Macroeconomic Volatility and External Imbalances*

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Abstract

We explore the relationship between macroeconomic volatility of a country and its net foreign asset position. We show that in OECD economies over the period 1970-2005 changes in country specific macroeconomic volatility are strongly positively associated with changes in net external asset position. We show that this relation arises naturally in the context of a standard open economy consumption/saving/investment model. Changes in macroeconomic volatility act as observable changes in the rate of time preference which increase the gain from inter-temporal trade and hence make large imbalances more likely. We conclude that time varying macroeconomic volatility is a quantitatively important factor to understand and forecast the evolution of external imbalances across OECD countries.

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KEY WORDS: Business cycle volatility, Precautionary saving, Current account, Net foreign asset position

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1 Introduction

This paper argues that time varying macroeconomic volatility is a quantitatively important determinant of decisions of agents living in the country and hence of a country macroeconomic outcomes. Our main focus is on the impact that macroeconomic volatility has on the net foreign asset position through consumption and saving decisions. We first show that, for OECD countries over the last 30 years, changes in macroeconomic volatility are strongly positively associated with large changes in net foreign asset position.

In order to understand these patterns we introduce time varying macroeconomic uncertainty in a standard open economy model and show that the model can account for this relationship well. The intuition is simple: in response to increases in domestic uncertainty agents increase their precautionary saving balances. Decreasing returns in domestic capital, increasing risk of domestic capital and the assumption of open economy imply that the bulk of additional saving will go into foreign assets. If changes in uncertainty are persistent, the accumulation of foreign assets continues through time and can lead to sizeable changes in net foreign asset positions.

Our findings suggest then that time varying uncertainty, which is usually ignored in macroeconomic analysis, is an important factor to understand macroeconomic outcomes, especially in the context of open economies. In particular we find that time varying uncertainty alone can generate, in a typical sample path, dispersion in net foreign asset positions that is about one half of the dispersion we observe in OECD data. We also find the model useful to precisely understand and quantify the channels through which uncertainty affects agents' decision and to understand how the effects of uncertainty depend on structural aspects of the economy such as preferences, persistence of shocks, size and access to international financial markets.

This paper is related to two strands of literature. The first is the one which studies the recent phenomenon of "global imbalances" and search for causes of the growing dispersion of external imbalances in various countries.[1] Our study suggests that, in a world with integrated capital markets and persistent differences in country specific volatilities, large imbalances are bound to emerge as differences in volatility act as differences in rate of time preferences and hence create a strong motives for intertemporal trade. The second strand is the literature that studies the effect of uncertainty on macroeconomic outcomes (see for example Barlevy 2004, Bloom 2007 Justiniano and Primiceri, 2008). The paper

[1] See for example Backus et al. 2006, Blanchard, 2007, Caballero, Fahri and Gourinchas (2008), Fogli and Perri (2006) and Mendoza, Quadrini and Rios-Rull (2006)

is organized as follows. Section 2 provides empirical evidence on the relationship between volatility of output growth and external imbalances. Section 3 presents the model. In section 4 we describe how we use the model to understand the data. Section 5 analyzes the importance of different structural factors in how uncertainty affects the economy and Section 6 concludes.

2 Empirical evidence

This section first establishes that for developed countries changes in macroeconomic volatility are positively associated with sizeable changes in net foreign asset position. This relationship constitutes our key piece of evidence about the role of precautionary motives in determining inter-temporal trade patterns across countries.

Our sample consist of the set of all OECD countries for which we could obtain comparable (across time and countries) macroeconomic data starting in the early 1980s.[2] Our benchmark measure of macroeconomic volatility for a country in a given time interval is the standard deviation of quarterly real GDP growth over the interval. Our benchmark measure of net foreign asset position is total gross foreign assets minus total gross foreign liabilities over GDP, averaged over the same interval. To investigate the relationship between these two variables we first split the sample period in two sub-samples, an early one, from 1970 to 1985 and a late one, from 1990 to 2005. We then compute the average net foreign asset position and the standard deviation of GDP growth over the two subperiods for each country. Figure 1 plots the change between subperiods in average net foreign asset position against the change between subperiods in volatility across all countries in the sample.

The figure clearly shows a positive association between changes in volatility and changes in net foreign asset position. Notice how most countries have experienced, over the two subperiods under consideration, a reduction in business cycle volatility (also known as the "international great moderation"), but there is considerable variation in the extent of this reduction. Some countries, such as Britain and Netherlands, have experienced a reduction in growth volatility larger than 50 basis points. In these countries the net foreign asset to GDP ratio has on average declined by 20 percentage points. On the other end, some countries, such as Korea or Switzerland, have experienced no reduction in growth volatility at all. In these countries the net foreign asset to GDP ratio has on average increased by 20 percentage

[2] Our dataset includes 20 countries with data starting in the first quarter of 1970 and ending in the last quarter of 2005.All the national accounts data is from the OECD Quarterly National Accounts. The foreign asset position data is from Lane and Milesi-Ferretti (2006).

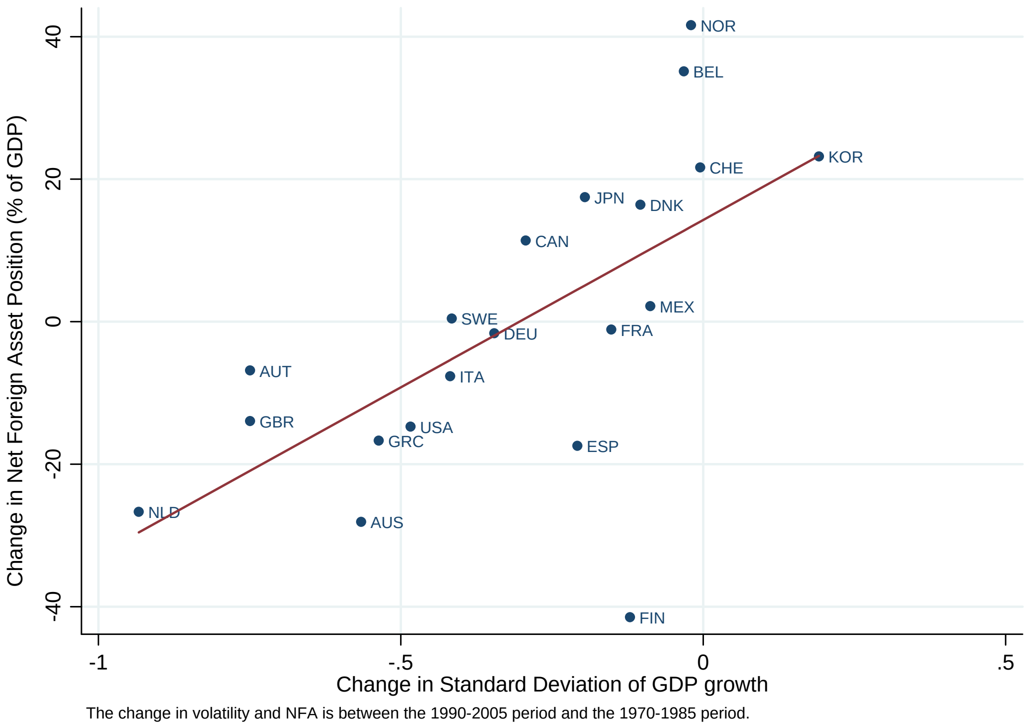

Figure 1: Changes in volatility and net foreign asset positions

points. This evidence suggests that differences across countries in macroeconomic volatility are associated to large differences in external imbalances over long periods of time.

Next, we then explore the comovement of the two variables at shorter horizons. Figure 2 provides a comprehensive summary of our dataset plotting trends of net foreign asset position and volatility of GDP growth in each year for all countries in our sample. Both measures are computed in each year using 10 years rolling windows (always using quarterly data for volatility and yearly data for NFA position), where the time indicator in each graph represents the mid year of the window.

The figure reveals that, for most countries the strong association between volatility and external asset position still holds at the yearly frequency. In particular most countries which experience a decline in volatility also experience a decline in net foreign asset position, with the declines in the two variables being in many cases coincident within each country but not necessarily synchronous across countries. Observe how, for example, Italy experiences a simultaneous decline in volatility and net foreign asset position in the 1980s while Germany experiences a similar decline in the 1990s. Also, interestingly, the (fewer) instances in which volatility increases (Norway and Switzerland in the 1980s, Japan post 1980s, Korea in the

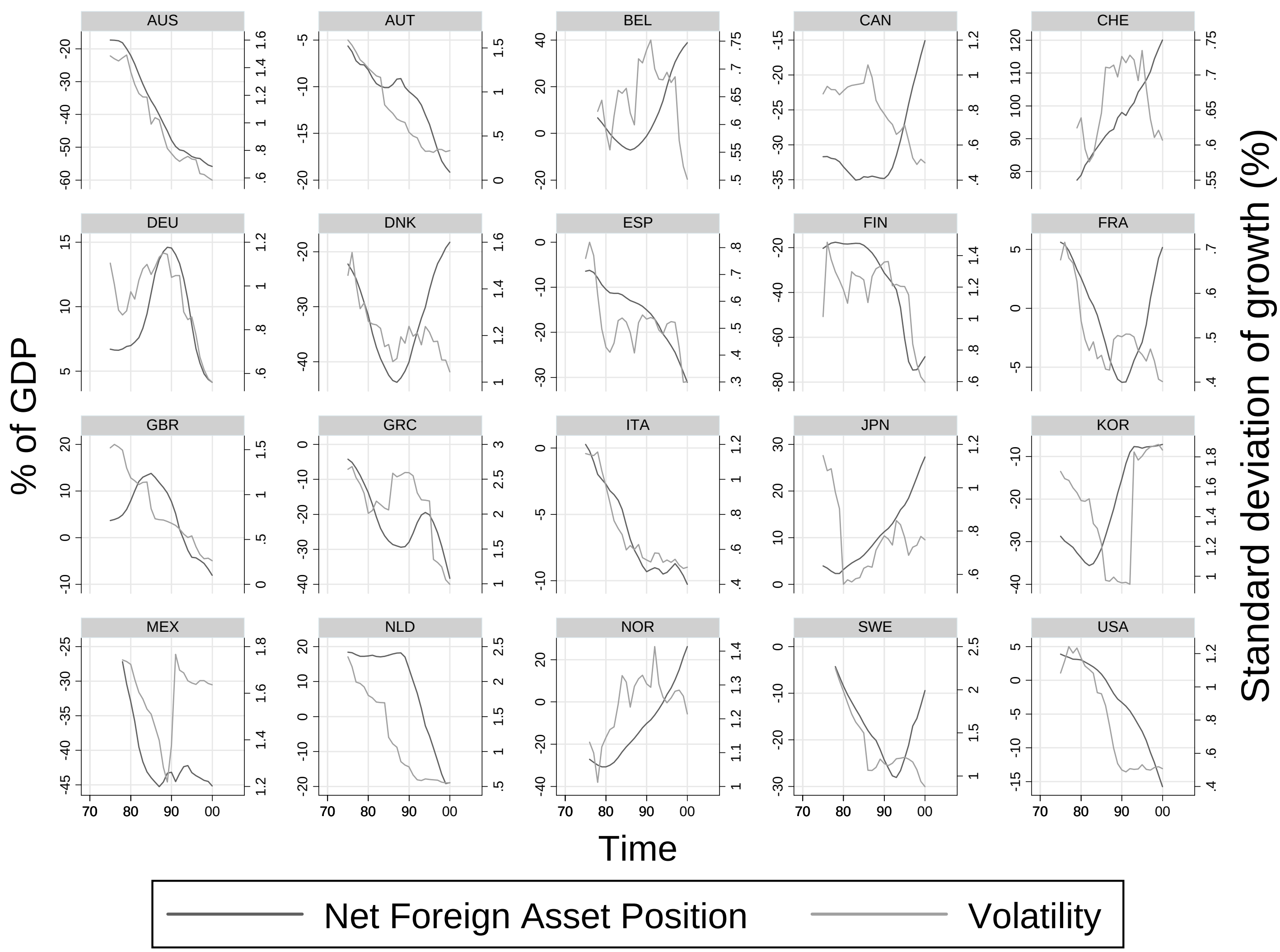

Figure 2: Volatility and net foreign asset positions

1990s) are also characterized by the accumulation of the net foreign assets.

We next turn to linear regression analysis in order to quantify the extent of the co-movement between the two variables while controlling for potential sources of spurious correlation. Table 1 reports the coefficients obtained regressing our measure of net foreign assets (averaged over 10 years windows) on volatility (computed as the standard deviation of GDP growth over the same window) and on a set of controls, which include country and year fixed effects (included in all specifications), average GDP growth, average inflation, standard deviation of inflation, and two measures of financial openness. The first measure is gross international financial diversification (foreign assets plus foreign liabilities over GDP) while the second measure is the Chinn-Ito index of financial openness. All the controls are also computed using the 10 year window. Table 1 reports the results obtained for four different specifications of the regression. The results in the first column are those obtained in the baseline regression that only includes volatility as a control, together with country and time fixed effects. We then add progressively more controls. Specifically, we add average GDP growth in column (ii), our two measures of inflation over the period in column (iii) and the two measures of financial openness in column (iv). We find that the volatility of GDP growth is significant at the 1% level in all specifications, even when standard errors are estimated in the most conservative fashion, i.e. allowing for arbitrary correlation structure for the errors at the country level.[3]

The magnitude of the coefficient is stable across specifications and economically relevant. As an example, a 1% reduction in volatility (like the one experienced by Australia over our sample period) is associated with a decline of the ratio of net foreign asset position to GDP of about 18% (which is about 1/2 of the total decline in net foreign asset experienced by Australia). Both country and time dummies are also strongly significant reflecting the importance of country specific factors and of common time trends (such financial globalization) in explaining trends in net foreign assets. The rationale for including the additional variables in the regression is to control for potential changes in policy which would at the same time affect country volatility and external imbalances. We first control for policies indirectly by including average GDP growth over the period as, for example, good macroeconomic policies might lead to higher growth (and hence higher international borrowing) and at the same time lower volatility. We also control for policies directly by including two commonly used measures of monetary policy (average and standard deviation of inflation) and two measures of financial integration. We find it remarkable that none of these measures is significant in explaining the changes in net foreign assets.

[3]OLS and robust (without accounting for clustering) standard errors are sizeably smaller.

Table 1: Volatility and External Imbalances

	Dependent variable is Net Foreign Assets					
	(i)	(ii)	(iii)	(iv)	(iv)	(iv)
Volatility of GDP Growth	18.15***	18.49***	19.48***	17.90***	16.90***	
	(4.407)	(4.93)	(5.52)	(5.54)	(4.85)	
Average GDP Growth		1.213	3.01	4.86	8.591	-2.05
		(6.48)	(6.49)	(8.13)	(6.53)	(6.39)
Average Inflation			1.25	1.55	0.406	-1.66
			(1.73)	(1.58)	(1.64)	(1.44)
Volatility of Inflation			0.08	0.66	0.845	2.85
			(3.21)	(3.26)	(2.63)	(3.11)
Financial Openess 1				1.611	-0.078	-0.52
				(2.32)	(2.20)	(2.58)
Financial Openess 2				-3.61	-2.49	-2.86
				(4.90)	(4.63)	(5.83)
Trade Openess					-0.82	-0.90
					(0.53)	(0.58)
N	506	506	506	494	494	494
adj. R^2	0.897	0.897	0.898	0.870	0.879	0.861

Robust standard errors in parentheses account for clustering at the country level.

All regressions include a constant, country and year fixed effects.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In table 2 we investigate the robustness of our results to alternative way of computing volatility of GDP growth and to changes in the sample. In the first two columns we report results when we compute all our variables (including volatility) over 5, as opposed to 10, years windows. Notice how the coefficient on volatility remains strongly significant and although it is lower it is not statistically different from the one previously estimated. are not reported for In the second two columns we compute the volatility of GDP growth by estimating a univariate GARCH(1,1) on quarterly data from our sample and then take yearly averages of the quarterly series of conditional standard deviation resulting from the GARCH. Notice that volatility is still significant, although less so than in previous specifications. We believe that this is due to the higher level of high frequency variation in the volatility estimated from the GARCH, which is not associated with high frequency variation in net foreign asset position. So this result suggest that most of the association between volatility and newt foreign asset positions happens at medium low frequencies. In the last 2 columns we restrict the sample to include only the 1985-2005 which is a period of lower business cycles volatility and higher financial integration.

For the sake of brevity we do not report all the additional controls included in table 1 but for none of the specifications reported in table 2 they are significant.

Table 2: Volatility and External Imbalances – Alternative Measures and Sample

	Dependent variable is Net Foreign Assets[a]					
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Volatility GDP Growth_5yrs	10.41***	10.11***				
	(3.028)	(2.954)				
Growth_5yrs		-1.111				
		(4.172)				
Volatility GDP Growth			14.23**	14.41**		
(from GARCH)			(5.098)	(5.148)		
Growth_1yr				0.598		
				(1.296)		
Volatility GDP Growth					16.42**	15.21**
(1985-2005)					(6.628)	(7.217)
Average GDP Growth						-2.599
						(8.103)
N	582	582	626	626	320	320
adj. R^2	0.825	0.825	0.763	0.762	0.923	0.923

a) Net foreign asset position in each specification is computed on the same window used for computing volatility

Robust standard errors in parentheses account for clustering at the country level.

All regressions include a constant, country and year fixed effects.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Our final empirical result shows how the relation between macroeconomic volatility and net foreign asset position is affected by the size of the countries considered. In the first column of table 3 we report again the results from the basic regression in table 1. In columns 2 through 5 of the table we report the coefficient of the same regression run on different samples, including countries increasing in size. The key result from the table is that the point estimates of the coefficient of volatility on imbalances are declining with the size of the countries in the sample, suggesting that for small countries, for example, an increase in volatility should lead to a larger reduction of imbalances, relative to large countries.[4] In the next section we'll see that this property will arise naturally in the class of models we consider.

Table 3: Volatility and External Imbalances –Small and Large Countries

Dependent variable is Net Foreign Assets

	(i)	(ii)	(iii)	(iv)	(v)
	All countries		Small countries		Large
		$<= Sweden$	$<= Mexico$	$<= Canada$	
Mean growth	1.213	6.643	7.034	4.129	-11.88
	(6.476)	(4.373)	(5.303)	(5.249)	(11.65)
Volatility	18.49***	24.25**	21.22***	19.25***	13.74**
	(4.931)	(9.522)	(6.270)	(5.838)	(4.650)
N	506	197	298	350	156
adj. R^2	0.897	0.912	0.900	0.896	0.693

Standard errors in parentheses account for clustering at the country level

All regressions include country and year fixed effects

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The main result of this section is that for OECD countries there is a strong and robust association between changes over time in volatility and changes in net foreign asset position. In the next section we will show such a link arises naturally in a simple open economy model of consumption/saving/investment decisions.

3 Model

We consider a version of the standard one-good two-country business cycle model (as Backus, Kehoe Kydland, 1992 or Baxter and Crucini, 1995) with a variety of assumptions about international asset trade and with time varying business cycle volatility. In the model agents face persistent country specific productivity shocks and in general international financial markets do not allow perfect insurance of country specific risk: this

[4]This result is only suggestive as statistically we cannot reject the hypothesis that the coefficient of interest is the same for small and large countries

implies that agents in both countries have a precautionary saving motive. If the volatility of shocks changes over time and across countries, the precautionary motive also changes and this naturally generates, in a open economy equilibrium, external imbalances, with the more volatile country accumulating a net positive external position vis-a-vis the with the less volatile one. So this model (if solved with non linear methods) has a natural link between changes in volatility and changes in imbalances and is a good laboratory to check whether precautionary saving motive can account for the observed link between volatilities and imbalances.

The world economy consists of two equal size countries, $i = 1, 2$, each inhabited by a large number of infinitely-lived consumers and endowed with a constant returns to scale production technology operated by competitive firms. Time is discrete and each period is a quarter. The countries produce a single good, and their preferences and technology have the same structure and parameter values. The labor input consists only of domestic labor, and production is subject to country-specific technology shocks.

In each period t, the economy experiences one of finitely many events $s_{t.}$ We denote by $s^t = (s_0, \ldots, s_t)$ the history of events up through and including period t. The probability, as of period zero, of any particular history s^t is $\pi(s^t)$. We assume that idiosyncratic risk within each country is perfectly insured among residents so we can consider a representative consumer in each country who has preferences of the form

$$\sum_{t=1}^{\infty} \sum_{s^t} \beta^t \pi(s^t) U(c_i(s^t), l_i(s^t)) \tag{1}$$

where $c_i(s^t)$ and $l_i(s^t)$ denote consumption and labor of the representative consumer in country i after history s^t, $U(c, l)$ is a standard utility function and $\beta > 0$ is a positive parameter capturing their rate of time preference. The representative agents in the two countries are endowed with one unit of time and they supply labor to domestic firms in exchange for a wage $w_i(s^t)$, own and (possibly) trade share in domestic and foreign firms, trade internationally an uncontingent default-free bond $b_i(s^t)$ which pays a gross interest $R(s^t)$ and choose consumption in each state of the world to maximize their expected lifetime utilities, given in (1) subject to the following budget constraints:

$$\begin{aligned} & c_1(s^t) + b_1(s^t) + \lambda_1(s^t)p_1(s^t) + \lambda_1^F(s^t)p_2(s^t) \qquad (2) \\ \leq \; & l_1(s^t)w_1(s^t) + \lambda_1(s^{t-1})(d_1(s^t) + p_1(s^t)) + (\lambda_1^F(s^{t-1}))(d_2(s^t) + p_2(s^t)) + b_1(s^{t-1})R(s^{t-1}) \\ & c_2(s^t) + b_2(s^t) + \lambda_2(s^t)p_2(s^t) + \lambda_2^F(s^t)p_1(s^t) \qquad (3) \\ \leq \; & l_2(s^t)w_2(s^t) + \lambda_2(s^{t-1})(d_2(s^t) + p_2(s^t)) + (\lambda_2^F(s^{t-1}))(d_1(s^t) + p_1(s^t)) + b_2(s^{t-1})R(s^{t-1}) \end{aligned}$$

and initial conditions

$$\lambda_i(s^0), \lambda_i^F(s^0), b_i(s^0) \text{ given}$$

In (2) and (3) $d_i(s^t)$ denote dividend paid by firms in country i, $\lambda_i(s^t)$ and $\lambda_i^F(s^t)$ denote holdings of shares of domestic and foreign firms, and $p_i(s^t)$ denote the price of shares of domestic and foreign firms. In the case in which we exogenously restrict

$$\begin{aligned} \lambda_1(s^t) &= \lambda_2(s^t) = 1 \text{ for every } s^t \\ \lambda_1^F(s^t) &= \lambda_2^F(s^t) = 0 \text{ for every } s^t \end{aligned}$$

our setup reduces exactly to the Baxter and Crucini model in which the only asset that is trade internationally is a single non contingent bond. Competitive firms own the capital stock installed in each country $k_i(s^t)$ and hire labor to operate a Cobb-Douglas technology and solve the following problem

$$\begin{aligned} & \max_{l_i(s^t),k_i(s^t),x_i(s^t)} \sum_{t=1}^{\infty} \sum_{s^t} d_i(s^t)Q_i(s^t) \\ & s.t. \\ d_i(s^t) &= A_i(s^t)l_i^{1-\alpha}(s^t)k_i^{\alpha}(s^{t-1}) - w_i(s^t)l_i(s^t) - x_i(s^t) \\ k_i(s^t) &= (1-\delta)k_i(s^{t-1}) + x_i(s^t) - \phi k_i(s^{t-1}) \left[\frac{x_i(s^t)}{k_i(s^{t-1})} - \delta \right]^2 \\ & k_i(s^0) \text{ given} \end{aligned}$$

where $Q_i(s^t)$ are state contingent prices used by firms to evaluate dividend payments in state s^t, $A_i(s^t)$ is a country-specific total factor productivity shock which follows an exogenous process with time varying volatility (the process will be specified in the next section), α is a constant parameter determining the relative importance of capital and labor in production, $x_i(s^t)$ represent investment, δ and ϕ are fixed parameters that determine the rate of capital depreciation and the size of capital adjustment costs, respectively. .Notice how the state-contingent consumption prices $Q_i(s^t)$ affect firms decisions regarding how to divide earnings between investment and dividend payments. In the reminder of the paper we assume that domestic firms use the stochastic discount factor of the representative domestic household to price the marginal cost of foregoing current dividends in favor of extra investment[5], i.e.

$$Q_i(s^t) = \beta^t \pi(s^t) U_c(c_i(s^t), l_i(s^t))$$

.An equilibrium for this economy is defined as a collection of mappings for prices $w_i(s^t), r_i(s^t), p_i(s^t), R(s^t)$, exogenous processes $A_i(s^t)$ quantities $c_i(s^t), x_i(s^t), k_i(s^t)$, and portfolio choices $b_i(s^t), \lambda_i(s^t), \lambda_i^F(s^t)$ such that, when consumers and firms take prices and exogenous processes as given, the quantities and portfolio choices solve their optimization problems and such that the markets for consumption/investment goods, capital, labor, bonds and stocks clear in each country, in each date t and in each state s^t.

4 Results

We will now use the model just described to answer the following questions:

i) What are the effects of a change in volatility of business cycle shocks in a particular country?

ii) What is the relation between volatility and net foreign asset position implied by the model and more specifically which fraction of the dispersion of external imbalances in OECD countries can be explained by time varying volatility?

iii) How does the importance of volatility changes depend on structural features of the economy?

To answer these questions, we first choose parameter values and then characterize the numerical solution of the model.

4.1 Parameters and computation

We need to set a functional form for the utility function $U(c, l)$, values for the discount factor β, for the technology parameters α, δ and ϕ and most importantly for the process for TFP shocks $A_i(s^t)$. The discount factor β, the capital depreciation rate δ, the share

[5] When ownership of the domestic firm is internationally dispersed it is possible to make different assumption about $Q_i(s^t)$ as foreign and domestic consumers may value differently dividend payments in a given state.

of capital in production α and the capital adjustment costs ϕ are set so that a symmetric equilibrium in the model (i.e. an equilibrium in which both countries face equally volatile shocks) displays an average return to capital of 4%, a yearly average capital to GDP ratio of 2.5, an average share of GDP going to labor equal to 64% and an investment series which is 3 times as volatile as the GDP series. These values are typical for the US and other major world economies and the structure of the model allow us to easily and precisely identify the parameters. The functional form and the parameters describing preferences of the representative agents in both countries are obviously important.. In the benchmark case we assume a standard Cobb Douglas utility

$$U(c,l) = \frac{1}{1-\sigma}\left[c^{\mu}(1-l)^{\mu}\right]^{1-\sigma}$$

and we set the parameter μ in order to match a fraction of time spent working equal to 1/3 and we set the curvature parameter to 2 In section 6 below we will explore more the role if the curvature parameter and of the functional form for utility.The last important input of the model is the stochastic process for TFP shocks. We will specify it as a bi-variate autoregressive process of the form

$$\begin{bmatrix} \log(A_1(s^t)) \\ \log(A_2(s^t)) \end{bmatrix} = \begin{bmatrix} \rho & \psi \\ \psi & \rho \end{bmatrix} \begin{bmatrix} \log(A_1(s^{t-1})) \\ \log(A_2(s^{t-1})) \end{bmatrix} + \begin{bmatrix} \varepsilon_1(s^t) \\ \varepsilon_2(s^t) \end{bmatrix} \tag{4}$$

where ρ and ψ are fixed parameters and $\varepsilon_i(s^t)$, are jointly normal shocks with zero mean, variance $\sigma_i^2(s^t)$ and correlation coefficient η.The key difference relative to the standard calibration of productivity process is that the standard deviation of the shocks $\sigma_i^2(s^t)$ is stochastic. We first set the parameters $\rho = 1$, $\psi = 0$. As discussed by Baxter and Crucini (1995), this choice of parameters is not inconsistent with data and allows a model like the one discussed above to better match the international cross correlations of output and consumption. Given that choice we can construct a panel for $\varepsilon_i(s^t)$ for all countries in our sample simply using quarterly growth rates of productivity[6] $A_i(s^t)$. We then use the constructed panel for $\varepsilon_i(s^t)$ to construct a panel for $\sigma_i(s^t)$ computing the standard deviation of $\varepsilon_i(s^t)$ on a series of rolling windows. We finally use the constructed panel for $\sigma_i(s^t)$ to

[6]Since capital stock varies very little at quarterly frequencies we obtain an approximate model-consistent measure of productivity simply as the growth rate of GDP minus the labor share $(1-\alpha)$ in production times the growth of employment.

estimate the following process for the variance

$$\sigma_i(s^t) = \rho_\sigma \sigma_i(s^{t-1}) + \sum_i \beta_i cdum_i + \sum_t \beta_t tdum_t + \eta_i(s^t)$$

where $cdum_i$ and $tdum_t$ are country and time dummies, ρ_σ represents the persistence of the standard deviation and $\eta_i(s^t)$ represent shocks to the volatility. This procedure produces estimates of $\rho_\sigma = 0.97$ and of $Std(\eta_i(s^t)) = 0.03\%$. We use these estimates, together with the uncondtional mean of $\sigma_i(s^t)$ to construct a stationary Markov chain for $\sigma_i(s^t)$. We finally assume independence across countries of these processes of residual variance to construct a bivariate Markov chain that we can use as an input in the model above[7]. A final parameter that needs to be chosen is the correlation of productivity shock across countries and we simply set it to 0.3 so to match the average correlation of productivity across all possible pairs of countries in our sample for the period 1970.1 2005.1. Table 2 summarizes our benchmark choices of parameter values.

Table 4. Benchmark Parameter Values

Name	Symbol	Value
Preferences and Technology		
Discount Factor	β	0.99
Utility function	$\frac{1}{1-\sigma}\left[c^\mu(1-l)^\mu\right]^{1-\sigma}$	
Consumption share	γ	0.32
Curvature	μ	2
Capital share	α	0.36
Depreciation rate	δ	0.025
Capital Adjustment Cost	ϕ	3
TFP Shocks		
Persistence	ρ	1
Spillover	ψ	0.0
Correlation	η	0.3
Persistence of $\sigma_i(s^t)$	ρ_σ	0.97
Volatility of innovations to $\sigma_i(s^t)$	$Std(\eta_i(s^t)$	0.03%

Note finally that, since we are interested in capturing the effect of changes in volatilities, we cannot numerically compute equilibria of this model using linearization based

[7]The standard deviation of shocks $\sigma_i(s^t)$ in each country can take 11 possible values so that the bivariate Markov Chain has 121 possible states.

methods, as, in such methods, individuals' and firms' decision rules are independent from second moments of the shocks. We instead compute decision rules using a global solution method that is designed to generate close approximations to true equilibrium allocations across a large portion of the state space; in particular we solve the model by approximating policy functions for consumption $c_i(s^t)$, investment $x_i(s^t)$, bond and stock purchases $b_i(s^t), \lambda_i(s^t), \lambda_i^F(s^t)$, and price functions $w_i(s^t)$ $r_i(s^t), p(s^t)$, $R(s^t)$ as quadratic functions defined over a state space which consists of productivities $A_i(s^t)$, standard deviations of productivities $\sigma_i(s^t)$, installed capital $k_i(s^{t-1})$, bond and stock holdings $b_i(s^{t-1})$ $\lambda_i(s^{t-1}), \lambda_i^F(s^{t-1})$.

4.2 The impact of volatility changes

As a benchmark case we consider the economy parameterized above and in which the only assets traded is a non contingent bond. In Figure 3 below we show the 20 years expected responses of key variables to a permanent unanticipated increase in volatility in country 1. In particular we start both countries with equal standard deviation of volatilities and with other state variables equal to their long run average[8] and we increase the volatility of country 1 from 0.84% to 1.04% (see panel 1).

Notice in panel b how the increase in relative volatility, albeit rather small, leads to a sizeable net foreign asset accumulation from country 1 and a corresponding imbalance in country 2.

In order to understand the dynamics leading up to the imbalance, in panels c through f we report the expected paths of labor, consumption, capital stock, investment, current account and real interest rate. Since consumers in country 1 hold all claims to country 1 GDP, an increase in volatility increases their risk and their precautionary saving motive. This effect makes them more "patient" by effectively changing the "risk adjusted" rate of time preference in country 1. Since there is no similar effect in country 2 the equilibrium interest rate on international bonds (which before the shock was equal to the reciprocal of the common "risk adjusted" discount factor) falls now in between the the reciprocal of the two different discount factors; as a consequence consumption of agents in country 1 will fall on impact but drift upward after and consumption in country 2 will raise on impact and drift downward in subsequent periods. The preferences imply that households desired path of leisure mimics the path of consumption and thus labor supply in country 1 increases

[8]Note in this economy certainty equivalent does not hold hence the long run expected value o of variables are in general different from the value of the variables in the deterministic steady state.

on impact, increasing returns to capital in country 1 and leading to additional capital in country 1 while the opposite happens in country 2. In the long run though the increase in consumption in country 1 is associated with an increase in leisure which eventually leads to reduction in capital invested in country 1 and to the opposite in country 2. Note that, as long as differences in volatility are permanent are permanent, the imbalance continue to grow. This is because an ever increasing consumption path and and an ever falling labor and capital path in country 1 can only be financed by accumulating a growing amounts of foreign assets.

Note also how all variables (i.e. investment, consumption, capital, labor) except net foreign assets have a small and non monotone response to a change in volatility, thus explaining why in our empirical exercise the change in foreign assets and the changes in volatility were so strongly associated.

One aspect that might puzzle the reader is the allocation of capital. Panels e and f show that when capital in country 1 becomes more risky (with the same return) more capital is allocated (in the short run) to country 1. As discussed above this is due to the change in precautionary saving motive and to the assumption about preferences which induce a tilt in the time path for leisure. In figure 4 below we show that if we change preferences so to eliminate wealth effect from labor leisure decision (i.e. if we assume that preferences have the "GHH" functional form $U(c,l) = (\frac{1}{1-\sigma}(c-\mu(1+\xi)l^{1+\xi})^{1-\sigma})$ the responses for investment and capital are different. In particular with these preferences labor is independent from the path of consumption and hence the increase in risk in country 1 reduce the risk adjusted relative return of investing in country 1 and induces a reallocation of capital from country 1 to country 2.

4.3 The role of market structure

TO BE COMPLETED

4.4 Numerical results

TO BE COMPLETED

5 Conclusions

TO BE COMPLETED

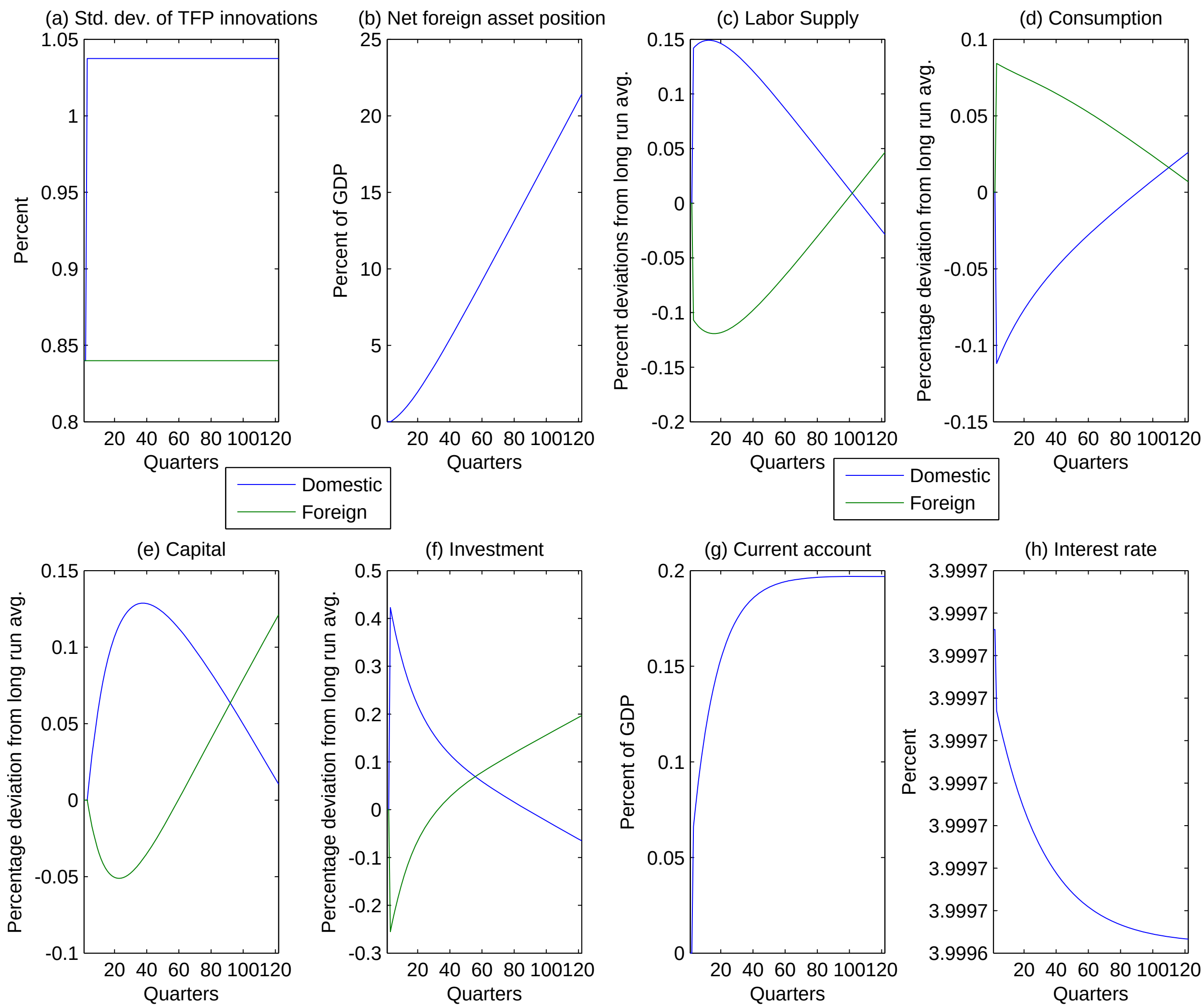

Figure 3: Response to a volatility shock (Standard preferences)

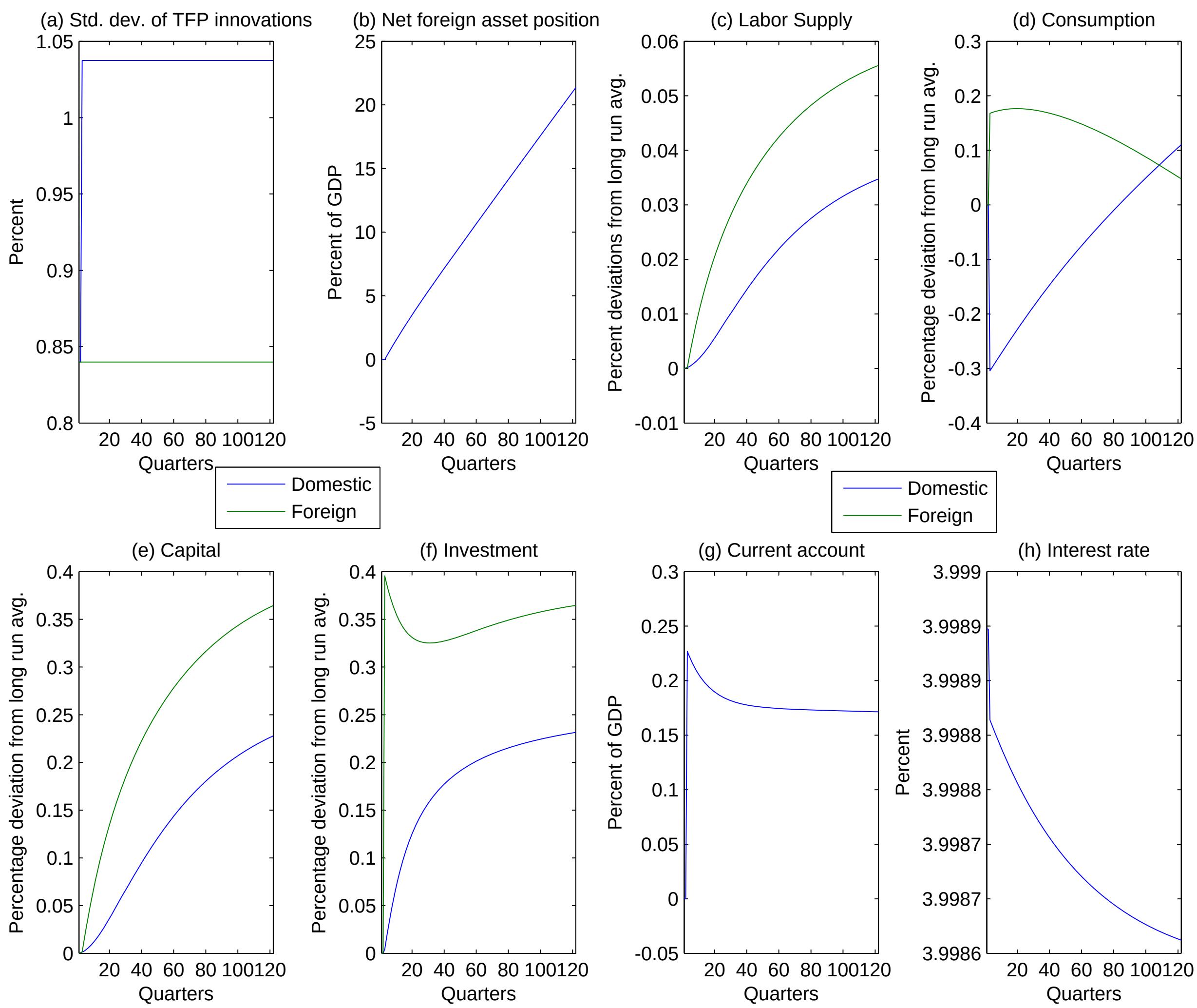

Figure 4: Response to a volatility shock (GHH preferences)

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