NBER WORKING PAPER SERIES

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Working Paper 17796
http://www.nber.org/papers/w17796

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
January 2012

The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research. This research is supported by the UK Economic and Social Research Council, Award Number ES/1024174/1. Devereux thanks SSHRC, the Royal Bank, and the Bank of Canada for financial support.

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NBER Working Paper No. 17796
January 2012
JEL No. F3,F33,F4,F41

ABSTRACT

Over the one and a half decades prior to the global financial crisis, advanced economies experienced a large growth in gross external portfolio positions. This phenomenon has been described as Financial Globalization. Over roughly the same time frame, most of these countries also saw a substantial fall in the level and variability of inflation. Many economists have conjectured that financial globalization contributed to the improved performance in the level and predictability of inflation. In this paper, we explore the causal link running in the opposite direction. We show that a monetary policy rule which reduces inflation variability leads to an increase in the size of gross external positions, both in equity and bond portfolios. This is a highly robust prediction of open economy macro models with endogenous portfolio choice. It holds across many different modeling specifications and parameterizations. We also present preliminary empirical evidence which shows a negative relationship between inflation volatility and the size of gross external positions.

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1 Introduction

Data on external asset positions show that the gross size of country portfolios has increased substantially over the past four decades. Over the same period the volatility of inflation has declined in most countries as monetary authorities have shifted the focus of monetary policy towards inflation stabilization and away from output stabilization. This paper investigates whether these two phenomena are related. The question we address is: has the increased monetary policy focus on nominal stability resulted in greater financial globalization?

We are not the first to explore the link between financial globalization and inflation. But to our knowledge, all the literature has focused on the causation going in the other direction. For instance, many authors have suggested that increasing globalization in goods and financial markets has led to a decline in national inflation rates, either through direct market mechanisms or by influencing the behavior of monetary authorities[1].

We do not dispute the possibility that financial globalization may influence inflation, either directly through trade effects or indirectly through affecting the conduct of monetary policy. But we argue in this paper that there is a very strong theoretical case that the link may also go the other way. We find that monetary policy which reduces the variability of domestic inflation leads to an increase in the diversification of international portfolios, generating higher gross external assets and liabilities. We show that this result is highly robust across a wide variety of modeling specifications and parameter assumptions.[2] In addition, we provide some preliminary empirical evidence for this link.

Our approach is to provide a theoretical investigation of the impact of monetary policy and nominal stability on the size of external asset positions in a general theoretical

[1]For instance, Rogoff (2004, 2006) suggests that increasing economic openness may steepen the trade-off between inflation and output, and reduce the equilibrium inflation rate chosen by monetary authorities. Chen et al. (2004) find empirical evidence that increasing openness, by reducing non-competitive distortions in domestic markets, reduces the inflation bias in monetary policy. In addition, it has been suggested that there are direct disinflationary forces imparted by international trade (Pain et al. 2006, Borio and Filardo 2007). Alternatively, financial globalization could affect inflation indirectly by imposing a 'disciplining effect' on domestic monetary policy. This link is explicitly tested in Tytell and Wei (2004). They find evidence that financial globalization has led to lower inflation rates. Related research by Kose et al. (2007) suggest that there are 'collateral' benefits of financial globalization coming from its effect on the quality of domestic economic policy. Stark (2011) also conjectures that financial globalization was a contributing factor in improved monetary policy performance in OECD countries.

[2]Note that we are not claiming that inflation stabilization is the only (or even the main) cause of financial globalization. We are simply showing that it may be one (possibly) quite important factor.

model in which gross external financial positions are endogenous. The theoretical model is a two-country DSGE structure with Calvo-style sticky prices. The home and foreign countries produce differentiated baskets of final goods. Consumers display home-bias in preferences. There are stochastic shocks to productivity, tastes and nominal interest rates. Monetary policy in each country is modeled as a Taylor rule. There is international trade in nominal bonds and equities, and following recent literature, we compute equilibrium gross portfolios. The size of these portfolios will depend on the structure and stochastic environment of the model, including the properties of the monetary rule.

The benchmark model with a standard Taylor rule displays home bias in equity holdings while each country holds a long position in bonds denominated in their own currency. By varying the feedback coefficient on inflation in the Taylor rule it is possible to analyze the relationship between the anti-inflation stance of monetary policy, the variance of inflation and equilibrium portfolio positions.

In the baseline parameterization of the model, as the policy feedback coefficient on inflation is increased, the variance of inflation falls and the absolute size of equilibrium gross positions in both equities and bonds increase. So the model predicts a *negative* relationship between the variance of inflation and the size of equity and bond portfolio positions. This negative relationship appears to be very robust across a wide range of parameter variations.

The underlying cause of this negative relationship can be explained in terms of simple expressions for equilibrium portfolios which show that the equilibrium gross portfolio position in any asset is proportional to the variability of home income relative to foreign income and inversely related to the variability of relative asset returns. Lower variability of relative asset returns compared to the variability of relative income implies that gross portfolios have to be larger in order to provide adequate hedging of income shocks. We show that the model implies that, as the feedback coefficient on inflation in the Taylor rule is increased, the variability of relative asset returns decreases compared to the variability of relative income. This leads to an increase in gross asset positions.

We further show that the size of gross positions depends on the correlation between relative asset returns and cross-country income shocks. The more relative asset returns are correlated with income shocks, the larger are equilibrium gross holdings. Our model shows that, when asset markets are incomplete (meaning there are fewer independent assets than there are sources of uncertainty) a reduction in inflation variability increases the correlation between relative asset returns and income shocks. In effect, inflation stabilization moves equilibrium closer to the complete markets outcome. This tends to raise the size of equilibrium gross holdings.

There are thus two effects which link a reduction in inflation variability to an increase in the size of gross portfolio positions, a *return variability effect* and a *return-income correlation effect*. The model shows that both effects contribute to an expansion of gross positions the more monetary policy focuses on inflation stabilization.

The relationship between gross positions and inflation volatility can be investigated empirically using the Lane and Milesi-Ferretti (2001, 2007) data on gross external portfolio positions. In order to put our theoretical results in context, we first report panel regression estimates for advanced economies for the period 1970-2007 which show a statistically significant negative relationship between inflation variability and the size of gross portfolio positions. This empirical result appears to be quite robust to different specifications of the regression equation and different definitions of the variables. In particular the results are robust for overall gross positions and also the gross positions in bonds and equities separately.

The paper is part of a large literature on the theoretical and empirical underpinnings of international capital flows. On the theory side, Devereux and Sutherland (2010, 2011) and Tille and Van Wincoop (2010) develop techniques for computing equilibrium portfolios in DSGE models. Applications to the 'home bias' puzzle include Coeurdacier *et al* (2010), Engel and Matsumoto (2009), Heathcote and Perri (2007), and Benigno and Nistico (2009). Empirically, Lane and Milesi-Ferretti (2008a, 2008b) and Lane and Shambaugh (2010) have explored the determinants of international portfolio positions. With respect to the relationship between monetary policy rules and international portfolios, Devereux and Sutherland (2008) show that a monetary policy focused on stabilizing PPI inflation can increase nominal bond positions by enhancing the risk sharing properties of nominal bonds. De Paoli *et al* (2010) examine the implication of different types of monetary policy rules for international portfolio positions and welfare. Neither Devereux and Sutherland (2008) nor De Paoli *at al* (2010) focus on the relationship between CPI inflation volatility and gross international portfolio positions in the way that is addressed in this paper.

There is also a large empirical literature on the determinants of international financial globalization. Okawa and van Wincoop (2010) develop a gravity based model of international financial linkages where bilateral financial holdings are determined by basic principles of portfolio diversification, adjusted for relative informational asymmetries across countries. They show that their model allows for a theory-based estimate of the size of financial frictions. Lane and Milesi-Ferretti (2008a, 2008b) and Faruqee *et al* (2004) use simple models of portfolio diversification to examine the determinants of bilateral cross border equity holdings. None of these papers explore the influence of inflation on international financial holdings, however.

The paper proceeds as follows: Section 2 presents a brief empirical analysis of the relationship between gross asset positions and inflation variability over the period 1970-2007. Section 3 describes our theoretical model. Section 4 derives some useful relationships which aid in the analysis of gross positions within the theoretical model. Section 5 derives some simple analytical results based on a simplified version of the model. Section 6 presents the main numerical analysis of the general model. Section 7 discusses the results and section 8 concludes the paper.

2 Empirical Evidence

In order to put our theoretical model in context we first report some basic panel regression estimates of the relationship between gross positions and inflation variability.

We estimate a panel regression of the following form

$$100 \ln(GP_{i,t}/GDP_{i,t}) = \beta_0 + \beta_1 \sigma_{i,t}(\pi) + \beta_2 Open_{i,t} \tag{1}$$

where $GP_{i,t}$ is a measure of the size of the gross portfolio position of country i in period t and $\sigma_{i,t}(\pi)$ is a measure of inflation variability for country i in period t.

The theoretical model we describe below assumes that international asset markets are completely open and unhindered by capital controls and that asset trade is not subject to transactions costs. Empirically, however, asset markets are subject to a wide range of frictions which have tended to change through time and vary across countries. We control for these frictions by including $Open_{i,t}$ as a measure of financial openness in the above regression equation.

Our main results focus on the total gross position, GP, which we define as

$$GP = \frac{(Total\ External\ Assets + Total\ External\ Liabilities)}{2}$$

We also estimate several variants of our basic equations where the dependent variable is the gross position in equity-type assets, and another where the dependent variable is the position in debt-type assets, where again the gross position is defined as the average of the asset and liability position in the relevant type of asset.

We define $\sigma_{i,t}(\pi)$ to be the standard deviation of the CPI inflation rate of country i for the period $t-k$ to t where inflation is measured as the annual percentage change in the CPI measured at quarterly intervals. In the main results we report below we choose k to be 6 years, so $\sigma_{i,t}(\pi)$ is the standard deviation of annual inflation based on the 24 quarterly observations of the CPI up to and including the final quarter of year t. We also estimate variants of our equation where k is equal 3, 4 or 5 years.

Data on gross asset and liability positions is taken from Lane and Milesi-Ferretti (2007) who provide annual data for the period 1970-2007 on gross external positions for 178 countries for various classes of assets. Our measure of the variability of inflation is based on CPI inflation data obtained from the IMF IFS database for the period 1965-2007. The highest frequency available for all countries is quarterly. We measure financial openness using the Chinn-Ito index (Chinn and Ito, 2007), which provides an annual *de jure* measure of financial openness based on a consistent assessment of capital controls and regulations for 181 countries for the period 1970-2008.

Before discussing the estimation results it is useful to consider the general features of the data. The three panels in Figure 1 plot the cross country averages of the data for the G7 countries (excluding Germany), while Table 1 shows a cross-country comparison of the data based on individual country averages for each country for two sub-periods (1970-1989 and 1990-2007). Table 1 also shows the same data for a wider group of countries. Figure 1 and Table 1 show a strong upward trend in the data for gross positions through the sample period. This upward trend is common to all countries. Figure 1 and Table 1 also show a strong downward trend in inflation volatility through the sample. This is also common to all countries. There is also a general trend towards greater financial openness. There are no obvious country outliers in the G7 group of countries in terms of the general behavior of the data, but the UK, because of its position as a major financial center, tends to have a much larger gross positions than other countries in the G7.

We begin our empirical analysis by focusing on the G7 group of advanced countries: Canada, France, Germany, Italy, Japan, UK and USA. The results for this country grouping are presented in Table 2, Columns 1 to 4.

Initially consider the simple pooled OLS estimates of (1) for the period 1970-2007. Column 1 of Table 2 reports the estimated coefficients for the case where country dummies and a time trend are included in the list of regressors.[3] For this version of the estimation equation the estimated coefficient on the variability of inflation is negative and the coefficient on the Chinn-Ito index is positive.

The magnitude of the coefficient on inflation variability suggests that inflation vari-

[3] To save space, the estimated coefficients on the country dummies are not reported.

Table 1: Summary of data for G7 and G22

	Gross portfolio % of GDP		StDev of Inflation		Chinn-Ito Index	
	70-89	90-07	70-89	90-07	80-89	90-07
Canada	50	91	2.02	1.06	2.50	2.50
France	36	149	2.33	0.58	-0.29	2.08
Germany	35	112			2.50	2.50
Italy	27	83	3.93	0.86	-0.82	2.14
Japan	20	59	3.21	0.93	1.64	2.43
UK	117	277	3.92	1.44	0.84	2.50
USA	24	69	2.38	0.83	2.50	2.50
Australia	25	81	2.66	1.78	0.49	1.76
Austria	47	134	1.65	0.78	1.01	2.28
Belgium	100	293	2.37	0.73	0.99	2.28
Denmark	46	140	2.64	0.65	0.08	2.46
Finland	31	131	3.15	1.18	0.74	2.28
Greece	24	68	6.44	2.47	-1.14	1.02
Ireland	86	551	4.25	1.12	-0.36	1.99
Korea		38		1.78	-0.82	-0.32
Netherlands	79	259	1.87	0.84		2.50
New Zealand	33	95	3.39	1.96	0.24	2.50
Norway	43	109	2.44	1.13	0.04	1.77
Portugal		126	5.72	1.75	-1.03	1.92
Spain	23	93	3.41	0.96	-0.30	1.85
Sweden	31	147	2.23	1.83	1.17	2.13
Switzerland	139	375	2.16	1.09		

Table 2: Panel regression results

	(1) G7 Total portfolio	(2) G7 Total portfolio	(3) G7 Equities	(4) G7 Debt	(5) G22 Total portfolio	(6) G22 Equities	(7) G22 Debt
Constant	-194.2***	-219.4***	-400.0***	-217.6***	-262.2***	-486.2***	-269.0***
	(30.45)	(8.71)	(14.33)	(7.62)	(12.02)	(15.10)	(10.56)
StDev Inflation	-5.12***	-3.20***	-2.06*	-3.45***	-1.11*	-0.72	-1.10*
	(4.36)	(3.94)	(1.65)	(3.92)	(1.85)	(0.83)	(1.74)
Chinn-Ito Index	7.20***	2.38	6.18**	1.87	2.77**	2.47	3.17**
	(4.18)	(1.36)	(2.32)	(0.98)	(2.14)	(1.33)	(2.33)
Trend	4.41***	6.16***	8.75***	4.42***	7.46***	11.66***	5.82***
	(24.35)	(10.02)	(12.13)	(6.39)	(18.13)	(19.25)	(12.31)
AR coeff		0.92	0.89	0.92	0.91	0.91	0.92
R^2	0.94	0.99	0.99	0.99	0.99	0.99	0.98
St Err Est	20.62	7.73	11.77	8.38	10.07	14.51	10.58
F-stat	411.35	28.59	68.30	20.95	29.14	36.90	18.03
DW-stat	0.17	1.74	1.76	1.74	1.84	1.89	1.78

Column (1): simple OLS. Columns (2)-(7): OLS corrected for AR(1) residuals.
*** indicates significant at 1% level
** indicates significant at 5% level
* indicates significant at 10% level
t-stats in brackets

ability has quite a large effect on the size of gross positions. For instance, a coefficient of -5.1 implies that a fall in the standard deviation of annual inflation by 1 percentage point raises the size of gross portfolio positions by approximately 5% of GDP. The average range of the standard deviation of inflation over the sample period is approximately 5 percentage points, so these estimates suggest that changes in inflation variability might account for a change in the size of gross positions of approximately 25% of GDP, which is quite a large effect.

The coefficient on the Chinn-Ito index is also quite large. The Chinn-Ito index varies between -1 and +2.5 over the sample period, so a coefficient of 7.2 implies a change in gross portfolio positions of approximately 25% of GDP. Again this is a large effect.

While the results reported in Column 1 of Table 2 are strongly significant, the Durbin-Watson statistic indicates the presence of strong positive auto-correlation in the residuals. Column 2 of Table 2 reports the results for a variant of the model where we correct for this auto-correlation. The estimated coefficient on inflation variability continues to be negative and significant, but is somewhat smaller than the coefficient reported in Column 1. The coefficient on the Chinn-Ito index continues to be positive but is no longer significant.

Columns 3 and 4 repeat the AR(1) corrected regression for cases where the dependent variable is respectively equity-type assets and debt-type assets. The general message of these results, in terms of the coefficient signs, is similar to the results already reported for the total gross position, i.e. the coefficient on inflation variability is negative and the coefficient on the Chinn-Ito index is positive. But notice that the estimated coefficient on inflation variability appears to be smaller in absolute value (and marginally significant) in the case of equities than it is in the case of debt. Also notice that the estimated coefficient on the Chinn-Ito index appears to be larger in absolute value in the case of equities than it is in the case of debt (where it is insignificant). This suggests that inflation variability has a larger effect on gross positions in debt than it does on gross positions in equity-type assets, while financial openness is more important for equity positions than it is for debt positions.

Columns 5 to 7 report results for an extended sample of countries which includes a wider set of developed economies. The full list of 22 countries is given in Table 1.

Column 5 of Table 2 shows that extending the analysis for the G7 to this group of 22 countries yields similar results. The coefficients on inflation variability and the Chinn-Ito index are significant, have the same signs and have a similar absolute size to those reported for the G7. Columns 6 and 7 report results for equity assets and debt asset respectively for the group of 22 countries. Compared to Column 5 (which shows the results for total gross positions), the general pattern of results in these two columns is similar but somewhat less significant in the case of equities (Column 6) but more significant in the case of debt assets (Column 7).

The results reported in Table 2 are not intended to be a comprehensive empirical investigation of the determinants of gross positions but they do appear to confirm that inflation variability is a potentially important factor in the expansion of gross positions over the past four decades. Inflation variability appears to have a significant negative effect on gross positions and this effect appears to be reasonably robust across a range of empirical specifications and a wide range of countries. In the following sections we describe a two-county general equilibrium model and show that the model's predictions are consistent with the above empirical findings, at least in terms of its qualitative properties.

3 A Model of Monetary Policy and Gross Portfolio Positions

We analyze a model of two countries with multiple types of shocks. There are country specific productivity shocks, shocks to preferences, which we call 'demand' shocks, as well as shocks to monetary policy. In addition, we allow trade in equities and bonds. Home and foreign equities represent claims on firm profits of each country, and home and foreign nominal bonds are denominated in the currency of each country. This roughly gives us a breakdown of gross asset and liability positions corresponding to the Lane and Milesi-Ferretti database.

3.1 Households

We first describe the preferences and opportunity sets of home consumers. Agents in the home country have a utility function of the form

$$U_0 = E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\rho}}{1-\rho} - \frac{H_t^{1+\phi}}{1+\phi} \right) \tag{2}$$

where $\rho > 0$, $\phi > 0$, C is composite consumption, H is labor supply and β is the discount factor.

We define C_t as a consumption index defined across home and foreign goods, given by:

$$C_t = \left[\gamma_t^{\frac{1}{\theta}} C_{H,t}^{\frac{\theta-1}{\theta}} + (1-\gamma_t)^{\frac{1}{\theta}} C_{F,t}^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}} \tag{3}$$

where C_H and C_F are aggregators over individual home and foreign produced goods. At the level of individual goods, we assume a constant elasticity of substitution across goods equal to $\lambda > 1$. The parameter θ in (3) is the Armington elasticity of substitution between home and foreign goods. The parameter γ_t measures the importance of consumption of the home good in preferences over traded goods. For $\gamma_t > 1/2$, we have 'home bias' in preferences. We assume that γ_t is affected by a stochastic 'demand' shock, which affects the intensity of preferences for the home good relative to the foreign good. In particular, we assume that

$$\gamma_t = \gamma \exp(v_t)$$

where $v_t = \psi v_{t-1} + \varepsilon_{v,t}$, where, $0 < \psi < 1$ and $\varepsilon_{v,t}$, is a zero-mean normally distributed i.i.d. shock with $Var[\varepsilon_v] = \sigma_v^2$.

The foreign consumption aggregator is defined as

$$C_t^* = \left[(1 - \gamma_t^*)^{\frac{1}{\theta}} C_{H,t}^{*\frac{\theta-1}{\theta}} + \gamma_t^{*\frac{1}{\theta}} C_{F,t}^{*\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}} \tag{4}$$

where $\gamma_t^* = \gamma \exp(-v_t)$.Thus, when $\gamma > 1/2$, there is on average home bias towards the domestically produced good in both home and foreign preferences. But a positive shock to v_t will shift both home *and* foreign demand towards the home produced good, and away from the foreign produced good.

Given this specification, the aggregate CPIs for home and foreign agents are therefore

$$P_t = \left[\gamma_t P_{H,t}^{1-\theta} + (1 - \gamma_t) P_{F,t}^{1-\theta} \right]^{\frac{1}{1-\theta}} \tag{5}$$

$$P_t^* = \left[(1 - \gamma_t^*) P_{H,t}^{*1-\theta} + \gamma_t^* P_{F,t}^{*1-\theta} \right]^{\frac{1}{1-\theta}} \tag{6}$$

where P_H and P_F are the aggregate price indices for home and foreign goods. An asterisk indicates that the price is denoted in the foreign currency.

Home consumers supply labor and receive profits from the home firm. Define the budget constraint of the home country consumer as

$$P_t C_t + P_t F_t = W_t H_t + P_t \Pi_t + P_t \sum_{k=1}^{N} \alpha_{k,t-1} r_{kt} \tag{7}$$

where F_t denotes home country net external assets in terms of the home consumption basket, W_t is the home nominal wage, Π_t represents real profits of home firms, (defined further below). The final term represents the total return on the home country portfolio where $\alpha_{k,t-1}$ represents the real *external* holdings of asset k (defined in terms of home country consumption, purchased at the end of period $t-1$ for holding into period t) and

$r_{k,t}$ represents the gross real return on asset k.. We allow for trade in up to $N = 4$ assets; home and foreign equity, as well as home and foreign nominal bonds.[4]

Home nominal bonds represent a claim on a unit of home currency. The real payoff to a home nominal bond purchased at time t is therefore $1/P_{t+1}$. The real price of the bond is denoted $Z_{B,t}$. The gross real rate of return on a home nominal bond is thus $r_{Bt+1} = 1/(P_{t+1}Z_{B,t})$. For the foreign nominal bond, the real return in terms of the foreign consumption good is $1/(P^*_{t+1}Z^*_{B,t})$. But this must be converted into home good returns, so that the real return on foreign bonds, in terms of home consumption, is $r_{B^*t+1} = Q_{t+1}/(Q_tP^*_{t+1}Z^*_{B,t})$, where $Q_t = SP^*_t/P_t$ is the real exchange rate of the home economy.

Home equities represent a claim on home aggregate profits in the traded goods sector. The real payoff to a unit of the home equity purchased in period t is defined to be $\Pi_{t+1}+Z_{E,t+1}$, where $Z_{E,t+1}$ is the real price of home equity and Π_{t+1} represent real profits. Thus the gross real rate of return on the home equity is $r_{E,t+1} = (\Pi_{t+1} + Z_{E,t+1})/Z_{E,t}$.

Without loss of generality, we let the foreign nominal bond act as the Nth asset, so that $r_{N,t+1} = r_{B^*t+1} = Q_{t+1}/(Q_tP^*_{t+1}Z^*_{B,t})$.

Optimal consumption and labor supply choices for the home household imply:

$$C_t^{-\rho} = \beta E_t C_{t+1}^{-\rho} r_{N,t+1}, \tag{8}$$

$$W_t = C_t^{\rho} H_t^{\phi} P_t. \tag{9}$$

Optimal portfolio choices imply:

$$E_t C_{t+1}^{-\rho}(r_{k,t+1} - r_{N,t+1}) = 0, \qquad k = 1..N-1. \tag{10}$$

The foreign agent's optimizing conditions are analogous to (8)-(9). The portfolio selection equation for the foreign agent must take account of the fact that real exchange rate changes alter the optimal relationship between marginal utility and excess returns, so that:

$$E_t C_{t+1}^{*-\rho} \frac{(r_{k,t+1} - r_{N,t+1})}{Q_{t+1}} = 0, \qquad k = 1..N-1. \tag{11}$$

3.2 Firms

We make the following assumptions about the production structure of each economy. Firms produce goods using labor. Each firm produces a single differentiated product. The production function for firm i in the home country is $Y(i) = A_t L^{\mu}(i)$, where $0 < \mu \leq 1$,

[4] Note that F_t is defined as $F_t = \sum_{k=1}^{N} \alpha_{k,t}$.

$A_t = \exp(a_t)$ and a is a common stochastic productivity shock across all firms. Home and foreign productivity shocks follow a joint process of the form

$$\begin{bmatrix} a_t \\ a_t^* \end{bmatrix} = \begin{bmatrix} \varsigma_{1,1} & \varsigma_{1,2} \\ \varsigma_{2,1} & \varsigma_{2,2} \end{bmatrix} \begin{bmatrix} a_{t-1} \\ a_{t-1}^* \end{bmatrix} + \begin{bmatrix} \varepsilon_{a,t} \\ \varepsilon_{a^*,t} \end{bmatrix}$$

where a_t^* is the foreign productivity shock and $\varepsilon_{a,t}$ and $\varepsilon_{a^*,t}$ are zero-mean normally distributed i.i.d. shocks with $Var[\varepsilon_a] = Var[\varepsilon_{a^*}] = \sigma_a^2$ and $Cov[\varepsilon_a, \varepsilon_{a^*}] = \sigma_{a,a^*}$.

Firms maximize profits. Sticky prices are modeled as Calvo-style contracts with a probability of re-setting price given by $1-\kappa$. Initially we assume that firms set prices in their own currency (PCP), but we will also consider a version of the model where there is local currency pricing (LCP). Here we describe only the PCP case.

If firms use the discount factor Ω_{t+i} to evaluate future profits, then the dynamics of the newly-set price $\widetilde{P}_{Ht}$ and the home price index P_{Ht} are:[5]

$$\widetilde{P}_{H,t} = \frac{E_t \sum_{s=0}^{\infty} \Omega_{t+s}\kappa^s MC_{t,t+s}Y_{t,t+s}}{E_t \sum_{s=0}^{\infty} \Omega_{t+s}\kappa^s Y_{t,t+s}}, \qquad P_{H,t} = \left[(1-\kappa)\widetilde{P}_{H,t}^{1-\lambda} + \kappa P_{H,t-1}^{1-\lambda}\right]^{\frac{1}{1-\lambda}}, \tag{12}$$

where $Y_{t,t+s}$ represents the period $t+s$ output of firms which set prices in period t and $MC_{t,t+s}$ is the period $t+s$ marginal cost of firms that set prices in period t, where

$$MC_{t,t+s} = \frac{1}{\mu}\frac{W_{t+s}}{A_{t+s}}\left(\frac{Y_{t,t+s}}{A_{t+s}}\right)^{\frac{1-\mu}{\mu}}$$

Each home country firm i faces demand for its good from home consumers and foreign consumers. Using the properties of demand curves, we can define equilibrium in the market for good i in the home country as

$$Y_t(i) = \left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\lambda}[C_{H,t} + C_{H,t}^*]. \tag{13}$$

Now, aggregating across all home firms, aggregate output of the home good is defined as

$$Y_t = V_t^{-1}\int_0^1 Y_t(i)di = C_{H,t} + C_{H,t}^* \tag{14}$$

where we have defined $V_t = \int_0^1 \left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\lambda} di$. It follows that home country employment (employment for the representative home household) is given by

$$N_t = \int_0^1 N(i)di = \left(\frac{Y_t V_t}{A_t}\right)^{\frac{1}{\mu}} \tag{15}$$

[5] We assume that each firm receives a subsidy, financed by lump-sum taxes, which offsets the monopoly mark-up in pricing.

The profits of home firm i are

$$\Pi_t(i)P_t = P_{H,t}(i)Y_t(i) - W_tL_t(i)$$

using (13) and aggregating implies

$$\Pi_t P_t = \int_0^1 \left\{ P_{H,t}(i) \left(\frac{P_{H,t}(i)}{P_{H,t}} \right)^{-\lambda} [C_{H,t} + C^*_{H,t}] - W_tL_t(i) \right\} di$$

thus, using (14) and (15), aggregate home profits are

$$\Pi_t P_t = P_{H,t}Y_t - W_tN_t$$

The pricing, output and profit equations for the foreign firm are analogous.

3.3 Monetary Authorities

Monetary authorities follow a policy that targets the path of, i_t, the nominal rate of return on the gross nominal bonds of their respective currencies. We assume that the target for i_t is governed by a Taylor rule. For the home country, this is described by

$$i_t = \beta^{\frac{1}{\vartheta-1}} i_{t-1}^{\vartheta} \left[\left(\frac{P_t}{P_{t-1}} \right)^{\chi} \left(\frac{Y_t}{\tilde{Y}_t} \right)^{\delta} \exp(\varepsilon_{m,t}) \right]^{1-\vartheta} \tag{16}$$

where $0 < \vartheta < 1$, $\chi > 1$, and $\delta > 0$, and $\tilde{Y}_t$ represents potential output of the home country. $\varepsilon_{m,t}$ is a random monetary policy disturbance which is zero-mean, i.i.d. and normally distributed with $Var[\varepsilon_m] = \sigma_m^2$. The foreign monetary disturbance, ε_{m^*}, has a similar form with $Var[\varepsilon_{m^*}] = \sigma_m^2$ and $Cov[\varepsilon_m, \varepsilon_{m^*}] = 0$.

Note that the rule (16) determines the nominal interest rate as a function of the historic CPI inflation rate. We choose the CPI inflation rate because this represents a better description of the actual practice in countries that have been explicitly following inflation targeting policies. More generally, even outside of the explicit inflation targeters, the CPI is by far the most visible and relevant price index for guiding monetary policy. Finally, while our focus is not on optimal policy, in the presence of local currency pricing, it has been established that targeting CPI inflation may be preferable to PPI inflation targeting (Engel, 2011).

We will assume that potential output, $\tilde{Y}_t$, is constant. This assumption would not be justified if we were modeling the optimal choice of policy rule since shocks to productivity and preferences clearly change the welfare relevant measure of potential output. As our purpose is to represent actual rather than optimal monetary policymaking, we ignore the impact of shocks on $\tilde{Y}_t$. In practice policymakers are not able directly to observe shocks affecting potential output and therefore tend to measure potential output using a moving average measure of actual output. This tends not to change much in the short run in response to shocks.

Rule (16) allows for a degree of partial adjustment in monetary policy, which is determined by the parameter ϑ.

The feedback parameter on inflation, χ, will be a key parameter in the analysis which follows. A higher value of χ implies that monetary policy is more focused on inflation stabilization. In equilibrium this will result in lower variability of inflation. The central issue we will investigate is the relationship between χ and the size of equilibrium gross holdings of equities and bonds.

4 Portfolio Choice

Our main interest is in the characteristics of the portfolio positions, and their relationship to the stance of monetary policy. In this vein, we follow Devereux and Sutherland (2011) in computing the characteristics of the portfolios using a second order approximation to the portfolio selection equations for the home and foreign country (10) and (11), in conjunction with a first order approximation to the home and foreign budget constraints and the vector of excess returns.

The Devereux and Sutherland (2011) approach allows us to derive reduced-form solutions for gross portfolio holdings of equities and bonds. In order to interpret these solutions we now derive some useful expressions which show how portfolio holdings are related in equilibrium to the second moments of income and asset returns. These expressions are not reduced-form solutions in the sense that the second moments of income and asset returns themselves depend on portfolio holdings. They do however highlight some of the underlying intuition for the link between inflation variability and gross portfolio positions.

In all the cases we analyze below the home and foreign economies are entirely symmetric. If it is assumed that assets 1 and 2 are respectively home and foreign equities then it follows that $\alpha_1 = -\alpha_2$ in equilibrium. Likewise, if assets 3 and 4 are home and foreign bonds then in equilibrium it follows that $\alpha_3 = -\alpha_4$. It is useful to define $\alpha_e = -\alpha_1 = \alpha_2$ and $\alpha_b = -\alpha_3 = \alpha_4$. Thus α_e is a measure of the gross external position in equities and α_b is a measure of the gross external position in bonds, where "gross external position" is defined to be the position that one country holds in the assets issued by the other country. It is also useful to define $r^e_{x,t} = r^{*e}_t - r^e_t$ to be the return on foreign equities relative to the return on home equities and $r^b_{x,t} = r^{*b}_t - r^b_t$ to be the return on foreign bonds relative to the return on home bonds.

Following Devereux and Sutherland (2011), we obtain the condition

$$E_t\left(c_{t+1} - c^*_{t+1} - \frac{1}{\rho}q_{t+1}\right) r_{x,t+1} = 0 \tag{17}$$

where $z = \frac{Z-\bar{Z}}{\bar{Z}}$, except for $r_{x,t}$, which is defined as $r_{x,t} = [r^e_{x,t}, r^b_{x,t}]'$.

Note that using the definition of F_t and home country profits we may write the home country budget constraint as

$$P_tC_t + P_tF_t = P_{H,t}Y_t + P_tr_{N,t}F_{t-1} + P_t\sum_{k=1}^{N-1}\alpha_{k,t-1}r_{xt} \tag{18}$$

Taking a first order approximation around the initial point where $F = 0$, we obtain

$$c_t + f_t = y_t + p_{H,t} - p_t + \beta^{-1}f_{t-1} + \widetilde{\alpha}'r_{x,t} \tag{19}$$

where f is measured in terms of level deviations from the steady state (of zero), relative to steady state GDP and $\widetilde{\alpha} = [\frac{\alpha_e}{\beta\overline{Y}}, \frac{\alpha_b}{\beta\overline{Y}}]' = [\tilde{\alpha}_e, \tilde{\alpha}_b]'$ represents the zero order (or steady state) portfolio, relative to steady state GDP.[6]

Using the equivalent condition for the foreign country, and leading by one period, we arrive at the condition

$$\Delta c_{t+1} = \Delta y_{t+1} + q_{t+1} + \beta^{-1}2f_t - 2f_{t+1} + 2\widetilde{\alpha}'r_{x,t+1} \tag{20}$$

where $\Delta c = c - c^*$, $\Delta y = y - y^* - \tau$ and $\tau = p^*_F + s - p_H$ is the home terms of trade. Now iterating forward on (20), using the appropriate transversality constraint, gives

$$E_{t+1}\sum_{j=0}^{\infty}\beta^j\Delta c_{t+1+j} = E_{t+1}\sum_{j=0}^{\infty}\beta^j(\Delta y_{t+1+j} + q_{t+1+j}) + \beta^{-1}2f_t + 2\widetilde{\alpha}'r_{x,t+1} \tag{21}$$

From the Euler equations for consumption growth for the home and foreign country, we have

$$E_t\Delta c_{t+1} = \Delta c_t + \frac{E_tq_{t+1} - q_t}{\rho} \tag{22}$$

[6] To simplify notation in this expression (and those which follow) we omit the residual of approximation. Note that, unlike in Devereux and Sutherland (2011) where shock processes are assumed to have finite support, the shock processes in this model are normally distributed. This implies that the appropriate interpretation of the order of approximation is in terms of "order in probability".

Now, using (21) with (22) we arrive at the expression for real exchange rate adjusted relative consumption in period $t+1$ as

$$\Delta c_{t+1} - \frac{1}{\rho} q_{t+1} = (1-\beta)\left[\Gamma_{y,t+1} + \beta^{-1} 2 f_t + 2\widetilde{\alpha}' r_{x,t+1}\right] \tag{23}$$

where

$$\Gamma_{y,t+1} = E_{t+1} \sum_{j=0}^{\infty} \beta^j \left(\Delta y_{t+1+j} + \frac{(\rho-1)}{\rho} q_{t+1+j} \right)$$

represents the present value of expected innovations to relative income, plus the present value of expected innovations to the real exchange rate. Note that in the case of $\rho = 1$, the second term drops out, and innovations in current and expected future real exchange rates do not directly affect the value of $\Delta c_{t+1} - \frac{1}{\rho} q_{t+1}$.

Putting (23) together with the orthogonality condition (17), we may compute the expressions characterizing the equilibrium portfolio as

$$\tilde{\alpha} = -\frac{1}{2} \Sigma_r^{-1} \text{cov}_t(r_{x,t+1}, \zeta_{y,t+1}) \tag{24}$$

where $\zeta_{y,t+1} = \Gamma_{y,t+1} - E_t \Gamma_{y,t+1}$ and where Σ_r is the co-variance matrix of $r_{x,t+1} - E_t r_{x,t+1}$. Thus, the optimal portfolio position is determined by the way in which innovations in the excess return vector co-vary with innovations in the expected present discounted value of relative income (adjusted by the real exchange rate). Note that expression (24) is not a reduced form because the second moments on the right-hand side depend on $\tilde{\alpha}$.

The Appendix shows that equation (24) is equivalent to the following expressions for equilibrium asset holdings

$$\tilde{\alpha}_e = -\frac{1}{2} \text{corr}\left(\zeta_{y,t}, r_{x,t}^e | r_{x,t}^b\right) \frac{\text{StDev}\left(\zeta_{y,t} | r_{x,t}^b\right)}{\text{StDev}\left(r_{x,t}^e | r_{x,t}^b\right)} \tag{25}$$

$$\tilde{\alpha}_b = -\frac{1}{2} \text{corr}\left(\zeta_{y,t}, r_{x,t}^b | r_{x,t}^e\right) \frac{\text{StDev}\left(\zeta_{y,t} | r_{x,t}^e\right)}{\text{StDev}\left(r_{x,t}^b | r_{x,t}^e\right)} \tag{26}$$

These expressions show that the size of the gross position in asset i depends on two factors:

1 $\text{corr}\left(\zeta_{y,t}, r_{x,t}^i | r_{x,t}^j\right)$, the correlation of the return differential of asset i with innovations in the present value of relative income (conditional on the return differential of asset j)

2 $\text{StDev}\left(\zeta_{y,t} | r_{x,t}^j\right) / \text{StDev}\left(r_{x,t}^i | r_{x,t}^j\right)$, the standard deviation of innovations in the present value of relative income (conditional on the return differential of asset j) relative to the standard deviations of returns on asset i (conditional on the return differential of asset j)

Again note that (25) and (26) are not reduced form expressions because the second moments on the right-hand side depend on $\tilde{\alpha}$.

Expressions (25) and (26) will prove useful in interpreting the impact of inflation variability on portfolio positions. These expressions have a very intuitive explanation. Agents wish to hold a portfolio of assets which hedge against shocks to relative income, ζ_y. The extent to which asset i provides a good hedge against relative income shocks depends on the correlation between the return on asset i and relative income shocks, i.e. $\text{corr}\left(\zeta_{y,t}, r^i_{x,t} | r^j_{x,t}\right)$. An asset which is (negatively) correlated with income shocks is a good hedging instrument and so will be held in the equilibrium portfolio with a positive gross position. The stronger the correlation the more of that asset will be held. But the amount of the asset that needs to be held to hedge income shocks also depends on the size of fluctuations in income relative to the size of fluctuations in the return on asset i, i.e. $\text{StDev}\left(\zeta_{y,t} | r^j_{x,t}\right) / \text{StDev}\left(r^i_{x,t} | r^j_{x,t}\right)$. The larger are fluctuations in income relative to fluctuations in the return on asset i the larger must be the gross position in asset i in order to provide the desired degree of hedging.

These two effects, (i.e. *the correlation effect* measured by $\text{corr}\left(\zeta_{y,t}, r^i_{x,t} | r^j_{x,t}\right)$, and *the variability effect* measured by $\text{StDev}\left(\zeta_{y,t} | r^j_{x,t}\right) / \text{StDev}\left(r^i_{x,t} | r^j_{x,t}\right)$), will prove useful in interpreting the link between inflation variability and the size of gross positions.

5 Monetary Policy and Gross Portfolios: A Simple Example

In the quantitative analysis below, we show that gross portfolio positions are sensitive to monetary policy, and in particular that a tighter monetary policy rule - associated with a higher value of χ (the feedback coefficient on inflation in the Taylor rule) - leads to an expansion of gross bond and equity positions. Here, we develop a special case to demonstrate the intuition for this result. To do this, we examine a drastically simplified version of the above model.

In this case, rather than Calvo-style pricing, we assume that all prices are re-set period by period with fraction κ of firms setting prices in each period in advance of shocks being realized for that period and fraction $(1-\kappa)$ setting prices after shocks have been realized. In addition, we assume that there are shocks only to productivity and that these shocks are i.i.d. (i.e. $\varsigma_{1,1} = \varsigma_{2,2} = \varsigma_{2,1} = \varsigma_{1,2} = 0$). For transparency, assume that there are only relative shocks, so that $a^* = -a$. We also assume that there is no home bias in preferences, i.e. $\gamma = 1/2$, and that utility is linear in work effort, i.e. $\phi = 0$. Finally, we assume that the production function is linear in labor input, i.e. $\mu = 1$ and there is no inertia in interest rate setting, i.e. $\vartheta = 0$.

With only one source of stochastic shocks, perfect risk sharing can be achieved with just two assets. We therefore consider separately the case where there are two equities (home and foreign) and two nominal bonds (denominated in home and foreign currency).

Using the assumptions just stated, we may derive an expression for the present value of innovations in expected relative home income, ζ_{yt}, as follows

$$\zeta_{yt} = \frac{(\chi/\delta)(\theta - 1)(1 - \kappa)}{\chi/\delta + \kappa\theta} 2\varepsilon_{at} \tag{27}$$

Thus a shock to home productivity (relative to foreign productivity) raises the expected present value of relative home income, for $\theta > 1$. This expression holds for both the equities-only and bonds-only cases.

5.1 Equities only

Again, using the assumptions specific to this example, we can establish that the excess return on home equity relative to foreign equity is

$$r^e_{xt} = (1 - \beta)\frac{\kappa(\lambda - 1)\theta + (\chi/\delta)[\theta - 1 + \kappa(\lambda - \theta)]}{\chi/\delta + \kappa\theta} 2\varepsilon_{at} \tag{28}$$

Thus a shock to home productivity (relative to foreign productivity) raises the excess relative return on home equity (assuming $\theta > 1$).

Since markets are complete in this example, households can fully insure against shocks by holding a portfolio of home and foreign equities. By definition, the full insurance portfolio has a payoff which perfectly offsets innovations to expected relative home income, ζ_{yt}. The optimal portfolio must therefore satisfy

$$\tilde{\alpha}_e r^e_{xt} = -\zeta_{yt}$$

Using this condition and the expressions for ζ_{yt} and r^e_{xt} given in (27) and (28) the equity portfolio is

$$\tilde{\alpha}_e = \frac{1}{2}\frac{1}{(1 - \beta)}\frac{(\chi/\delta)(\theta - 1)(1 - \kappa)}{\kappa(\lambda - 1)\theta + (\chi/\delta)[\theta - 1 + \kappa(\lambda - \theta)]} \tag{29}$$

Thus the home country takes a long position in foreign equity, $\tilde{\alpha}_e > 0$ (assuming $\theta > 1$ and $\lambda > \theta$).[7]

[7] Recall that $\widetilde{\alpha}_e$ measures the gross external position in equities, where the "gross external position"

The key feature of (29) is that gross holdings of equities depend on the parameters of the monetary rule. It is simple to show that (provided $\lambda > \theta$) as the weight on CPI inflation in the monetary rule rises (i.e. as χ rises), the size of the gross equity position rises.

Further insight into the underlying determinants of gross positions can be gained by considering the expressions for asset positions stated in (25) and (26). For the equities-only case in the current model the following expressions can be derived

$$\text{StDev}\left(\zeta_{y,t}\right) = \frac{(\chi/\delta)(\theta-1)(1-\kappa)}{\chi/\delta+\kappa\theta}2\sigma_a$$

$$\text{corr}\left(\zeta_{y,t}, r^e_{x,t}\right) = 1$$

$$\text{StDev}\left(r^e_{x,t}\right) = (1-\beta)\frac{\kappa(\lambda-1)\theta+(\chi/\delta)[\theta-1+\kappa(\lambda-\theta)]}{\chi/\delta+\kappa\theta}2\sigma_a$$

Note that these expressions are for unconditional moments since there is only one type of asset traded.

These expressions show that χ affects portfolio holdings through its impact on the standard deviation of $\zeta_{y,t}$ and $r^e_{x,t}$. More specifically, it can be shown that, as χ rises, $\text{StDev}(\zeta_{y,t})$ increases and $\text{StDev}(r^e_{x,t})$ decreases.

The link between inflation variability and the standard deviation of relative income, $\text{StDev}(\zeta_{y,t})$, can be explained as follows. The presence of sticky nominal prices implies that, as monetary authorities adopt a monetary stance which is focused on inflation stabilizing, the volatility of real output increases. This translates into more volatility in relative income, as indicated by the behavior of $\text{StDev}(\zeta_{y,t})$.

The impact of inflation variability on equity returns can also be explained in simple economic terms. Sticky nominal prices imply that profit margins are affected by variability in nominal marginal costs. A reduction in the volatility of CPI inflation tends to reduce the variability of nominal marginal costs and thus tends to stabilize profits and equity returns. This, combined with the effect of inflation stabilization on $\text{StDev}(\zeta_{y,t})$ implies that the size of gross equity holdings increase as χ is increased.

This simple example illustrates how *the variability effect* (which operates via the impact of inflation variability on $\text{StDev}(\zeta_{y,t})\,/\text{StDev}(r^e_{x,t})$) links inflation variability to the size of gross positions. Note that *the correlation effect* (which operates via $\text{corr}(\zeta_{y,t}, r^e_{x,t})$)

is defined to be the position that one country holds in the equities issued by the other country. It is reasonable to assume that the elasticity of substitution between goods for sale within a country (λ) is higher than the elasticity of substitution between home and foreign hoods (θ).

does not arise in this example because, in a complete markets case, this correlation is equal to unity regardless of the parameters of the monetary policy rule.

5.2 Bonds only

Now consider the case where financial trade is restricted to home and foreign bonds. Using the assumptions outlined above for this special case the excess return on home bonds relative to foreign bonds is

$$r^b_{xt} = \frac{\theta(1-\kappa)}{\chi/\delta + \kappa\theta} 2\varepsilon_{at} \tag{30}$$

Given the form of the monetary rule (16), a productivity shock leads to a rise in the home nominal interest rate, which causes an appreciation of the home currency, so there is a positive excess return on home bonds relative to foreign bonds.

In the bonds-only case the optimal bond portfolio must satisfy

$$\tilde{\alpha}_b r^b_{xt} = -\zeta_{yt}$$

so

$$\tilde{\alpha}_b = \frac{1}{2}\frac{(\chi/\delta)(\theta-1)}{\theta} \tag{31}$$

Thus the home country takes a long position in foreign bonds, $\tilde{\alpha}_b > 0$ (assuming $\theta > 1$).[8]

Again, the key feature of (31) is that gross holdings depend on the parameters of the monetary rule. As the weight on CPI inflation in the monetary rule, χ, rises, the absolute size of the gross bond position rises.

As in the equities-only case, further insight into the underlying determinants of gross positions can be gained by considering the expressions for asset positions stated in (25) and (26). For the bonds-only case the following expression can be derived

$$\text{StDev}\left(\zeta_{y,t}\right) = \frac{(\chi/\delta)(\theta-1)(1-\kappa)}{\chi/\delta + \kappa\theta} 2\sigma_a$$

$$\text{corr}\left(\zeta_{y,t}, r^b_{x,t}\right) = 1$$

$$\text{StDev}\left(r^b_{x,t}\right) = \frac{\theta(1-\kappa)}{\chi/\delta + \kappa\theta} 2\sigma_a$$

These expressions show that the standard deviation of $\zeta_{y,t}$ increases, and the standard deviation of $r^b_{x,t}$ decreases, as χ increases.

[8] Again, recall that $\tilde{\alpha}_b$ measures gross external position in bonds, where the "gross external position" is defined to be the position that one country holds in the bonds issued by the other country.

The underlying economic explanation for the link between inflation variability and the variability of relative income is identical to the equities-only case, i.e. the presence of sticky nominal prices implies that, as monetary authorities adopt a monetary stance which is focused on inflation stabilizing, the volatility of real output increases. This translates into more volatility in relative income, as indicated by the behavior of $\text{StDev}(\zeta_{y,t})$.

The link between χ and the variability of relative bond returns is also easily understood. The nominal return on nominal bonds is fixed by assumption.[9] Unanticipated shocks which affect CPI inflation therefore directly impact on the real return on nominal bonds. A monetary policy stance which stabilizes inflation must by definition stabilize the real return on nominal bonds. This is the effect captured by the above expression for $\text{StDev}(r^b_{x,t})$.

In the case of bond holdings the variability of relative income increases and the variability of bond returns decreases as χ is increased. Both these effects contribute to the increase in the absolute size of gross bond holdings. This is again an example of the return variability effect. Again note that *the correlation effect* (which operates via $\text{corr}(\zeta_{y,t}, r^b_{x,t})$) does not arise in this example because, as before, when markets are complete, this correlation is equal to unity regardless of the parameters of the monetary policy rule.

6 Monetary Policy and Gross Portfolios: The General Case

The simple example model discussed above shows that, in the presence of sticky nominal prices, a monetary policy which stabilizes inflation tends to reduce the variability of real asset returns. This implies that gross portfolio positions in equities and bonds increase as inflation is stabilized.

We now turn to the general model (with Calvo price setting and a range of shocks) and show that this basic result continues to hold. We show that the underlying intuition for the basic result remains true, i.e. a reduction in inflation volatility tends to reduce the variability of asset returns, which tends to increase equilibrium gross positions in equities and bonds. We also demonstrate however, that when markets are incomplete, *the correlation effect* comes into play and can reinforce the negative relationship between inflation variability and the size of gross positions.

[9] Nominal returns vary from period to period, but at the time portfolio allocations are made the nominal returns on bonds between the current period and the following period are known with certainty.

The general model is too complex to analyze explicitly so we focus on numerical simulations for plausible parameter values.

6.1 Benchmark parameter values

We start with a benchmark case where there are just productivity and monetary shocks. The benchmark parameter values are listed in Table 3. Because there are only two sources of shocks, trade in equities and bonds allows full risk sharing.

The values for β, θ, and γ and the stochastic process for productivity shocks are consistent with the benchmark parameterization of Backus, Kehoe and Kydland (1994). The values of λ and μ are chosen to yield a steady state monopoly markup of 11% and share of profits in output of 0.63 (which is fairly standard). The Calvo parameter is chosen to yield an average frequency of price changes of 4 quarters (again which is quite standard). The values of ϕ and ρ are consistent with the estimates of Smets and Wouters (2003). The values of the Taylor rule parameters δ and ϑ are consistent with the estimates of Clarida, Gali and Gertler (2000).[10] The standard deviation of monetary policy shocks is chosen to imply that relative monetary policy shocks are approximately the same size as innovations in relative productivity.

Results are reported for a range of variations around this benchmark parameterization.

6.2 Gross portfolios in the benchmark case

The effect of varying the coefficient on inflation in the Taylor rule, χ, on equilibrium portfolio holdings of equities and bonds is illustrated in Figure 2. Panels (a) and (b) plot the equilibrium holdings of foreign equities and bonds by the home country for a range of values of χ. These figures show that the external position in foreign equities by the home country is positive and rising while the external position in bonds is negative and declining in χ. In other words the absolute size of gross positions increase as monetary policy becomes more focused on inflation stabilization.[11] For reference, panel (i) shows

[10] Clarida, Gali and Gertler (2000) report estimates of δ which are in the range 0.3 to 0.4. However, these estimates are based on an estimating model which allows for variations in capacity output. We choose a lower value of δ to reflect the fact that policymaker's estimates of changes in capacity output (which are not explicitly captured by our model) may dampen the impact of output on monetary policy.

[11] The portfolio positions shown in these plots show external asset holdings relative to GDP. It is apparent that the model is predicting very large gross positions in both equities and bonds. Portfolio positions of this magnitude are not realistic (for most countries) so the model is clearly not a good match for the data in this respect. The model, however, assumes that international asset trade is costless

Table 3: Benchmark Parameter Values

Discount factor	$\beta = 0.99$
Elasticity of substitution for individual goods	$\lambda = 10$
Elasticity of work effort in utility function	$\phi = 1$
Intertemporal elasticity of substitution	$\rho = 1$
Average share of home goods in consumption basket	$\gamma = 0.85$
Elasticity of substitution between home and foreign goods	$\theta = 1.5$
Production function	$\mu = 0.7$
Calvo price adjustment parameter	$\kappa = 0.75$
Taylor rule: coefficient on output	$\delta = 0.2$
Taylor rule: interest rate smoothing	$\vartheta = 0.7$
Demand shocks	$\psi = 0.0$, $\sigma_v = 0.0$
Monetary shocks	$\sigma_m = 0.01/\sqrt{2}$
Productivity shocks	$\varsigma_{1,1} = \varsigma_{2,2} = 0.9$,
	$\varsigma_{1,2} = \varsigma_{2,1} = 0.1$,
	$\sigma_a = 0.008$, $\sigma_{a,a^*} = 0.25\sigma_a^2$

the effect of varying the inflation feedback parameter on the variability of inflation. This figure shows that inflation variability declines as χ is increased.

Figure 2 shows that the basic result demonstrated in the simple example model holds in the general model for the benchmark set of parameter values.

The portfolio expressions (25) and (26) can again be used to investigate the intuition for the relationship between inflation stabilization and the size of equilibrium asset holdings. Panels (c) to (h) of Figure 2 plot the relevant conditional moments. These figures show that some of the basic properties of conditional moments are similar to those found in the simple example model. Thus the conditional standard deviations of both bond and equity returns decline as monetary policy becomes more focused on inflation stabilization. The behavior of the conditional standard deviation of relative income is somewhat more complicated than in the simple model. The conditional variability of relative income increases in the case of equities but is non-monotonic in the case of bonds, first increasing and then decreasing as χ increases. But even when the conditional standard deviation of relative income is decreasing, the conditional standard deviation of bond returns is decreasing more quickly, so the net result is that equilibrium bond holdings are increasing in absolute value as χ increases.

Panels (c) to (h) of Figure 2 demonstrate that the underlying explanation for the increase in gross positions is the same as in the simple example model, i.e. as the volatility of inflation is reduced it is necessary for households to hold larger (in absolute size) gross positions in equities and bonds in order to achieve the desired degree of risk sharing. This is again an example of *the volatility effect*.

Notice from panels (c) and (d) of Figure 2 that the correlation between both bond and equity returns and relative income is unity regardless of the value of χ. The correlation effect therefore does not arise in this example. This again reflects the fact that markets are complete.

The benchmark configuration of our model is very similar to the model used by Engel and Matsumoto (2009) to analyze equity home bias. Our model differs only in the form of price setting (i.e. we have Calvo price setting rather than one period fixed prices) and monetary policy (i.e. we have a Taylor rule rather than a money targeting rule). For the benchmark parameter set the total value of home equity is 37 times steady state GDP,

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and unhindered by capital controls or other market frictions. Tille and van Wincoop (2010) show that it is straightforward to incorporate small transactions costs into a portfolio choice problem of the type analyzed here. If such costs were introduced into the current model it is likely equilibrium gross portfolios would be reduced to more realistic levels.

so the equity position illustrated in Figure 2, panel (a) is consistent with a substantial degree of equity home bias for the full range of χ.[12] Our model therefore reproduces the main Engel and Matsumoto result. But notice that one of the implications of the results illustrated in Figure 2 is that the degree of equity home bias is sensitive to the variability of inflation. More specifically, equity home bias is stronger when inflation is relatively volatile but declines as inflation is stabilized.

Figure 2 shows that bond holdings in the benchmark case are negative, i.e. each country is a net borrower in the currency of the other country. This pattern is contradicted by the data for most advanced economies. Typically advanced economies hold positive positions in foreign-currency bonds. The benchmark configuration of our model is therefore not realistic in this respect. This aspect of the benchmark model is, however, corrected when demand shocks are introduced.

Figure 3 illustrates the case with demand shocks with the parameters of the demand shock process given by $\psi = 0.8$ and $\sigma_v = 0.01$. This parameterization implies that demand shocks are roughly as volatile and persistent as relative productivity shocks. All other parameter values are identical to their benchmark values. Panel (b) of Figure 3 shows that bond holdings have now switched sign and are positive for all values of χ. This more closely corresponds to the typical position for advanced countries.

The other panels of Figure 3 illustrate further details of how demand shocks affect the behavior of equilibrium portfolios. Panels (a) and (b) show that the size of equity and bond holdings continue to be increasing in χ. Panel (i) of Figure 3 shows that the volatility of CPI inflation is declining in χ and panels (g) and (h) show that the conditional standard deviation of equity and bond returns is again declining in χ. The main contrast with the benchmark case (without demand shocks) is that the conditional standard deviation of relative income is now declining in χ. But the standard deviation of relative income declines less quickly than the standard deviation of both equity and bond returns, so the basic intuition discussed above continues to hold, i.e. as inflation is stabilized larger gross positions in equities and bonds are required in order to achieve the desired level risk sharing. So the volatility effect continues to be an important part of the underlying explanation for the link between inflation variability and the size of gross positions.

[12] At $\chi = 6$ panel (a) of Figure 1 shows equity holdings of 2.5 times steady state GDP. This implies that the home country holds approximately 93% of home country equity. The Foreign country holds the same percentage of Foreign equity.

6.3 The correlation between relative income and asset returns

Devereux and Sutherland (2008) analyze a model very similar to the benchmark model and show that the size of the equilibrium gross position in bonds increases as the coefficient on inflation in the Taylor rule is increased. They however emphasize a different intuition for this result. They argue that inflation volatility causes extraneous noise in the real return on bonds which partly undermines the efficiency of bonds as a hedge against productivity shocks. A monetary rule which focuses on inflation stabilization will reduce the extraneous noise in bond returns and therefore imply that bonds become a better hedge against productivity shocks. Inflation stabilization therefore encourages an expansion of gross holdings of bonds.

Given the similarities between the model described above and the model used by Devereux and Sutherland (2008) it is important to trace the links between the intuition offered in Devereux and Sutherland (2008) and the intuition emphasized in this paper.[13] In fact the links between the two papers can be easily understood in terms of *the variability effect* and *the correlation effect*. The result emphasized in Devereux and Sutherland (2008) is an example of *the correlation effect*.

Figure 4 illustrates the Devereux and Sutherland (2008) result using the model of this paper. This figure illustrates the effect of χ on bond holdings in the benchmark model where there are shocks to productivity and monetary policy, but no shocks to demand, and asset trade is restricted to trade in home and foreign currency bonds. Panel (a) of Figure 4 shows that the absolute size of the gross position in bonds is increasing in χ.[14] As already explained, Devereux and Sutherland (2008) argue that the underlying explanation for the increase in the (absolute) size of the gross position in bonds is that bonds become a better hedge against productivity shocks as inflation is stabilized. In other words, as χ increases, the correlation between relative income and bond returns tends towards +1 or -1. Panel (b) of Figure 4 shows that in fact the correlation tends towards -1. And (26) shows that, other things being equal, this will cause an increase in the (absolute) size of the gross bond position. The results illustrated in Figure 4 are therefore entirely

[13] While Devereux and Sutherland (2008) analyze a model with many similarities to the model of the current paper, they only comment very briefly on the effect of inflation stabilization on the size of gross positions. In particular they only consider this issue in passing in a special case of the model. They do not decompose portfolio holdings using (25) and (26) and they offer only a brief intuition for the effect of inflation stabilization on the size of gross positions.

[14] In order to offer a clear illustration of the Devereux and Sutherland (2008) result, Figure 6 shows a much wider range for χ than used in Figures 1 and 2.

consistent with the intuition offered by Devereux and Sutherland (2008).[15]

But notice from Figure 4 that the effect of inflation stabilization that works through the correlation between bond returns and relative income is only one channel that links inflation stabilization to the gross bond position. Panels (c) and (d) of Figure 4 show that inflation stabilization also reduces the volatility of bond returns relative to the volatility of relative income. This is exactly *the variability effect* emphasized above in relation to Figures 2 and 3. Equation (26) shows that, just as in the cases illustrated in Figures 2 and 3, a reduction in the standard deviation of bond returns relative to the standard deviation of relative income implies that the gross bond position must increase in order to achieve the desired degree of risk sharing.

Figure 4 shows therefore that *the variability effect* emphasized above (i.e. the impact of inflation stabilization on the variability of asset returns) reinforces *the correlation effect* emphasized by Devereux and Sutherland (2008) (i.e. the impact of inflation stabilization on the correlation between asset returns and relative income).

Now re-consider the general case illustrated in Figure 3, where there are shocks to productivity, monetary policy and demand and where there is trade in both equities and bonds. Previously we emphasized the link between inflation stabilization and gross asset positions that operates through *the variability effect* (i.e. the effect of inflation stabilization and the variability of asset returns). However, notice from panels (c) and (d) of Figure 3, that inflation stabilization also affects the correlation between asset returns and relative income. In fact, as χ increases, the correlation between both equity returns and bond returns and relative income increases from zero towards +1. In other words, both bonds and equities become better hedging instruments as inflation is stabilized. As can be seen from (25) and (26), this reinforces the impact of inflation stabilization on gross positions. This is *the correlation effect* identified by Devereux and Sutherland (2008) and panels (c) and (d) of Figure 3 show that this effect generalizes from the bonds-only case considered by Devereux and Sutherland (2008) to the case where there is trade in both equities and bonds.[16]

[15] Devereux and Sutherland (2008) further emphasized that, if monetary policy were to stabilize inflation completely, bonds would become a perfect hedge for productivity shocks. In other words perfect risk sharing would be possible. In terms of the case illustrated in Figure 4, this would be the limiting case where χ tends to infinity and there is perfect negative correlation between bond returns and relative income.

[16] Notice that, in the limiting case, when χ tends to infinity and inflation is perfectly stabilized, the correlations between both equity returns and bond returns and relative income tend to +1. In this limiting case complete risk sharing is achieved.

Note that, while the correlation effect illustrated in panels (c) and (d) of Figure 3 reinforces the asset return volatility effect illustrated in panels (g) and (h), the correlation effect only arises when markets are incomplete. In the case illustrated in Figure 2, where there are only productivity and money shocks and trade in both equities and bonds, markets are complete. This implies that *both* bond returns and equity returns are perfectly correlated with relative income regardless of the level of χ. In this case the correlation effect is not present. The return volatility effect nevertheless continues to operate, as shown in panels (g) and (h) of Figure 2.

6.4 Generalizations

Figures 5 to 20 illustrate the relationship between χ and asset holdings for a range of parameter variations.

Figure 5 shows the case where the elasticity between home and foreign goods, θ, is reduced from 1.5 to 0.8. The absolute size of both bond and equity positions is higher than in the benchmark case, but the basic qualitative features of the relationship remain the same. Gross positions continue to be increasing in χ.

Figures 6 and 7 illustrate the effect of assuming local currency pricing, LCP, (in contrast to the benchmark case, where producer currency pricing, PCP, is assumed). Figure 6 shows the case of LCP and $\theta = 1.5$, while Figure 7 is the case of LCP and $\theta = 0.8$. The general qualitative features of the relationship between χ and gross positions continue to hold in these cases, except that in Figure 6 (LCP and $\theta = 1.5$) the gross bond position is now only very slightly upward sloping.

Figure 8 illustrates the case where there are only shocks to productivity and demand, but no shocks to monetary policy. Again the general features of the relationship between χ and gross portfolio positions is similar to the benchmark case.

Figures 9 to 20 illustrate the effects of varying, respectively, the elasticity of labor supply ($1/\phi$), risk aversion (ρ), consumption home bias (γ), the Taylor rule coefficient on output (δ), the interest rate smoothing coefficient (ϑ), the persistence of demand shocks (ψ), the Calvo price adjustment parameter (κ) and the variance of demand shocks and monetary shocks. In all these cases the general qualitative properties of the relationship between χ and gross positions in equities and bonds is largely unchanged by the parameter variations. In some cases, the gross equity becomes negative (i.e. the home country holds a short position in foreign equity) or the gross bond position is negatively related to χ for low values of χ. These effects are however quantitatively quite small. The dominant property is that gross positions are positive and increasing in χ.

The effects of these parameter variations on the conditional standard deviations of asset returns and relative income and the conditional correlation of asset returns with relative income are not illustrated, but the general properties illustrated in Figures 2 and 3 continue to hold for the parameter variations illustrated in Figures 5 to 20.

We conclude that the general properties illustrated for the benchmark parameter set (with productivity, money and demand shocks) are robust across a wide range of parameter variations.

7 Discussion

Our model suggests that a more aggressive monetary policy which reduces the variability of inflation in almost all cases leads to an increase in gross external assets and liabilities. As we mentioned in the introduction, previous researchers have argued that the causation may go in the other direction. Econometric evidence such as Tytell and Wei (2004) finds that measures of financial globalization have significantly negative coefficient estimates in cross country inflation (level) equations. By contrast, our empirical evidence finds that inflation *variability* is significant in panel regressions of financial globalization. Sorting out the full set of causal links between the level of inflation, the variability of inflation, and financial globalization is beyond the scope of this paper. Both inflation and international portfolio positions are endogenous and affected by all aspects of the macroeconomy, and it is difficult to obtain robust instruments for either variable. Moreover, our theory by no means precludes the possibility that there may be additional forces leading from international financial globalization to inflation either directly or indirectly through endogenous monetary policy. Our main point is that evidence suggesting that increased capital market openness has been associated with reductions in average inflation rates does not necessarily establish the direction of causation, since we have shown that there are strong theoretical reasons to think that there may also be a link between inflation stability and the size of gross external financial positions.

The effect of inflation variability on gross external assets depends on the correlation and variability channels defined above. Are these channels empirically relevant? Our model predicts that a fall in the variance of the relative returns on bonds and equity will lead to a rise in gross external positions. The relative return on nominal bonds is represented by the variance of expected exchange rate changes. In fact, over the major period of financial globalization discussed in this paper, as noted by Rogoff (2006), there was a decline in variability in nominal exchange rates between the major economies. Likewise, there is evidence of an increase in the co-movement of major world stock markets since the mid 1990s (see e.g. Kizys and Pierdzioch, 2009). This should be associated with a fall in the variability of *relative* equity returns.

The second component of the variability effect is determined by the conditional variance of relative income across countries. One way to measure this would be to look at business cycle co-movement across countries. Here, the results of the literature are quite ambiguous. Heathcote and Perri (2002) and Stock and Watson (2003) find that business cycle co-movement among the major economies fell in the 1990's relative to earlier periods. In principal, this should lead to an increase in the conditional variance of relative income across countries. However, using a wider sample of countries, Kose *et al* (2003) find that correlations tended to increase over time during the 1960-99 period.

Note however, that in the case of demand shocks, our model predicts that a fall in inflation variability will still lead to a rise in financial globalization, even though it will cause a decline in the conditional variance of relative income. This is because the rise in gross holdings coming from the fall in the conditional variance of asset returns dominates the effect of the fall in the conditional variance of relative income. Thus, establishing the importance of inflation variability in gross external assets does not necessarily require a fall in business cycle co-movements across countries.

8 Conclusions

This paper investigates the relationship between inflation variability and the size of external asset positions. Panel regression results based on Lane and Milesi-Ferretti's data on gross portfolios show a fairly robust negative relationship between inflation variability and the size of gross positions. Using a general two-country dynamic general equilibrium model, we solve for gross positions and show that the model predicts a relationship between inflation variability and the size of gross positions which has the same general features as the data. Our solutions show that the link between inflation variability and the size of gross positions can be explained by a combination of a return variability effect and a return-income correlation effect. A reduction in inflation variability tends to reduce the variability of returns for both bonds and equities. It is therefore necessary to hold larger positions in bonds and equities in order to achieve the desired level of risk sharing. Lower inflation variability also reduces the amount of extraneous noise in bond and equity positions and thus increases the correlation between asset returns and relative income.

This increases the hedging efficiency of both bonds and equities and therefore increases equilibrium gross positions in bonds and equities.

The paper thus shows that there are strong theoretical reasons to think that there may be a link between inflation stability and the size of gross external financial positions, this suggests that evidence that capital market openness has been associated with reductions in average inflation rates does not necessarily establish the direction of causation.

Appendix

The unconditional one-period ahead covariance matrix of the vector $\begin{bmatrix} r_x^e & r_x^b & \zeta_y \end{bmatrix}'$ can be written as follows

$$\begin{bmatrix} \sigma_e^2 & \sigma_{e,b} & \sigma_{e,\zeta} \\ \sigma_{e,b} & \sigma_b^2 & \sigma_{b,\zeta} \\ \sigma_{e,\zeta} & \sigma_{b,\zeta} & \sigma_\zeta^2 \end{bmatrix}$$

Equation (24) implies

$$\tilde{\alpha} = -\frac{1}{2}\Sigma_r^{-1}\text{cov}_t(r_{x,t+1}, \zeta_{y,t+1}) = -\frac{1}{2}\begin{bmatrix} \sigma_e^2 & \sigma_{e,b} \\ \sigma_{e,b} & \sigma_b^2 \end{bmatrix}^{-1}\begin{bmatrix} \sigma_{e,\zeta} \\ \sigma_{b,\zeta} \end{bmatrix} \tag{32}$$

So

$$\tilde{\alpha}_e = -\frac{1}{2}\frac{\sigma_{e,\zeta}\sigma_b^2 - \sigma_{e,b}\sigma_{b,\zeta}}{\sigma_e^2\sigma_b^2 - \sigma_{e,b}^2} \tag{33}$$

$$\tilde{\alpha}_b = -\frac{1}{2}\frac{\sigma_{b,\zeta}\sigma_e^2 - \sigma_{e,b}\sigma_{e,\zeta}}{\sigma_e^2\sigma_b^2 - \sigma_{e,b}^2} \tag{34}$$

Following Eaton (2007) Section 3.4 it is possible to show that the covariance matrix of the vector $\begin{bmatrix} r_x^e & \zeta_y \end{bmatrix}'$ conditional on r_x^b is given by

$$\begin{bmatrix} \sigma_e^2 & \sigma_{e,\zeta} \\ \sigma_{e,\zeta} & \sigma_\zeta^2 \end{bmatrix} - \frac{1}{\sigma_b^2}\begin{bmatrix} \sigma_{e,b} \\ \sigma_{b,\zeta} \end{bmatrix}\begin{bmatrix} \sigma_{e,b} & \sigma_{b,\zeta} \end{bmatrix} = \begin{bmatrix} \frac{\sigma_e^2\sigma_b^2 - \sigma_{e,b}^2}{\sigma_b^2} & \frac{\sigma_{e,\zeta}\sigma_b^2 - \sigma_{e,b}\sigma_{b,\zeta}}{\sigma_b^2} \\ \frac{\sigma_{e,\zeta}\sigma_b^2 - \sigma_{e,b}\sigma_{b,\zeta}}{\sigma_b^2} & \frac{\sigma_\zeta^2\sigma_b^2 - \sigma_{b,\zeta}^2}{\sigma_b^2} \end{bmatrix}$$

from which it follows that

$$\begin{aligned} \text{corr}\left(\zeta_{y,t}, r_{x,t}^e | r_{x,t}^b\right) &= \frac{\sigma_{e,\zeta}\sigma_b^2 - \sigma_{e,b}\sigma_{b,\zeta}}{(\sigma_e^2\sigma_b^2 - \sigma_{e,b}^2)^{1/2}(\sigma_\zeta^2\sigma_b^2 - \sigma_{b,\zeta}^2)^{1/2}} \\ \text{StDev}\left(\zeta_{y,t} | r_{x,t}^b\right) &= \frac{(\sigma_\zeta^2\sigma_b^2 - \sigma_{b,\zeta}^2)^{1/2}}{\sigma_b} \\ \text{StDev}\left(r_{x,t}^e | r_{x,t}^b\right) &= \frac{(\sigma_e^2\sigma_b^2 - \sigma_{e,b}^2)^{1/2}}{\sigma_b} \end{aligned}$$

Substituting these expressions into (25) and simplifying yields (33).

Likewise the covariance matrix of the vector $[\begin{array}{cc} r_x^b & \zeta_y \end{array}]'$ conditional on r_x^e is given by

$$\left[\begin{array}{cc} \sigma_b^2 & \sigma_{b,\zeta} \\ \sigma_{b,\zeta} & \sigma_\zeta^2 \end{array}\right] - \frac{1}{\sigma_e^2}\left[\begin{array}{c} \sigma_{e,b} \\ \sigma_{e,\zeta} \end{array}\right]\left[\begin{array}{cc} \sigma_{e,b} & \sigma_{e,\zeta} \end{array}\right] = \left[\begin{array}{cc} \frac{\sigma_e^2\sigma_b^2-\sigma_{e,b}^2}{\sigma_e^2} & \frac{\sigma_{e,\zeta}\sigma_b^2-\sigma_{e,b}\sigma_{e,\zeta}}{\sigma_e^2} \\ \frac{\sigma_{e,\zeta}\sigma_b^2-\sigma_{e,b}\sigma_{e,\zeta}}{\sigma_e^2} & \frac{\sigma_\zeta^2\sigma_b^2-\sigma_{b,\zeta}^2}{\sigma_e^2} \end{array}\right]$$

from which it follows that

$$\begin{aligned} \operatorname{corr}\left(\zeta_{y,t}, r_{x,t}^b | r_{x,t}^e\right) &= \frac{\sigma_{e,\zeta}\sigma_b^2-\sigma_{e,b}\sigma_{e,\zeta}}{(\sigma_e^2\sigma_b^2-\sigma_{e,b}^2)^{1/2}(\sigma_\zeta^2\sigma_b^2-\sigma_{b,\zeta}^2)^{1/2}} \\ \operatorname{StDev}\left(\zeta_{y,t} | r_{x,t}^e\right) &= \frac{(\sigma_\zeta^2\sigma_b^2-\sigma_{b,\zeta}^2)^{1/2}}{\sigma_e} \\ \operatorname{StDev}\left(r_{x,t}^b | r_{x,t}^e\right) &= \frac{(\sigma_e^2\sigma_b^2-\sigma_{e,b}^2)^{1/2}}{\sigma_e} \end{aligned}$$

Substituting these expressions into (26) and simplifying yields (34).

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Figure 1: Average of G7 data (excluding Germany)

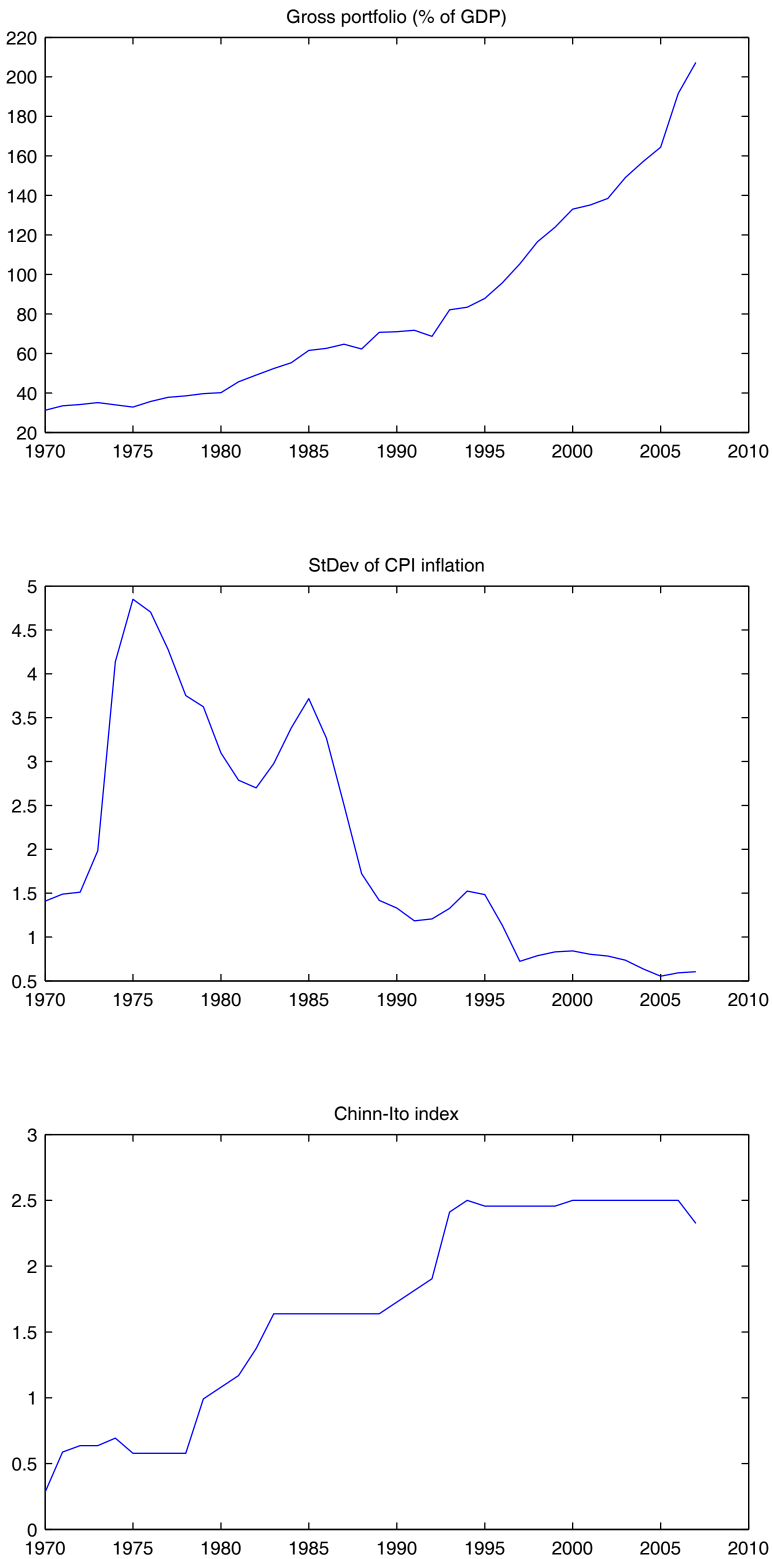


Figure 2: Inflation stabilization and gross portfolio holdings. Benchmark parameter values with shocks to productivity and monetary policy.

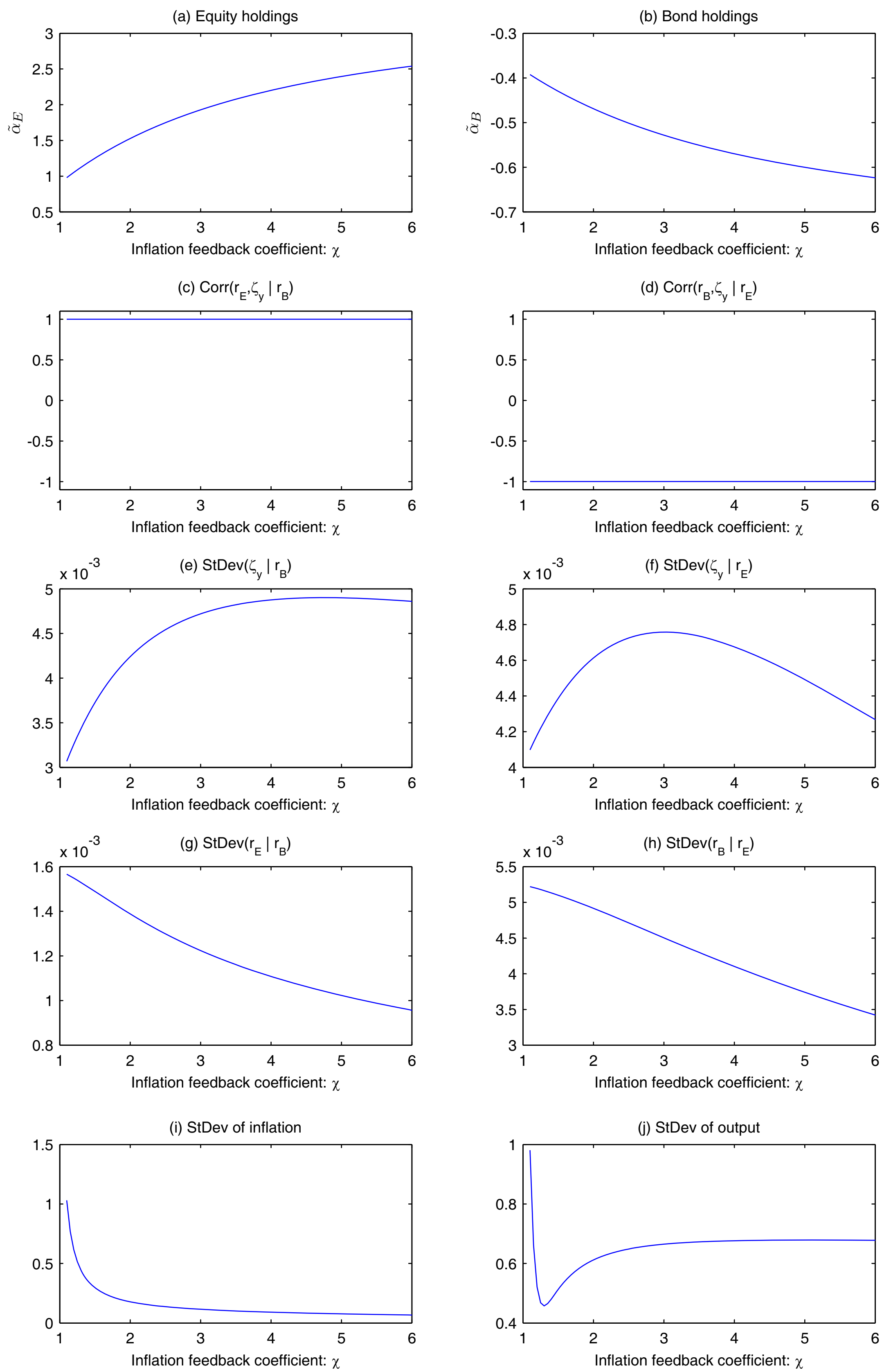


Figure 3: Inflation stabilization and gross portfolio holdings. Benchmark parameter values with shocks to productivity, monetary policy *and demand.*

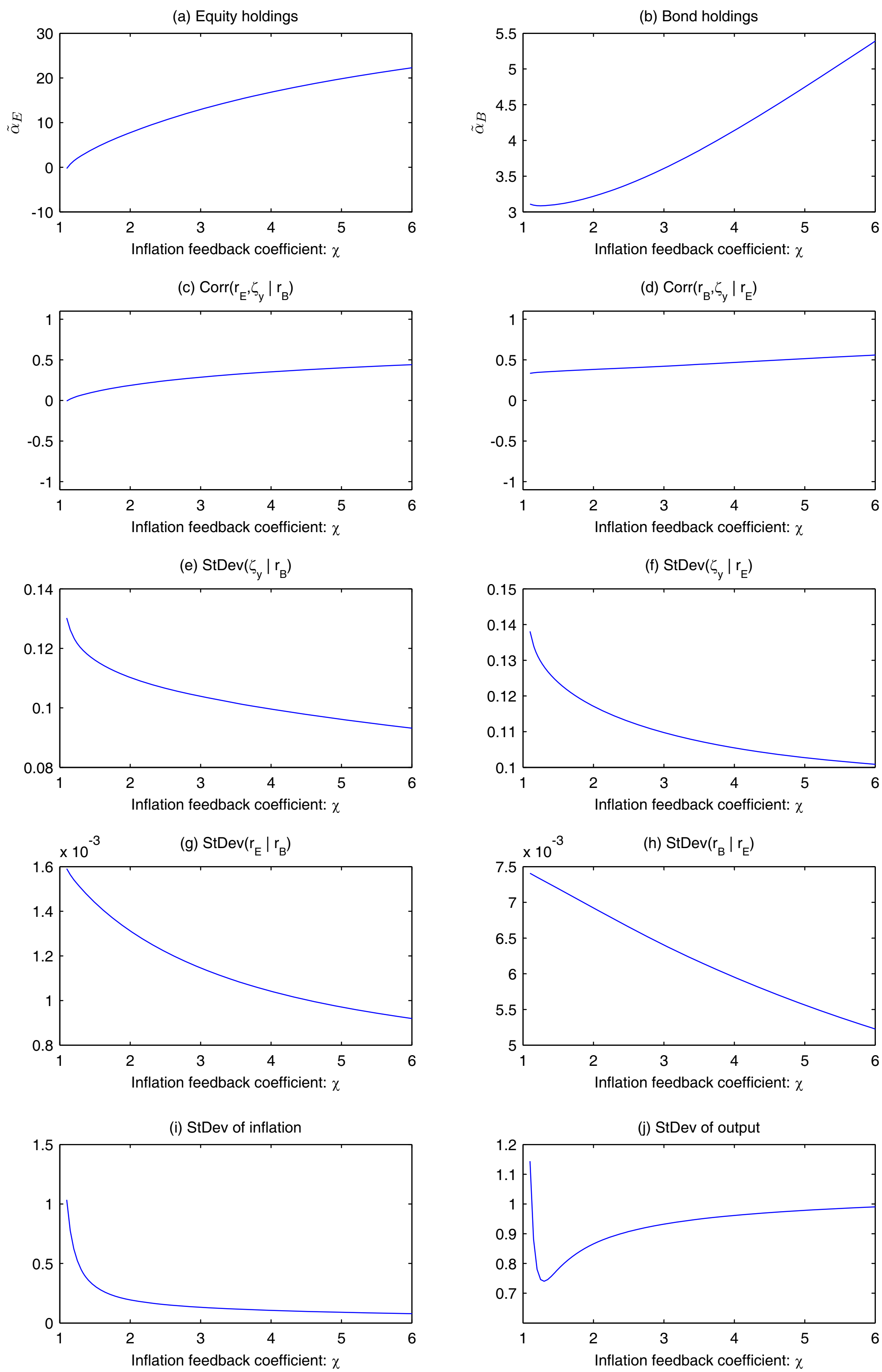


Figure 4: Inflation stabilization and gross bond holdings. Benchmark parameter values with shocks to productivity and monetary policy. (cf. Devereux and Sutherland, 2008)

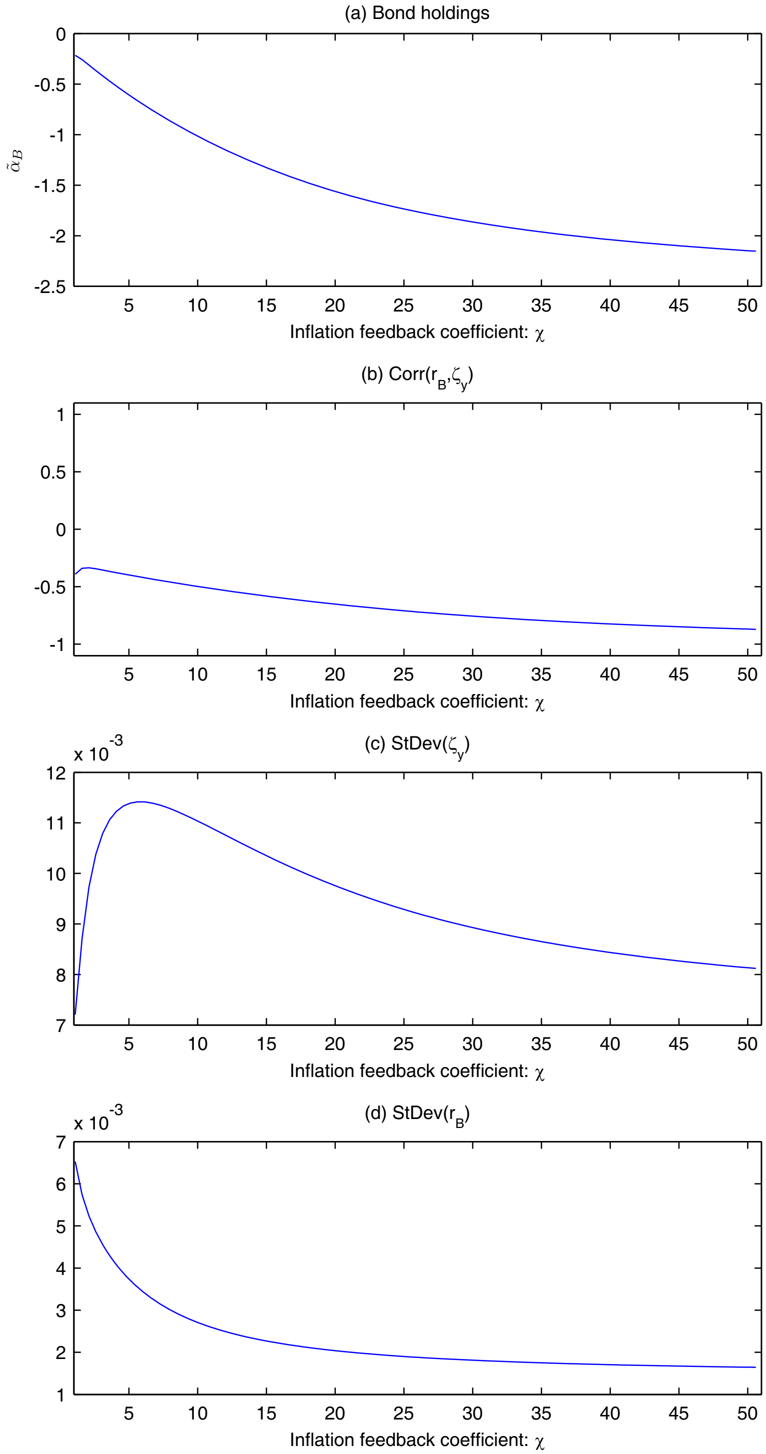


Figure 5: Lower trade elasticity (θ=0.8)

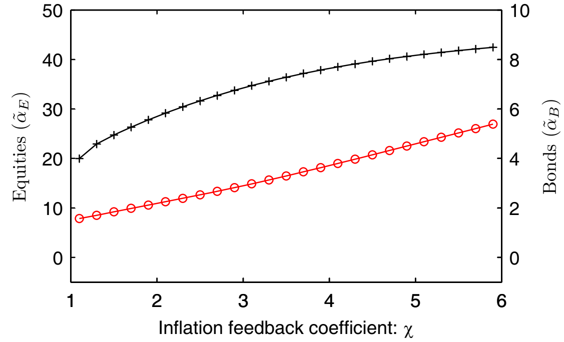


Figure 6: LCP (and θ=1.5)

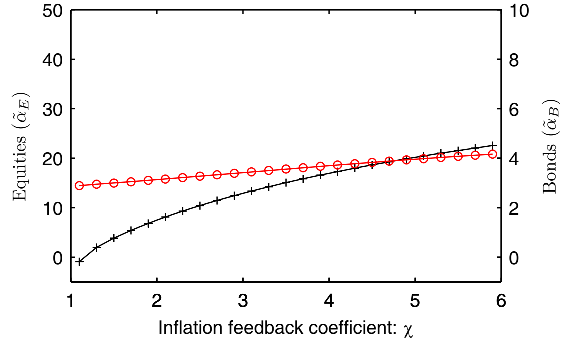


Figure 7: LCP and lower trade elasticity (θ=0.8)

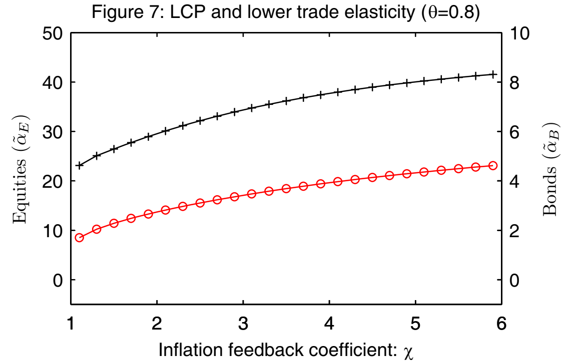


Figure 8: No money shocks

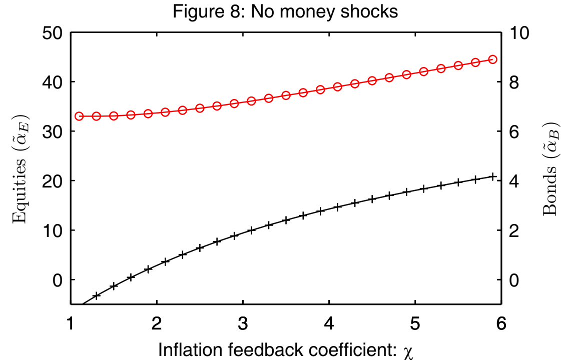


Figure 9: Lower elasticity of labour supply (ϕ=1.5)

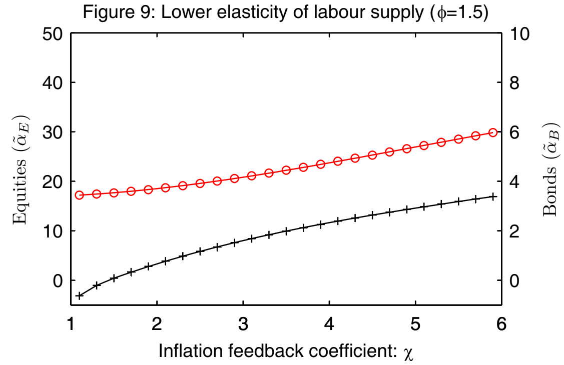


Figure 10: Higher risk aversion (ρ=2)

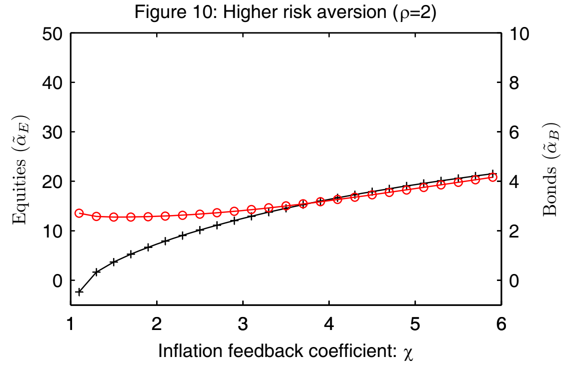


Figure 11: Lower consumption home bias (γ=0.75)

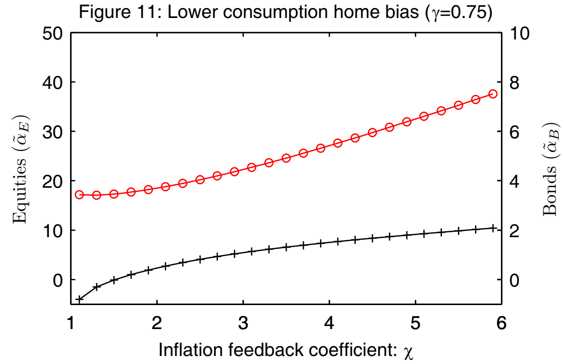
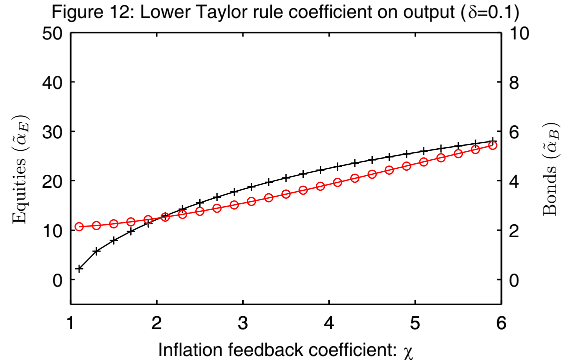


Figure 12: Lower Taylor rule coefficient on output (δ=0.1)



Equities —+— Bonds —o—

Figure 13: Lower degree of interest rate smoothing (ϑ=0.5)

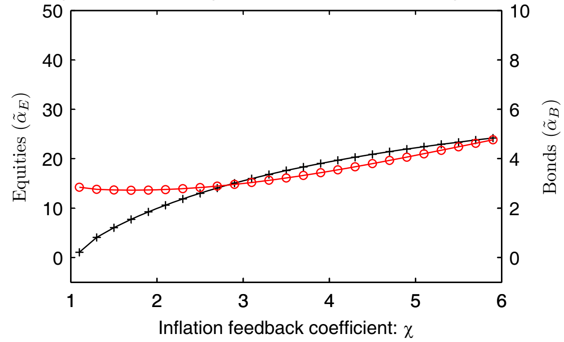


Figure 14: Lower persistence of demand shocks (ψ=0.7)

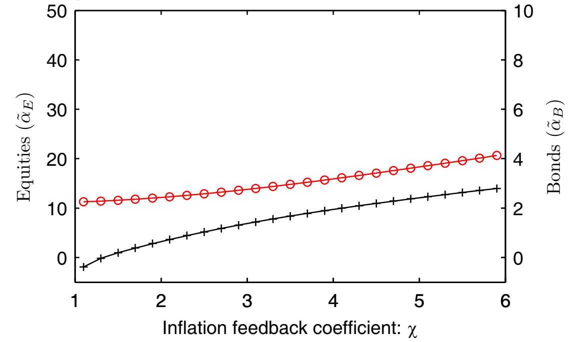


Figure 15: Higher persistence of demand shocks (ψ=0.9)

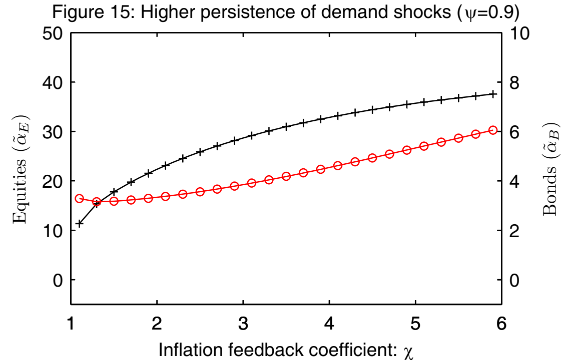


Figure 16: Lower Calvo adjustment parameter (κ=0.6)

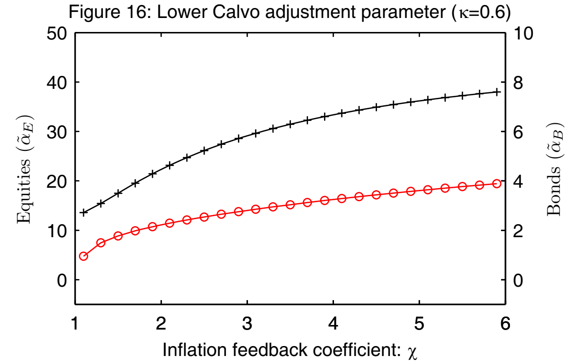


Figure 17: Higher variance of money shocks (σ_M=0.01)

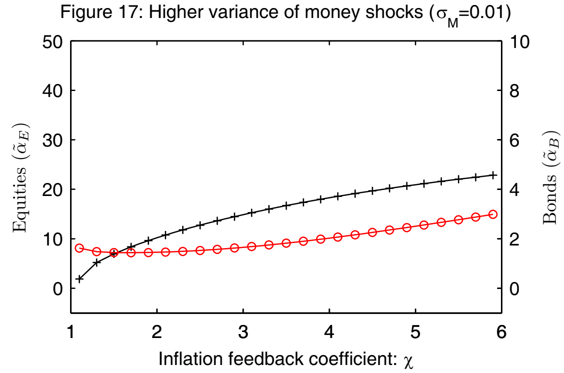


Figure 18: Lower variance of money shocks (σ_M=0.005)

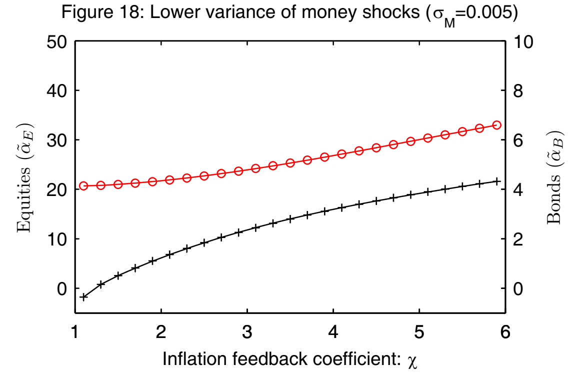


Figure 19: Higher variance of demand chocks (σ_v=0.015)

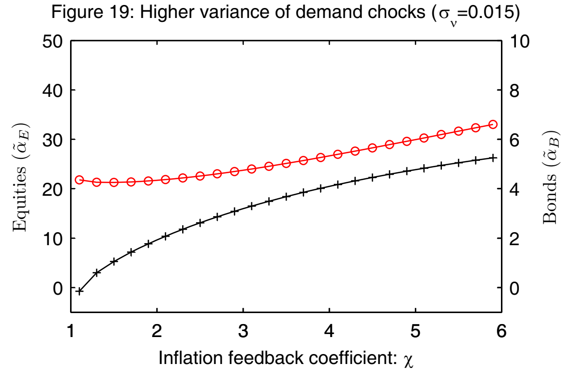


Figure 20: Lower variance of demand shocks (σ_v=0.0075)