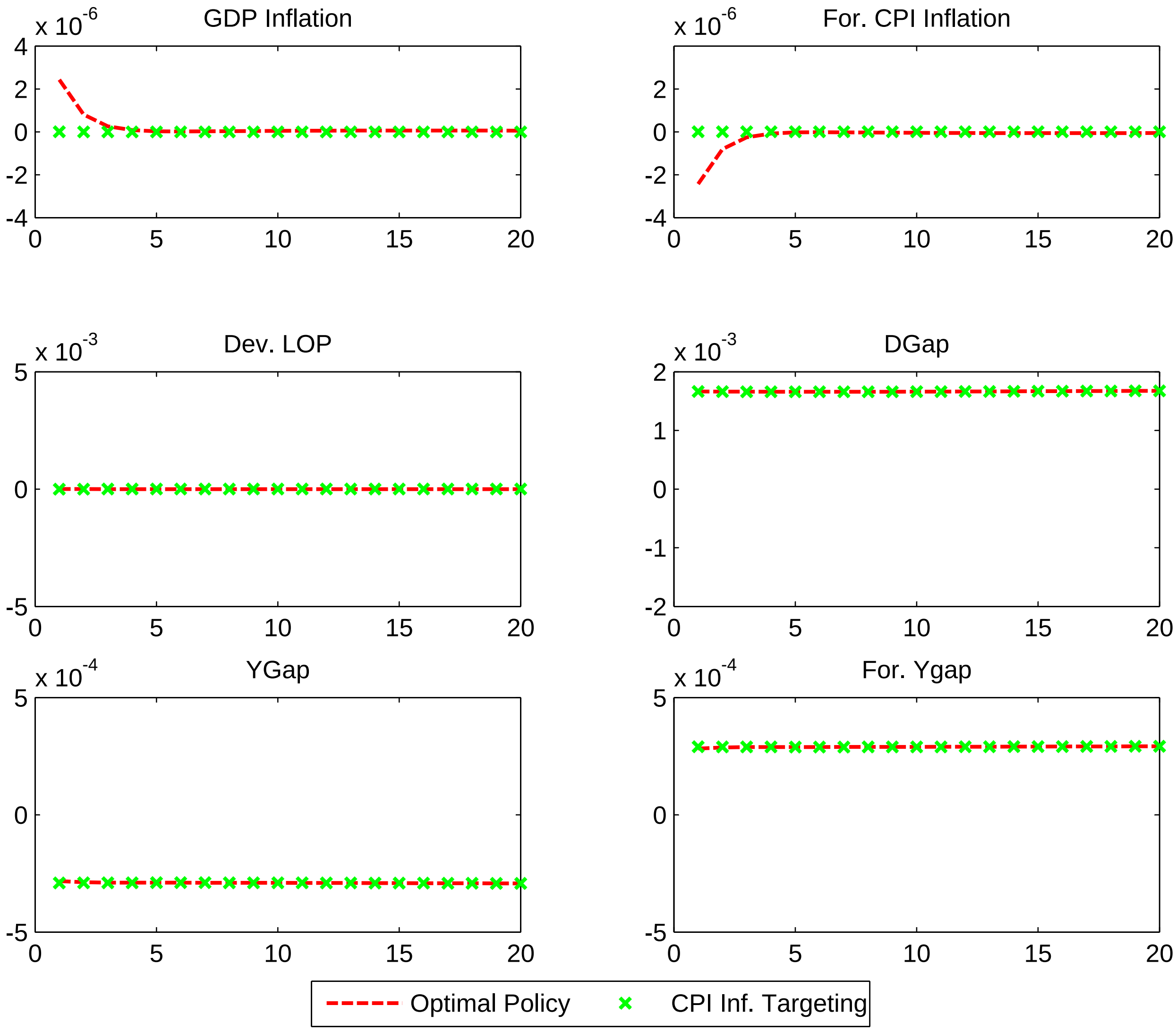


Figure 5a. News Shocks with High Elasticity and LCP: Consumer Price Stability and Optimal Policy

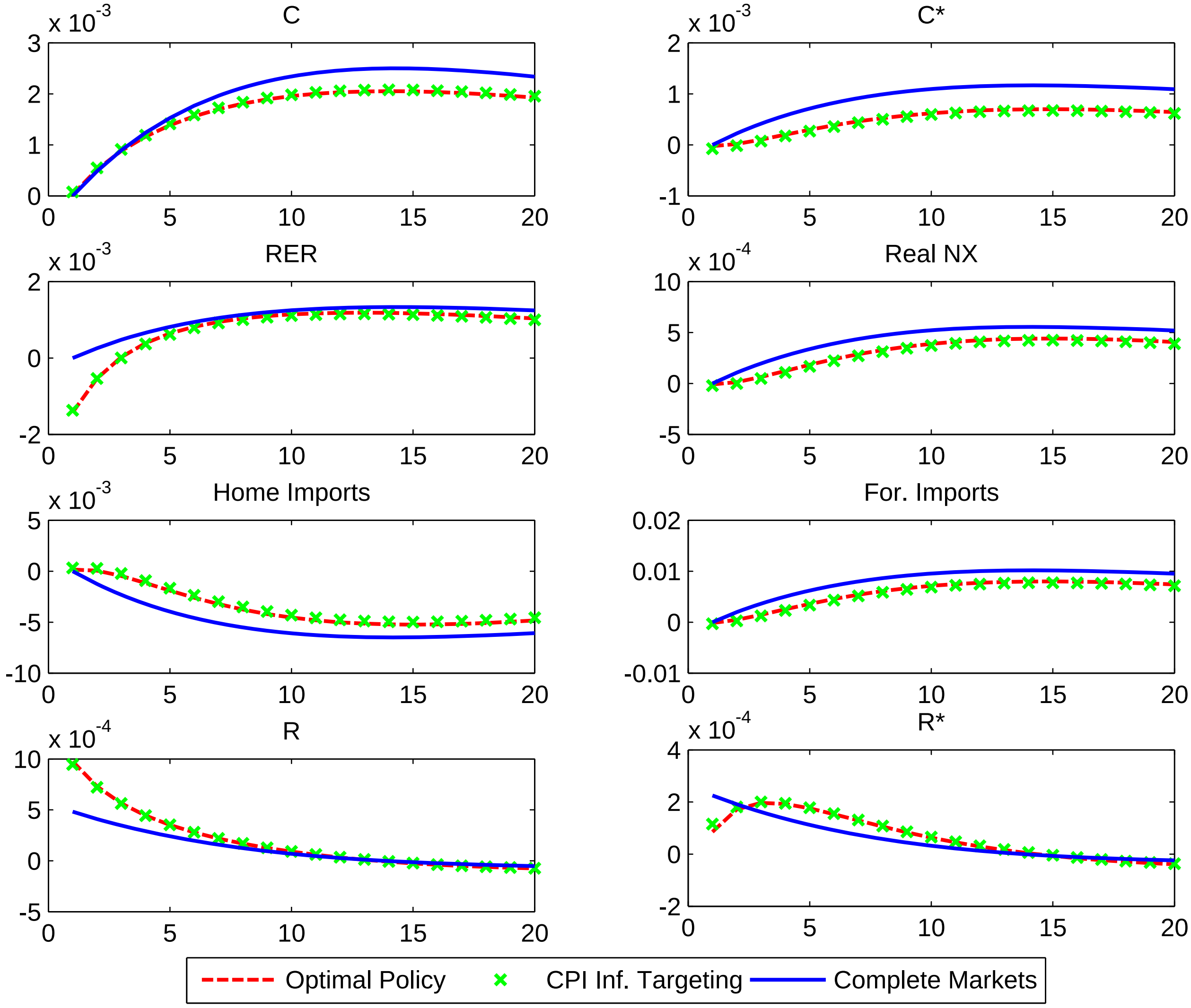
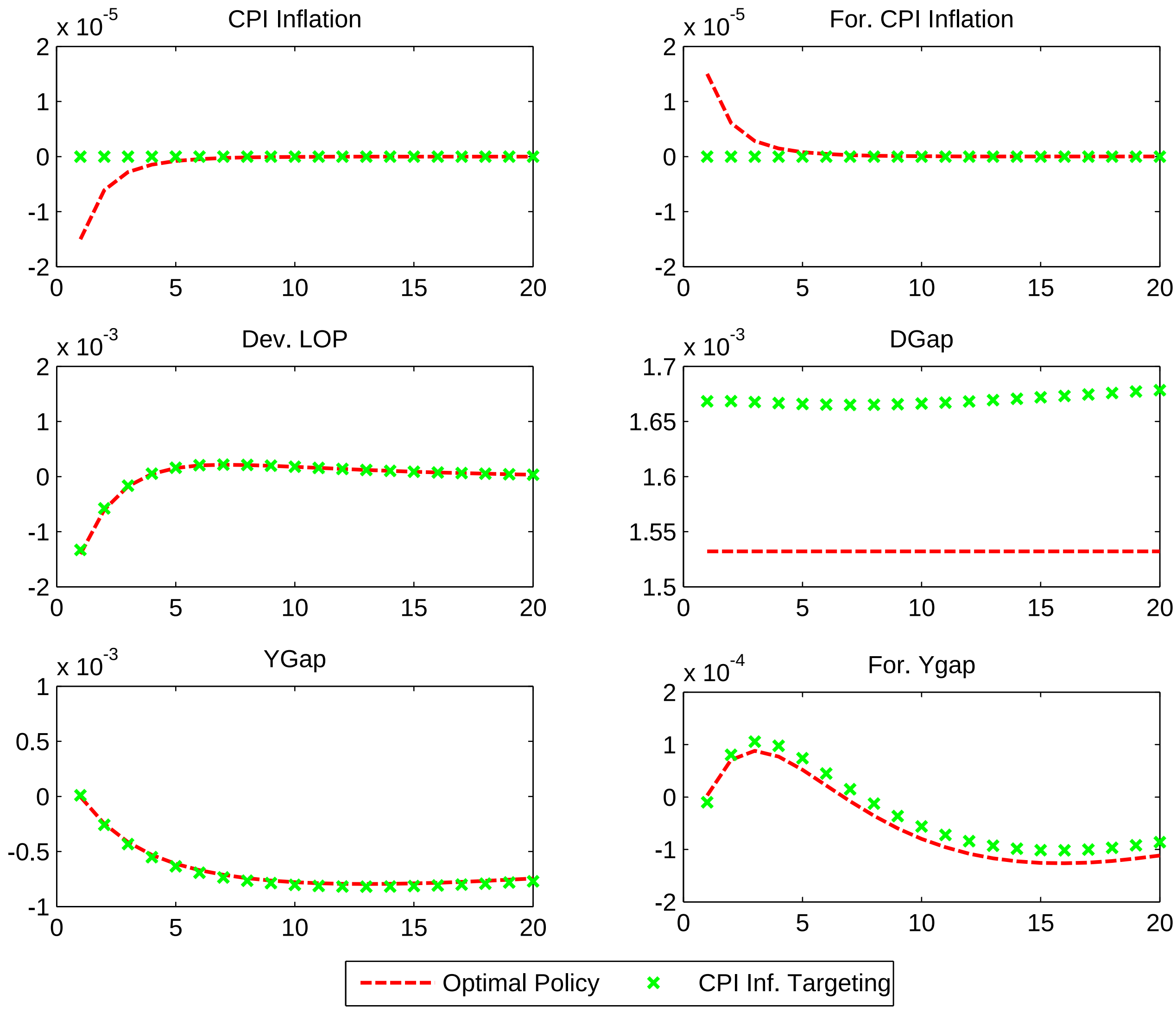


Figure 5b. News Shocks with High Elasticity and LCP: Consumer Price Stability and Optimal Policy



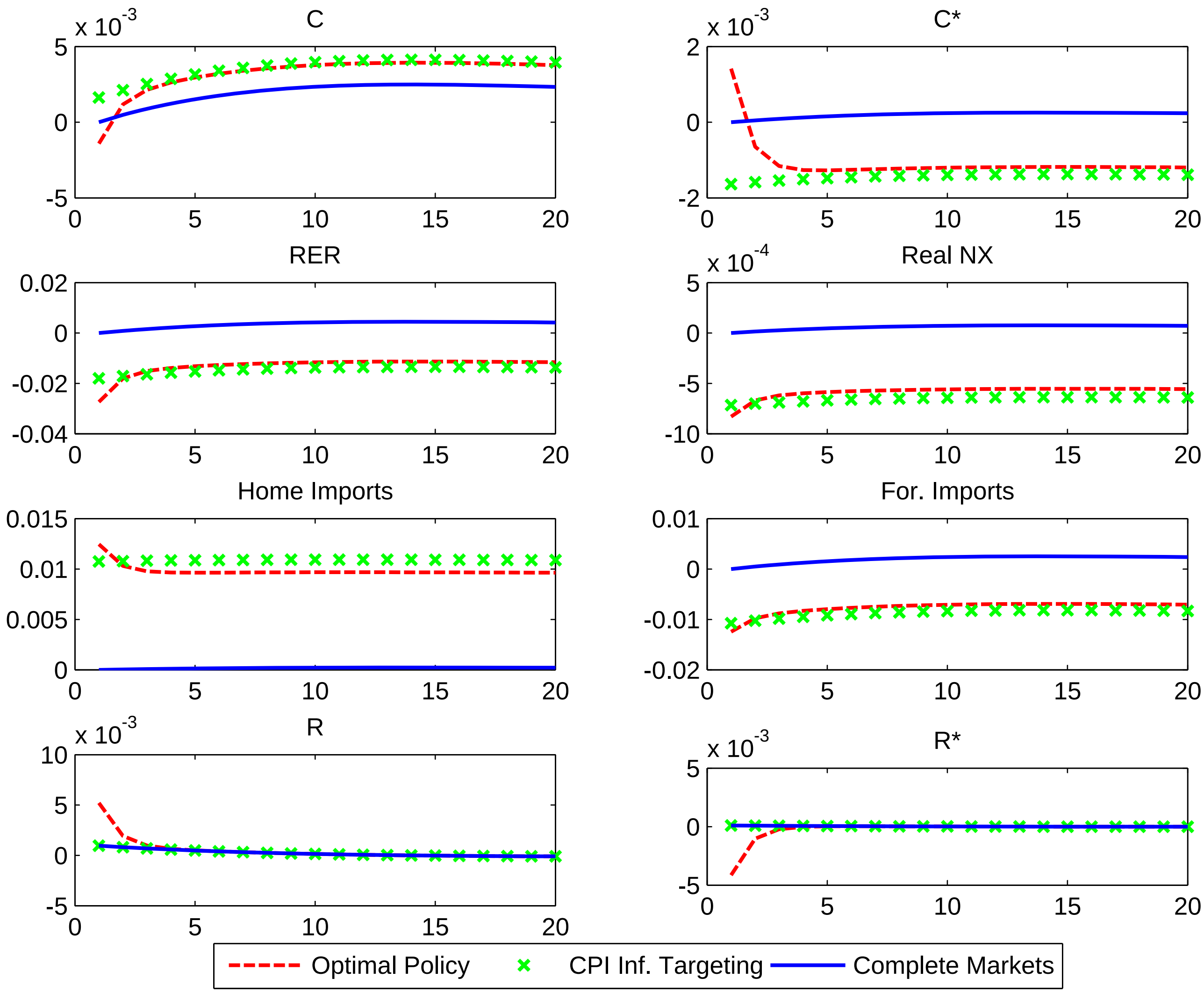

C
x 10^-3
C*
x 10^-3
RER
Real NX
x 10^-4
Home Imports
For. Imports
R
x 10^-3
R*
x 10^-3
Optimal Policy
CPI Inf. Targeting
Complete Markets

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

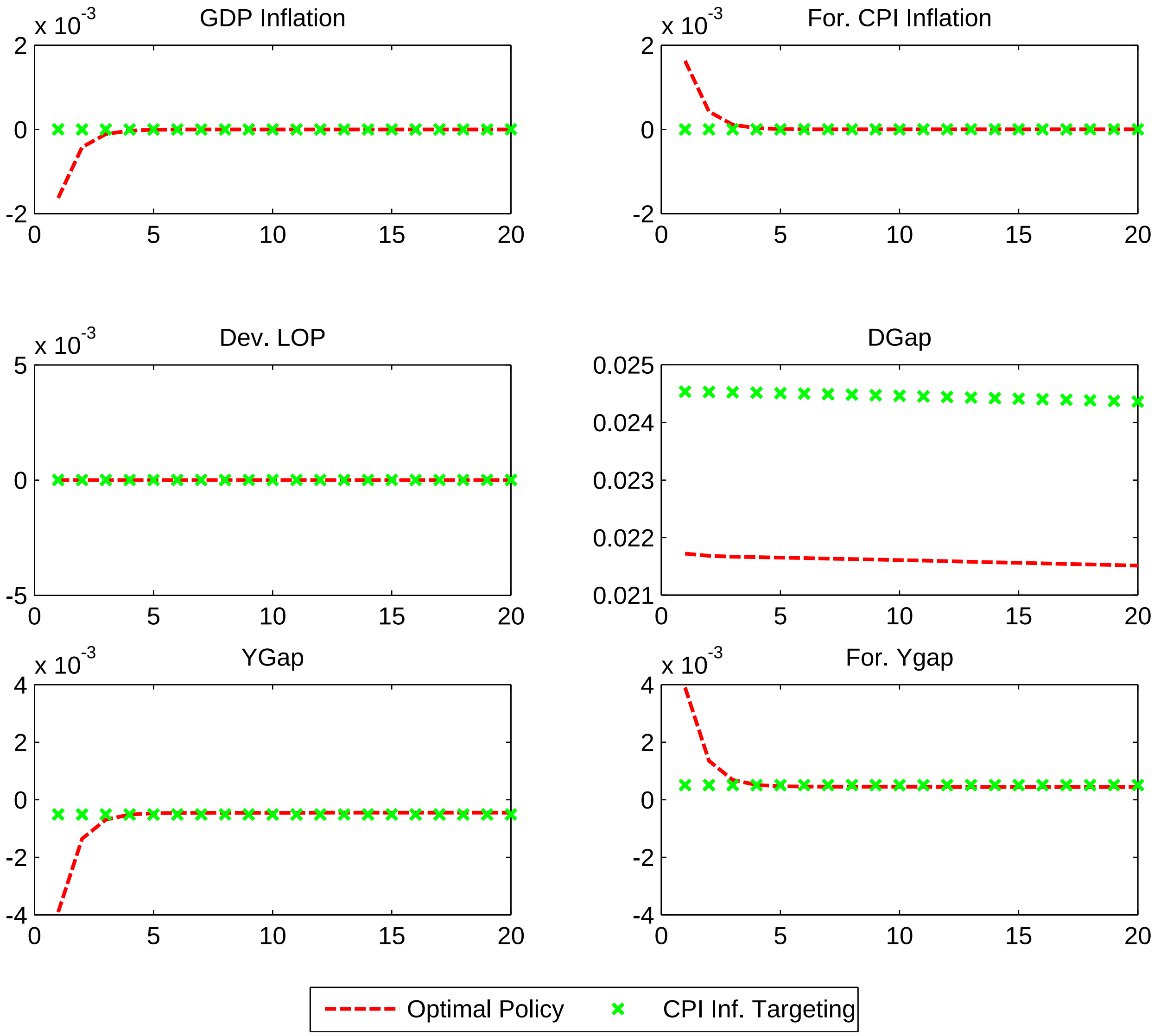


Figure 7a. News Shocks with Low Elasticity and LCP:
Consumer Price Stability and Optimal Policy

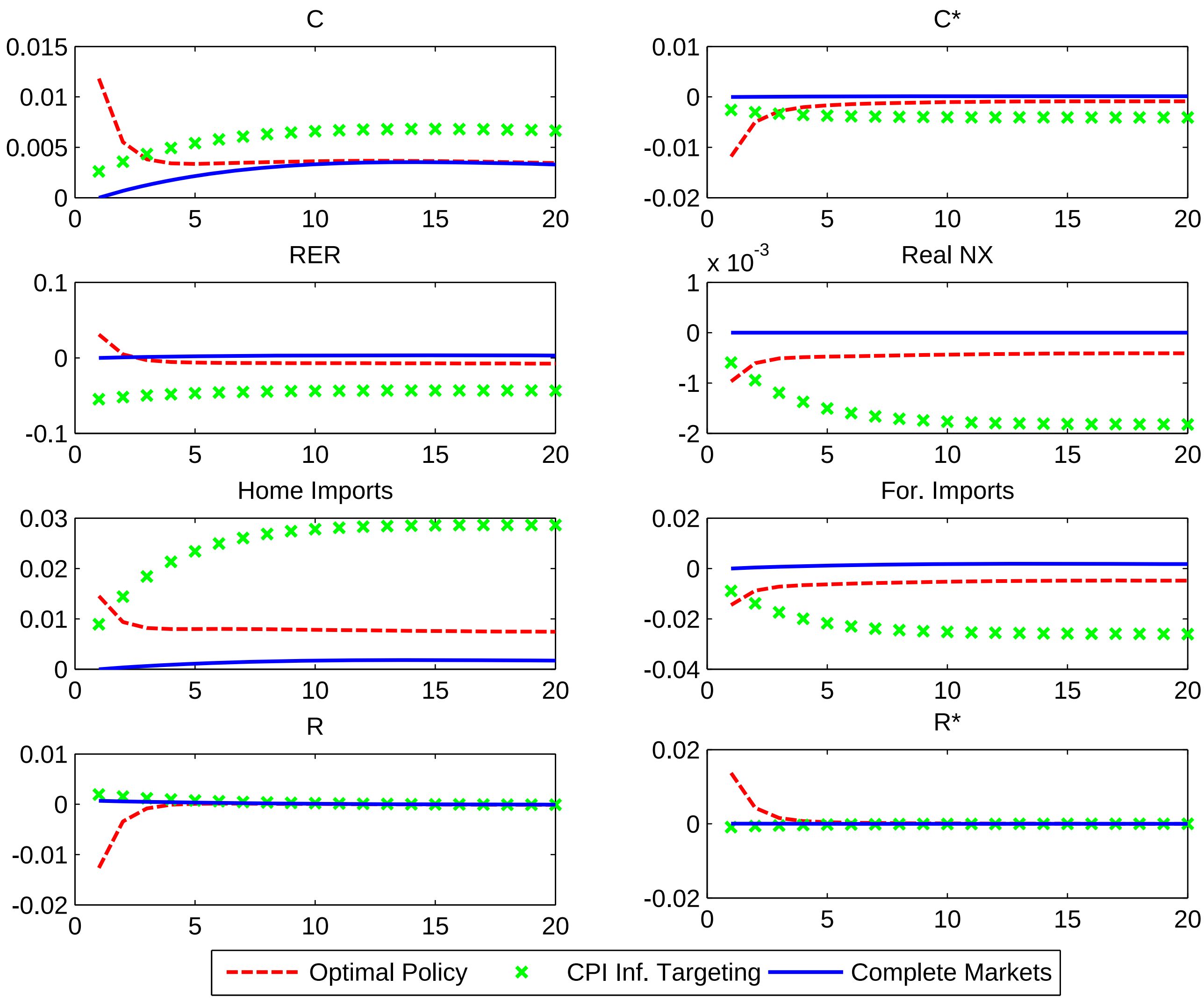


Figure 7b. News Shocks with Low Elasticity and LCP:
Consumer Price Stability and Optimal Policy