THE "GREAT MODERATION" AND THE US EXTERNAL IMBALANCE

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ABSTRACT

The early 1980s marked the onset of two striking features of the current world macro-economy: the fall in US business cycle volatility (the "great moderation") and the large and persistent US external imbalance. In this paper we argue that an external imbalance is a natural consequence of the great moderation. If a country experiences a fall in volatility greater than that of its partners, its relative incentives to accumulate precautionary savings fall and this results in an equilibrium permanent deterioration of its external balance. To assess how much of the current US imbalance can be explained by this channel, we consider a standard two country business cycle model in which households are subject to country specific shocks they cannot perfectly insure against. The model suggests that a fall in business cycle volatility like the one observed for the US relatively to other major economies can account for about 20% of the current total US external imbalance.

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1 Introduction

One of the most striking features of the US economy over the last twenty years has been a large reduction in business cycle volatility. This phenomenon, also known as the "great moderation", has been the topic of a large and growing debate among economists and policy-makers, which has focused mostly on explaining why it has occurred.[1]   Most studies conclude that a significant part of the observed decline in macroeconomic volatility has been driven by a reduction in the volatility of the underlying macro shocks hitting the economy. This finding constitutes the starting point of our paper, which asks whether and to what extent the great moderation can explain another important phenomenon that has characterized the US economy in the last two decades, namely the large and persistent US external imbalance. The reason why we think there is such a connection is both empirical and theoretical.

Empirically, many researchers date the onset of the great moderation around 1983-1984 (see for example Stock and Watson, 2003); interestingly, just around that time the current US external balance begun to deteriorate.

Theoretically, in a world in which country specific shocks cannot be perfectly insured, the equilibrium external balance of a country is affected by, among many other factors, the strength of its precautionary saving motive relative to that of its partners. This, in turn, is affected by the relative volatility of the shocks faced by the country. As the relative volatility of the shocks falls, a country faces less risk vis-à-vis its partners and, as a consequence, its precautionary motive is weakened and the component of its external assets accumulated for self insurance purposes falls. We develop this idea using a standard two country business cycle model with investment, in which the only internationally traded asset is a single non contingent bond. Moreover, each country faces a fixed limit on its international borrowing. In this framework country specific shocks cannot be perfectly insured, there is an explicit precautionary motive to save and we can numerically characterize the mapping between the relative volatility of the shocks hitting the two economies and the external balance of the two countries. We then use this mapping to quantitatively assess how much of the observed deterioration of the US net foreign asset position can be explained by the

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[1]A partial list of the relevant literature includes McConnell and Perez-Quiros (2000), Blanchard and Simon (2001), Ahmed, Levin, and Wilson (2002), Leduc and Sill (2003), Stock and Watson (2003), Bernanke (2004) and Arias, Hansen and Ohanian (2006).

reduction in the volatility of the US shocks. We find that, with reasonable parameterizations of the model, the great moderation can generate an external imbalance which is about 4.5% of GDP 25 years after its onset and reaches 7% of GDP in the long run. Actual US imbalances are quite larger than these numbers, nevertheless the imbalances explained by the great moderation are non-trivial and account for about 20% of the observed ones.

This paper contributes to the recent literature which attempts to assess the sustainability and the evolution of the current US imbalances (see for example Backus et al. 2006, Edwards, 2005 or Obstfeld and Rogoff, 2005). Our contribution to this literature is that at least a part of the US imbalances are due to the efficient market response to an underlying structural change in the world economy and that, regarding that portion, we should not expect any sudden adjustment. Two recent papers also reach a similar conclusion. One is by Caballero, Fahri and Gourinchas (2006) who argues that part of the recent US imbalances can be explained by the different growth experiences of US, Japan, Europe and Emerging Markets. Another is by Mendoza, Quadrini and Rios-Rull (2006) who argue that US imbalances can be explained by the fact that the United States experienced a faster process of internal financial liberalization than the rest of the world.

Our work is also related to the research that studies the importance of precautionary saving in incomplete markets (see for example Ayiagari, 1995). These studies typically find that in a closed economy aggregate precautionary saving is quantitatively small because of general equilibrium effects. The higher the risk a country faces the larger the precautionary balance it will want to hold. However, as these balances increase returns to capital fall, curtailing the equilibrium amount of precautionary saving. Our study instead focuses on an open economy, so in a given country these general equilibrium effects are smaller and precautionary saving can become larger.

The paper is organized as follows. Section 2 provides some evidence relevant to our hypothesis. Section 3 presents the model. In section 4 we describe the experiment, discuss parameter values and present results. Section 5 concludes.

2   Data

In this section we document some facts that are central to the hypothesis of this paper. First, we show that among large developed economies (US, Japan and the European Union, henceforth the G3) US has displayed the largest reduction in business cycles volatility; in other words, although the "moderation" has a been a world-wide phenomenon, only US has experienced a "great" one. Second, we document that the onset of the great moderation in the US has coincided with the beginning of the recent deterioration in the US net foreign asset position.

2.1   Business cycle volatility in the G3 Economies

Figure 1 reports several commonly used measures of business cycle fluctuations for the G3 economies for the period starting in the first quarter of 1960 and ending the last quarter of 2005. All data are from the OECD Quarterly National Accounts.

The panels in the first column (labeled growth rates) report the series for the quarterly log real GDP detrended using first differences, which emphasize very short term fluctuations. The panels in the second column (labeled HP) report log real GDP detrended using a Hodrick-Prescott filter with a smoothing parameter of 1600; this detrending method isolates cycles shorter than 32 quarters. The third and fourth columns report the same variable detrended using high-pass filters which exclude cycles longer than 60 (labeled HP60) and 80 quarters (labeled HP80), respectively. These high pass filters include the so called "medium run cycles" which contain a significant fraction of GDP cyclical variation (see for example Comin and Gertler, 2005) and thus of country specific risk. The panels clearly show the onset of the US great moderation around 1984 and show that the decline in the US business cycle volatility appears at several different frequencies. From figure 1 it also emerges that, as noted for example by Stock and Watson (2005), a decline in business cycles volatility occurred in Japan and in the European Union too, although its magnitude is not as large or as uniform across frequencies as in the US.

To get a better sense of the magnitude of the reduction in volatility, Table 1 below reports the percentage standard deviations of the series in figure 1 for the pre (1960.1-1983.4) and post-moderation (1984.1-2005.4) period, along with the change
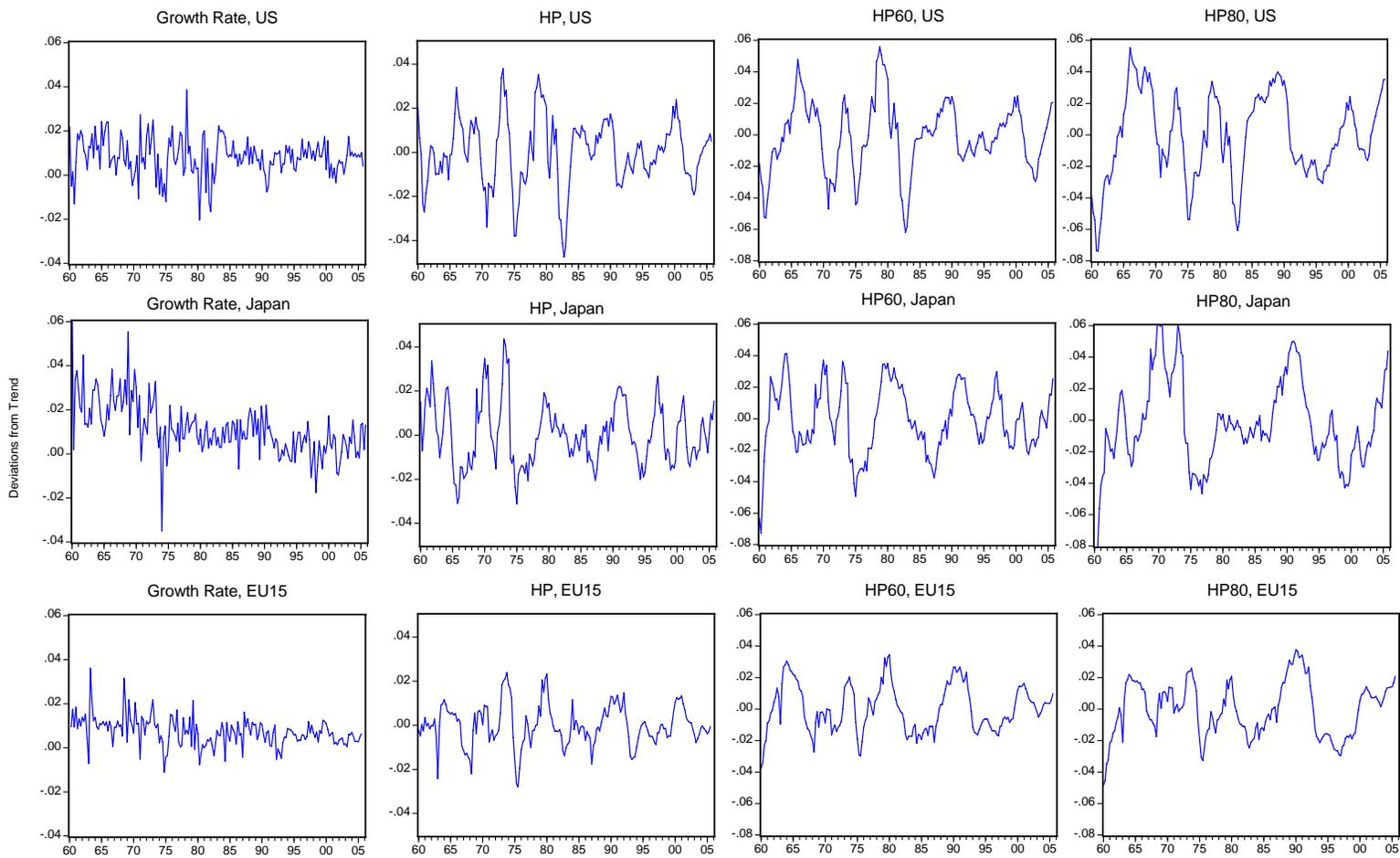
Figure 1: BUSINESS CYCLES IN THE G3 ECONOMIES

in volatility across periods.[2] The key message of the table is that the US, regardless of the frequency, is the country which has experienced the largest reduction in volatility. Note for example how, in the European Union, high and medium run business cycle volatility, as captured by the HP80 filter, has actually slightly increased.

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[2]In the table we use the same sample split for all 3 countries. Results are very similar when we experiment with different sample splits.

Table 1. Changes in volatility of Real GDP cycles in the G3

Filter	Country	Percentage Standard Deviation		
		1960.1-1983.4	1984.1-2005.4	Change
Growth rate	US	1.08	0.51	-0.57
	Japan	1.25	0.78	-0.47
	EU	0.77	0.42	-0.35
HP	US	1.90	0.96	-0.94
	Japan	1.68	1.12	-0.56
	EU	1.08	0.73	-0.35
HP60	US	2.84	1.32	-1.52
	Japan	2.42	1.56	-0.86
	EU	1.61	1.31	-0.30
HP80	US	3.15	2.05	-1.10
	Japan	3.13	2.35	-0.88
	EU	1.58	1.84	+0.26

2.2 The great moderation and US external imbalances

Figure 2 provides some evidence on the timing of the great moderation and the onset of US external imbalances.

The left panel reports estimates of the instantaneous conditional US business cycle volatility obtained fitting a simple GARCH model on the time series for US real GDP. Consistently with the previous literature the panel shows a sharp fall of volatility estimates around 1983-1984.[3] The right panel shows how the US external imbalance started to appear just around that time (data on the US net foreign asset position are from Lane and Milesi-Ferretti, 2006). Obviously this might purely a coincidence and these facts might be completely unrelated; or it might be the case

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[3]We specify the GARCH model as

$$
\begin{aligned}
y_t &= \beta_0 + \beta_1 y_{t-1} + \varepsilon_t \\
\sigma_{\varepsilon_t}^2 &= \beta_2 + \beta_3 \varepsilon_{t-1}^2 + \beta_4 \sigma_{\varepsilon_{t-1}}^2
\end{aligned}
$$

where y_t is the log of US real GDP, ε_t is a normal random variable with time varying variance $\sigma_{\varepsilon_t}^2$ and $\beta_0, \beta_1, \beta_2, \beta_3, \beta_4$ are parameters to be estimated. The figure reports the estimated path for σ_{ε_t}.
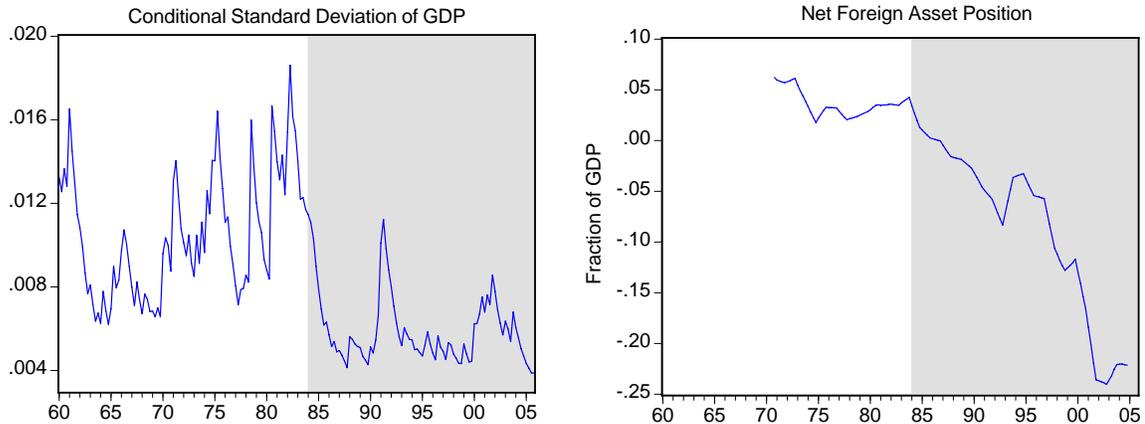
Figure 2: US Business cycle volatility and external imbalances

that some fundamental change in the US or the world economy is responsible for both these phenomena. In this paper we will not explore these possibilities but we will take the decline in volatility as exogenously given and ask how much of the growing external imbalances it can explain. We will do so in the next section with the help of a standard general equilibrium model.

3   The model

We consider a version of the standard one-good two-country business cycle model of Backus, Kehoe, and Kydland (1992). One additional assumption we make, relative to the standard model, is that we restrict international asset trade to a single uncontingent bond, as in Baxter and Crucini (1995), and we impose limits on borrowing. In the model agents face country specific shocks and use international borrowing and lending both for smoothing consumption and for allocating investment efficiently. The presence of borrowing limits, together with the persistence of business cycles shocks, makes it hard to perfectly insure country specific shocks and this lack of insurance generates a precautionary saving motive, which is essential for understanding the relation between external imbalances and country specific shock volatilities.

The world economy consists of two 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. Throughout the rest of the paper we will refer to US as country 1. The countries produce a single good, and their preferences and technology have the same structure and parameter values. Although the technologies have the same form, they differ in two important respects: in each country, 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

$$\sum_{t=0}^{\infty} \sum_{s^t} \beta^t \pi(s^t) U(c_i(s^t)) \tag{1}$$

where $c_i(s^t)$ denotes consumption of the representative consumer in country i after history s^t, $U(c) = \frac{c^{1-\gamma}}{1-\gamma}$, $\gamma > 0$ is a positive parameter determining risk aversion and intertemporal elasticity of substitution of representative consumers in both countries 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 labor which they supply inelastically to domestic firms[4], own domestic capital which they rent to domestic firms, trade internationally an uncontingent default-free bond and choose consumption and investment in each state of the world to maximize their expected lifetime utilities, given in (1) subject to the following budget constraints:

$$c_i(s^t) + x_i(s^t) + b_i(s^t) \leq w_i(s^t) + r_i(s^t)k_i(s^{t-1}) + b_i(s^{t-1})R_i(s^{t-1})$$

and capital accumulation constraints:

$$k_i(s^t) = (1 - \delta)k_i(s^{t-1}) + x_i(s^t) - \phi k_i(s^{t-1}) \left[\frac{x_i(s^t)}{k_i(s^{t-1})} - \delta \right]^2$$

for every s^{t-1} and s^t. Here $w_i(s^t)$ and $r_i(s^t)$ are the wage and rental rate on capital

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[4]The assumption of inelastic labor supply is not essential for our purposes.

in country i, δ is the depreciation rate of capital, $x_i(s^t)$ is investment in country i, ϕ is a parameter that determines the magnitude of capital adjustment costs, $R(s^{t-1})$ is the gross interest rate on uncontingent borrowing and lending between period $t-1$ and period t, $b_i(s^t)$ denotes the quantity of uncontingent bonds purchased at t by a consumer in country i. An important assumption of the model is that countries face fixed limits to their international borrowing. Without these limits the single bond traded in this economy would allow agents to insure very well against country specific shocks (as noted by Baxter and Crucini, 1995) and so the precautionary saving motive, which is crucial for generating the persistence of the external imbalance, would disappear. We assume that constraints on international borrowing have the form $\frac{b_i(s^t)}{y_i(s^t)} \geq -\bar{b}$, where $\bar{b}$ is some positive number and $y_i(s^t)$ is aggregate output in country i.

Finally, competitive firms hire capital and labor to operate a Cobb-Douglas technology and solve the standard static profit maximization problem

$$\max_{l_i(s^t),k_i(s^{t-1})} A_i(s^t)l_i^{1-\alpha}(s^t)k_i^{\alpha}(s^{t-1}) - w(s^t)l_i(s^t) - r_i(s^t)k_i(s^{t-1}).$$

where α is a constant parameter and $A_i(s^t)$ is a country-specific total factor productivity shock which follows an exogenous process. Note that aggregate output in country i at s^t, denoted by $y_i(s^t)$, can be written as a function of domestic labor supply $l_i(s^t)$ and capital stock installed in country i in the previous period $k_i(s^{t-1})$. Since labor is inelastically supplied and equal to 1, we can write GDP in each country as

$$y_i(s^t) = A_i(s^t)k_i^{\alpha}(s^{t-1})$$

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

4 The experiment

We will now use the model just described as a measuring tool to quantify the size and the persistence of the imbalances generated by a country specific reduction in business cycles volatility, as the one experienced by the US and documented in section 2. In order to do so, we first compute equilibria in a completely symmetric world, in which both countries face the same constant volatility of shocks. We then assume that at a given point in time along this equilibrium path, the volatility of US shocks falls to a new constant level and that agents in both countries learn about this change instantaneously. We finally evaluate the expected responses of selected macro variables to this change. Summarizing, we will be computing impulse responses to a change in second moments, as opposed to traditional impulse responses to changes in first moments. To perform this experiment, we will first choose parameter values and then characterize the numerical solution of the model.

4.1 Parameters and computation

We need to set values for the preference parameters β and γ, for the technology parameters α, δ and ϕ and for the borrowing constraint $\bar{b}$. We also need to specify an exogenous process for the TFP shocks $A_i(s^t)$. The discount factor β, the capital depreciation rate δ, the share 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 capital equal to 36% and investment series which is 3 times as volatile as the GDP series.[5] 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 risk aversion γ and the borrowing constraint parameter $\bar{b}$ are important for our analysis but there is no obvious data which allow us to precisely identify them. In our benchmark parametrization we set the risk aversion to 5, which is in between the value typically used in macro studies (which use numbers

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[5]Note that due the precautionary saving motive in this economy the long run averages of variables are in general different from the value of the variables in the deterministic steady state. For example, for our benchmark parameterization, long run average capital is about 1.7% higher than capital in the deterministic steady state.

around 2) and finance studies (which usually set it to values of 10 or higher). We also limit international borrowing to be less than 100% of GDP. In the sensitivity analysis section below we experiment with different values both for the risk aversion and for limits to international borrowing. The last important input of the model is the stochastic process for TFP shocks. In this class of models it is common to specify it as a bi-variate autoregressive process of the form

$$
\begin{bmatrix} \log(A_1(s^t)) \\ \log(A_2(s^t)) \end{bmatrix} = \begin{bmatrix} \rho & \psi \\ \psi & \rho \end{bmatrix} \begin{bmatrix} \log(A_1(s^{t-1})) \\ \log(A_2(s^{t-1})) \end{bmatrix} + \begin{bmatrix} M(t)\varepsilon_1(s^t) \\ \varepsilon_2(s^t) \end{bmatrix} \qquad (2)
$$

where ρ and ψ are fixed parameters and $\varepsilon_i(s^t)$, are jointly normal shocks with zero mean, variance σ_ε^2 and correlation coefficient η, and the term $M(t)$ is a declining function of time that captures the reduction in business cycles volatility. Note that we model the great moderation as a reduction in volatility in US (country 1) business cycles only and that we keep business cycles volatility in the other country (the rest of the world) constant. In reality, volatility fell also in other countries, but our assumption captures in a simple way the fact, documented in table 1, that in the US the reduction in business cycle volatility has been larger than in other countries.

In the model these shocks are the drivers of business cycles fluctuations including the medium run ones, so we pick the parameters of the process to match statistics for log GDP filtered with a high pass filter (the series labeled HP80 in table 1 above). First we specify $M(t)$ as follows

$$
M(t) = \begin{cases} 1 & \text{if } t < 1984 \\ 1 - \lambda & \text{if } t \geq 1984 \end{cases}
$$

where $0 < 1 - \lambda < 1$; then choose σ and ρ to match the persistence and the volatility of HP80 log GDP in the US in the pre-moderation period. Note that the degree of persistence of the shocks is a key parameter as it determines the strength of the precautionary saving motive, so in the sensitivity analysis section we will experiment with different values for ρ. The parameter λ affects the decline of the ratio of US volatility to foreign volatility. Table 1 reveals that, for HP80 GDP, the ratio fell by about 15% for US versus Japan and by 79% for US relative to the European Union. As a conservative estimate, we set λ so to match a decline of 33%, but we experiment

with different values.[6] Our results are not very sensitive to the parameters ψ and η which determine the structure of business cycle co-movement between countries. We simply set $\psi = 0$ and $\eta = 0.4$ so that the model reproduces the co-movement of HP80 GDP between US, the European Union and Japan in the 1960-2005 period.[7]

For computational reasons we transform the process (2) into a 9 states Markov chain; the parameters of the states and transition probability matrix of the Markov chain are estimated on simulated data from (2), by a combination of maximum likelihood and method of moments.[8] Table 2 summarizes our benchmark choices of parameter values.

Table 2. Benchmark Parameter Values

Name	Symbol	Value
Preferences and Technology		
Discount Factor	β	0.9895
Risk Aversion	γ	5
Capital share	α	0.36
Depreciation rate	δ	0.0255
Capital Adjustment Cost	ϕ	0.2
Borrowing limit	$\bar{b}$	100%
TFP Shocks		
Persistence	ρ	0.98
Spillover	ψ	0.0
Standard deviation	σ_ε	0.0075
Standard deviation ratio decline	λ	0.33
Correlation	η	0.4

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 methods, as, in such methods, individuals' and firms' decision rules are independent from second moments of the shocks. We instead compute decision rules

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[6]The parameter λ also affects the post-1984 population mean of productivity shocks in US. In order to abstract from this effect in all our experiments we rescale the post-1984 US productivity shocks so that their population mean is equal to the pre-1984 mean.

[7]Although there is some evidence that cross country business cycle correlation has actually declined through time (see Heathcote and Perri, 2004) in this experiment we keep it fixed to focus on the effects of the decline in volatility.

[8]Details of the estimation procedure together with the states and the transition probabilities of the Markov chain are available upon request.

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 purchases $b_i(s^t)$ and price functions $w_i(s^t)$ $r_i(s^t)$, $R(s^t)$ as piecewise bi-linear functions defined over a state space which consists of productivities $A_i(s^t)$, installed capital $k_i(s^{t-1})$ and bond holdings $b_i(s^{t-1})$.

4.2   Main results

Figure 3 shows the 60 years expected responses of key variables to a reduction in US volatility. As we discussed in the previous section, we assume that in the first quarter of 1984 the standard deviation of the innovations of US productivity shocks unexpectedly falls by 33% and then it stays constant at the new lower level for ever.[9] Panels 1 and 2 contain our key results and show that, in response to a reduction in the shocks volatility, US expects (averaging across possible shock realizations) a persistent negative net foreign asset position, which reaches, 25 years after the volatility reduction, about 4.5% of GDP. Panel 2 in figure 2 suggests that the current US imbalances are about 24% of GDP, so our proposed channel could explain about 20% of the current total US external debt. Keep in mind, however, that the net foreign asset position in figure 2 includes also position with developing countries (such as China) and oil exporting countries which are not explicitly modeled here. If one focuses only on the US external debt with Japan and the European Union, our estimate of the imbalance in 2004 is about 12% of GDP, suggesting that our story could explain around one third of the external imbalances of US with other developed economies.[10] Note finally that the external imbalance increase rapidly initially but

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[9]The responses displayed in the figures are averages over a large number of model simulations. In each simulation we start with both countries with identical shocks and with identical capital stock equal to the deterministic steady state. We then simulate both economies for 300 periods with shocks having equal variance (so the average capital stock reaches its long run value) and in period 300 (which in panels 1 through 6 corresponds to the first quarter of 1984) we reduce the variance of the US shocks.

[10]In order to compute the foreign asset position of US with Japan and the European Union only, one needs data on bilateral net foreign asset positions which are not readily available in standard data sources for all types of assets. We estimated that position to be 12% by first computing the US net foreign asset position vis-à-vis the European Union and Japan for securities only (including debt and equity) derived using data from the Treasury International Capital (TIC) reporting system. We then assumed that the ratio of the US net foreign asset position vis-à-vis the rest of the world to the US foreign asset position vis-à-vis Europe and Japan, is the same when calculated for all assets

then stabilizes. By year 2100 (not shown in the graph) the expected imbalance is constant at a level of 7% of GDP.

In order to understand the dynamics leading to the imbalance, in panels 3 through 6 we report the expected paths of investment, capital stock, consumption and real interest rate. Since US consumers hold all claims to US GDP, a fall in US GDP volatility diminishes their risk and their precautionary saving motive. This effect makes them more "impatient" as they prefer current over future consumption. This preference is reflected in the declining path of US consumption.(see panel 5). How do US consumers obtain higher current consumption in exchange for future consumption?

There are two ways they can do it: one is by reducing capital stock, the other is by borrowing on international markets. Because of the presence of adjustment costs, the reduction of the capital stock is implemented only gradually, so initially US consumers will borrow heavily on international markets (see panels 1 and 2 which show that, for the first 20 years after the shocks, the current account balance remains low and the net foreign asset position declines rapidly). This drives up the international interest rate $R(s^t)$ and this increase makes investment and capital stock fall in the foreign country as well.[11] In other words, foreigners substitute domestic capital with international bonds as international bonds now pay a higher interest rate. Over time the fall in US capital stock and US foreign assets increases the exposure of US consumers to risk and thus reduces their "impatience" ; as a consequence their demand for current consumption falls, they are able to finance their consumption path simply from the reduction in investment and they no longer need to use international markets. In panel 3 observe that around year 2020 the current account deficit is negligible. This also stops the upward pressure on the interest rates and the decline of investment abroad.

To understand the final effects of the change it is helpful to observe panel 5, which reports the consumption patterns. The panel shows that both countries achieve higher, relative to the pre-moderation period, levels of consumption. Notice, however, that countries enjoy the additional consumption in different times and for different reasons. US residents face lower income risk in the process, become effectively more

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and for securities only.

[11]There is no long-run growth in the model. If there were, there would not be a reduction in the capital stock its growth would slow down growth.
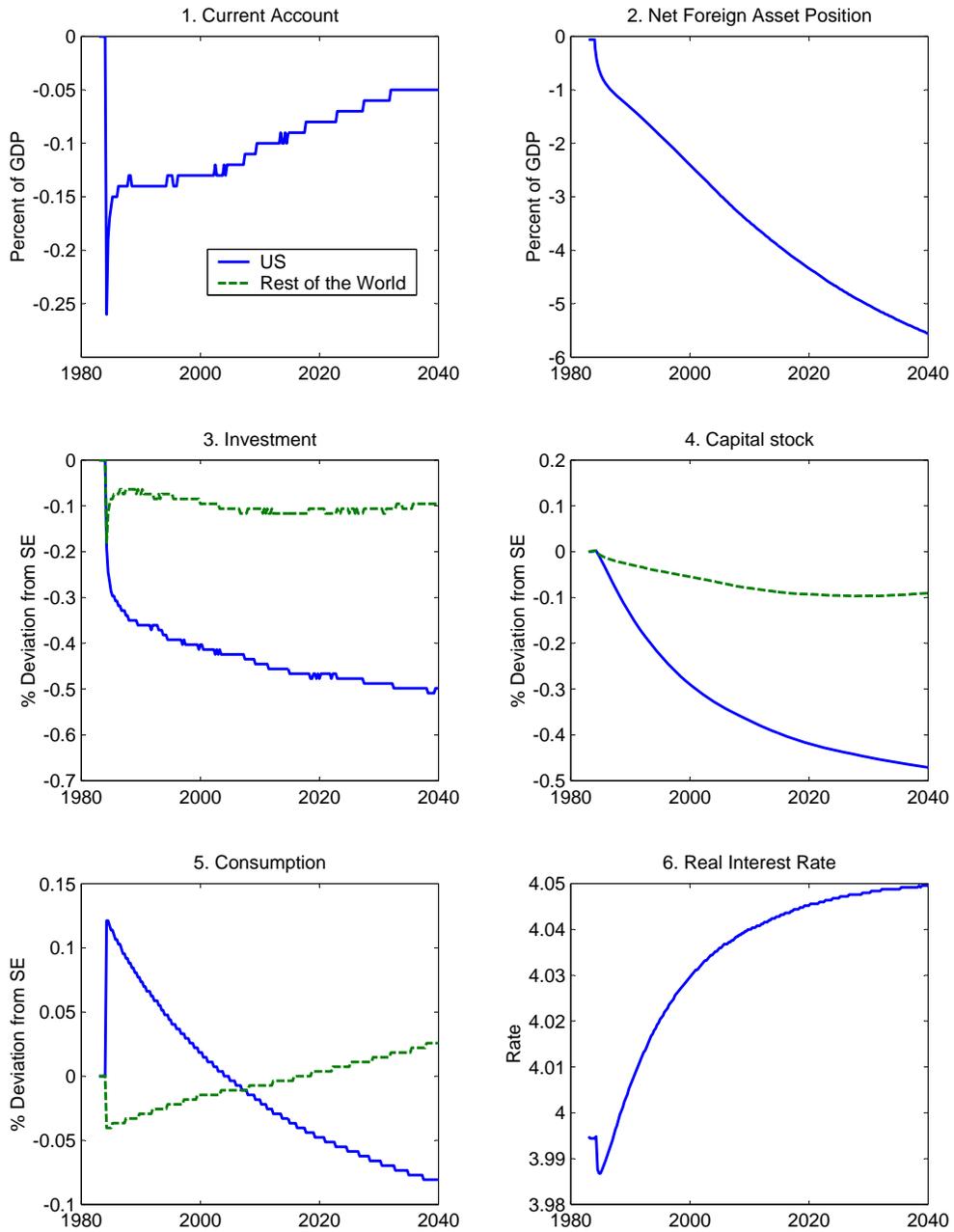
Figure 3: IMPULSE RESPONSES TO A REDUCTION IN US VOLATILITY

impatient, so find it optimal to enjoy the extra consumption early in time, by borrowing on international markets and slowly running down their capital stock. The foreign country instead does not face a reduction in its volatility but faces an increase on the international interest rates so it will find optimal to increase saving and enjoy higher consumption later in time. This inter-temporal redistribution of consumption requires transfers of resources from the rest of the world to the US in the early periods and the reverse transfers in the later periods; in equilibrium the early transfers from the rest of the world to the US show up as US current account deficits while the late transfers from the US to the rest of the world show up as interest payments on the accumulated US external imbalance.

Intuition about the final outcome can also be gained by thinking of this issue as a portfolio problem. Residents of both countries are forced to hold their own risky capital but can trade a risk free asset in zero net supply. It is immediate to show that when the risky assets have the same characteristics and agents have the same preferences the only possible long run equilibrium portfolio is the one in which residents of both countries hold a 0 amount of the bond, i.e. an equilibrium in which there are no long run imbalances. But when the US domestic assets become less risky (without changing its expected return) then US residents would like to rebalance their portfolio in favor of the risky asset. One way they can do so is by going short in the bond; foreign agents, on the other hand, will be happy to hold additional bonds if they pay a higher return. So an equilibrium long run portfolio after the US faces a reduction in volatility would involve the US being short in bonds, the rest of the world being long on bonds and a real interest rate higher relative to the one in the symmetric equilibrium. This is exactly what the impulse responses suggest is going to happen to country portfolios in the long run.

One final consideration should be devoted to the effects that the fall in volatility has on the long run allocation of capital. Panels 3 and 4 show that in the long run capital falls in both economies but in the US it falls more than in the rest of the world so that the US share of world capital falls. This last aspect might seem puzzling if one realizes that after the great moderation the US capital has the same expected return as the one in the rest of the world but is less risky so one would expect US share of world capital to rise. The friction that prevents this from happening here is the lack of diversification, that is the fact that all claims to US income are held by US residents. Since they are the only ones who face the reduction in risk, their desired

stock of buffer assets falls and this is reflected in the fall in the US capital stock. We conjecture that in a model in which agents can also choose between holding domestic and foreign capital a country specific reduction in volatility might lead to a surge in investment in that country and possibly to a larger imbalance.

4.3 Sensitivity analysis

In this section we check how sensitive our findings are to changes in parameter values. The goal is to identify the elements which determine the quantitative importance of our channel. In particular we examine how the response of external imbalances to reduction in volatility changes when we change the risk aversion, the limits to international borrowing, the persistence of international shocks and the extent of the great moderation.

As our main interest is the size of the external imbalance induced by the great moderation, for every alternative parametrization we report the size of the net foreign asset position in 2010, that is 25 years after the onset of the great moderation

Table 3. Sensitivity of US imbalances (% of GDP) to

	Risk Aversion, σ				
	$\sigma = 2$	$\sigma = 5$	$\sigma = 8$		
Imbalance	1.8	4.5	5.0		
	Borrowing Constraint (% of GDP) $\bar{b}$				
	$\bar{b} = 0$	$\bar{b} = .7$	$\bar{b} = 1$	$\bar{b} = 1.3$	$\bar{b} = \infty$
Imbalance	0	3.6	4.5	5.4	-0.2
	Persistence of shocks, ρ				
	$\rho = 0.96$	$\rho = 0.98$	$\rho = 0.993$		
Imbalance	2.4	4.5	9.0		
	Fall in US volatility, λ				
	$\lambda = 1/4$	$\lambda = 1/3$	$\lambda = 1/2$		
Imbalance	3.9	4.5	7.0		

The first row examines the effect of the risk aversion. Note how at lower level of risk aversion the external imbalance generated by our mechanism is substantially smaller. When US agents are less risk averse they reduce less their precautionary

saving in response to the reduction of risk; as a consequence their desire to consume early is reduced and so are their external imbalances. The second row highlights the effect of the tightness of borrowing constraint. The effect of reduction in volatility on the external imbalance is non linear in the borrowing constraints. Obviously when the constraints are set to 0 no borrowing is allowed and the response to US imbalances to changes in volatility is 0. When constraints are initially relaxed some borrowing is possible. As the constraints relax US consumers can reduce their precautionary balance more in response to a fall in volatility and so the fall in volatility generates an imbalance which is larger the looser the constraint is. But as the constraints get very loose so that they no longer bind in equilibrium, the economy gets arbitrarily close to full risk sharing (see for example Baxter and Crucini, 1995). In a full risk sharing equilibrium agents no longer have a precautionary saving motive and so the reduction in the buffer stock of saving and the corresponding long run imbalances do not emerge in response to a change in volatility

The next row shows that the persistence of the shocks plays an important role. When shocks are very persistent precautionary motive is strong (as these shocks are hard to self insure) and thus a reduction in shock volatility causes a large fall in the precautionary motive and a large imbalance. Notice that when ρ is set to .993 the imbalance reaches about 9% of GDP[12]. When shocks are less persistent they are easier to insure so agents hold less of a precautionary buffer and as a consequence the reduction in shock volatility generates a much smaller imbalance.

Finally the last row shows that, not surprisingly, the larger the reduction in volatility, the larger the imbalance. When US volatility falls by 50% (instead of 33 % as in the benchmark case) the imbalance reaches 7% of GDP. If instead the reduction in volatility is only 25% the imbalance falls to 3.9%.

5   Conclusions

We have presented a simple framework to evaluate how much of the current US imbalance can be explained by the "great moderation", that is the reduction in business cycle volatility that started in the mid 1980s and which has affected the US more

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[12]The value of .993 is the highest we can set in our numerical procedure.

than its partners. We find that, *ceteris paribus*, the great moderation could be responsible for about 20% of the current US external imbalance. Our study suggests that the this part of the external imbalance deriving from the great moderation is not pathological and it does not require any correction but rather the opposite; it arises so that in a world with limited insurance possibilities agents can share the benefits of a unilateral reduction in volatility. We want to stress that our conclusion applies only to a fraction of the current US external imbalances. Understanding the causes and consequences of the remaining (and large) part of those imbalances remains a hotly debated and important research question.

Finally our empirical analysis is only limited to the US and our theoretical framework is exceedingly simple as we assume that the only internationally traded asset is a non contingent bond. In on-going work (Fogli and Perri, 2006) we extend this study in both directions, by examining the link between macroeconomic volatility and external imbalances in a large cross section of countries (in emerging countries where macroeconomic volatility is greater the effects we described might be quantitatively more important) and by considering a richer asset market structure where we allow for international diversification through stocks.

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