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Country Portfolios, Collateral Constraints and Optimal Monetary Policy

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Abstract

Recent literature shows that, when international financial trade is absent, optimal policy deviates significantly from strict inflation targeting, but when there is trade in equities and bonds, optimal policy is close to strict inflation targeting. A separate line of literature shows that collateral constraints can imply that cross-border portfolio holdings act as a shock transmission mechanism which significantly undermines risk sharing. This raises an important question: does asset trade in the presence of collateral constraints imply a greater role for monetary policy as a risk sharing device? This paper finds that the combination of asset trade with collateral constraints does imply a potentially large welfare gain from optimal policy (relative to inflation targeting). However, the welfare gain of optimal policy is even larger when there is no international asset trade (but collateral constraints bind within each country). In other words, the risk sharing role of asset trade tends to reduce the welfare gains from policy optimisation even when collateral constraints act as a shock transmission mechanism. This is true even when there are large and persistent collateral constraint shocks.

Keywords: Optimal monetary policy, Financial market structure, Country Portfolios, Collateral constraints

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1   Introduction

This paper analyses optimal monetary policy in a world where there is international trade in equities and bonds and borrowers are subject to collateral constraints. The combination of international asset trade and collateral constraints adds an important new element to the cross border effects of monetary policy.

In a recent contribution to the literature on optimal monetary policy in open economies, Corsetti *et al* (2010, 2011) show that financial market incompleteness (in the extreme form of financial autarky or bond-only economies) can imply large welfare gains from monetary policy optimisation relative to inflation targeting. They show that the absence of international financial trade creates a strong welfare role for monetary policy as a risk sharing device. Senay and Sutherland (2016) on the other hand show that trade in equities and bonds, while still short of financial completeness, tends to reduce the gains from monetary policy optimisation very significantly. The risk sharing provided by trade in equities and bonds thus appears to be sufficient to allow optimal monetary policy to focus on inflation stabilisation.

Both Corsetti *et al* (2010, 2011) and Senay and Sutherland (2016) analyse models where the only form of financial market imperfection is the absence of a full set of state contingent assets. In a separate line of literature Devereux and Yetman (2010) and Devereux and Sutherland (2011b) analyse the implications of collateral constraints.[1] They show that collateral constraints, in conjunction with international trade in equities and bonds, can imply that asset trade causes a significant increase in shock transmission across countries. This is because cross-border collateral constraints imply that "fire sales" of assets in one country (which are required to meet the collateral constraint) cause parallel fire-sales (and asset price declines) in the other country. This shock transmission mechanism can significantly undermine the risk-sharing properties of equity and bond trade.

The fact that collateral constraints can offset the risk sharing benefits of asset trade creates the possibility that monetary policy re-emerges as an important risk sharing device in a model which combines collateral constraints with trade in equities and bonds. Indeed, given that asset trade may now act as a shock transmission mechanism, an interesting question is whether asset trade enhances

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[1] Devereux and Yetman (2010) and Devereux and Sutherland (2011b) develop two country models where 'borrower' households in each country are subject to collateral constraints in the form assumed in the literature initiated by Kiyotaki and Moore (1997).

(rather than reduces) the role of monetary policy as a risk sharing device.

This paper develops a more general version of the Devereux and Sutherland (2011b) model which incorporates variable capital and sticky nominal prices. We show that asset trade in combination with collateral constraints does indeed imply non-trivial gains from monetary policy optimisation relative to strict inflation targeting. We find that the optimal monetary rule implies a strong feedback on the spread between equity returns and the return on borrowing. Thus optimal monetary policy tends to stabilise the credit spread. It also tends to reduce inefficient fluctuations in the amount of real capital that are triggered by collateral constraints.

However, when we consider a case which combines collateral constraints with financial autarky, we find that there are even larger welfare gains from policy optimisation. This latter result shows that asset trade is welfare improving and implies lower welfare gains from policy optimisation even when there are collateral constraints. In other words the risk sharing role of asset trade outweighs its role in shock transmission. This is true even if collateral constraint shocks are very large and persistent or if the credit spread is very sensitive to shocks.

A key feature of the Devereux and Sutherland (2011b) model is that, within the collateral constraint, borrowers have a portfolio choice over home and foreign capital. The combined effect of the portfolio and collateral constraint therefore creates a transmission channel for shocks to pass from one country to the other. The full analysis of optimal policy within this model must therefore combine welfare analysis of monetary policy with optimal portfolio choice by borrowers. Senay and Sutherland (2016) show how this can be done in a model without collateral constraints. An important contribution of this paper is to extend this analysis to a model with collateral constraints.[2]

This paper proceeds as follows. The model is described in Section 2. We briefly illustrate the dynamic properties of the model in Section 3. Our specification of

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[2]We solve the model assuming that the collateral constraint is always binding. Devereux and Yu (2014) and Devereux *et al* (2015) analyse related models where the collateral constraint is assumed to be occasionally binding. Devereux and Yu (2014) analyse the positive and welfare implications of international financial integration. In particular, they show how financial integration in the presence of collateral constraints can have both risk sharing and shock transmission effects. Devereux *et al* (2015) analyse optimal monetary and capital control policy in anticipation of and response to sudden stops.

monetary policy and welfare is described in Section 4 and our approach to solving for equilibrium portfolios and optimal policy is outlined in Section 5. The results are presented and discussed in Section 6 while Sections 7 concludes the paper.

2   The Model

There are two countries, home and foreign. As in Devereux and Sutherland (2011b), in each country there are two types of households, borrowers and savers. Borrowers are less patient than savers. Borrowers hold capital which they rent to intermediate goods firms. Savers also hold real capital but, crucially, they are only able to use it directly to produce intermediate goods using a technology which is less productive than that available to intermediate goods firms. Borrowers are subject to a collateral constraint. In our simulations we choose values for discount rates and technology to ensure that the collateral constraints are always binding (in the steady state).

Final goods are produced using intermediate goods as the only input. Final goods are produced by imperfectly competitive firms which are subject to Calvo (1983) pricing.

2.1   Borrowers

Borrower z in the home country maximizes a utility function of the form

$$U_{b,t} = E_t \sum_{i=0}^{\infty} \beta_{b,t+i} \frac{C_{b,t+i}^{1-\rho}(h)}{1-\rho} \tag{1}$$

where $\rho > 0$, $C_b(h)$ is the consumption of borrower household h and β_b is the discount factor, which is determined as follows

$$\beta_{b,t+i+1} = \bar{\beta}_b \beta_{b,t+i} \left(1 + C_{b,t+i}\right)^{-\eta}, \ \beta_{b,t} = 1 \tag{2}$$

where $0 < \eta < \rho$, $0 < \bar{\beta}_b < 1$, C_b is aggregate home consumption of borrowers.[3]

In the benchmark version of the model we assume that borrower households can hold capital located in either country. In this case the flow budget constraint

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[3]Following Schmitt Grohe and Uribe (2003), β_b is assumed to be taken as exogenous by individual decision makers. The impact of individual consumption on the discount factor is therefore not internalized.

of the home country borrower household is

$$P_t C_{b,t} - P_t B_t + P_t z_t K_{H,t} + P_t z_t^* K_{F,t}$$
$$= -R_{t-1} P_t B_{t-1} + (1-\delta) P_t z_t K_{H,t-1} + P_t x_t K_{H,t-1} \quad (3)$$
$$+ (1-\delta) P_t z_t^* K_{F,t-1} + P_t x_t^* K_{F,t-1}$$

where K_H is home capital owned by borrowers, K_F is the foreign capital owned by borrowers, z is the price of home capital goods (in terms of final goods), z^* is the price of foreign capital goods (in terms of final goods), R is the real rate of interest on borrowing and x and x^* are the rental rates of home and foreign capital (in terms of final goods). δ is the depreciation rate of real capital. It is assumed that all labour is supplied by saver households so borrower households have no labour income.

Borrowing is subject to the collateral constraint

$$B_t \leq \kappa_t \left(z_t K_{H,t} + z_t^* K_{F,t} \right) \quad (4)$$

where $\kappa_t = \bar{\kappa} \exp(\hat{\kappa}_t)$ where $0 < \bar{\kappa} < 1$ and $\hat{\kappa}_t = \eta_\kappa \hat{\kappa}_{t-1} + \varepsilon_{\kappa,t}$, $0 \leq \eta_\kappa < 1$ and $\varepsilon_{\kappa,t}$ is a zero-mean normally distributed i.i.d. shock with $Var[\varepsilon_\kappa] = \sigma_\kappa^2$.

The first order conditions for borrowers imply

$$\beta_{b,t} C_{b,t}^{-\rho} = E_t \left[\beta_{b,t+1} C_{b,t+1}^{-\rho} R_{t+1} \right] + \beta_{b,t} \mu_t \quad (5)$$

$$\beta_{b,t} C_{b,t}^{-\rho} = E_t \left[\beta_{b,t+1} C_{b,t+1}^{-\rho} r_{H,t+1}^e \right] + \beta_{b,t} \kappa_t \mu_t \quad (6)$$

$$\beta_{b,t} C_{b,t}^{-\rho} = E_t \left[\beta_{b,t+1} C_{b,t+1}^{-\rho} r_{F,t+1}^e \right] + \beta_{b,t} \kappa_t \mu_t \quad (7)$$

where μ_t is the Lagrange multiplier associated with the collateral constraint and

$$r_{H,t+1}^e = \frac{[(1-\delta) z_{t+1} + x_{t+1}]}{z_t} \qquad r_{F,t+1}^e = \frac{[(1-\delta) z_{t+1}^* + x_{t+1}^*]}{z_t^*}$$

are the rates of return on home and foreign capital.

Notice that the borrower has a portfolio decision to make over the composition of the capital holdings located in the two countries. Equations (6) and (7) can be combined to yield the following optimality condition for portfolio allocation

$$E_t \left[\beta_{b,t+1} C_{b,t+1}^{-\rho} \left(r_{H,t+1}^e - r_{F,t+1}^e \right) \right] = 0 \quad (8)$$

As shown by Devereux and Sutherland (2011b), despite the presence of the collateral constraint, this condition is in a form which allows the application of the

Devereux and Sutherland (2011a) portfolio solution methodology. The application of this solution methodology will be discussed in more detail below.

Notice also that if the collateral constraint is not present the Lagrange multiplier, μ_t, would be zero in equations (5), (6) and (7). This implies that, up to a first order approximation, $E_t\left[r^e_{H,t+1}\right] = E_t\left[R_{t+1}\right]$, i.e. the rate of return on capital is equated to the cost of borrowing. The presence of the collateral constraint breaks this equality and therefore introduces a premium, or a spread, between the return on capital and the cost of borrowing, thus $E_t\left[r^e_{H,t+1}\right] - E_t\left[R_{t+1}\right] > 0$. It is useful to define

$$SPR_t = E_t\left[r^e_{H,t+1} - R_{t+1}\right]$$

to be the "spread". The monetary policy rule specified below will include a feedback term that responds to this spread.

In the analysis reported below we also consider a version of the model were there is no international trade in financial or real assets. In this alternative case borrowers can only hold capital located in their own country. The home budget constraint therefore takes the form

$$P_t C_{b,t} - P_t B_t + P_t z_t K_{H,t}$$
$$= -R_{t-1}P_t B_{t-1} + (1-\delta)P_t z_t K_{H,t-1} + P_t x_t K_{H,t-1} \qquad (9)$$

and the collateral constraint is

$$B_t \leq \kappa_t z_t K_{H,t}$$

In this alternative formulation of the model borrower households do not have any portfolio decision and equations (7) and (8) are irrelevant.

2.2 Intermediate goods firms

Intermediate producers use the following technology

$$Y_{b,t} = \bar{A}_b A_t K^{1-\varphi_b}_{b,t-1} L^{\varphi_b}_{b,t}$$

where $K_{b,t} = K_{H,t} + K^*_{H,t}$ is the stock of home capital owned by home and foreign borrowers (and rented to firms), L_b is labour input and $\bar{A}_b A_{b,t}$ is total factor productivity and A_t is determined as follows

$$\log(A_t) = \eta_A \log(A_{t-1}) + \varepsilon_{A,t}$$

where $0 \leq \eta_A < 1$ and $\varepsilon_{A,t}$ is a zero-mean normally distributed i.i.d. shock with $Var[\varepsilon_A] = \sigma_A^2$.

Profits are given by

$$q_t Y_{b,t} - x_t K_{b,t} - w_t L_{b,t}$$

where q is the price of intermediate goods (in terms of final goods), w is the real wage rate (in terms of final goods) and x is the rental rate of home capital.

Total capital used by intermediate goods firms is the sum of home capital owned by home and foreign borrowers, i.e.

$$K_{b,t} = K_{H,t} + K_{H,t}^*$$

The first order conditions for employment of labour and capital are

$$x_t = q_t \left(1 - \varphi_b\right) \bar{A}_b A_{b,t} K_{b,t-1}^{-\varphi_b} L_{b,t}^{\varphi_b}$$

$$w_t = q_t \varphi_b \bar{A}_b A_{b,t} K_{b,t-1}^{1-\varphi_b} L_{b,t}^{\varphi_b - 1}$$

2.3   Savers

Home country saver household h maximises a utility function of the form

$$U_{s,t} = E_t \sum_{i=0}^{\infty} \beta_{s,t+i} \frac{C_{s,t+i}^{1-\rho}(h)}{1-\rho} \tag{10}$$

where $\rho > 0$, $\phi > 0$, $C_s(h)$ is the consumption of saver household h and β_s is the discount factor, which is determined as follows

$$\beta_{s,t+i+1} = \bar{\beta}_s \beta_{s,t+i} \left(1 + C_{s,t+i}\right)^{-\eta}, \ \beta_{s,t} = 1 \tag{11}$$

where $0 < \eta < \rho$, $0 < \bar{\beta}_s < 1$, C_s is aggregate home consumption of savers. Savers are assumed to be more patient that borrowers so $\bar{\beta}_s > \bar{\beta}_b$.

The flow budget constraint of the home country saver household is

$$
\begin{aligned}
P_t C_{s,t} + P_t S_t + P_t z_t K_{s,t} &= R_{t-1} P_t S_{t-1} + (1-\delta) P_t z_t K_{s,t-1} \\
&\quad + P_t q_t Y_{s,t} + P_t w_t H + P_t \Pi_t
\end{aligned}
\tag{12}
$$

K_s is the capital stock owned by savers, Y_s is the output of intermediate goods produced by savers and H is the labour supply of savers (which is assumed to be exogenous and constant). Π_t is the profits of capital producing firms plus the profits of final goods producers.

Savers produce intermediate goods using the following technology

$$Y_{s,t} = \bar{A}_s A_t K_{s,t-1}^{1-\varphi_s}$$

where total factor productivity is $\bar{A}_s A_t$ and A_t is a shock (defined above) which is common to both borrower and saver production technologies.

In the benchmark version of the model we assume that the market for borrowing and lending is integrated across the two countries. Equilibrium therefore implies

$$S_t + S_t^* = B_t + B_t^*$$

The first order conditions for savers imply

$$\beta_{s,t} C_{b,t}^{-\rho} = E_t \beta_{s,t+1} C_{s,t+1}^{-\rho} R_{t+1} \qquad (13)$$

$$\beta_{b,t} C_{b,t}^{-\rho} = E_t \beta_{b,t+1} C_{b,t+1}^{-\rho} r_{s,t+1}^e \qquad (14)$$

where

$$r_{s,t+1}^e = \frac{\left[(1-\delta) z_{t+1} + q_{t+1}(1-\varphi_s) \bar{A}_s A_{s,t+1} K_{s,t}^{-\varphi_s} \right]}{z_t}$$

is the rate of return on capital owned by savers in the Home country.

Equilibrium in the market for borrowing and lending implies

$$E_t [R_{t+1}] = E_t [R_{t+1}^*] \qquad (15)$$

In an alternative version of the model we assume that the market is segmented across the two countries so equilibrium in the two separate markets for borrowing and lending implies

$$S_t = B_t \qquad S_t^* = B_t^*$$

2.4 Capital producers

Final goods are converted into real capital by perfectly competitive profit maximising firms and sold at price z where the cost of producing I units of real capital is given by

$$I + F(I)$$

in terms of final consumption goods where $F(0) = 0$, $F'(.) > 0$, $F''(.) > 0$. We assume

$$F(I) = \frac{\psi}{2} \frac{(I - \bar{I})^2}{\bar{I}}$$

where $\bar{I}$ is steady state I.

The first order condition for producers of capital goods is

$$z_t = 1 + \varphi'(I_t)$$

and the capital stock follows the following accumulation process

$$K_{b,t} + K_{s,t} = (1 - \delta)(K_{b,t-1} + K_{s,t-1}) + I_t$$

The profits of capital goods producers are paid to saver households.

2.5 Final goods consumption

We define $C_{i,t}$ $(i = s, b)$ to be consumption basket which aggregates Home and Foreign final goods according to:

$$C_i = \left[\frac{1}{2}^{\frac{1}{\theta}} C_{H,i}^{\frac{\theta-1}{\theta}} + \frac{1}{2}^{\frac{1}{\theta}} C_{F,i}^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}} \tag{16}$$

where C_H and C_F are baskets of individual home and foreign produced final goods. The elasticity of substitution across individual goods within these baskets is $\nu > 1$. The parameter θ in (16) is the elasticity of substitution between home and foreign goods. Note that the home and foreign baskets are equally weighted so there is no 'home bias' in preferences.

The price index associated with the consumption basket C_t is

$$P_t = \left[\frac{1}{2} P_{H,H,t}^{1-\theta} + \frac{1}{2} P_{F,H,t}^{1-\theta} \right]^{\frac{1}{1-\theta}} \tag{17}$$

and where $P_{H,H}$ is the price index of home goods for home consumers and $P_{F,H}$ is the price index of foreign goods for home consumers. The corresponding prices for foreign consumers are $P_{H,F}$ and $P_{F,F}$.

Note that the terms of trade for the home country can be defined as follows

$$\tau = \frac{P_{F,F}}{P_{F,H}}$$

2.6 Final goods producers

Each firm in the final goods sector produces a single differentiated product. Sticky prices are modelled in the form of Calvo-style contracts with a probability of re-setting price given by $1 - \lambda$. We assume producer currency pricing (PCP).

If firms use the discount factor Ω_t to evaluate future profits, then firm z chooses its prices for home and foreign buyers, $p_{H,H,t}(z)$ and $p_{H,F,t}(z)$, in home currency to maximize

$$E_t \sum_{i=0}^{\infty} \Omega_{t+i} \lambda^i \left\{ y_{H,H,t+i}(z) \frac{[p_{H,H,t}(z) - q_{t+i}]}{P_{t+i}} + y_{H,F,t+i}(z) \frac{[p_{H,F,t}(z) - q_{t+i}]}{P_{t+i}} \right\} \quad (18)$$

where $y_{H,H}(z)$ is the demand for home good z from home buyers and $y_{H,F}(z)$ is the demand for home good z from foreign buyers and q is the price of the intermediate good.

Profits of final goods firms are paid to saver households.

2.7 Aggregation and Market clearing

Total home demand for final goods is

$$D_t = C_{b,t} + C_{s,t} + I_t + \mathcal{F}(I_t)$$

where home demand for home final goods is given by

$$D_{H,H,t} = \frac{1}{2} D_t \left(\frac{P_{H,H,t}}{P_t} \right)^{-\theta}$$

and foreign demand for home final goods is given by

$$D_{H,F,t} = \frac{1}{2} D_t^* \left(\frac{P_{H,F,t}^*}{P_t^*} \right)^{-\theta}$$

Equilibrium in intermediate goods market implies

$$Y_{b,t} + Y_{s,t} = V_{H,H,t} D_{H,H,t} + V_{H,F,t} D_{H,F,t}$$

where $V_{H,H,t}$ and $V_{H,F,t}$ are measures of price dispersion in final goods markets.

2.8 Portfolio allocation

Apart from the existence of the collateral constraint, a key distinguishing feature of the above model, that sets it apart from much of the existing literature on optimal monetary policy in open economies, is that it allows for international trade in multiple assets. Recently developed solution techniques (Devereux and Sutherland, 2011a) make it possible to solve for equilibrium portfolio allocation

in models of this type and Devereux and Sutherland (2011b) show how these new techniques can be employed in the case where a collateral constraint is binding.

It is simple to show that the borrower's budget constraint and the home and foreign collateral constraints can be re-written so that the borrower's portfolio decision appears in a format consistent with the Devereux/Sutherland approach. Using the definitions of $r_{H,t}^e$ and $r_{F,t}^e$, the borrower budget constraint can be written as follows

$$z_t K_{H,t} + z_t^* K_{F,t} - B_t$$
$$= \ r_{H,t}^e z_{t-1} K_{H,t-1} + r_{F,t}^e z_{t-1}^* K_{F,t-1} - R_{t-1} B_{t-1} - C_{b,t}$$

Define D_t and D_t^* to be the total capital holdings of respectively home and foreign borrowers, i.e.

$$D_t = z_t K_{H,t} + z_t^* K_{F,t} \qquad D_t^* = z_t K_{H,t}^* + z_t^* K_{F,t}^*$$

and define X_t to be the share of foreign capital in the home borrower's portfolio

$$X_t = \frac{z_t^* K_{F,t}}{z_t K_{H,t} + z_t^* K_{F,t}}$$

so the budget constraint becomes

$$D_t - B_t = r_{H,t}^e D_{t-1} + \left(r_{F,t}^e - r_{H,t}^e \right) X_{t-1} D_{t-1} - R_{t-1} B_{t-1} - C_{b,t} \qquad (19)$$

Note that home and foreign holdings of capital must sum to home and foreign capital stocks, i.e.

$$K_{b,t} = K_{H,t} + K_{H,t}^* \qquad K_{b,t}^* = K_{F,t} + K_{F,t}^*$$

so

$$D_t^* = z_t K_{b,t} + z_t^* K_{b,t}^* - D_t$$

The home and foreign collateral constraints can now be written in terms of D_t as follows

$$B_t \leq \kappa_t D_t \qquad B_t^* \leq \kappa_t^* \left(z_t K_{b,t} + z_t^* K_{b,t}^* - D_t \right) \qquad (20)$$

The budget constraint written in the form of (19) is in a format which allows the Devereux/Sutherland approach to be applied while the collateral constraints in the form of (20) do not contain any portfolio allocation variables. Portfolio variables therefore only appear in the borrower's budget constraint (as assumed in the Devereux/Sutherland approach). Note that in (19) the portfolio excess return is given by

$$\left(r_{F,t}^e - r_{H,t}^e \right) X_{t-1} D_{t-1}$$

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3 Inflation Targeting and the Dynamic Response to Shocks

Before we describe our approach to evaluating welfare and analysing optimal policy it is useful first to describe the properties of the above model in the case where monetary policy is exclusively focused on targeting producer price inflation. We discuss the properties of the model with reference to the impulse response functions in Figures 1 and 2. These impulse responses are based on the benchmark parameter set shown in Table 1.

The parameters of the discount factors are chosen to imply a steady state discount rate of approximately 1% per quarter for savers and 1.5% for borrowers. Following Devereux and Sutherland (2011b) and Mendoza and Smith (2006) η is set equal to 0.022. The trade elasticity, θ, is set equal to 1.5, which matches the value in Backus et al (1992). The share of real capital in production is set equal to 0.3 for both borrowers and savers, whereas steady state TFP ($\bar{A}_b$ and $\bar{A}_s$) is assumed to be unity for intermediate goods firms and 0.5 for savers (thus implying that borrowers have access to a more productive technology than savers). The depreciation rate of real capital, δ, is set at 0.025 while the parameter of the adjustment cost function, ψ, implies a standard deviation of investment which is approximately twice that of output. The Calvo pricing parameter, λ, is set at 0.75 and the elasticity of substitution between individual goods, ν, is set equal to 10. These values are typical in the New Keynesian literature. The collateral constraint parameter, κ, is set at 0.75, which matches the value used in Devereux and Sutherland (2011b). The parameters of the shock processes for TFP and the collateral constraint are those used in Devereux and Sutherland (2011b) (which are based on Jermann and Quadrini, 2009).

Impulse responses to the two shocks (TFP and the collateral constraint) are shown in Figures 1 and 2. The line marked with triangles in each plot shows the impulse response in the benchmark case (i.e. where there is international trade in equity and bond markets). The line marked with circles in each plot shows impulse responses in the alternative case where there is no international financial trade. In both these cases collateral constraints are assumed to be binding. For comparison each plot also shows (marked with asterisks) the case where there is international trade in equities and bonds but where collateral constraints are absent.

Table 1: Benchmark Parameter Values

Discount factors	$\bar{\beta}_b = 0.988,\ \bar{\beta}_s = 1.027,\ \eta = 0.022$
Elasticity of substitution: individual goods	$\nu = 10$
Risk aversion	$\rho = 1$
Trade elasticity	$\theta = 1.5$
Steady state TFP	$\bar{A}_b = 1,\ \bar{A}_s = 0.5$
Share of capital in production	$1 - \varphi_b = 1 - \varphi_s = 0.3$
Depreciation	$\delta = 0.025$
Capital adjustment costs	$\psi = 0.2$
Calvo price setting	$\lambda = 0.75$
Collateral constraint parameter	$\bar{\kappa} = 0.75$
TFP shocks	$\eta_A = 0.9,\ \sigma_A = 0.005$
Collateral constraint shocks	$\eta_\kappa = 0.9,\ \sigma_\kappa = 0.011$

Figure 1 shows the effect of a positive TFP shock in the home country. In the absence of the collateral constraint the TFP shock raises output, investment, consumption and equity prices. The rise in investment leads to a gradual rise in the capital stock for both savers and borrowers.

The collateral constraint (both with and without international asset trade) tends to magnify these effects. The rise in equity prices eases the collateral constraint and causes a shift of real capital from savers to borrowers. The rise in borrowing puts upward pressure on the real interest rate while the rise in equity prices implies a downward shift in expected equity returns. The spread between equity returns and borrowing therefore falls. The overall effect of the collateral constraint is to create a financial accelerator effect which magnifies the effect of the shock on investment. There is also a small magnifying effect on output.

The main contrast between the cases with and without financial trade are in terms of the cross country effects. In the case where there is no international asset trade the main impact of the shock, and the amplification effect of the collateral constraint, is concentrated on the home country. Thus equity prices rise more in the home country than the foreign country, there is a larger effect on the spread in the home country than in the foreign country and larger shift of capital from savers to borrowers in the home country than in the foreign country. This contrasts with the case where there is international asset trade. In this latter case the amplification effect of the collateral constraint is quite evenly spread across the two countries. This reflects the transmission effects of the collateral constraint. The rise in equity prices in the home country eases the collateral constraint for both home and foreign borrowers (because both home and foreign borrowers hold home equity). This allows both home and foreign borrowers to acquire more capital in both home and foreign countries and this implies that the initial shock (and the amplification effect of the collateral constraint) is transmitted to both countries.

Figure 2 shows the impulse response to a collateral constraint shock to the home country (i.e. a shock to κ in equation (4)). Collateral constraint shocks are obviously only relevant in the case where the collateral constraint exists so Figure 2 shows only two plots, representing the cases with and without international asset trade (and a binding collateral constraint). Figure 2 shows that a positive shock to κ (which represents an easing of the collateral constraint) leads to an initial

rise in the home equity price, a rise in the cost of borrowing, a fall in the rate of return of equities and a fall in the credit spread. There is a consequent shift in real capital from savers to borrowers and a rise in output. These effect all go into reverse as the shock decays.

The main contrast between the cases with and without asset trade is again in terms of the transmission of the shock between countries. When there is trade in assets the easing of the collateral constraint in the home country allows home borrowers to expand their holdings of both home and foreign capital. The rise in home equity prices also eases the collateral constraint of foreign borrowers and they are also able to expand their holdings of both home and foreign capital. These effects imply that a shock to the home collateral constraint is quite evenly spread across the two countries when there is asset trade but are strongly concentrated on the home country when there is no asset trade.

Figures 1 and 2 illustrate how the collateral constraint both acts as an amplification mechanism and as a source of shocks. The figures also illustrate how the collateral constraint can become a cross country transmission mechanism when there is international asset trade.

4 Welfare and the Monetary Policy Rule

The particular welfare measure on which we focus is the unconditional expectation of aggregate period utility. For the home economy this is defined as follows

$$U = E\frac{C^{1-\rho}}{1-\rho} \tag{21}$$

where time subscripts are omitted to indicate that this is a measure of unconditional expectation. Damjanovic *et al* (2008) argue that unconditionally expected utility provides a useful alternative to Woodford's (2003) 'timeless perspective' when analysing optimal policy problems. For the purposes of this paper, unconditional expected utility provides a simple and convenient way to compute welfare in a context where portfolio allocation is endogenous. The next section provides a more detailed discussion of the complications that arise in the simultaneous computation of welfare and equilibrium portfolios.

Welfare in each country is the sum of borrower and saver utility

$$W = U_b + U_s$$

where

$$U_b = E \frac{C_b^{1-\rho}}{1-\rho}, \qquad U_s = E \frac{C_{s,}^{1-\rho}(h)}{1-\rho}$$

Because there two types of households in each country (i.e. savers and borrowers), monetary policy may have distributional consequences. This implies that welfare comparisons between monetary policy rules are more complicated than is the case in standard open economy models. To overcome this problem we choose a simple and natural principle, which is to restrict attention to monetary policy rules which are (weakly) Pareto improving relative to strict inflation targeting, i.e. rules which are (weakly) welfare superior to inflation targeting for both saver and borrower households.

In common with Corsetti *et al* (2010, 2011) and much of the previous literature we focus on co-operative policy in the sense that policy rules for each country are simultaneously chosen to maximise global welfare, i.e. the sum of the home and foreign welfare measures.

We model monetary policy in the form of a targeting rule. In general the optimal targeting rule is model dependent. Corsetti *et al* (2010, 2011) show that the optimal targeting rule typically includes measures of inflation and a number of welfare gaps. Because of the complicated interaction between policy and portfolio choice we do not derive the fully optimal policy rule for our model. Instead we postulate that the optimal rule can be approximated in the following form

$$(\hat{P}_{Y,t} - \hat{P}_{Y,t-1}) + \delta_Y(Y_{G,t} - Y_{G,t-1}) + \delta_\tau(\tau_{G,t} - \tau_{G,t-1})$$
$$+\delta_{SPR}(SPR_t - SPR_{t-1}) + \delta_B(D_{b,t} - D_{b,t-1}) \qquad (22)$$
$$+\delta_S(D_{s,t} - D_{s,t-1}) + \delta_x(D_{x,t} - D_{x,t-1}) = 0$$

where Y_G, τ_G, D and L are defined as follows

$$Y_G = \hat{Y} - \hat{Y}^{fb}$$

$$\tau_G = \hat{\tau} - \hat{\tau}^{fb}$$

$$D_b = -\rho\left(\hat{C}_b - \hat{C}_b^*\right)$$

$$D_s = -\rho\left(\hat{C}_s - \hat{C}_s^*\right)$$

$$D_x = -\rho\left(\hat{C}_s - \hat{C}_s^*\right) - \rho\left(\hat{C}_b - \hat{C}_b^*\right)$$

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and where a hat over a variable represents its log deviation from the non-stochastic steady state and the superscript fb indicates the first best value of a variable. Thus Y_G is a measure of the output gap and τ_G is a measure of the terms of trade gap. As will be explained in more detail below, D_b, D_s and D_x are measures of the deviation from full risk sharing. There is an analogous targeting rule for the foreign economy.

The targeting rule in (22) contains seven terms. The first term depends on producer price (PPI) inflation. The central role of inflation stabilisation in optimal policy in New Keynesian models is a well-known consequence of staggered price setting. In essence, staggered price setting implies that inflation causes distortions in relative prices between goods. Inflation is thus (other things equal) welfare reducing.

The second term in (22) measures the welfare-relevant output gap. Again the role of the output gap in optimal targeting rules in New Keynesian models is well-known and needs no further explanation.

The third term in the targeting rule measures the welfare-relevant terms-of-trade gap. As Corsetti *et al* (2010, 2011) explain in detail, in an open economy, because there are different baskets of goods produced in different countries, shocks may have distortionary effects on the relative price of these different baskets. These distortions are welfare reducing in the same way as the within-country price distortions generated by inflation are welfare reducing. The terms of trade gap therefore plays the same role in the monetary policy rule as the PPI inflation term.

The fourth term in (22) measures the impact of the credit spread. In the absence of the collateral constraint the credit spread is zero. The size of the credit spread therefore captures the welfare distortion that is caused by the presence of the collateral constraint and the fourth term in the targeting rule captures the welfare trade-off between using monetary policy to stabilise the credit spread relative to other welfare gaps.

The fifth, sixth and seventh terms in the targeting rule are measures of deviations from full risk sharing. These terms capture the welfare reducing effects of incomplete financial markets. (Corsetti *et al* (2010, 2011) refer to this "demand imbalances".) To understand these terms note that, if a complete set of financial instruments were available for trade (within and between countries), equilibrium

in financial markets would imply that the ratio of marginal utilities (for savers and borrowers) across countries would equal the relative price of consumption baskets, i.e.

$$\frac{C_{b,t}^{*-\rho}}{C_{b,t}^{-\rho}} = \frac{C_{s,t}^{*-\rho}}{C_{s,t}^{-\rho}} = 1$$

and the ratio of marginal utilities across savers and borrowers within each country would be constant, i.e.

$$\frac{C_{b,t}^{-\rho}}{C_{s,t}^{-\rho}} = X, \qquad \frac{C_{b,t}^{*-\rho}}{C_{s,t}^{*-\rho}} = X^*$$

where X and X^* are constants. In terms of log-deviations these conditions imply

$$-\rho \left(\hat{C}_b - \hat{C}_b^* \right) = 0$$

$$-\rho \left(\hat{C}_s - \hat{C}_s^* \right) = 0$$

$$-\rho \left(\hat{C}_b - \hat{C}_s \right) = 0$$

$$-\rho \left(\hat{C}_b^* - \hat{C}_s^* \right) = 0$$

It is thus clear that D_b, D_s and D_x in (22) are measures of deviations from full risk sharing. And it is clear that these terms in the monetary policy rule capture the extent to which monetary policy is adjusted in order to achieve greater risk sharing.

The seven terms in the policy rule capture a range of potential welfare trade-offs that feature in the optimal setting of monetary policy. Internal (i.e. with-in country) trade-offs are captured by the inflation term, the output gap, the credit spread and the risk-sharing gap between savers and borrowers. External (i.e. open economy) trade-offs are captured by the terms of trade and demand imbalances. The object of the analysis presented below is to determine the optimal values of the parameters of the policy rule and thus to determine the role of asset market trade and collateral constraints in the optimal setting of monetary policy.

5   Portfolio Choice and Model Solution

Our objective in this paper is to analyse optimal monetary policy in the above specified model. As already explained, a key distinguishing feature of the above

model is that it allows for international trade in multiple assets. This paper therefore uses the portfolio solution techniques developed in Devereux and Sutherland (2011a).

Combining the analysis of optimal policy with endogenous portfolio choice presents some new technical challenges. These challenges arise because there is an interaction between policy choices and portfolio choice. Portfolio choices depend on the stochastic properties of income and the hedging properties of available assets. Monetary policy affects the stochastic behaviour of income and the hedging properties of assets and therefore affects optimal portfolio choice. In turn, the equilibrium portfolio affects consumption and labour supply choices and thus affects macroeconomic outcomes and welfare. Thus, in addition to the standard routes via which policy affects the macro economy, the optimal choice of monetary policy must take account of the welfare effects of policy that occur via the effects of policy on portfolio allocation.

Our solution approach follows the recent portfolio literature based on Devereux and Sutherland (2011a) in computing equilibrium portfolios using a second order approximation to the portfolio selection equations for the home and foreign country in conjunction with a first order approximation to the home and foreign budget constraints and the vector of excess returns. In Senay and Sutherland (2016) we showed how to combine this portfolio solution approach with an analysis of optimal monetary policy. In this paper we extend this joint analysis to also include collateral constraints.

As already explained, we model monetary policy as targeting rule (22). We optimise the choice of parameters in the targeting rule by means of a grid search algorithm. Each grid point represents a different setting of the parameters of the targeting rule and for each grid point there is an equilibrium portfolio allocation and a corresponding general macroeconomic equilibrium and level of welfare. We use the Devereux and Sutherland portfolio solution approach to evaluate the equilibrium portfolio at each grid point. This equilibrium portfolio is then used to compute macroeconomic equilibrium and a second order approximation of welfare at each grid point.

To be specific, our policy optimisation problem involves a grid search across the six coefficients of the policy rule in (22), i.e. δ_Y, δ_τ, δ_{SPR}, δ_b, δ_s and δ_x, in order to identify the parameter combination which maximises the unconditional

expectation of period welfare (as defined in (120)).[4]

It should be noted that this methodology does not compute fully optimal policy because fully optimal policy may involve more inertia than is embodied in the above specified targeting rule (as is shown in Corsetti *et al* (2010, 2011) in some cases). Our optimal rule is therefore the optimal rule within the restricted class of rules defined by (22). The focus on a non-inertial targeting rule is a convenient simplification given the extra complications and computational burden arising from the endogenous determination of equilibrium portfolios.

6 Optimal Policy

6.1 The Benchmark Case

The results for the benchmark set of parameter values listed in Table 1 are shown in Table 2.

The figures reported in the first column show the results for the case where there is trade in both equities and bonds and the collateral constraint binds. The first six rows in the table show the coefficients of the optimised policy rule. Note that, judging from the size of the optimised coefficient, the credit spread appears to be a particularly significant term in the optimal policy rule. The seventh row in Table 2 shows the welfare gain from the optimal policy rule relative to strict inflation targeting. This welfare gain is measured in terms of percentage equivalent steady state consumption units so the gain from policy optimisation is approximately 0.11% of steady state consumption.

The eighth row in Table 2 shows the portfolio share of foreign equity in the home portfolio when policy is set optimally. So, in the benchmark case, the home country has a very small bias (i.e. has a portfolio weight just over 50%) towards foreign equity (and the foreign country has an identical bias towards home equity).

The remaining rows of Table 2 compare the volatility of a number of variables arising from optimal policy and inflation targeting. Optimal policy implies that the standard deviation of PPI inflation is 0.12% per quarter (compared to 0 in the case of inflation targeting). Optimal policy implies a very small reduction in

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[4]Given that the model is symmetric, the foreign country has a similarly defined targeting rule and the coefficients of that rule are assumed to be identical to the coefficients of the home rule, with appropriate changes of sign.

the volatility of the output gap and a somewhat larger reduction in the volatility of the credit spread. The latter effect obviously reflects the significance of the coefficient on the credit spread in the optimised policy rule.

The effects of optimal policy relative to inflation targeting are further illustrated in the impulse responses plotted in Figures 3 and 4. The line marked the circles in each panel shows the impulse response in the case of inflation targeting for the benchmark case while the line marked with the triangles shows the impulse response when policy is set according to the optimal rule. Figure 3 shows the response to a TFP shock and Figure 4 shows the response to a collateral constraint shock. Figures 3 and 4 show that optimal policy tends to dampen the response of the credit spread, equity prices, the return on equity and the real return on borrowing. It also tends to stabilise investment and the capital stock held by both borrowers and savers.

The second column in Table 2 shows the results for the case where the collateral constraint binds but there is no international trade in equities or bonds. The coefficients of the optimised policy rule are quite similar to the case with international asset trade but it is now apparent that the welfare gains from policy optimisation are significantly higher than in the case with asset trade. The welfare gain from optimisation is now approximately 0.21% of steady state consumption, which is almost twice the welfare gain when there is asset trade.

The volatility results reported in the second column of Table 2 show that optimal policy marginally reduces the standard deviation of the output gap and the terms of trade gap and, as in the asset trade case, has a more significant effect on the volatility of the credit spread.

As a further point of comparison the third column in Table 2 reports results for the case where there is asset trade but where there is no collateral constraint. In this case the optimal policy rule is only marginally different from inflation targeting and the welfare gains from optimisation relative to inflation targeting are virtually zero.

A comparison of the first and third columns of Table 2 shows that the presence of a binding collateral constraint has quite a significant impact on optimal policy. There are non-trivial welfare gains from optimal policy (relative to inflation targeting) when there is a collateral constraint. But the welfare gains are trivial when there is no collateral constraint.

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A comparison of the first and second columns of Table 2 shows the impact of asset trade on the welfare gains from optimal policy. In the context of this model, where the collateral constraint creates a channel for the transmission of shocks from one country to another, a relevant question is whether asset trade results in a greater role for active policy in order to offset real shocks. The fact that the optimal policy rule is quite similar in the cases illustrated in columns one and two in Table 2, while the welfare gain from policy optimisation is lower in column 1 than in column 2, suggests that asset trade tends to reduce the role of monetary policy optimisation in the face of real shocks. In other words, the shock transmission mechanism created by the collateral constraint does not offset the risk sharing benefits of asset trade.

As outlined above in the introduction, Corsetti *et al* (2010, 2011) show that imperfect asset markets imply that optimal monetary policy should deviate from inflation targeting in order to improve risk sharing. Senay and Sutherland (2016) show that this role declines sharply when there is trade in bonds and equities. Devereux and Sutherland (2011b) show that trade in bonds and equities can create a strong shock transmission mechanism when combined with a collateral constraint. As explained above, this raises the question of whether asset trade may increase the role of monetary policy rather than reduce it, when combined with a collateral constraint. The results reported in Table 2 suggest that this is not the case. However, these results show an important role remains for monetary policy even when there is trade in equities and bonds (in contrast to the results reported in Senay and Sutherland (2016)).

6.2   Parameter variations

Table 3 shows the welfare results for a number of parameter variations.

The first row shows a case where the trade elasticity, θ, is less than unity. The welfare difference between optimal policy and inflation targeting is shown for the same three asset market structures as reported in Table 2 for the benchmark case. The welfare differences are almost identical to the benchmark case so it appears that the value of θ has no significant quantitative or qualitative effect on the welfare comparison.

The second, third and fourth rows of Table 3 show cases where, respectively, the variance of collateral shocks is larger than the benchmark case, the persistence

Table 2: Benchmark Results

		Equity trade with collateral constraint	Financial autarky with collateral constraint	Equity trade without collateral constraint
Policy rule	δ_Y	-0.068	-0.616	0
	δ_τ	0	-0.250	0
	δ_{SPR}	-0.301	-0.300	0
	δ_b	-0.007	-0.001	0
	δ_s	-0.042	0.007	-0.018
	δ_x	0.014	0.013	0
Welfare difference		0.108	0.211	0.00004
Portfolio share		0.5014	$-$	0.5013
Standard Deviations				
CPI Inflation	(optimal)	0.12	0.16	0.0011
Output gap	(optimal)	0.0086	0.012	0.0
	(inf tar)	0.0096	0.013	0.0
ToT gap	(optimal)	0	0.011	0.0
	(inf tar)	0	0.012	0.0
Spread	(optimal)	0.42	0.59	0.0
	(inf tar)	0.47	0.66	0.0

of collateral shocks is higher than in the benchmark case, and the variance of collateral shocks is set to zero (so the only source of shocks is TFP). It is apparent that the presence, size and persistence of collateral shocks have significant effects on the size of the welfare difference between optimal policy and inflation targeting. The larger and more persistent are collateral shocks the larger are the welfare differences. But it is also apparent that the ordering and relative size of the welfare differences when compared across financial market structures is little affected by the size and persistence of collateral shocks. In all three cases the welfare difference is very small when there is no collateral constraint (i.e. column 3) and the welfare difference is much larger in the case of financial autarky (when combined with the collateral constraint) than in the case of asset trade (combined with the collateral constraint), i.e. the comparison between columns 2 and 1. Thus the general qualitative conclusions stated in the benchmark case appear to be unaffected by the size and persistence of collateral constraint shocks.

The fifth row of Table 3 shows a case where capital adjustment costs (represented by the parameter ψ) are higher than in the benchmark case. This is an interesting case to consider because the more costly it is to vary the total capital stock the more important is the transfer of the existing capital stock between savers and borrowers in response to shocks. A higher value for ψ will therefore tend to magnify the financial accelerator effects of collateral constraints. The welfare differences shown in row five of Table 3 confirm that the welfare benefits of policy optimisation are higher than in the benchmark case. However, as with the other parameter variations shown in Table 3, the ordering and relative size of the welfare differences across financial market structures are very similar to the benchmark case.

The last row of Table 3 shows a case where the steady state leverage ratio is higher than that in the benchmark case (i.e. κ is higher). This tends to reduce the welfare benefits of policy optimisation (relative to inflation targeting) but again does not appear to alter to relative ranking of welfare benefits when compared across financial market structures.

All the parameter variations shown in Table 3 thus appear to confirm the conclusions illustrated in the benchmark case.

Table 3: Parameter variations: welfare difference

	Equity trade with collateral constraint	Financial autarky with collateral constraint	Equity trade without collateral constraint
Low trade elasticity ($\theta = 0.85$)	0.108	0.210	0.000009
Larger collateral shocks ($\sigma_\kappa = 0.022$)	0.416	0.826	0.00004
More persistent collateral shocks ($\eta_\kappa = 0.95$)	0.124	0.258	0.00004
No collateral shocks ($\sigma_\kappa = 0$)	0.0064	0.0072	0.00004
Higher capital adjustment costs ($\psi = 1.0$)	0.300	0.558	0.00003
Higher steady state leverage ($\kappa = 0.8$)	0.248	0.483	0.00004

7 Conclusion

This paper examines the implications of collateral constraints and international trade in equities and bonds for optimal monetary policy. Previously Corsetti *et al* (2010, 2011) have shown that, when international financial trade is absent, optimal policy deviates significantly from strict inflation targeting, while Senay and Sutherland (2016) show that, when there is trade in equities and bonds, optimal policy is close to strict inflation targeting. Thus opening up international trade in equities and bonds tends to eliminate the role of monetary policy as a risk sharing device.

In a separate line of literature Devereux and Sutherland (2011b) show that collateral constraints can imply that cross-border portfolio holdings act as a shock transmission mechanism which significantly undermines risking sharing. This raises the possibility that asset trade in the presence of collateral constrains implies a greater role for monetary policy as a risk sharing device. This paper finds that the combination of asset trade with collateral constraints does imply a potentially large welfare gain from optimal policy (relative to inflation targeting). Thus collateral constraints do tend to create a role for monetary policy as a risk sharing device even when there is trade in equities and bonds. However, the welfare gain of optimal policy is even larger when there is no international asset trade (but collateral constraints bind within each country). In other words, the risk sharing role of asset trade tends to reduce the welfare gains from policy optimisation even when collateral constrains act as a shock transmission mechanism. This is true even when there are large and persistent shocks to the collateral constraint.

References

Backus, D., P. Kehoe and F. Kydland (1992) "International real business cycles" *Journal of Political Economy,* 100, 745–775.

Calvo, G. A. (1983) "Staggered Prices in a Utility-Maximizing Framework" *Journal of Monetary Economics,* 12, 383-398.

Corsetti, G., L. Dedola and S. Leduc (2010) "Optimal Monetary Policy in Open Economies" in *Handbook of Monetary Economics Vol.3B* B. Friedman and M. Woodford (eds)., Elsevier, 862-933.

Corsetti, G., L. Dedola and S. Leduc (2011) "Demand Imbalances, Exchange Rate Misalignment and Monetary Policy" mimeo.

Damjanovic, T., Damjanovic, V., and C. Nolan (2008) "Unconditionally optimal monetary policy" *Journal of Monetary Economics,* 55, 491-500.

Dedola, L. and G. Lombardo (2012) "Financial frictions, financial integration and the international propagation of shocks" Economic Policy, 27, 319-359.

Devereux, M. and J. Yetman (2010) "Leverage constraints and the international transmission of shocks" NBER Working Paper No 16226.

Devereux, M. and A. Sutherland (2011a) "Solving for country portfolios in open economy macro models" *Journal of the European Economic Association,* 9, 337-369.

Devereux, M. and A. Sutherland (2011b) "Evaluating International Financial Integration Under Leverage Constraints" *European Economic Review,* 55, 427-442.

Jermann, U. and V. Quadrini, (2009) "Macroeconomic effects of financial shocks" USC mimeo.

Kiyotaki, N. and J. Moore (1997) "Credit cycles" *Journal of Political Economy,* 105, 211–248.

Mendoza, E. and K. Smith (2006) "Quantitative implications of a debt-deflation theory of Sudden Stops and asset prices" *Journal of International Economics,* 70 (1), 82–114.

Schmitt-Grohe, S. and M. Uribe (2003) "Closing Small Open Economy Models", *Journal of International Economics,* 59, 137-59.

Senay, O. and A. Sutherland (2016) "Optimal Monetary Policy, Exchange Rate Misalignments and Incomplete Financial Markets" University of St Andrews, School of Economics and Finance Working Paper No 1603.

Woodford, M. (2003) *Interest and Prices: Foundations of a Theory of Monetary Policy* Princeton University Press, Princeton, NJ.

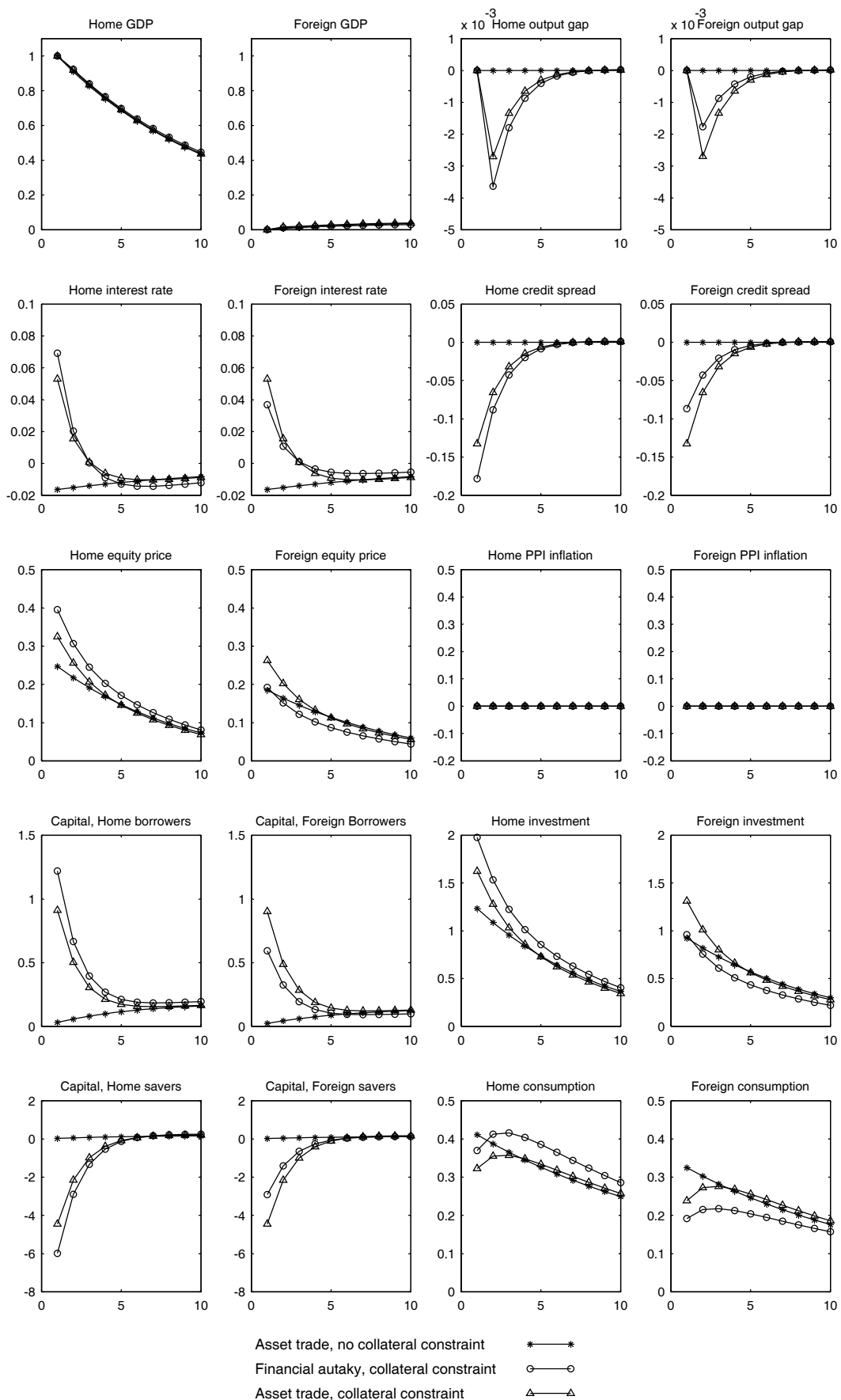Figure 1: TFP shock, comparison of financial market structures

Figure 2: Collateral constraint shock, comparison of financial market structures

Asset trade, no collateral constraint   *——*

Financial autaky, collateral constraint   o——o

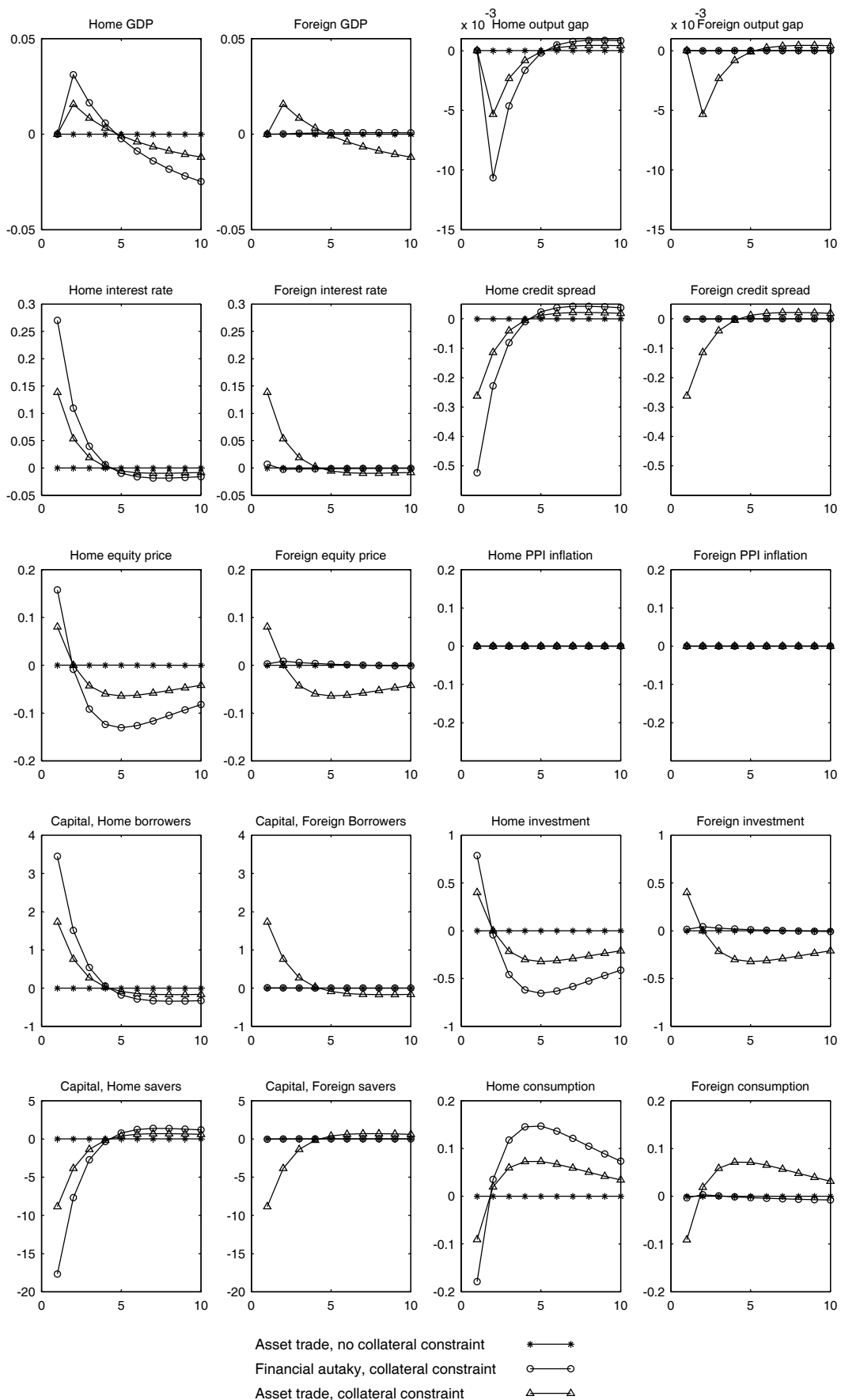Asset trade, collateral constraint   △——△

Figure 3: TFP shock, optimal policy versus inflation targeting
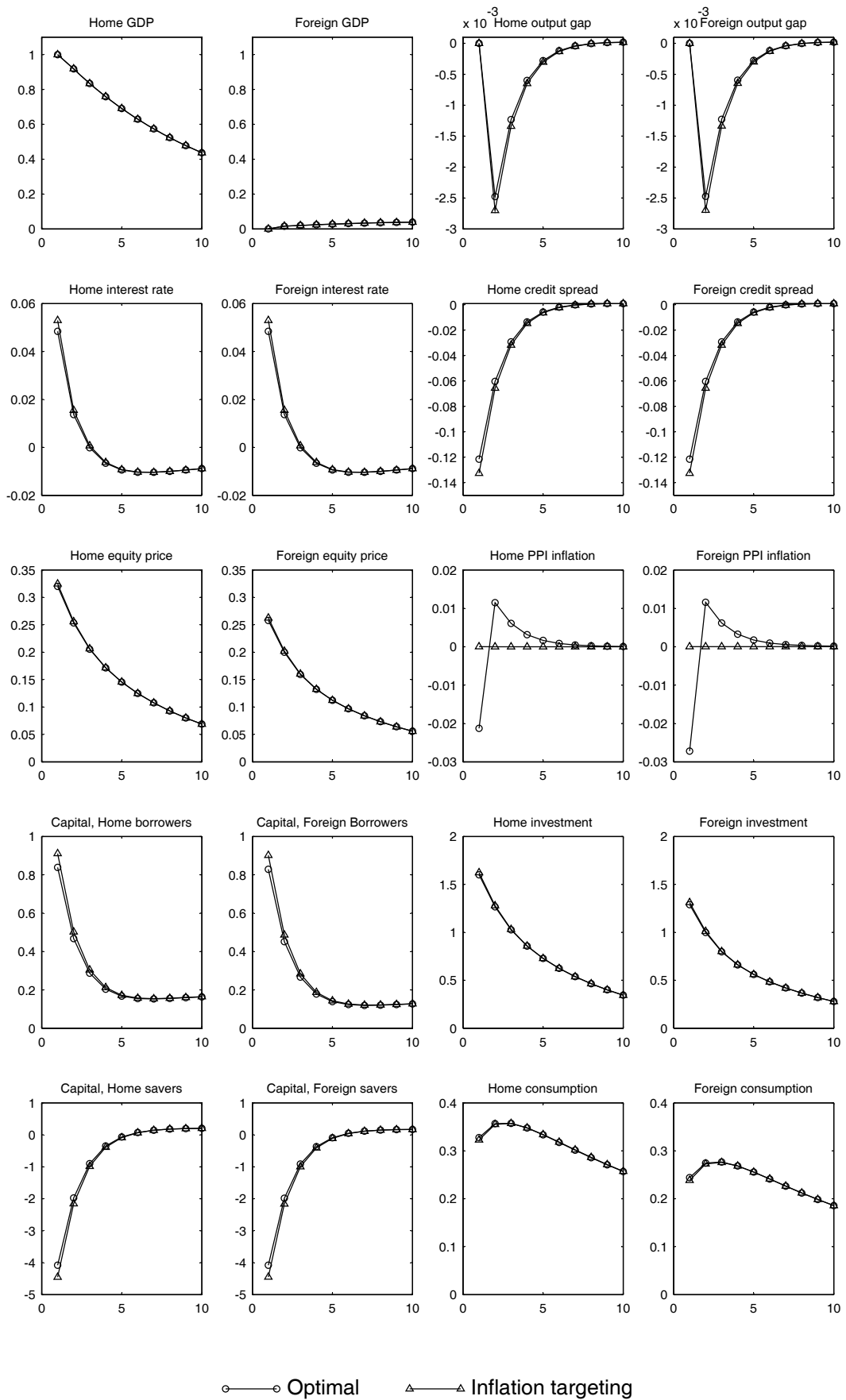
Figure 4: Collateral constraint shock, optimal policy versus inflation targeting