Essays on International Macroeconomics

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Preface

This thesis contains three papers on subjects falling within the broad field of International Macroeconomics. Here we provide a brief summary of each paper.

The first paper investigates the international distribution of external balances in a world economy model. Quantitative analysis of the model indicates both macroeconomic uncertainty and financial frictions have a substantial effect on the international dispersion of external balances.

The second paper uses a world economy framework to investigate how real exchange rate movements influence the international distribution of external balances. Approximations of the model provide preliminary evidence in favour of there being a meaningful link between real exchange rate movements and the international diversity of external balances.

The third paper investigates the link between exchange rate flexibility, the international balance sheet and economic recoveries by analysing a dataset covering 201 recovery episodes occurring between 1971 and 2007. The key finding is that when the external foreign currency denominated debt of a country is relatively large, growth of GDP during the recovery from a recession is faster under a pegged exchange rate regime than it is under a more flexible arrangement.

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Contents

Chapter **1**

The Distributional Consequences of Macroeconomic Uncertainty in Global Equilibrium

We investigate the international distribution of external balances using a world economy model featuring country-specific macroeconomic uncertainty. Incomplete international financial markets and a collateral constraint on borrowing both serve to limit risk-sharing opportunities. In this environment, insurance against uncertainty takes the form of physical capital accumulation and intertemporal trade between countries. The cross-country dispersion of net foreign assets is close to its empirical counterpart. Macroeconomic uncertainty accounts for about one third of the international variation of cross-border asset holdings in the model. Approximations suggest that decreases in financial frictions were an important driver of increases in the international dispersion of external balances observed in the data.

The considerable cross-country heterogeneity of external balances has become a defining feature of the global financial landscape. At the end of 2006, after around 30 years of growing cross-border financial integration, the range between the 10th and 90th percentiles of the international distribution of net foreign assets as a proportion of GDP was approximately 100 percentage points. The standard deviation of the same distribution was about 56 percent.[1] Concerns regarding the sustainability of these imbalances and the consequences of a significant international redistribution of capital from its present state have motivated an on-going debate.

Efforts to improve awareness of factors driving the distribution of external balances have figured prominently in these discussions. To this end, we examine the link between macroeconomic uncertainty and international capital flows. We quantitatively analyse a model world economy in which the precautionary saving response to country-specific macroeconomic volatility plays a central role in the motivation of cross-border flows. The pattern of net foreign asset holdings in this framework is broadly consistent with the facts presented above. At the same time, the model is also relevant to earlier periods. In 1986, when financial globalisation was just gathering pace in emerging markets, the aforementioned real-world measures of dispersion were about 20 percent lower. Our model captures this evolution: When financial frictions are increased to reflect the lower degree of financial openness in 1986, the increase in the model-generated cross-country concentration of net foreign asset positions is comparable to the data. So, the framework throws some light on the influence of financial liberalisation in the presence of macroeconomic uncertainty. In sum, the world economy model helps us gain a credible handle on the contribution of macroeconomic uncertainty to the international dispersion of net foreign asset holdings.

But why should macroeconomic uncertainty make a difference to intertemporal trade

[1] Our panel data covers 97 countries (21 developed and 76 developing/emerging market). All external balance variables are demeaned by year. To smooth out short run fluctuations, (demeaned) net foreign assets to GDP is averaged over a rolling 10-year window. To be clear, under this approach the averaged value of net foreign assets to GDP for 2006 is the average over the period 2001 to 2010. Both net foreign assets and GDP are PPP adjusted. See the Appendix in Section 1.5 for a detailed description of the data.

among nations? Recent work by Fogli and Perri (2015) and Hoffman, Krause and Tillman (2014) offers empirical and theoretical evidence in favour of a link between external balances and country-specific macroeconomic uncertainty for OECD and developing/emerging market nations. Uncertainty takes the form of perturbations to the volatility of disturbances buffeting an economy. Their framework suggests that in the absence of complete international risk-sharing markets, a country facing heightened relative macroeconomic volatility – represented by increased variability of country level GDP growth net of global shocks – will increase saving relative to the rest of the world as a means of ensuring a smooth consumption path. Part of this precautionary saving finds its way overseas, thus connecting uncertainty with cross-border capital flows; countries or regions confronting high levels of relative volatility become lenders to those enjoying relatively calm conditions. Going further, this mechanism also indicates how uncertainty can be associated with the cross-country dispersion of external balances. That is, time-varying volatility widens the spread of potential shocks that an economy can experience, thereby giving rise to a more diffuse range of possible external balances. To the extent that all countries are exposed to this uncertainty, the presence of idiosyncratic volatility shocks will affect the international variability of external balances.

For this hypothesised link between uncertainty and the dispersion of external balances to be economically meaningful, the magnitude of idiosyncratic macroeconomic volatility in the data needs to display substantial variation across countries in a typical year. In

Table 1.1: Relative Volatility

		Interquantile Range		
	St. Dev.	95v5	90v10	75v25
All Countries	3.2	10.0	7.3	3.9
Developed	1.3	4.3	2.7	1.2
Developing/EM	3.3	10.8	7.6	3.9

The data covers 97 countries (21 developed and 76 developing/emerging market) and the period 1986-2010. All variables measured in percent. *St. Dev.* equals the mean annual cross-country standard deviation of relative volatility. *Interquantile Range* equals the mean annual range between the specified percentiles.

other words, it must be common for some countries to be experiencing a relative moderation in volatility while other nations are suffering through relatively unstable times. The statistics displayed in Table 1.1, based on the sample period 1986 through 2011, show that observed conditions meet this requirement: both measures indicate ample international heterogeneity of relative volatility.[2] In the average year, we find the standard deviation of relative volatility across all countries to be a quantitatively important 3.2 percent; likewise, the median distance between the 90th and 10th percentiles of the annual international distribution is a sizeable 10 percentage points.[3] Interestingly, there is a marked difference between the degree of cross-country heterogeneity in developed and developing/emerging market countries.

Since neither Fogli and Perri (2015) nor Hoffman et al (2014) examine both OECD and developing/emerging nations, they do not assess how much of the global dispersion of external balances can be accounted for by country-specific uncertainty. Our goal here is to put forward an answer to this question. To be clear, this paper and the two previously cited studies both sidestep the many other potential drivers of global imbalances, some of which are discussed in the literature review below. Fundamentally, this approach seeks to understand the role of macroeconomic uncertainty in isolation, to gauge its influence on capital flows.

[2]We follow Fogli and Perri (2015) by measuring idiosyncratic macroeconomic volatility in a given country as the standard deviation of country-level GDP growth less the average standard deviation of GDP growth for all other countries. Specifically, we measure the standard deviation of GDP growth over a rolling 10-year window as,

$$\sigma_{y,i,t0} = \sqrt{\frac{1}{9}\sum_{t=-5}^{+4}(g_{i,t} - \bar{g}_{i,t0})^2}$$

where $g_{i,t}$ is the (log) growth of GDP for country i in year t and $\bar{g}_{i,t0}$ is the average GDP growth for country i over the 10-year window around $t0$. Then, idiosyncratic macroeconomic volatility, which we will also refer to as relative volatility or macroeconomic uncertainty, for country i at time $t0$ equals,

$$\tilde{\sigma}_{i,t0} = \sigma_{y,i,t0} - \frac{1}{N-1}\sum_{j\neq i}^{N}\sigma_{y,j,t0}$$

where N equals the number of countries.

[3]The statistics presented in Table 1.1 are virtually identical if we use the median year instead of the mean.

The foundation of our analysis is an artificial world economy comprised of numerous ex ante identical small open economies, each producing a homogeneous tradable good using labour and physical capital. Countries lend and borrow from one another using a risk-free (non-state contingent) bond. Foreign borrowing is limited by a collateral constraint. Given these limits on risk sharing, country-specific stochastic (transitory) productivity shocks bring about precautionary saving and in turn, ex post heterogeneity amongst nations. Put another way, countries employ capital accumulation and international trade in the risk-free bond as means of smoothing consumption in the face of idiosyncratic productivity shocks. Due to the international diversity in shock histories, these risk-sharing activities give rise to cross-country variation in cumulative asset positions (both foreign and domestic). By augmenting this framework to include a time-varying element in the volatility of productivity shocks, we elucidate the link between macroeconomic uncertainty and the international dispersion of foreign asset holdings. Moreover, through randomly allocating countries to one of two developmental groups (developed and developing/emerging market) we allow our key driver of precautionary saving to incorporate the sharp distinction between macroeconomic uncertainty in developed and developing nations, as observed in Table 1.1.

We calibrate the parameters of the model to match salient characteristics of a large panel of 97 countries (21 developed and 76 developing/emerging markets) over the 30 years through 2010. Our focus is directed at the quantitative implications of the model, with particular emphasis on the long-run global distribution of external balances. Aside from exhibiting reasonable business cycle dynamics, the baseline model for 2006 displays a long-run equilibrium in which the relatively high volatility developing/emerging market region is a net lender to the developed region where volatility is low by comparison. Measures of cross-country net foreign asset to GDP dispersion in the model featuring time-varying volatility are about 90 percent that in the data for 2006.[4] The model performs less well on the trade balance and current account. When we turn our attention

[4] When discussing the results from our analysis the term net foreign assets will be used to refer to the net foreign asset to GDP ratio. Likewise for the trade balance and current account.

to 1986 and tighten financial frictions to obtain gross world debt levels observable at that time, the international dispersion of net foreign assets is around 80 percent as diffuse as the data. The effect of macroeconomic uncertainty is significant: in each of our approximations, time-varying volatility consistently accounts for about one third of model-generated dispersion.

Related Literature – This paper is most closely related to the literature examining the relationship between macroeconomic uncertainty and external balances, prominent examples of which include the papers by Fogli and Perri (2015) and Hoffman, Krause and Tillman (2014) discussed above. A complementary paper by Fogli and Perri (2006) contends that by lowering macroeconomic volatility in the US relative to the rest of the world, the Great Moderation played a non-trivial role in the rise of the US current account deficit over the 25 years through 2006. Additional insight consistent with these findings is provided by Gourio, Siemer and Verdelhen (2015) who present empirical evidence that emerging market countries confronted with heightened volatility – in the form of a rise in the country-specific component of a nation's stock market return volatility – tend to exhibit both decreased capital inflows and increased capital outflows. These papers considered levels of economic development one at a time. Accordingly, my paper contributes to this strand of the literature by employing a framework in which developed and developing/emerging market countries both coexist and interact with one another.

Echoing our own approach, a number of existing papers also employ stochastic world economy models featuring a continuum of countries and incomplete international insurance markets.[5] Starting with the investigation into the impact of international differences in rates of taxation and time preference on external balances by Clarida (1990), these papers have covered a variety of issues including the relationship between cross-country

[5]Fundamentally, this approach to modelling global equilibrium is a variant of the benchmark Bewley-Aiyagari-Huggett setup, with the heterogeneous households in those earlier models viewed instead as heterogeneous countries. See the survey articles by Guvenen (2012) and Heathcote, Storesletten and Violante (2009) for a comprehensive review of the literature on macroeconomic models with heterogeneous households.

technological differences and physical capital accumulation (Castro (2005)), the impact of trade openness on economic development (Castro (2006)), the Feldstein-Horioka puzzle (Bai and Zhang (2010)), imperfect international risk sharing (Bai and Zhang (2012)), and international debt deleveraging (Fornaro (2014)). Of greatest relevance for our purposes is the work of Chang, Kim and Lee (2013) which uses a multi-country model of global equilibrium under incomplete markets to show that the precautionary saving response to country-specific productivity shocks is able to match the international dispersion of net foreign assets in the data but is unable to explain the diversity of current account or trade balance positions. Also of relevance is Sandri (2009), which relies on a world economy framework with countries separated into six regions, each with a different endowment volatility, to illustrate how the combination of such regional heterogeneity and the precautionary saving motive can generate cross-country imbalances in current account and net foreign asset positions. The models used by Chang et al. and Sandri both impose a fixed borrowing limit on all countries, while at the same time employing a shock process with constant volatility. In contrast, by disciplining national leverage with a collateral constraint our model incorporates the more conservative notion that debt is limited by asset holdings, in turn bringing borrowing decisions more in line with typical real-world practice. Moreover, the inclusion of data-consistent time-varying volatility shocks also differentiates our framework.

The previously mentioned literature on external balances is also part of the broader field of research attempting to explain the global imbalances that have emerged since the 1980s. On the theory side, the distribution of capital flows has been put down to a number of factors including (but not limited to): international heterogeneity in the supply of financial assets (Caballero, Farhi and Gourinchas (2008)); cross-country differences in the availability of risk sharing opportunities (Mendoza, Quadrini and Rios-Rull (2009)); changes in the valuation of external assets and liabilities (Devereux and Sutherland (2010)); the motivation to insure against the risk of a sudden stop (Durdu, Mendoza and Terrones (2009)); and export-led growth policies (Dooley, Folkerts-Landau and Garber (2003)). On the empirical side, the imbalances and the capital flows that underlie them have been characterised by, amongst others, Gourinchas and Jeanne (2013); Alfaro, Kalemli-Ozcan and Volosovych (2014); and Obstfeld, Taylor and Shambaugh (2010). See Gourinchas and Rey (2015) for more detail on the literature concerning global imbalances.

The main body of this paper covers the delineation of our world economy model (section 1) and the investigation of its quantitative properties (section 2). Section 3 concludes.

1.1 World Economy Model

The world economy consists of a continuum of small open economies (countries) subject to idiosyncratic productivity shocks. There is no aggregate (world-level) uncertainty in the model. The basic structure of each country resembles the standard discrete time, single good, single asset framework typified by Mendoza (1991), though here the small open economy is framed in terms of an infinitely lived representative firm-household as in Mendoza (2010). This firm-household is tasked with both consumption and production decisions. Limited risk-sharing opportunities at the international level provide an impetus for precautionary saving. The configuration of the small open economy makes three key departures from the canonical setup. Firstly, the volatility of the exogenous productivity process is perturbed by time-varying shocks. Secondly, borrowing is collateralized by the firm's holdings of physical capital. Finally, interest on the internationally traded risk-free bond incorporates a spread reflecting the cost of financial intermediation, as in Chang et al. (2013).

1.1.1 The Firm-Household

Let c_t represent household consumption of the single tradable good and l_t be the agent's labour supply. The time period is denoted by t. Expected lifetime utility of the infinitely lived firm-household is,

$$E_0 \sum_{t=0}^{\infty} (\beta^t U(c_t, l_t)))$$

E_0 is the expectations operator conditional on information available at time zero and β is the discount factor. The period utility function takes the form introduced by Greenwood, Hercowitz and Huffman (1988),

$$U(c_t, l_t) = \frac{\left(c_t - \frac{l_t^{\omega}}{\omega}\right)^{1-\gamma} - 1}{1-\gamma}$$

where γ is the coefficient of relative risk aversion and $1/(\omega - 1)$ is the Frisch elasticity of labour supply. This preference specification implies that household labour supply is independent of consumption.

A Cobb-Douglas technology, $x_t k_t^{\alpha} l_t^{1-\alpha}$, produces the single good using labour (l_t) and physical capital (k_t). Physical capital depreciates at rate δ and changes to the capital stock incur an adjustment cost which is a function of net investment, $\frac{\theta}{2}(k_{t+1} - k_t)^2$.

Drawing on Fogli and Perri (2015), total factor productivity (x_t) adheres to the following autoregressive process:

$$\log(x_t) = \rho_x \log(x_{t-1}) + e^{v_t} \epsilon_t^x \tag{1.1}$$

where ϵ_t^x represents a stochastic i.i.d perturbation to TFP with mean zero and variance σ_x^2. Persistence of x is given by ρ_x. Disturbances to the variability of TFP (v_t) follow,

$$v_t = \rho_v \log(v_{t-1}) + \epsilon_t^v \tag{1.2}$$

where ϵ_t^v is a stochastic i.i.d shock to the volatility of TFP with mean zero and variance σ_v^2. Persistence of v is captured by ρ_v. ϵ_t^x and ϵ_t^v are assumed to be independent of one another.

Financial markets are assumed to be complete within countries and incomplete at the international level. The agent can lend and borrow using an internationally traded one period non-state-contingent bond (b_t) denominated in units of the single good. The firm-household's bond position is a proxy for net foreign asset holdings, and when $b_t < 0$

the agent is a net debtor. Interest on the bond, R_t, combines the market clearing interest rate (r) and a fixed spread (ϕ) reflecting financial intermediation costs,

$$R_t = \begin{cases} r_l = r - \phi & \text{for } b_{t+1} \geq 0 \\ r_b = r + \phi & \text{otherwise} \end{cases}$$

Chang et al. (2013) found the inclusion of this type of interest rate spread made the shape of the model generated cross-sectional distribution of net foreign assets more realistic relative to results obtained with no spread.

In sum, the resources available to the firm-household give rise to the following budget constraint,

$$\frac{b_{t+1}}{1+R_t} = x_t k_t^{\alpha} l_t^{1-\alpha} + b_t - c_t - [k_{t+1} - (1-\delta)k_t] - \frac{\theta}{2}(k_{t+1} - k_t)^2$$

Borrowing is restricted to proportion η of physical capital holdings,[6]

$$b_{t+1} \geq -\eta k_{t+1}$$

This endogenous borrowing constraint is a simple and tractable means of encapsulating the notion that availability of credit is limited by a country's wealth. Although we do not provide a derivation here, this type of constraint can be shown to emerge when borrowers have limited commitment to repay debt.

1.1.2 Global Equilibrium

Stated recursively, the decision problem facing the firm-household is,

$$V(b, k, \mathbf{z}) = \max_{b',k'} \left\{ \frac{\left(c - \frac{l^{\omega}}{\omega}\right)^{1-\gamma} - 1}{1-\gamma} + \beta E[V(b', k', \mathbf{z}')|\mathbf{z}] \right\}$$

subject to,

$$\frac{b'}{1+R} = x k^{\alpha} l^{1-\alpha} + b - c - [k' - (1-\delta)k] - \frac{\theta}{2}(k' - k)^2,$$

$$b' \geq -\eta k',$$

[6] A similar form of constraint is used in a different context by Guerrieri and Lorenzoni (2015).

$$R = \begin{cases} r_l = r - \phi & \text{for } \; b' \geq 0 \\ r_b = r + \phi & \text{otherwise} \end{cases}$$

The usual convention of no subscript and prime superscript signify current and next period timing of state and control variables. The state space for each country comprises the endogenously determined bond holdings (b) and physical capital stock (k) of the firm-household, along with the exogenous vector of disturbances to TFP and the volatility of TFP, $\mathbf{z} \equiv (x, v)$. The sets containing all possible realisations of b, k and $\mathbf{z}$ are denoted $\mathcal{B}$, $\mathcal{K}$ and $\mathcal{Z}$ respectively. The firm-household's optimality conditions are detailed in the Appendix in Section 1.6.

Our chief concern is the stationary recursive competitive equilibrium of the global economy, which is defined as,

- the set of policy rules for consumption, $c(b, k, \mathbf{z})$, labour supply, $l(b, k, \mathbf{z})$, physical capital, $k'(b, k, \mathbf{z})$, and bond holdings, $b'(b, k, \mathbf{z})$;
- a value function: $V(b, k, \mathbf{z})$
- a world interest rate R
- a probability distribution, $m(b, k, \mathbf{z})$, of countries over possible states

such that,

- the policy rules and value function solve the individual country problem given R,
- the probability distribution is stationary and consistent with the optimal policy rules and shock process;
- the world bond market clears: $\displaystyle\int_{\mathcal{B}\times\mathcal{K}\times\mathcal{Z}} b'(b, k, \mathbf{z}) \mathrm{d}m = 0$

1.1.3 Calibration

The parameters used in our benchmark model are summarised in Table 1.2. In our quantitative experiments, one time period equals a year. The benchmark year is 2006. Following standard practice for the modelling of small open economy models, we set the capital intensity (α) equal to 0.36 and the annual rate of depreciation on capital (δ) equal to 10 percent. The discount factor (β) is adjusted (according to the algorithm described in Section 1.1.4) until the market clearing interest rate in the stochastic stationary state (r) equals 4 percent per annum, a typical value for multi-country models featuring incomplete markets. All approximated solutions satisfy the standard theoretical requirement that $\beta(1+r) < 1$ in order for the long-run global bond distribution to be stationary.

Table 1.2: Benchmark Parameters

	Value	Source/Target
Capital Intensity	$\alpha = 0.36$	Standard Value
Depreciation Rate	$\delta = 0.1$	Standard Value
Discount Factor	$\beta = 0.9612$	$R = 4\%$
Coefficient of Relative Risk Aversion	$\gamma = 4$	see text
Capital Adjustment Cost	$\theta = 0.017$	$\sigma_i/\sigma_y \approx 3$
Frisch Elasticity of Labour Supply	$1/(\omega - 1) = 2.2$	Mendoza (1991)
Maximum Leverage	$\eta = 0.47$	World Debt/World GDP = 18%
Interest Rate Spread	$\phi = 0.1\%$	Chang et al. (2013)
TFP Shock - Developing/EM	$\sigma_{1,x}$=0.0258, $\rho_{1,x} = 0.4$	Mendoza (1991) and Uribe (2013)
Developed	$\sigma_{2,x} = .0129$, $\rho_{2,x} = 0.4$	Mendoza (1991)
Volatility Shock - Developing/EM	$\sigma_{1,v}$=0.633, $\rho_{1,v} = 0.8$	see text
Developed	$\sigma_{2,v}$=0.46, $\rho_{2,v} = 0.8$	see text

The elasticity of intertemporal substitution (EIS) is a particularly important parameter due to the centrality of precautionary saving in our quantitative analysis. However, there is no obvious candidate value given the controversy surrounding the estimation of the EIS in the empirical literature. In their meta-analysis of 169 published papers covering 104 nations Havranek, Horvath, Irsova and Rusnak (2015) highlight substantial heterogeneity in estimates of the EIS both within and between countries; accordingly, choosing the appropriate EIS is doubly precarious in the context of our global model.

For that reason, we combine a benchmark specification in which the EIS ($1/\gamma$) equals 0.25, a level between the extremes observed in the empirical and theoretical literature, with sensitivity analysis using more extreme values.

The capital adjustment cost parameter (θ) is used to obtain a ratio of investment volatility to output volatility (σ_i/σ_y) of approximately 3 in the stochastic stationary equilibrium, in line with the data. Given the absence of labour market frictions in the model and our need to generate the countercyclical trade balance observed in the data, it is necessary for us to set the Frisch elasticity of labour supply near the upper end of empirical estimates. Following Mendoza (1991), a value of 2.2 is chosen for this labour supply elasticity, $1/(\omega - 1)$.[7]

To determine the maximum permissible leverage ratio (debt as a proportion of physical capital stock) for the firm-household (η) we adapt the approach of Fornaro (2014) to our collateral constraint. Specifically, η is chosen so that the ratio of gross world debt to world GDP in the stochastic stationary equilibrium equals 18 percent, the average value of the corresponding ratio over the rolling 10-year window for 2006 in our panel dataset.

We assume the spread between lending and borrowing rates (ϕ) is 0.1 percent per annum in our baseline specification. Since this spread lies at the lower bound of empirical estimates in Chang et al. (2013), it is the least conservative choice for our model. Consequently, we consider the impact of widening the spread in our sensitivity analysis.

Heterogeneity – The source of cross-country heterogeneity in the model is the exogenous TFP process, given by (1.1) and (1.2). Realisations of this process depend on the outcome of several events. The parameters defining the variability of TFP are contingent upon the country's level of economic development and as a result, the first event involves the country entering a draw to determine its allocation between two broad categories: developed and developing/emerging market. Subsequently, the country draws realisa-

[7] Relatively high values for the Frisch elasticity are frequently found in the RBC literature, with the indivisible labour model of Hansen (1985) being a seminal example.

tions of the productivity shock and the disturbance to the volatility of productivity. In addition to the contribution made by these lotteries, the ultimate level of productivity also depends on prior realisations of the productivity process.

In our quantitative investigation, each of the events constituting the productivity process are approximated with a two-state Markov processes designed to capture relevant features of panel data on GDP from the Penn World Tables. This specification implies there are 8 possible exogenous states in the model.

Elements of the transition probability matrix for assignment to country category are chosen to meet two criteria: (i) the annual probability of switching from developing/emerging market status to developed must match a rough estimate of the probability of a non-OECD country gaining accession to the OECD in a given year;[8] (ii) the proportion of world GDP produced by developed countries in the stochastic stationary equilibrium must equal 54 percent, as in our data for the benchmark year (2006).

The parameters of the TFP shock for country group j ($\sigma_{j,x}$ and $\rho_{j,x}$) are set in line with values employed in the literature on small open economy models. Following Mendoza (1991), the standard deviation and persistence of the TFP shock for the developed country group equal 1.29 percent and 0.4 respectively. The analysis of business cycle characteristics in a panel of 120 countries by Uribe (2013) indicates that the standard deviation of GDP in poor and emerging market countries is about twice as large as that

[8] We use OECD membership as a proxy for developed country status. In 1960, the OECD was established and it had 20 members at that time. Our estimate begins with an approximation of the typical number of countries outside the original 20 members for the years since the OECD's inception. We view 150 countries as a reasonable choice here. This implies there have been 8,250 country-year observations for which we can record the membership status for these non-OECD nations. Another 15 countries joined the OECD over the 55 years through 2015. We remove the post-accession years for these new members from our previous tally and are left with 7,881 observations. Therefore, 15 accessions to membership occurred during the 7,881 country-year observations, which can plausibly be viewed as implying that the probability of gaining membership in a particular year was about 0.002. This value is used as our rough estimate for the probability of switching from developing/emerging market to developed in the transition matrix. To the best of my knowledge, a more precise measure of this probability is not currently available in the literature. Using a more finely divided scale of country income groupings than our own, Kremer, Onatski and Stock (2001) estimated a transition probability matrix for country movement between income groupings using data for 140 countries over the period 1960 through 1996. Although not directly comparable to our transition probabilities due to its reliance on a different approach to grouping countries, their analysis does not make our estimate seem unreasonable.

in developed countries. On the basis of this finding, the standard deviation of the TFP shock for the developing/emerging market group equals 2.58 percent. The persistence of the TFP shock in developing/emerging market countries is 0.4.

In the data, the cross-country dispersion of the relative volatility of GDP growth does not exhibit a clear and consequential tendency toward increase or decrease over the course of the sample period for either country group. To capture this observation, the standard deviation of the disturbance to the volatility of TFP for country group j ($\sigma_{j,v}$) in our baseline approximation is selected to ensure the dispersion of relative volatility for country group j in a simulation of the model matches the mean of the annual cross-country standard deviations of relative volatility for country group j in the data. Persistence of relative volatility in the data does not differ substantially between country groups. In light of this, we set the persistence of the volatility shock (ρ_v) equal to the average first-order autocorrelation of relative volatility for the whole panel.

The two possible realisations of the TFP shock and the shock to the volatility of TFP for country group j in our approximations are $\pm\sigma_{j,x}$ and $\pm\sigma_{j,v}$ respectively. The long-run (unconditional) probability of each realization (Π) is assumed to be 0.5 for both Markov chains. Using an approach intended to deliver the required level of persistence in the Markov process, the elements of the probability matrix governing transition between current (p) and future (q) realisations of the TFP shock for country group j equal,[9]

$$\pi^x_{j,p,q} = \begin{bmatrix} (1-\rho_{j,x})\Pi + \rho_{j,x} & (1-\rho_{j,x})\Pi \\ (1-\rho_{j,x})\Pi & (1-\rho_{j,x})\Pi + \rho_{j,x} \end{bmatrix}$$

The transition matrix for the shock to the volatility of TFP ($\pi^v_{j,p,q}$) is also constructed this way.

The three Markov chains underlying the discretised productivity process combine to yield an 8×8 transition matrix. The shocks to TFP and the volatility of TFP are assumed to be independent of one another both within and between country groups.

[9] This is a common method, used by Mendoza (1991) and Cochrane (1988) among others.

1.1.4 Computation

Here we provide a broad outline of our approach to numerically approximating the world economy model. See the Appendix in Section 1.7 for a more detailed explanation of this method. The problem facing the individual country (firm-household) is solved for a given discount factor (β) by applying an adapted version of the Endogenous Gridpoint Method (EGM) introduced by Guerrieri and Lorenzoni (2015) to a discretised state space.[10] The main outcome of this procedure is a set of optimal policy rules for possible realisations of the productivity process and evenly spaced grids for bond holdings and the capital stock. The bounds of the bond and capital grids are found through trial and error: over repeated approximations of the model, the limits of the state space are adjusted until we identify the set which adequately captures the stochastic stationary distribution, $m(b, k, \mathbf{z})$. The number of gridpoints is 150 for bond holdings and 300 for the capital stock.

In the next step of the computation we move from the policy rules defining the choices of the individual country to a characterisation of the optimal decisions made by the continuum of economies comprising the world economy. To do this, we must first recast the policy functions over a more finely divided variant of our initial state space by applying linear interpolation to our original optimal decision rules. These modified policy rules are combined with the transition probability matrix for the productivity process to estimate the stochastic stationary distribution of countries over the state space. If the world bond market clears then the algorithm is complete; otherwise, we guess a new discount rate and repeat the steps beginning with the approximation of the firm-household policy rules. The assessment of solution accuracy in the Appendix in Section 1.8 indicates that our computation method achieves an acceptable degree of precision.

[10] The EGM was originally introduced by Carroll (2006).

1.2 Results

The discussion of our results is divided into four sections. Firstly, an outline of key business cycle moments for the benchmark model with time-varying volatility is provided. We move on to describe the international distribution of external balances in versions of the world economy model with and without shocks to the volatility of TFP. Then we consider how financial frictions influence the concentration of external balances. Finally, a sensitivity analysis is presented.

As we move from one version of the model to the next, we always clearly indicate any departures from the benchmark parameter set. When approximating the model under these alternative parameterisations, the discount factor necessary for bond market clearing also deviates from its benchmark level.

1.2.1 Business Cycle Moments

Before exploring the distribution of external balances, we assess the realism of business cycle dynamics in the benchmark version of one of the small open economies in our global framework featuring time-varying volatility shocks. Table 1.3 reports key long-run business cycle moments. Counterpart statistics from the data are also displayed. The model does a reasonably good job of approximating the data for both developed and developing/emerging market countries. Output variability and autocorrelation clearly resemble the data. The volatilities of key aggregates are realistic multiples of output volatility.[11] Importantly, the small open economy's trade balance is countercyclical.

The difference between the relative volatility of consumption (σ_c/σ_y) for each country

[11] It should be noted that consumption in the model captures household expenditure on nondurable goods whereas our data on consumption includes both durable and nondurable goods. Since durables consumption is more valatile than nondurable consumption, a model consistent data moment for consumption, excluding durables expenditure, would be lower than the one in the table. So, the volatility of consumption in the model is probably best viewed as being greater than the most appropriate data moment though not by an unacceptable amount. It would be very difficult to obtain more disaggregated data for the broad group of countries in our sample and consequently, we're not able to provide a more directly comparable data moment for consumption.

Table 1.3: Business Cycle Moments

	Data		Model	
	Developed	Developing/EM	Developed	Developing/EM
σ_y (%)	4.56	7.57	3.69	8.12
σ_c/σ_y	0.98	0.99	1.03	0.86
σ_i/σ_y	2.56	3.11	2.78	3.07
σ_{tb}/σ_y	0.52	0.55	0.65	0.59
$\rho(c, y)$	0.77	0.77	0.80	0.85
$\rho(i, y)$	0.59	0.41	0.69	0.69
$\rho(tb, y)$	-0.04	-0.06	-0.16	-0.08
$\rho(y, y_{-1})$	0.62	0.60	0.64	0.60

All data was detrended with a quadratic time trend. Each listed moment is the mean for the country group. Details of the data are provided in the Appendix in Section 1.5. Variables: y is output, c is consumption, i is gross investment, and tb is the trade balance.

group in the model deserves further comment. When the standard deviation of TFP in our model calibration is increased (by increasing $\sigma_{j,x}$ and $\sigma_{j,v}$), the relative volatility of consumption falls. Consequently, the relative volatility of consumption is higher for developed countries than it is for developing/emerging market nations in our approximations of the model. This ranking contradicts the typical observation from the data which shows the relative volatility of consumption to be higher for developing/emerging market countries. The model presented by Chang, Kim and Lee (2013), which has a similar structure to our own, also exhibits decreases in the relative volatility of consumption when the standard deviation of innovations to TFP increases. Although the ranking of consumption variabilities in our model does not conform with the data, we still view the levels for each region as being acceptable.

1.2.2 Distribution: Model without time-varying volatility shocks

The statistics presented in Table 1.4 indicate that when each artificial small open economy is not subject to volatility shocks, there is a sizeable margin between the dispersion of external balances in the model and the data. Even the performance on net foreign assets, where this version of the model fares best, leaves about 38 percent of the cross-country variation in the data unexplained. The interquantile ranges in Table 1.5 offer additional evidence of the discrepancy between dispersion in the model without time-varying volatility and the data.

Interestingly, the multi-country framework presented by Chang et al. (2013), which also features constant volatility of TFP, produced an international standard deviation of net foreign assets in line with the data. The most relevant distinction between our model without time-varying volatility and their's is the type of borrowing constraint in force: we employ a collateral constraint while they have a fixed limit, thus suggesting that in the presence of our more onerous, and arguably more realistic credit restriction, some other driver of precautionary saving is needed to bring the model in line with the data.

Table 1.4: The Role of Time-Varying Volatility in the Benchmark Model

	Standard Deviation			Fit		
		Model		Model		
	Data	no tvv	with tvv	no tvv	with tvv	tvv share
NFA/Y	56.5	35.2	52.8	62.2	93.4	33.3
CA/Y	5.7	2.3	3.1	41.1	53.5	23.3
TB/Y	14.7	2.7	3.7	18.6	25.3	26.3

All variables measured in percent. The terms *no tvv* and *with tvv* respectively denote the benchmark model without and with time-varying volatility. *Fit* measures the proportion of standard deviation in the data accounted for by the model. The *tvv share* measure indicates the proportion of standard deviation in the *with tvv* model accounted for by the presence of time-varying volatility. Data sample includes 21 developed countries and 76 developing/emerging market countries. See Appendix in Section 1.5 for details of the data sample. The benchmark year is 2006. NFA/Y, CA/Y and TB/Y denote net foreign assets, current account and trade balance, each as a proportion of GDP.

1.2.3 Distribution: Model with time-varying volatility shocks

As Table 1.4 shows, once the productivity process has been augmented with time-varying volatility shocks, the model generated global distribution of net foreign assets positions moves much closer to the data, explaining 93 percent of the international dispersion; the volatility shocks account for a substantial proportion (33 percent) of this variation. The close correspondence between net foreign asset dispersion in the model and data is emphasised by Figure 1.1. Furthermore, after breaking our approximated distribution into quantiles in Table 1.5, it is also apparent that the model performs well for stock positions, with interquantile ranges covering both the core and breadth of net foreign asset positions bearing clear resemblance to the data.

Table 1.5: Interquantile Fit: Data vs. Benchmark Model

		Interquantile Fit			
		20v1	10v1	4v1	3v2
NFA/Y	no tvv	0.69	0.70	0.71	0.46
	with tvv	0.98	1.04	1.09	0.93
CA/Y	no tvv	0.43	0.44	0.45	0.42
	with tvv	0.56	0.58	0.57	0.47
TB/Y	no tvv	0.18	0.19	0.20	0.19
	with tvv	0.24	0.25	0.26	0.27

Interquantile Fit measures the range between the mean external balance within each of the stated quantiles in the model as a proportion of the same range in the data. *20v1* divides the distribution into 20 quantiles and then compares the average external balance in each of the 20th and 1st quantiles; *10v1* compares the average in each of the 10th and 1st deciles; *4v1* compares the average in each of the 4th and 1st quartiles; and *3v2* compares the average in each of the 3rd and 2nd quartiles. Data sample includes 21 developed and 76 developing/emerging market countries. Benchmark year is 2006. See Appendix in Section 1.5 for details of data sample. NFA/Y, CA/Y and TB/Y denote net foreign assets, current account and trade balance, each as a proportion of GDP.

Further insight is provided in Figure 1.2, which shows how the proportion of countries at each level of net foreign asset holdings differs between approximations with and without time-varying volatility. The presence of macroeconomic uncertainty, in the form of disturbances to the volatility of TFP, widens the range of possible productivity levels an economy can experience, which in turn, leads to greater international diversity in lending and borrowing decisions; ultimately, the pattern in Figure 1.2 emerges, with fewer countries having relatively low asset or low liability positions versus the rest of the world, and more nations at comparatively extreme levels of net foreign assets.

In contrast to the results for net foreign assets, the dispersion of current account and trade balance positions in the model with time-varying volatility are far smaller than the data. This divergence is apparent in the cross-country standard deviation, the interquantile fit statistics and Figure 1.1. The spread of the flow external balances was also underestimated in the model presented by Chang et al. (2013), and they

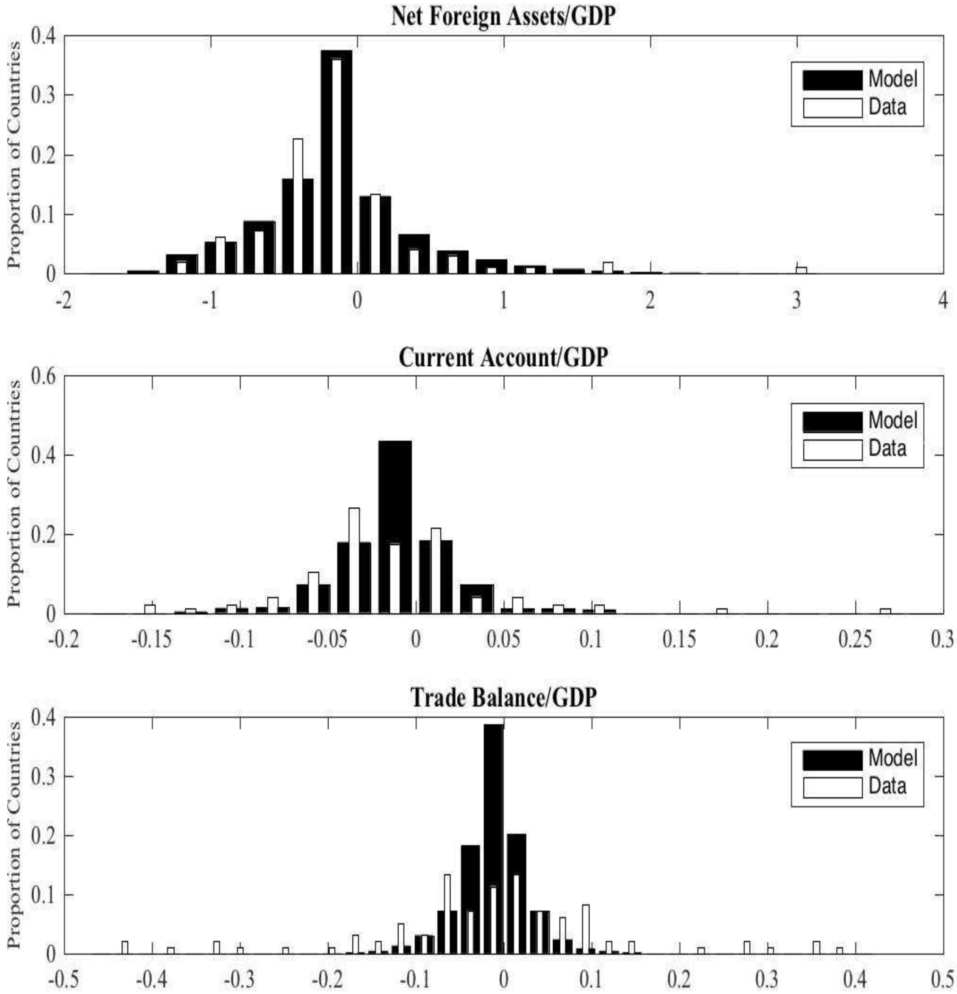

Figure 1.1: Distribution of External Balances in Benchmark Model (with tvv)

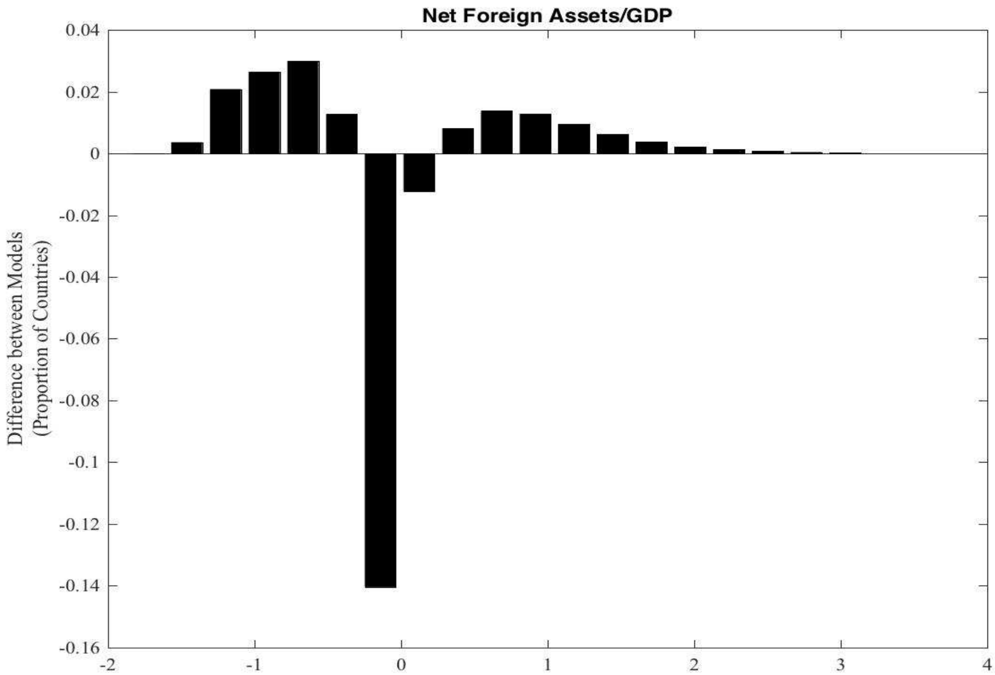

Figure 1.2: The Impact of Macroeconomic Uncertainty on Net Foreign Assets

surmise that the absence of terms of trade movements in their framework, as is the case in our own model, may help explain the inconsistency. Alternatively, real exchange rate movements, which are also absent from our model, might be helpful since they can influence international trade, external asset and liability valuations, and a country's capacity to engage in collateralised borrowing. While each of these conjectures appear plausible, they remain quantitative questions that are beyond the scope of this paper. An initial effort to address these issue in Hughes (2016) involving the quantitative analysis of a world economy model featuring real exchange rate fluctuations (but not terms of trade movements) finds the proportion of model generated international dispersion of net foreign assets, the current account and the trade balance that can be attributed to the effect of real exchange rate movements on a country's incentive to engage in intertemporal trade to be 23, 53 and 35 percent respectively. Although preliminary, this finding does suggest a substantial role for real exchange rate movements, particularly in the determination of the cross-country concentration of flow external balances.

When we consider the development level subgroups of our world economy in Table 1.6 the model still performs well for stock external balances and poorly for flows. The standard deviation of net foreign assets in developing/emerging market countries is close to the data. Although the model appears to mis-estimate the spread of net foreign assets in developed countries by a larger margin, the standard deviation in the data is unrealistically inflated by a relatively extreme observation for a single country; removal of this datapoint leads the dispersion of net foreign assets in the model to equal 89 percent of that in the data, a relatively small disparity.[12] As in the global distribution, macroeconomic uncertainty accounts for around one third of the dispersion of net foreign assets at both levels of development. The congruence of the model with the data for net foreign assets in each development group is illustrated in Figure 1.3.

[12] Although this extreme observation is considered an outlier for the developed country group, it is not categorised as one on the world level since it does not fall outside the percentile bounds used to construct the full sample (see Appendix in Section 1.5 for details). Furthermore, the dispersion of developed country net foreign assets in the data declines by a substantial amount upon removing this individual observation while the standard deviation for all countries moves by an insignificant amount when the same observation is discarded.

Table 1.6: The Distribution of External Balances by Country Group

	Standard Deviation			Fit		
		Model		Model		
	Data	no tvv	with tvv	no tvv	with tvv	tvv share
Panel A: Developed Countries						
NFA/Y	57.6	26.0	40.1	45.2	69.5	35.0
CA/Y	7.5	1.4	1.8	19.3	23.6	18.2
TB/Y	13.1	1.8	2.4	13.8	18.4	25.0
Panel B: Developing/EM Countries						
NFA/Y	56.4	43.3	63.9	76.8	113.4	32.2
CA/Y	5.1	3.1	4.1	60.0	79.7	24.8
TB/Y	14.6	3.5	4.8	24.2	32.9	26.4

All values measured in percent. The terms *no tvv* and *with tvv* respectively denote the benchmark model without and with time-varying volatility. *Fit* measures the proportion of the standard deviation in the data accounted for by the model. The *tvv share* measure indicates the proportion of standard deviation in the *with tvv* model accounted for by the presence of time-varying volatility. Benchmark year is 2006. See Appendix in Section 1.5 for details of the data.

1.2.4 Evolution of Distribution

Here, we quantitatively investigate how the global distribution of external balances is influenced by financial liberalisation in the presence of macroeconomic uncertainty. Upon integrating with international financial markets, a country gains access to expanded risk sharing opportunities. Consequently, capital account liberalization has the potential to alter precautionary saving activity and, in turn, international borrowing and lending decisions. If the responsiveness of capital flows to macroeconomic uncertainty changes with financial globalization, so will the cross-country diversity of external balances.

So far, our attention has been trained on the world in 2006, a time when international financial integration was relatively widespread. To assess the impact of financial liberalization, we ask how our key metrics of interest differ in alternative versions of the world economy framework featuring more stringent financial frictions designed to proxy for the greater restrictions on cross-border flows in 1986. Following Chang et al. (2013), we adjust financial frictions in our model by changing the restrictiveness of the interest rate spread and collateral constraint, one at a time. When the interest rate spread is increased, borrowing becomes more costly and saving less rewarding, thereby reducing the degree to which the firm-household resorts to trade in the international risk-free bond

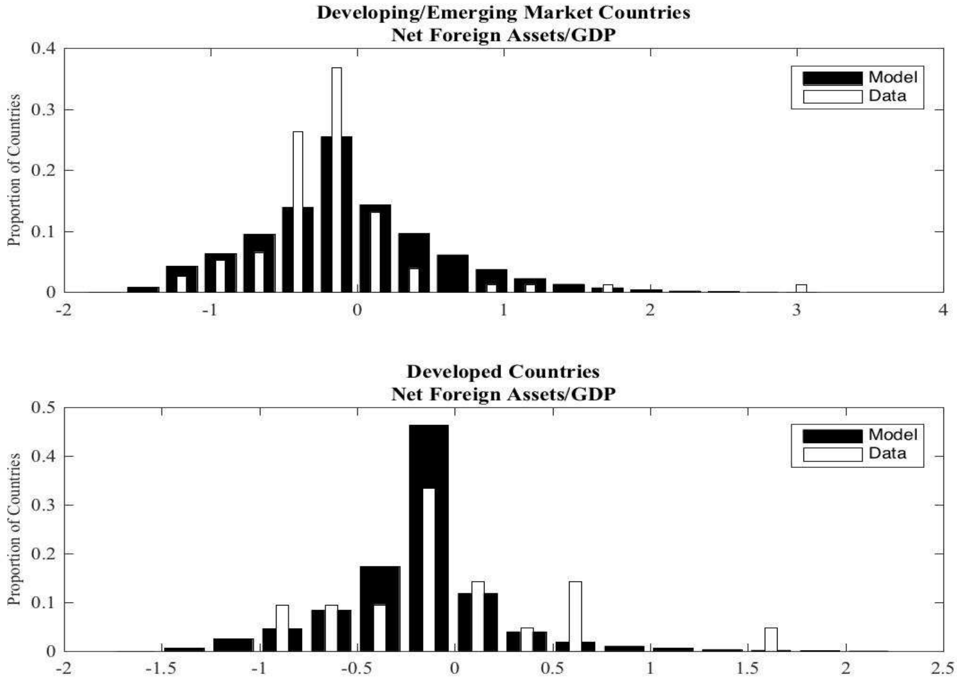

Figure 1.3: The Distribution of Net Foreign Assets by Development Group

in response to shocks; the international distribution of external balances then becomes more concentrated. The impact of changes to the collateral constraint is slightly more involved. In this scenario, the change in parameterisation is a decrease in the maximum permitted leverage ratio (η). A tightening of this constraint implies the firm-household has less capacity to use borrowing as a means of absorbing adverse shocks. In turn, the cross-section of worldwide borrowing becomes less diffuse and gross global debt declines. To increase global savings and restore bond market equilibrium, the discount factor decreases (i.e. the personal rate of time preference increases relative to the risk-free interest rate on the bond). Taken together, these developments indicate that the dispersion of external balances will decline under a more restrictive collateral constraint.[13]

When quantitatively analysing the evolution of external balances we depart from the

[13]For more detail on the dynamics of a deleveraging episode in closed and open economy settings see Guerrieri and Lorenzoni (2015) and Fornaro (2014) respectively.

approach taken by Chang et al. in three notable respects. Firstly, as mentioned above, we employ a collateral constraint on borrowing rather than the fixed limit present in their framework, so the degree to which risk sharing opportunities expand with financial openness in our test is constrained by the firm-household's capital stock. Secondly, in our experiments, we adjust the financial friction until the gross world debt to world GDP ratio, a defining gauge of real-world financial globalization, matches the data for 1986, whereas they focused on the plausibility of the smallest country-level net foreign asset to GDP ratio in the model's long-run stationary distribution. Thirdly, Chang et al. did not allocate countries to developmental groupings and as a result, were not able to change the composition of world GDP to match the data for 1986, as we do here.[14]

Table 1.7 contains the results of this experiment. Under the tightened version of the collateral constraint, the cross-country dispersion of net foreign assets is 74 percent of that in the data, while the corresponding proportion under the increased interest rate spread is 83 percent. Although our benchmark approximations (repeated in Table 1.7) achieved a closer fit, these experiments with more restrictive financial frictions still deliver an international concentration of net foreign assets of a similar order of magnitude to the data in 1986. This outcome is suggestive of a substantial role for financial liberalisation in the diffusion of foreign asset holdings in the presence of time-varying volatility. Moreover, macroeconomic uncertainty consistently accounts for around one third of this dispersion of external stocks.

1.2.5 Sensitivity Analysis

In this section we examine how the global distribution of external balances changes when key parameters are adjusted. Under each scenario, the model is approximated with and without time-varying volatility so that we can detect any changes to the relative contribution of macroeconomic uncertainty, should they occur. Also, other than the

[14]The transition matrix for country group allocation is amended to obtain the developmental group GDP weightings for 1986 in our sample panel; the same modified allocation matrix is used throughout these tests. In our data, developed countries generate 64 percent of global GDP in 1986.

Table 1.7: The Evolving Distribution of External Balances

	Standard Deviation			
	Data	Model	Fit	tvv share
Panel A: Adjusting the collateral constraint (year = 1986)				
NFA/Y	46.4	34.5	74.4	29.0
CA/Y	4.5	2.7	64.2	21.1
TB/Y	9.1	3.0	33.0	22.6
Panel B: Adjusting the interest rate spread (year = 1986)				
NFA/Y	46.4	38.4	82.8	39.9
CA/Y	4.5	2.7	65.6	25.1
TB/Y	9.1	3.1	34.5	28.3
Panel C: Benchmark (year = 2006)				
NFA/Y	56.5	52.8	93.4	33.3
CA/Y	5.7	3.1	53.5	23.3
TB/Y	14.7	3.7	25.3	26.3

All values measured in percent. *Fit* measures the proportion of standard deviation in the data accounted for by the model. The *tvv share* measure indicates the proportion of standard deviation in the model accounted for by the presence of time-varying volatility. Data covers 21 developed countries and 76 developing/emerging market countries. See Appendix in Section 1.5 for details of the data.

discount factor, which adjusts to clear the bond market, all remaining parameters are kept at benchmark 2006 values.

It is apparent from Table 1.8 that there is a strong negative association between the elasticity of intertemporal substitution ($1/\gamma$) and the standard deviation of external balances. Intuitively, since the desire for a smooth consumption path strengthens as γ rises, so does the reliance on the shock absorbing capacity of saving, borrowing and by implication, trade in foreign assets; the heightened responsiveness of foreign asset holdings gives rise to a more diverse range of external balances.

The final column of Table 1.8 indicates the dispersion of external balances when the interest rate spread (ϕ) has been increased. The spread used to test sensitivity here equals the largest spread obtained from the data by Chang et al. (2013). Consistent with the experiment in section 1.2.4, the standard deviation of external balances declines as ϕ rises above its level in the benchmark model.

Table 1.8: Sensitivity Analysis

			Model			
		Data	Benchmark	$\gamma = 2$	$\gamma = 8$	$\phi = 0.5\%$
NFA/Y	σ	56.5	52.8	34.2	73.3	11.1
	tvv share	–	33.3	37.9	27.9	62.7
CA/Y	σ	5.7	3.1	3.0	3.1	1.8
	tvv share	–	23.3	24.9	23.2	46.3
TB/Y	σ	14.7	3.7	3.3	4.2	1.9
	tvv share	–	26.3	26.7	25.1	47.3

All values measured in percent. The *tvv share* measure indicates the proportion of the cross-country standard deviation (σ) under each parameterisation accounted for by the presence of time-varying volatility. Data sample covers 21 developed countries and 76 developing/emerging market countries. Data year is 2006. See Appendix in Section 1.5 for details of data.

1.3 Discussion and Conclusion

This paper investigated how the precautionary response to country-specific macroeconomic uncertainty influences the global distribution of external balances in a world economy model featuring incomplete international insurance markets. Uncertainty appears in the guise of time-varying shocks to the volatility of national productivity. The quantitative implications of the model are limited to those stemming from intertemporal optimisation, so, our framework is restricted to being a means for evaluating how much cross-country dispersion of external balances can be expected to result from simple substitution of resources across time; the consequences of macroeconomic uncertainty are viewed through this lens. Nevertheless, our framework still generates some notable insights.

The international dispersion of net foreign assets in our benchmark model with time-varying volatility amounts to about 90 percent of dispersion in the data for 2006. The corresponding proportion when the model was re-calibrated to conditions in 1986 was 80 percent. Macroeconomic uncertainty steadily accounts for about one third of the model generated cross-country variability of net foreign assets.

How do these findings contribute to the debate over the sustainability of the current international distribution of cross-border holdings and the potential for a destabilising realignment in the future? There are many plausible drivers of capital flows that may counteract or reinforce the basic optimising activity considered here. It remains to be seen if the combination of these forces presents a material risk to economic stability. Even so, our results do give reason to anticipate a substantial degree of cross-country heterogeneity in foreign asset holdings that have been accumulated to satisfy the precautionary saving motive; macroeconomic uncertainty stimulates this saving. As financial frictions weaken, simple optimising behaviour exerts upward pressure on the international dispersion of external balances. As a result, the current diversity of foreign asset holdings might not necessarily be cause for alarm, and instead, could possibly be a natural result of a stable underlying preference for a smooth consumption path.

While our world economy model was able to produce a spread of stock external balances in line with the data, it was not able to do the same for flow balances. It's possible that we have the correct gauge of the flow response to the precautionary saving motive. However, there is reason to suspect that refinements to our framework, including the introduction of endogenous movements in the terms of trade and real exchange rate, would offer a more reassuring grasp of the link between simple optimising behaviour and the distribution of flow external balances. We leave this challenge for future work.

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1.5 Appendix A: Data

The panel covers the period from 1981 to 2010 and the following countries:

Developed
Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States.

Developing/Emerging Market
Argentina, Bangladesh, Belize, Benin, Bolivia, Botswana, Brazil, Burkina Faso, Burundi, Cote d'Ivoire, Cameroon, Cape Verde, Central African Republic, Chad, Chile, China, Hong Kong, Colombia, Comoros, Costa Rica, Cyprus, Djibouti, Dominica, Dominican Republic, Ecuador, Egypt, Ethiopia, Fiji, Gabon, Gambia, Ghana, Guatemala, Guinea, Honduras, India, Indonesia, Iran, Israel, Jordan, Kenya, Korea, Lao, Madagascar, Malawi, Malaysia, Mali, Malta, Mexico, Morocco, Mozambique, Nepal, Niger, Oman, Pakistan, Panama, Peru, Philippines, Poland, Saudi Arabia, Senegal, Sierra Leone, South Africa, Sri Lanka, St. Vincent and Grenadines, Sudan, Suriname, Taiwan, Tanzania, Thailand, Trinidad and Tobago, Tunisia, Turkey, Uganda, Uruguay, Venezuela, Zambia.

Countries and timeframe were selected on the basis of data availability.

The frequency of the data is annual.

All data relating to GDP, the components of GDP, and price deflators was obtained from the Penn World Table version 8.1 prepared by Feenstra, Inklaar and Timmer (2014).

The net foreign assets (NFA), total liabilities and total assets series were obtained from the External Wealth of Nations (EWN) dataset prepared by Lane and Milesi-Ferretti (2007). Total assets and total liabilities both include asset and liability positions in portfolio equity, FDI, debt, and financial derivatives. In addition, total assets also include FX reserves minus gold. NFA equals total assets less total liabilities. Adopting the approach of Gourinchas and Jeanne (2013), we convert the EWN data from its original denomination (current USD) to constant international dollars through dividing by the deflator,

$$Q = P\frac{CGDP}{RGDP}$$

where P is the price of capital formation, CGDP is real GDP measured at current PPP, and RGDP is real GDP at chained PPPs. The variables P, CGDP and RGDP were obtained from the Penn World Tables.

Countries with extreme values of key variables (NFA to GDP, trade balance to GDP, current account to GDP and GDP growth) were removed from the sample. Specifically, exclusion occurred when the modulus of any key variable was equal to or greater than the 99th percentile for that variable (in absolute terms) in one or more years.

Throughout the paper, the external balance variables are demeaned by year (i.e. the cross-country mean for a given year is subtracted from each country observation for that year) and then averaged over a 10-year rolling window.

1.6 Appendix B: The firm-household problem in detail

In recursive form, the problem facing the firm-household is,

$$V(b, k, \mathbf{z}) = \max_{b',k'} \left\{ \frac{\left(c - \frac{l^\omega}{\omega}\right)^{1-\gamma} - 1}{1-\gamma} + \beta E[V(b', k', \mathbf{z}')|\mathbf{z}] \right\} \tag{1.3}$$

subject to,

$$\frac{b'}{1+R} = xk^\alpha l^{1-\alpha} + b - c - [k' - (1-\delta)k] - \frac{\theta}{2}(k'-k)^2 \tag{1.4}$$

$$b' \geq -\eta k' \tag{1.5}$$

$$R = \begin{cases} r_l = r - \phi & \text{for } b' \geq 0 \\ r_b = r + \phi & \text{otherwise} \end{cases}$$

First-order conditions for c and l:

$$\left(c - \frac{l^\omega}{\omega}\right)^{-\gamma} = \lambda \tag{1.6}$$

$$l^{\omega-1}\left(c - \frac{l^\omega}{\omega}\right)^{-\gamma} = \lambda(1-\alpha)xk^\alpha l^{-\alpha} \tag{1.7}$$

For b',

$$\Big(\mu + \beta E[V_{b'}(b', k', \mathbf{z}')|\mathbf{z}]\Big)(1 + r_l) = \lambda \qquad \text{for } b' > 0 \tag{1.8}$$

$$\Big(\mu + \beta E[V_{b'}(b', k', \mathbf{z}')|\mathbf{z}]\Big)(1 + r_b) = \lambda \qquad \text{for } b' < 0 \tag{1.9}$$

$$\frac{\lambda}{1 + r_l} \geq \Big(\mu + \beta E[V_{b'}(b', k', \mathbf{z}')|\mathbf{z}]\Big) \geq \frac{\lambda}{1 + r_b} \qquad \text{if } b' = 0 \tag{1.10}$$

For k',

$$\frac{\beta E[V_{k'}(b', k', \mathbf{z}')|\mathbf{z}] + \eta\mu}{1 + \theta(k' - k)} = \lambda \tag{1.11}$$

where λ and μ are the Lagrange multipliers for the budget and collateral constraints respectively.

The complementary slackness condition is,

$$-\mu[b' + \eta k'] = 0$$

For the purposes of our numerical approximation we require the following envelope conditions for b and k,

$$V_b = \lambda \tag{1.12}$$

$$V_k = \lambda\left(\alpha x k^{\alpha-1} l^{1-\alpha} + (1 - \delta) + \theta(k' - k)\right) \tag{1.13}$$

1.7 Appendix C: Numerical Approximation

A solution for the global model has been obtained when we have satisfied the requirements of the stationary recursive competitive equilibrium (specified in section 1.1.2) to an acceptable degree of accuracy. Therefore, our numerical approximation is tasked with finding the policy rules, value function, world interest rate and probability distribution of countries over states such that: the policy rules and value function solve the firm-household problem (represented by optimality conditions (1.6)–(1.11)) given R; the probability distribution $m(b, k, x)$ is stationary and consistent with the policy rules and shock process; and the world bond market clears.

The central component of our approximation is an adapted version of the endogenous gridpoint method (EGM) introduced by Guerrieri and Lorenzoni (2015). They applied the nonlinear solution technique to a closed economy model in which household holdings of government bonds and durable goods were the endogenous states. Our implementation of the EGM occurs in stages 4 – 11 of the following solution algorithm:[15]

1. Specify discrete grids for bond holdings $G_b = [b_1, b_2, ..., b_{nb}]$, capital stock $G_k = [k_1, k_2, ..., k_{nk}]$, and the productivity shock $G_z = [z_1, z_2, ..., z_{nz}]$.
2. Set $n = 0$. Guess initial discout factor (β).
3. Guess values for $E[V^n_{b'}(b', k', \mathbf{z}')|\mathbf{z}]$ and $E[V^n_{k'}(b', k', \mathbf{z}')|\mathbf{z}]$ for $n = 0$. $E[V^n_{b'}(b', k', \mathbf{z}')|\mathbf{z}]$ must be a decreasing function of b and $E[V^n_{k'}(b', k', \mathbf{z}')|\mathbf{z}]$ a decreasing function of k. Let $\tilde{V}^n_b(b', k', \mathbf{z}) = E[V^n_{b'}(b', k', \mathbf{z}')|\mathbf{z}]$ and $\tilde{V}^n_k(b', k', \mathbf{z}) = E[V^n_{k'}(b', k', \mathbf{z}')|\mathbf{z}]$.
4. For each possible triple $(k, k', \mathbf{z})$ - where $k \in G_k$, $k' \in G_k$ and $\mathbf{z} \in G_z$ - solve for b' that satisfies the following optimality conditions (which combine the optimality conditions (1.8) – (1.11)):

$$\big(1 + \theta(k' - k)\big)\, \tilde{V}^n_b(b', k', x) = \frac{\tilde{V}^n_k(b', k', x)}{(1 + r_l)} \qquad \text{for } b' > 0$$

[15] Matlab code for this algorithm is available on request. Our code is based on the Matlab code accompanying the paper by Guerrieri and Lorenzoni (2015).

$$\frac{\tilde{V}_k^n(b',k',x)}{(1+r_l)} \geq \big(1+\theta(k'-k)\big)\,\tilde{V}_b^n(b',k',x) \geq \frac{\tilde{V}_k^n(b',k',x)}{(1+r_b)} \qquad \text{if } b'=0$$

$$\big(1+\theta(k'-k)\big)\,\tilde{V}_b^n(b',k',x) = \frac{\tilde{V}_k^n(b',k',x)}{(1+r_b)} \qquad \text{for } -\eta k' < b' < 0$$

$$\big(1+\theta(k'-k)\big)\,\tilde{V}_b^n(b',k',x) \geq \frac{\tilde{V}_k^n(b',k',x)}{(1+r_b)} \qquad \text{for } b' = -\eta k'$$

5. For each $(k,\mathbf{z})$ pair and the associated unconstrained range of b' (where $b' \in G_b$), solve for k' that meets the following conditions:[16]

$$\big(1+\theta(k'-k)\big)\,\tilde{V}_b^n(b',k',x) = \frac{\tilde{V}_k^n(b',k',x)}{(1+r_l)} \qquad \text{for } b' \geq 0$$

$$\big(1+\theta(k'-k)\big)\,\tilde{V}_b^n(b',k',x) = \frac{\tilde{V}_k^n(b',k',x)}{(1+r_b)} \qquad \text{for } -\eta k' < b' < 0$$

6. For each combination (k,k',b',x) found in steps $4-5$, compute Lagrange multipliers μ and λ. When $b' = -\eta k'$ use,

$$\mu = \frac{\beta\big[\tilde{V}_k^n(b',k',x) - \big(1+\theta(k'-k)\big)(1+r_b)V_b^n(b',k',x)\big]}{\eta - (1+r_b)\big(1+\theta(k'-k)\big)}$$

$$\lambda = \frac{\beta\tilde{V}_k^n(b',k',x) + \eta\mu}{\big(1+\theta(k'-k)\big)} \tag{1.14}$$

When $b' > -\eta k'$ set $\mu = 0$ and compute λ using (1.14).

[16] After completing step 4 we know the regions (defined in terms of k') where the collateral constraint does and does not bind for each $(k,\mathbf{z})$ pair. As we approach $b'=0$ for a given $(k,\mathbf{z})$ pair from $b'>0$ and $b'<0$, the change in b' as we move from one point on the k' grid to the next can become relatively large. This is less than ideal since the distance that we are interpolating over in step 9 below increases with the size of these jumps between values of b'. The approximation can more accurately capture the non-linearities in the model if these gaps between optimal values of b' can be narrowed. This can be most efficiently achieved by using a different approach to recalculate the optimal combinations of $(k,k',b',\mathbf{z})$ over the region where the collateral constraint is not binding. This alternative involves finding the optimal k' for every $(k,\mathbf{z},b')$ triple for which the borrowing constraint is slack. This shortens the gap between values of b' to an acceptable size.

7. For each combination $(k, k', b', \mathbf{z}, \lambda, \mu)$ compute controls (c, l) and initial bond holdings (b) by solving the following conditions for c, l and b:

$$\left(c - \frac{l^\omega}{\omega}\right)^{-\gamma} = \lambda$$

$$l^{\omega-1}\left(c - \frac{l^\omega}{\omega}\right)^{-\gamma} = \lambda(1-\alpha)xk^\alpha l^{-\alpha}$$

$$\frac{b'}{1+R} = xk^\alpha l^{1-\alpha} + b - c - [k' - (1-\delta)k] - \frac{\theta}{2}(k'-k)^2$$

8. For each combination $(k, k', b', b, \mathbf{z}, \mu, \lambda, c, l)$ compute $V_b(b, k, x)$ and $V_k(b, k, x)$ using the envelope conditions:

$$V_b = \lambda$$

$$V_k = \lambda\left(\alpha x k^{\alpha-1} l^{1-\alpha} + (1-\delta) + \theta(k'-k)\right)$$

9. Since the values of b obtained in step 7 do not necessarily belong to the discrete grid G_b, apply piecewise linear interpolation to the results of step 8 to obtain $V_b(b, k, \mathbf{z})$ and $V_k(b, k, \mathbf{z})$ for $b \in G_b$ and $k \in G_k$.

10. Use $V_b(b, k, \mathbf{z})$ and $V_k(b, k, \mathbf{z})$ from step 9, the transition probability matrix for the productivity shock, and conditions X and Y to obtain $E[V_{b'}^{n+1}(b', k', \mathbf{z}')|\mathbf{z}]$ and $E[V_{k'}^{n+1}(b', k', \mathbf{z}')|\mathbf{z}]$ for each possible discrete state. Let $\tilde{V}_b^{n+1}(b', k', \mathbf{z}) = E[V_{b'}^{n+1}(b', k', \mathbf{z}')|\mathbf{z}]$ and $\tilde{V}_k^{n+1}(b', k', \mathbf{z}) = E[V_{k'}^{n+1}(b', k', \mathbf{z}')|\mathbf{z}]$.

11. If the maximum absolute distance between $\tilde{V}_a^{n+1}$ and $\tilde{V}_a^n$ for $a = k, b$ is less than 1e-4 then search for firm-household equilibrium is complete. Otherwise, repeat steps 4 through 10 using $\tilde{V}_b^{n+1}(b', k', x)$ and $\tilde{V}_k^{n+1}(b', k', x)$ and set $n = n + 1$.

12. Use linear interpolation to compute decision rules from firm-household equilibrium over finer grids for bond holdings and capital stock. Label fine grids G_{bf} and G_{kf}.

13. Use the policy rules for bond holdings and capital stock from step 12 in conjunction with the transition probability matrix for the productivity shock to compute the

invariant probability distribution, $m(b,k,\mathbf{z})$. For all $b \in G_{bf}$, $k \in G_{kf}$ and $\mathbf{z} \in G_z$, iterate on the conditional distribution of state variables using the formula,

$$m_j(b'(b,k,\mathbf{z}), k'(b,k,\mathbf{z})|\mathbf{z}') = \sum_{\mathbf{z}} m_{j-1}(b,k,\mathbf{z}) pr(\mathbf{z}'|\mathbf{z})$$

where j denotes iteration number and $pr(\mathbf{z}'|\mathbf{z})$ is the probability of $\mathbf{z}_{t+1} = \mathbf{z}'$ when $\mathbf{z}_t = \mathbf{z}$. Repeat iterations until absolute difference between m_j and m_{j-1} is less than 1e-7.

14. Compute net global bond holdings using stationary distribution m. If global net bond holdings are less than 1e-3 then solution is complete as bond market is viewed as being cleared. Otherwise, guess new discount factor and return to step 3.

1.8 Appendix D: Accuracy of Numerical Approximation

Following standard practice, we assess the accuracy of our approximation using the normalised Euler equation error measure proposed by Judd (1992). This approach places an economic value (measured in units of consumption) on the difference between the approximated decisions of the firm-household and choices that are perfectly consistent with the model's optimality conditions. Rearranging the Euler equations for states where the collateral constraint is not binding (i.e. $\mu = 0$) we obtain the normalized Euler equation errors for bond holdings (EEb) and capital stock (EEk),

$$EEb = 1 - \frac{\left\{\beta(1+R)E\left[\left(c'(k',b',\mathbf{z}') - \frac{l'(k',b',\mathbf{z}')^{\omega}}{\omega}\right)^{-\gamma}\right]\right\}^{-\frac{1}{\gamma}} + \frac{l^{\omega}}{\omega}}{c}$$

$$EEk = 1 - \frac{1}{c}\left\{\left(\beta E\left[\frac{\alpha x' k'^{\alpha-1} l'(k',b',\mathbf{z}')^{1-\alpha} + \theta(k''(k',b',\mathbf{z}') - k') + (1-\delta)}{\left(c'(k',b',\mathbf{z}') - \frac{l'(k',b',\mathbf{z}')^{\omega}}{\omega}\right)^{\gamma}\left(1+\theta(k'-k)\right)}\right]\right)^{-\frac{1}{\gamma}} + \frac{l^{\omega}}{\omega}\right\}$$

where b' and k' are the values of the policy functions for bond holdings and capital stock in state $(k,b,\mathbf{z})$. The expectation is computed over the possible values of the shock next period ($\mathbf{z}'$). The errors are measured in base-10 logarithms. Thus, an error of -3 indicates the discrepancy between approximated and perfectly model consistent decisions equals \$1 for every \$1,000 spent on consumption. All error metrics are calculated using states where the collateral constraint does not bind. We report the maximum error (Max1), the maximum error over the stochastic stationary distribution (Max2), and the mean error calculated using the probability weights of the stochastic stationary distribution (Mean). The results of this accuracy test for our benchmark model with time-varying volatility are displayed in Table 1.9. All errors indicate an acceptable level of accuracy.

Table 1.9: Normalised Euler Equation Errors

	Max1	Max2	Mean
EEb	-3.0	-3.3	-4.2
EEk	-3.1	-3.4	-4.2

All errors measured in base-10 logarithms.

Chapter 2

Real Exchange Rate Variation and the Global Distribution of External Balances

I investigate the effect of real exchange rate movements on the international distribution of external balances in a model world economy featuring incomplete markets. Intertemporal trade between nations is the only means of insuring against country-specific uncertainty. By changing the return to delaying consumption, fluctuations in the real exchange rate influence the accumulation of foreign assets. In a plausibly calibrated approximation of the model, the proportion of the cross-country dispersion of net foreign assets, the current account and the trade balance that can be attributed to the effect of real exchange rate movements is 23, 35 and 53 percent respectively.

In an uncertain multi-country environment featuring real exchange rate fluctuations, how much of the international dispersion of external balances can we expect to result from basic intertemporal substitution of consumption? And, do variations in the real exchange rate play an economically meaningful role in this relationship? We present a preliminary response to these questions by quantitatively analysing a model world economy built from a continuum of two-sector small open endowment economies. Intertemporal trade among nations arises as a precautionary response to country-specific endowment shocks. In this framework, variation in the expected path of real exchange rates alters the effective return to postponing consumption, thereby affecting foreign asset accumulation and ultimately, the cross-country concentration of external balances. As we shall see below, the net effect of real exchange rate movements on intertemporal substitution depends on a tradeoff between two conflicting dynamics. Existing work has not sought to numerically approximate the outcome of this tradeoff in an integrated global framework.

How can real exchange rate movements specifically affect intertemporal trade between nations? Consider a small open economy, populated by a representative household, that lends to and borrows from other nations using a risk-free non-state-contingent bond denominated in units of an internationally traded good.[1] Each period this country receives a stochastic and exogenous endowment containing tradable and nontradable goods. Risk sharing opportunities are limited to the bond and there is a fixed limit on borrowing to rule out the possibility of insolvency. There is no storage technology for nontradables and so, the central decision facing the country is how to divide the tradable part of the endowment between consumption and intertemporal trade. Changes in the relative price of nontradable goods in terms of tradables are viewed as movements in the real exchange rate. Now, suppose a disturbance leads to an expectation that the real exchange rate is going to appreciate between this period and the next. Since interest on the bond is paid in units of the tradable good, the expectation of a real exchange rate appreciation implies a decrease in the return to saving or an easing of the cost of borrowing. As a result, there is an impetus for the country to bring forward tradables consumption in proportion to the elasticity of intertemporal substitution. At the same time, the expectation that the real exchange rate is going to appreciate also means that the relative price of tradables is expected to fall, and so, there is reason for the country to postpone tradables consumption in proportion to the elasticity of substitution

[1] This example makes use of the mechanism presented Obstfeld and Rogoff (1996, Ch. 4). We present more rigorous coverage of their argument in section 2.1.2.

between tradable and nontradable goods. Overall, there is a tradeoff stemming from changes to real exchange rate expectations, the outcome of which depends on the size of the two aforementioned elasticities. Only when both elasticities are the same do movements in real exchange rate expectations not alter consumption growth. Since changes to tradable consumption growth are accompanied by changes in bond holdings in this example, real exchange rate movements affect intertemporal trade between nations whenever the elasticity of intertemporal substitution does not equal the elasticity of substitution between tradable and nontradable goods.

Assuming this mechanism is present in all countries comprising the world economy, it is apparent that the association between the expected path of the real exchange rate and cross-country asset trade has the potential to influence the global distribution of external balances. Individual countries lend and borrow internationally to insure against endowment shocks. Therefore, as long as shocks histories vary by country, so will bond holdings. In turn, whenever real exchange rate movements influence how an individual country accumulates bonds in response to uncertainty, they will also affect the global distribution of external balances. In this paper, we use numerical approximations of a model world economy to quantify this relationship between the real exchange rate and the international distribution of external balances. Moreover, since tax policy and foreign exchange reserve accumulation can be used to manipulate the real exchange rate, our global framework, where intertemporal trade is influenced by movements in the real exchange rate, would be a suitable foundation for future work seeking to evaluate the effect of such policies on the international distribution of external balances. The analysis presented in this paper and the proposed extension will offer further insight into the factors driving the substantial and growing dispersion of external balances observed in the data (see Table 2.1).

In our world economy model, each country is an ex ante identical replica of the two-sector small open endowment economy in the preceding example. Country specific endowment shocks give rise to ex post heterogeneity amongst nations. There are no global distur-

Table 2.1: International Dispersion of External Balances

	Standard Deviation	
	1986	2006
NFA/Y	46.4	56.5
CA/Y	4.5	5.7
TB/Y	9.1	14.7

All variables measured in percent. *Standard Deviation* equals the cross-country standard deviation of the respective external balance in the specified year. All variables demeaned by year then averaged over rolling 10-year window. Data covers 97 countries and the years 1986-2006. See the Appendix in Section 2.5 for detailed description of data.

bances. It should be noted that the choice to adopt this relatively simple approach to global equilibrium is guided by our desire to begin the exploration of how real exchange rate movements influence the basic precautionary response to income uncertainty in the absence of other impediments to or stimulants of cross-border asset flows, and for that reason, this model does not incorporate several factors that have been proposed in the literature as important drivers of international capital movement.[2]

We calibrate the model using a multicountry panel which combines data from the Penn World Tables, the Groningen Growth and Development Centre 10-sector database, and the External Wealth of Nations database prepared by Lane and Milesi-Ferretti (2007). We approximate the model using an endogenous gridpoint method. In our analysis, countries are allocated to one of two developmental groups (developed or developing/emerging market). In the data, the volatility of GDP in developing/emerging market countries is a substantial amount higher than it is in developed nations. To capture this observation, the volatility of the stochastic endowment varies between developmental groups.

As is evident from the preceding description of the mechanism linking real exchange rate movements and external balances, the elasticities of intertemporal and intratemporal substitution are central to our investigation. We employ several plausible combinations of these parameters to illustrate the role of the real exchange rate. Our main concern when conducting this quantitative analysis is the long-run distribution of external balances.

[2]The literature review below provides references that explain some of the excluded factors that have been used to explain the pattern of capital movement observed in the data.

Broadly speaking, we find the effect of real exchange rate movements on the dispersion of external balances grows as the elasticity of intratemporal substitution increases relative to the elasticity of intertemporal subststution, in line with the aforementioned theory mechanism. The overall explanatory power of the model varies between stock and flow external balances. More specifically, under our preferred parameter set, the distribution of net foreign assets in the model is about 88 percent as spread out as the data.[3] Although the model's ability to explain the current account and trade balance is lower at 35 and 19 percent respectively, there is some suggestion that the real exchange rate plays a larger role in determining those flow balances. Our numerical approximations suggest the presence of real exchange rate fluctuations accounts for 23 percent of the international dispersion of net foreign asset holdings. The corresponding statistics for the current account and trade balance are 52 and 35 percent respectively. These preliminary results lead us to tentatively contend that the real exchange rate should be considered a relevant variable when analysing the aggregate outcome of simple intertemporal substitution of consumption in a global context.

Relevant Literature Broadly speaking, this paper adds to the body of literature that seeks to explain changes in the cross-country diversity of external balances that have occurred since the 1980s.[4] Within this strand of the literature our investigation is most directly related to the theory work that assigns an important role to real exchange rate movements in efforts to account for selected developments in the observed international distribution of external balances. Several such models highlight the role of government policy in stimulating capital flows. Dooley, Folkerts-Landau and Garber (2003) contend that certain emerging market governments undervalue their exchange rates through the

[3]When discussing the results of our quantitative analysis the term net foreign assets is used to refer to the net foreign assets to GDP ratio. Current account and trade balance also refer to values scaled by GDP.

[4]Contributions on the theory side of this field include, but are not limited to, Caballero, Farhi and Gourinchas (2008), Devereux and Sutherland (2010), Durdu, Mendoza and Terrones (2007), Fogli and Perri (2006, 2015), and Mendoza, Quadrini and Rios-Rull (2009). Amongst the contributions on the empirical side are Alfaro, Kalemli-Ozcan and Volosovych (2014), Gourinchas and Jeanne (2013), and Obstfeld, Shambaugh and Taylor(2010). A helpful survey of this literature is provided by Gourinchas and Rey (2014).

purchase of foreign assets so as to generate export-led growth in their home economy. Similarly, papers by Aizenman and Lee (2010), Benigno and Fornaro (2012) and Korinek and Serven (2016), put forward frameworks in which a developing/emerging market government is able to realise a productivity enhancing learning-by-doing externality for domestic firms when it uses the accumulation of foreign assets to engineer a real exchange rate depreciation. In contrast to this work, we abstract from government intervention and simply provide a first pass at quantifying how market driven real exchange rate movements influence intertemporal substitution and in turn, alter the international distribution of external balances. As we discuss in Section 3.4, this paper is an exploratory first step toward developing a multi-country framework that can be used to approximate the impact of policy induced changes in the real exchange rate on the global distribution of cross-border asset holdings.

Furthermore, we also add to the literature that uses a world economy framework featuring incomplete markets as a basis for estimating how much of the international diversity of external balances can be attributed to intertemporal substitution.[5] Work in this field has not attempted to quantify how goods prices might influence the international dispersion of cross-border flows so our contribution stems from our focus on the effect of real exchange rate fluctuations.[6]

The remainder of this paper is arranged as follows. Section 2 contains a description of our world economy model along with details of the parameterisation and numerical approximation method we employ. Section 3 contains the results of our quantitative analysis, and section 4 offers some concluding comments.

[5]The world economy framework in these papers is an open economy version of the closed economy Bewley-Aiyagari-Huggett type model with the households in the closed economy setup being replaced by countries here. The most relevant contributions on this topic include Chang, Kim and Lee (2013), Sandri (2011), and Hughes (2016).

[6]Fornaro (2014) uses a world economy framework with similarities to our own to assess the macroeconomic consequences of different exchange rate regimes during an international debt deleveraging episode. That paper incorporates goods price movements but does not attempt to isolate how the presence of real exchange rate fluctuations changes the long-run distribution of external balances.

2.1 World Economy Model

Consider a world economy comprised of a continuum of two-sector small open economies (countries). Time is discrete and indexed by t. Residing in each country is an infinitely lived representative household whose objective is to maximise the present value of its expected lifetime utility, which is given by,

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{{C_t}^{1-\gamma} - 1}{1-\gamma} \tag{2.1}$$

where C_t is consumption of a composite good in period t, β is the subjective discount factor, γ is the coefficient of relative risk aversion, and E_0 is the expectations operator conditional on information available at time zero. The composite consumption good is assembled from tradable and nontradable parts according to the CES Armington aggregator,

$$C_t = \left[\alpha C_{T,t}^{\frac{\eta-1}{\eta}} + (1-\alpha) C_{N,t}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}$$

where $C_{T,t}$ and $C_{N,t}$ are tradable and nontradable consumption respectively, α is the weighting factor for tradable goods, and η is the elasticity of substitution between tradable and nontradable goods.

Each period the household is endowed with stochastic and exogenous quantities of tradable ($Y_{T,t}$) and nontradable ($Y_{N,t}$) goods. The stochastic structure of the endowment processes is described in Section 2.1.3. All nontradables are consumed in the period of receipt; that is, $C_{N,t} = Y_{N,t}$. Opportunities to insure against endowment shocks are limited to an internationally traded one period non-contingent risk-free bond (B_t) denominated in units of the tradable good and paying interest r. Following Mendoza (1991), we require household debt to not exceed a fixed limit ($\bar{B}$) that rules out the possibility of insolvency and Ponzi schemes. The household's bond holdings in the model are considered to be a proxy for net foreign assets, and when $B_t < 0$ the household is a net debtor.

The household budget constraint is,

$$C_{T,t} + p_{N,t}C_{N,t} + \frac{B_{t+1}}{1+r} = Y_{T,t} + p_{N,t}Y_{N,t} + B_t \tag{2.2}$$

where the per unit price of the tradable good is normalised to one and the price of the nontradable good in units of the tradable good is $p_{N,t}$. We assume PPP holds for tradable goods, thus allowing us to view $p_{N,t}$ as as a proxy for the real exchange rate. In conjunction with the requirement that all nontradable income be consumed, constraint (2.2) indicates that the problem facing the household boils down to a decision over how to divide its tradable endowment between consumption and intertemporal trade.

2.1.1 Global Equilibrium

The household chooses $C_{T,t}$, $C_{N,t}$ and B_{t+1} to maximise utility (2.1), subject to the budget constraint (2.2) and the debt limit. In recursive form, the problem facing the household is,

$$V(B, \mathbf{y}) = \max_{B'} \left\{ \frac{C^{1-\gamma} - 1}{1-\gamma} + \beta E[V(B', \mathbf{y}')|\mathbf{y}] \right\}$$

subject to,

$$C_T + \frac{B'}{1+r} = Y_T + B,$$

$$C_N = Y_N,$$

$$C = \left[\alpha C_T^{\frac{\eta-1}{\eta}} + (1-\alpha) C_N^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}},$$

$$B' \geq \bar{B}$$

The usual convention of no subscript and prime superscript signify current and next period timing of state and control variables. The state space for each country includes bond holdings (B) and the exogenous endowment vector $\mathbf{y} = (Y_T, Y_N)$. The sets of all possible values of B and $\mathbf{y}$ are denoted $\mathcal{B}$ and $\mathcal{Y}$ respectively.

The following optimality conditions characterise the problem facing the household,

$$U_T = \beta(1+r)U_T' + \mu \tag{2.3}$$

$$\frac{1-\alpha}{\alpha}\left(\frac{C_T}{C_N}\right)^{\frac{1}{\eta}} = p_N \tag{2.4}$$

$$\mu(B' - \bar{B}) = 0 \tag{2.5}$$

where U_T is the first derivative of the utility function with respect to C_T, and μ is the shadow cost of the credit constraint. When the borrowing constraint is slack, condition (2.3) simply implies the agent will choose an intertemporal allocation of resources that equalises the marginal utilities of current and next period tradables consumption. A binding debt limit (as captured by $\mu > 0$) gives rise to a disparity between the benefit of incremental changes in current and future tradable consumption. Condition (2.4) equates the marginal rate of substitution between tradable and nontradable goods with the relative price of nontradables. Ceteris paribus, when tradable goods become relatively more expensive (i.e when p_N falls), the demand for tradables (C_T) declines. Condition (2.5) is the complementary slackness requirement for bond holdings.

The stationary competitive equilibrium for the global economy comprises: (i) the decision rules $C_T(B, \mathbf{y})$ and $B'(B, \mathbf{y})$ along with the price schedule $p_N(B, \mathbf{y})$; (ii) the value function $V(B, \mathbf{y})$; (iii) the world interest rate r; and (iv) the probability distribution of countries across states $m(B, \mathbf{y})$ such that,

- the decision rules $\{C_T(B, \mathbf{y}), B'(B, \mathbf{y})\}$ and value function $V(B, \mathbf{y})$ are optimal given $p_N(B', \mathbf{y})$ and r;
- the probability distribution, $m(B, \mathbf{y})$, is stationary and consistent with the endowment process, optimal decision rules and price schedule;
- the world bond market clears: $\int_{\mathcal{B}\times\mathcal{Y}} B'(B, \mathbf{y})\mathrm{d}m = 0$

2.1.2 The Real Exchange Rate and Foreign Asset Accumulation

Here we draw on the exposition provided by Obstfeld and Rogoff (1996, chapter 4) to describe the mechanism linking movements in p_N with intertemporal trade between countries. We focus on the behaviour of an individual country. Total expenditure on the composite consumption good within this economy is,

$$P_tC_t = C_{T,t} + p_{N,t}C_{N,t} \tag{2.6}$$

where P_t is the price of one unit of the composite consumption good in terms of the tradable good. Since the CES Armington aggregator underlies the composite good, the aggregate price level, P_t, in equilibrium is,

$$P_t = \left[\alpha^{\eta} + (1-\alpha)^{\eta} p_{N,t}^{1-\eta}\right]^{\frac{1}{1-\eta}} \tag{2.7}$$

A movement in P_t implies the real exchange rate has changed. Combining (2.4), (2.6) and (2.7) gives demand for $C_{T,t}$ as a function of P_t and C_t. That is,

$$C_{T,t} = \alpha \left[\frac{1}{P_t}\right]^{-\eta} C_t \tag{2.8}$$

Demand for C_N can be derived by similar means. When we recast the household problem as a decision regarding expenditure on the composite consumption good, the Euler equation for intertemporal optimality becomes,

$$E_t[C_{t+1}^{\gamma}] = E_t\left[\frac{P_t}{P_{t+1}}\right]\beta(1+r)C_t^{\gamma} \tag{2.9}$$

Substituting (2.8) in (2.9) brings us to a relationship linking the optimal path of C_T with expected changes in P. Specifically,

$$E_t[C_{T,t+1}] = \beta^{\frac{1}{\gamma}}(1+r)^{\frac{1}{\gamma}} E_t\left[\left(\frac{P_t}{P_{t+1}}\right)^{\frac{1}{\gamma}-\eta}\right] C_{T,t} \tag{2.10}$$

Since the trade balance is directly influenced by C_T, condition (2.10) also indicates how expected price movements can affect foreign asset accumulation. The key driver of this association is the size of the elasticity of intertemporal substitution ($1/\gamma$) relative to the size of the elasticity of intratemporal substitution (η).

We illustrate the role of these parameters by way of an example where a negative tradable endowment shock at date t brings about an expectation that the aggregate price level will increase between t and $t+1$. The magnitude of the accompanying decrease in $C_{T,t}$ depends on a tradeoff between two competing effects. On the one hand, the expected price increase implies a lowering of the interest rate denominated in units of composite consumption; in turn, this decreases the return to lending and thus prompts the household to substitute $C_{T,t}$ for $C_{T,t+1}$ in proportion to $1/\gamma$. We term this change in $C_{T,t}$ the *interest rate effect*. On the other hand, the expected rise in the aggregate price level is a corollary of an expected increase in the relative price of nontradables, p_N; as a result, the relative price of the tradable good is expected to fall, thus providing the household with an incentive to substitute $C_{T,t+1}$ for $C_{T,t}$. We call this second change the *nontradable price effect*. When $1/\gamma = \eta$, the optimal intertemporal allocation of resources is not influenced by the expected change in the aggregate price level, and for that reason, growth of tradable consumption between t and $t+1$ is the same as in a single sector version of our endowment economy. If $1/\gamma > \eta$ the *interest rate effect* exceeds the *nontradable price effect* and therefore, C_T is expected to grow less than in the scenario where $1/\gamma$ and η are equalised. The opposite occurs when $1/\gamma < \eta$. As long as there is a disparity between $1/\gamma$ and η, the consumption response to an endowment shock will depend on the expected path of prices. Moreover, given C_T determines the trade balance in our endowment economy, it follows that foreign asset accumulation will also respond to expectations regarding prices when $1/\gamma \neq \eta$.

2.1.3 Parameters

The world economy model is solved using an endogenous gridpoint method based on Korinek and Mendoza (2014) and Guerrieri and Lorenzoni (2015).[7] An outline of this

[7] The endogenous gridpoint method was first introduced by Carroll (2006).

numerical solution algorithm is provided in the Appendix in Section 2.6.

In our quantitative analysis, one time period equals one year. In line with existing multicountry models featuring incomplete markets, the market clearing interest rate (r) is 4 percent. Conditional on r, we adjust the subjective discount factor (β) until the world bond market clears. In all approximations, the solution has $\beta(1+r) < 1$, thus satisfying the standard theoretical requirement for a well-behaved long-run distribution of bond holdings. As in Bengui, Mendoza and Quandrini (2013), the weight on tradable goods in the Armington aggregator (α) is 0.3.

We prepare separate approximations of the model under differing combinations of the elasticities of intertemporal and intratemporal substitution. Initially, we equalise the two elasticities, denoted $1/\gamma$ and η respectively, so that we can approximate a version of the long-run distribution for a scenario where consumption growth is not influenced by real exchange rate movements. Then, we adjust η over a plausible range of values while holding γ constant. This process is repeated for several levels of γ. When setting γ, we remain within the extremes observed in the meta-analysis of several thousand empirical estimates of the elasticity of intertemporal substitution by Havranek, Horvath, Irsova and Rusnak (2015). In light of this, we consider values of $1/\gamma$ ranging from 1/8 through 1. For the elasticity of intratemporal substitution (η) we employ values extending from the low of 0.44 estimated by Stockman and Tesar (1995), to the high of 1.28 estimated by Ostry and Reinhart (1992).

Drawing on the work of Fornaro (2014) and Guerrieri and Lorenzoni (2015), we select the debt limit ($\bar{B}$) at which the gross world debt to world GDP ratio in the version of the model with $\eta = \frac{1}{\gamma}$ is 18 percent, which is the average of the equivalent variable for the 10-year window surrounding 2006 in the data. The debt limit remains constant at this level when η is adjusted for a given γ, but is recalibrated each time we change γ so that our analysis is able to isolate the effect of the mechanism described in section 2.1.2 and eliminate changes in dispersion stemming from movement in the debt limit.

The source of country heterogeneity is the realisation of the exogenous endowment process, which depends on three separate events. First, ex-ante identical economies enter a lottery to determine their allocation between developed and devloping/emerging market country groups. Subsequently, countries draw tradable (T) and nontradable (NT) endowments. Volatility and persistence of endowments vary between country groups. We approximate each event using a two state Markov chain. Consequently, there are eight possible combinations of tradable and nontradable endowments.

The elements of the Markov chain determining country group allocation are chosen to satisfy two conditions: (i) the developed countrys' share of the global endowment valued in units of the tradable good must equal the share of GDP generated by developed countries in our data for 2006[8]; (ii) the probability of switching between developing/emerging market and developed country groups must equal a rough estimate of the probability of a non-OECD country joining the OECD in a given year.[9]

The transition probability matrix for the tradable and nontradable endowments in each country group is prepared according to the 'simple persistence rule' used by Mendoza (1991) and Bengui, Mendoza and Quadrini (2013). Let $\sigma_{s,j}$ be the standard deviation of the endowment for sector $s \in [T, NT]$ in country group j. Under the simple persistence rule, the endowment autocorrelation for group j is required to be the same for both sectors, and is labelled ρ_j. The contemporaneous correlation between tradable and

[8]This share was 54 percent and is based on a 97 country sample from the Penn World Tables. See the Appendix in Section 2.5 for a detailed description of the data.

[9]We use OECD membership as a proxy for developed country status. In 1960, the OECD was established and it had 20 members at that time. Our estimate begins with an approximation of the typical number of countries outside the original 20 members for the years since the OECD's inception. We view 150 countries as a reasonable choice here. This implies there have been 8,250 country-year observations for which we can record the membership status for these non-OECD nations. Another 15 countries joined the OECD over the 55 years through 2015. We remove the post-accession years for these new members from our previous tally and are left with 7,881 observations. Therefore, 15 accessions to membership occurred during the 7,881 country-year observations, which can plausibly be viewed as implying that the probability of gaining membership in a particular year was about 0.002. This value is used as our rough estimate for the probability of switching from developing/emerging market to developed in the transition matrix. To the best of my knowledge, a more precise and directly applicable measure of this transition probability is not currently available in the literature. Using a more finely divided scale of country income groupings than our own, Kremer, Onatski and Stock (2001) estimated a transition probability matrix for country movement between income groupings using data for 140 countries over the period 1960 through 1996. Although not directly comparable to our transition probabilities due to its reliance on a different approach to grouping countries, their analysis does not make our estimate seem unreasonable.

nontradable endowments in group j is $\rho_{x,j}$. The mean value of the endowment in all sectors and country groups is assumed to equal one and perturbations to each endowment take one of two possible values equal to $\pm\sigma_{s,j}$. In turn, the state space for the endowment process in country group j is,

$$\mathbf{y}_j \in \left\{(Y^h_{T,j}, Y^h_{NT,j}), (Y^h_{T,j}, Y^l_{NT,j}), (Y^l_{T,j}, Y^h_{NT,j}), (Y^l_{T,j}, Y^l_{NT,j})\right\}$$

where superscripts h and l signify high and low realisations of each endowment. The probability of a country belonging to group j obtaining endowment combination n next period given that it currently has endowment combination m is denoted $\pi_{m,n,j}$ and is given by,

$$\pi_{m,n,j} = (1 - \rho_j)\Pi_{n,j} + \rho_j I$$

where $\Pi_{n,j}$ is the long-run probability of state n for group j, and I is an indicator that equals one when $m = n$ and zero otherwise. It is assumed that $\Pi(Y^h_{T,j}, Y^h_{NT,j}) = \Pi(Y^l_{T,j}, Y^l_{NT,j}) = \Pi$, and $\Pi(Y^h_{T,j}, Y^l_{NT,j}) = \Pi(Y^l_{T,j}, Y^h_{NT,j}) = 0.5 - \Pi$. Finally, $\rho_{x,j} = 4\Pi - 1$.

The parameters defining the behaviour of the tradable and nontradable endowments are calibrated using panel data from the Groningen Growth and Development Centre 10 sector database constructed by Timmer, de Vries and de Vries (2014). Our sample from this database covers 30 countries (22 developing/emerging market and 8 developed) and the time period 1975 to 2009.[10] We use the classification scheme proposed by De Gregorio and Wolf (1994) to assign the 10 industrial sectors in the data to tradable and nontradable categories.[11] We take real gross value added for sector s in the data to be the real world analogue for the sector s endowment in the model. Given this correspondence, we set $\sigma_{s,j}$, ρ_j and $\rho_{x,j}$ equal to their counterparts in the data. The resulting parameters are displayed in Table 2.2.

[10] See Appendix 2.5 for a detailed description of this panel.

[11] The tradable sector includes: agriculture; hunting, forestry and fishing; mining and quarrying; manufacturing; and transportation, storage and communication. The nontradable sector includes: electricity, gas and water supply; construction; wholesale and retail trade, hotels and restaurants; finance insurance and real estate services; government services; and community, social and personal services.

Table 2.2: Endowment Parameters

	Symbol	Developing/EM		Developed	
Standard Deviation (%)	$\sigma_{s,j}$	5.22 (T)	5.51 (NT)	4.69 (T)	2.57 (NT)
Persistence	ρ_j	0.74		0.60	
Contemporaneous Correlation	$\rho_{x,j}$	0.51		0.66	

The sector (s) is labelled T for tradable and NT for nontradable. Country group is labelled j. All endowment parameters based on data from the GGDC 10 sector Database. Sample cover 30 countries and the time period 1975-2009. See Appendix 2.5 for detailed description of data.

2.2 Results

2.2.1 Business Cycle Moments

Business cycle moments describing dynamics in one of the countries comprising our model world economy are shown in Table 2.3. The moments shown are based on an approximation of the model with $\eta = 0.86$ and $1/\gamma = 1/4$. These values of η and $1/\gamma$ are not extreme relative to existing empirical estimates and as a result, they represent our preferred parameterisation of the model. Due to the parsimonious structure of our model and the need to abstract from a number of channels that influence business cycle dynamics, we merely aim for the business cycle moments generated by the model to be reasonable and do not expect a close correspondence with the data. The trade balance in the model displays countercyclical behaviour but to a greater degree than the data. The volatility of consumption and the trade balance relative to the volatility of output both appear reasonable. Although the model generated variability of consumption seems a little low compared to the data at first glance, part of the difference can be accounted for by the fact that the consumption data includes durable and nondurable expenditure while the model only includes nondurable expenditures. Since durable consumption is more volatile than nondurable consumption in the data, the model consistent consumption measure would most likely be less volatile than the one in the table and therefore, closer to the model.

The volatility and autocorrelation of total GDP in units of tradables (Y) in the model are both quite high compared to the data.[12] The sectoral endowments (Y_T and Y_N)

[12]In the model total GDP in units of tradables is given by: $Y = Y_T + p_N Y_N$.

are both exogenous and thus, their model generated moments both match the data precisely. Therefore, the discrepancy between model and data for total GDP is caused by the behaviour of p_N in the model, which is more persistent and volatile than the data.[13] A means of making the behaviour of Y in the model more realistic is not currently apparent. It seems reasonable that future work incorporating terms of trade fluctuations might help overcome this problem by providing another channel of external adjustment that can lower the burden placed on p_N in each economy's response to a disturbance. Alternatively, extensions to our setup featuring endogenous production and labour supply might also bring the volatility and persistence of total GDP in the model closer to the data.

Table 2.3: Business Cycle Moments

	Data		Model	
	Developed	Developing/EM	Developed	Developing/EM
$\sigma(Y)$	2.61	4.88	5.54	7.95
$\sigma(p_N)$	3.09	7.74	8.79	14.30
$\sigma(C)/\sigma(Y)$	0.97	0.99	0.43	0.49
$\sigma(TB)/\sigma(Y)$	0.52	0.55	0.44	0.40
$\rho(C,Y)$	0.77	0.77	0.74	0.40
$\rho(TB,Y)$	-0.04	-0.06	-0.67	-0.78
$\rho(Y,Y_{-1})$	0.58	0.70	0.94	0.95
$\rho(p_N,p_{N,-1})$	0.52	0.62	0.85	0.84

All data was detrended with a quadratic time trend. Each listed moment is the mean of the same statistic for the specified country group. Variables: Y is total GDP in units of tradables, p_N is the price of nontradables in terms of tradables, C is composite consumption, and TB is the trade balance. Standard deviations are measured in percent. All components of the data metrics $\sigma(C)/\sigma(Y)$, $\sigma(TB)/\sigma(Y)$, $\rho(C,Y)$ and $\rho(TB,Y)$ are based on data from the Penn World Tables. The data moments $\sigma(Y)$, $\rho(Y,Y_{-1})$, $\sigma(p_N)$ and $\rho(p_N,p_{N,-1})$ are calculated using the GGDC dataset. Details of the data are provided in the Appendix in Section 2.5.

2.2.2 Distribution of External Balances

The first two rows of statistics in each panel of Table 2.4 measure the international dispersion of external balances when the elasticities of intertemporal and intratemporal substitution are equalised. These model statistics characterise the concentration of stock

[13]The price of nontradable goods in terms of tradable goods in the data equals the nontradable sector value added deflator as a proportion of the tradable sector value added deflator.

external balances when changes in the expected path of p_N do not effect consumption growth.[14] It is apparent from the results in Panel A that even when the role of the real exchange rate in the determination of external balances is nullified, intertemporal substitution of consumption at the country level can generate sizeable cross-country diversity in foreign asset holdings, accounting for as much as 83 percent of the standard deviation in the data. In contrast, the statistics presented in Panels B and C indicate the international dispersion of trade balance and current account positions in the model explains a far smaller proportion of variation in the data. A similar distinction between the size of model generated stock and flow external balance dispersions relative to the data was obtained in existing studies by Chang, Kim and Lee (2013) and Hughes (2016). Since real exchange rate movements have the potential to modify how a country in our world economy responds to an endowment shock, there is reason to believe the results for parametrisations where $\eta = 1/\gamma$ in Tables 2.4 are distorted by the absence of a factor that plays a role in the decision to substitute resources intertemporally.

Rows 3 onward in Panels A through C of Table 2.4 gauge the standard deviation of the international distributions of NFA, CA and TB positions respectively for assorted plausible combinations of $1/\gamma$ and η other than pairs with $1/\gamma = \eta$. Based on the description provided in Section 2.1.2, the parameterisation with $\eta < 1/\gamma$ should lead to the change in external balances at the country level during the period of an endowment shock (tradable or nontradable) being weaker than the outcome when the expected path of prices doesn't matter for intertemporal trade (i.e. when $\eta = 1/\gamma$). And, if $\eta > 1/\gamma$ the impact of the endowment shock is amplified relative to the response when $\eta = 1/\gamma$. Therefore, as η rises relative to $1/\gamma$ the size of each country's response to the idiosyncratic endowment shocks also increases, and as a result, the international

[14]The reason for the non-monotonic changes in the dispersion of external balances (as a proportion of GDP in units of tradables) as we move from left to right across the first row of each panel in Table 2.4 is that both η and $1/\gamma$ decrease as we move from one column to the next (since the results in the first row of each panel all have $\eta = 1/\gamma$) and as a result, there is an accompanying change in the behaviour of p_N and in turn, the denominator of the external balance measure, GDP in units of tradables. The standard deviation of unscaled Net Foreign Assets does increase monotonically as we move from left to right across the first row.

Table 2.4: International Distribution of External Balances

Panel A: Net Foreign Assets/GDP

η	$1/\gamma =$ 1	1/2	1/4	1/8
$1/\gamma$	44.7	42.7	40.6	47.0
	(79.1,∼)	(75.6,∼)	(71.9,∼)	(83.2,∼)
0.44	41.7	42.1	44.6	54.3
	(73.9,-6.6)	(74.5,-1.3)	(78.9,9.8)	(96.1,15.5)
0.86	44.1	46.1	49.9	60.1
	(78.0,-1.4)	(81.5,7.9)	(88.3,22.9)	(1.06,27.9)
1.28	45.9	48.6	52.5	62.5
	(81.3,2.8)	(86.1,14.0)	(92.9,29.2)	(1.1,33.1)

Panel B: Current Account/GDP

η	$1/\gamma =$ 1	1/2	1/4	1/8
$1/\gamma$	1.3	1.3	1.3	1.4
	(22.5,∼)	(22.6,∼)	(23.0,∼)	(25.1,∼)
0.44	1.1	1.2	1.6	2.0
	(19.3,-14.1)	(21.8,-3.9)	(27.5,19.9)	(35.6,42.0)
0.86	1.2	1.6	2.0	2.4
	(21.6,-3.9)	(27.2,20.2)	(35.1,52.7)	(42.8,70.6)
1.28	1.4	1.8	2.3	2.6
	(24.4,8.6)	(31.6,39.5)	(39.7,72.5)	(46.3,84.6)

Panel C: Trade Balance/GDP

η	$1/\gamma =$ 1	1/2	1/4	1/8
$1/\gamma$	2.2	2.1	2.1	2.4
	(15.0,∼)	(14.6,∼)	(14.2,∼)	(16.1,∼)
0.44	2.0	2.1	2.4	2.9
	(13.7,-9.1)	(14.3,-1.9)	(16.2,13.9)	(20.0,24.6)
0.86	2.2	2.4	2.8	3.4
	(14.7,-2.3)	(16.5,13.1)	(19.3,35.4)	(23.2,44.5)
1.28	2.3	2.7	3.1	3.6
	(15.8,5.0)	(18.2,24.8)	(21.1,48.3)	(24.8,54.2)

Each panel of the table shows the standard deviation of the international distribution of the stated external balance in the model for each combination of $1/\gamma$ and η. The first statistic in parentheses is the proportion of cross-country dispersion in the data for 2006 explained by the model. The second statistic in parentheses is the proportion of the international standard deviation of the external balance in the model attributable to real exchange rate fluctuations. All external balances are measured as a proportion of GDP. Data covers 97 countries (21 developed and 76 developing/emerging market). See the Appendix in Section 2.5 for a detailed description of data.

distribution of external balances should become more diffuse. Our results conform with this theory mechanism linking real exchange rate movements and external balances in each country.

When η grows in size relative to $1/\gamma$, two key changes are observed in our results: firstly, the proportion of the international dispersion of external balances in the data explained by the model increases; secondly, the share of the model generated cross-country standard deviation of external balances attributable to expectations regarding price movements also expands. Alongside these observations it is also apparent that the explanatory power of the model is uniformly higher for NFA than it is for the flow external balances. Furthermore, despite the model's weaker ability to explain the overall dispersion of flow external balances, the results do suggest that the proportionate contribution of expected price movements to model generated international dispersion is larger for flow balances than it is for NFA. Under the plausible parameterisation where $\eta = 0.86$ and $1/\gamma = 1/4$, expectations regarding price movements account for about 53 percent of the international standard deviation of CA balances. The corresponding proportion of the trade balance was 35 percent, though this share was smaller relative to the data than it was for the CA. The share of the dispersion of NFA attributable to real exchange rate expectations under the same parameters was comparatively low though still meaningful at 23 percent.

These results give reason to suspect that price expectations, and in turn, real exchange rate movements, might matter more for the flow external balances than they do for long-run foreign asset accumulation. Moreover, the results also suggest that intertemporal substitution of consumption may account for a larger share of the cross-country dispersion of external balances, in particular the CA, than previously thought since existing quantitative analysis based on multi-country world economy models with similarities to our own did not incorporate a role for real exchange movements. Future research, which is discussed in more detail below, will need to more rigorously test these assertions so that we can go beyond this exploratory analysis and provide a stronger inference on how real exchange rate movements influence the international diversity of external balances.

The distribution of external balances in the version of the model with $\eta = 0.86$ and $1/\gamma = 1/4$ is shown in Figure 2.1. The diagram also displays the distribution of the demeaned external balances in the data. Qualitatively, the model and data are somewhat similar though there are some key distinctions worth noting. The difference between the spread of the model and data on flow balances is apparent. Also, stock external balances are clustered around -0.5 (NFA/GDP = 50%) while the mode in the data is closer to zero. This likely results from the absence of a spread between lending and borrowing rates in our framework. Chang et al. (2013) found that incuding such a spread shifts the modal NFA balance closer to zero. The addition of an interest rate spread was not possible in our setup since doing so lowered the world debt to world GDP ratio by such a large amount that it was not possible to achieve the requirements for calibrating the debt limit detailed in Section 2.1.3.

2.3 Discussion and Conclusion

This paper looked into how real exchange rate variation might affect the international distribution of external balances in an integrated world economy framework. Our objective was to develop some insight into the role of market driven real exchange rate fluctuations in the decision to substitute resources intertemporally. Numerical approximations of the model hint at a relationship in which real exchange rate movements make a substantial contribution to the international dispersion of external balances. As the elasticity of intratemporal substitution increases relative to the elasticity of intertemporal substitution, the effect of real exchange rate expectations on the cross-country dispersion of external balances can become economically meaningful. Under plausible parameterisations of the model, the presence of real exchange rate movements in each country's decision making leads to sizeable increases in the global dispersion of cross-border flows.

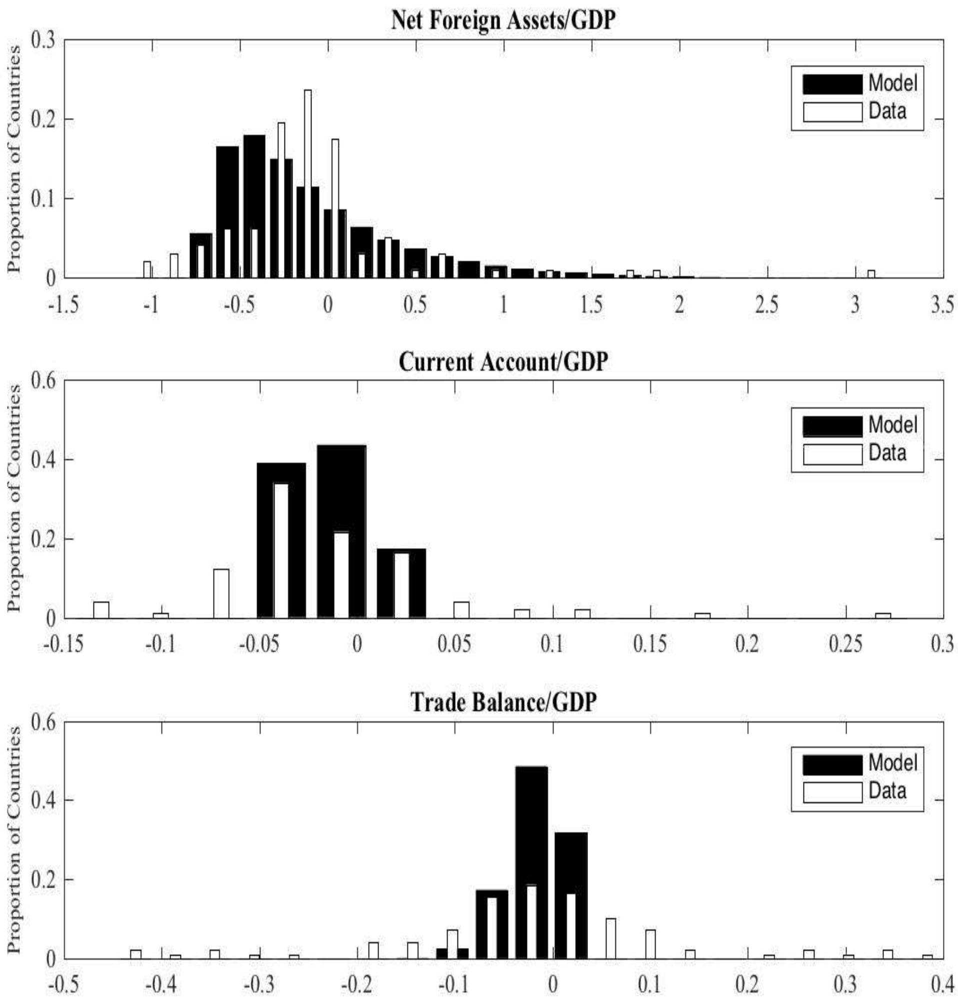

Figure 2.1: The International Distribution of External Balances

The results of this preliminary study point toward several potential avenues for future research. Firstly, it would be worthwhile to introduce a distinction between domestic and foreign tradable goods in the model so we can see how the international distribution of external balances changes when country-level adjustment incorporates a more fully developed trade channel featuring terms of trade fluctuations.[15] Secondly, it would be interesting to move from the endowment framework employed here to a world economy setup in which both production and capital accumulation are endogenous so that we can ascertain if the significance of real exchange rate fluctuations observed in this exploratory paper carries over to an environment where each country's current account depends on both saving and investment (i.e the absorption approach). Existing work using this more fully articulated approach but with a single industrial sector, and consequently no role for goods prices, suggests that intertemporal substitution of consumption makes a relatively large (small) contribution to the international dispersion of stock (flow) external balances. Whether this distinction between results for stock and flow balances holds in a version of the more sophisticated framework featuring real exchange rate movements remains an open question. The third extension to our work would be the addition of exchange rate policy to our world economy model, so that the frequently debated effects of real exchange rate undervaluation on the cross-country concentration of external balances can be approximated in a global context. Papers such as Benigno, Chen, Otrok, Rebucci and Young (2012) and Jeanne (2012) offer blueprints for how to implement such government activity in a two-sector small open economy framework.

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[15]Chang et al. (2013) do differentiate between domestic and foreign goods in their model but the terms of trade are constant. They do conjecture that introducing terms of trade movements would aid efforts to explain the international diversity of flow external balances.

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2.5 Appendix A: Data

There are two distinct sections of the panel. The first is comprised of data taken from the Penn World Tables and the External Wealth of Nations database. The second contains data from the Groningen Growth and Development Centre 10-sector database. We now describe each of these sections in turn.

Section 1

The first section of the panel covers the period from 1981 to 2010 and the following countries:

Developed Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States.

Developing/Emerging Market Argentina, Bangladesh, Belize, Benin, Bolivia, Botswana, Brazil, Burkina Faso, Burundi, Cote d'Ivoire, Cameroon, Cape Verde, Central African Republic, Chad, Chile, China, Hong Kong, Colombia, Comoros, Costa Rica, Cyprus, Djibouti, Dominica, Dominican Republic, Ecuador, Egypt, Ethiopia, Fiji, Gabon, Gambia, Ghana, Guatemala, Guinea, Honduras, India, Indonesia, Iran, Israel, Jordan, Kenya, Korea, Lao, Madagascar, Malawi, Malaysia, Mali, Malta, Mexico, Morocco, Mozambique, Nepal, Niger, Oman, Pakistan, Panama, Peru, Philippines, Poland, Saudi Arabia, Senegal, Sierra Leone, South Africa, Sri Lanka, St. Vincent and Grenadines, Sudan, Suriname, Taiwan, Tanzania, Thailand, Trinidad and Tobago, Tunisia, Turkey, Uganda, Uruguay, Venezuela, Zambia.

Countries and timeframe were selected on the basis of data availability.

The frequency of the data is annual.

All data relating to GDP, the components of GDP, and price deflators in this section of the panel was obtained from the Penn World Table version 8.1 prepared by Feenstra, Inklaar and Timmer (2014).

The net foreign assets (NFA), total liabilities and total assets series were obtained from the External Wealth of Nations (EWN) dataset prepared by Lane and Milesi-Ferretti (2007). Total assets and total liabilities both include asset and liability positions in portfolio equity, FDI, debt, and financial derivatives. In addition, total assets also include FX reserves minus gold. NFA equals total assets less total liabilities. Adopting the approach of Gourinchas and Jeanne (2013), we convert the EWN data from its original denomination (current USD) to constant international dollars through dividing by the deflator,

$$Q = P_k \frac{CGDP}{RGDP}$$

where P_k is the price of capital formation, $CGDP$ is real GDP measured at current PPP, and $RGDP$ is real GDP at chained PPPs. The variables P_k, $CGDP$ and $RGDP$ were obtained from the Penn World Tables.

Countries with extreme values of key variables (NFA to GDP, trade balance to GDP, current account to GDP and GDP growth) were removed from the sample. Specifically, exclusion occurred when the modulus of any key variable was equal to or greater than the 99th percentile for that variable (in absolute terms) in one or more years.

Throughout the paper, the external balance variables are demeaned by year (i.e. the cross-country mean for a given year is subtracted from each country observation for that year) and then averaged over a 10-year rolling window.

Section 2

The second section of the panel covers the period from 1975 to 2009 and the following countries:

Developed Denmark, France, Italy, Japan, Netherlands, Spain, United Kingdom, USA

Developing/Emerging Market Argentina, Bolivia, Brazil, Chile, China, Colombia, Costa Rica, Hong Kong, India, Indonesia, Kenya, Korea, Malaysia, Mexico, Morocco, Senegal, Singapore, South Africa, Taiwan, Tanzania, Thailand, Zambia

This section of the panel contains data from the GGDC 10-sector Database prepared by Timmer, de Vries and de Vries (2014). Variables include gross value added by (ISIC) industrial sector in current national prices and constant 2005 national prices. Sectoral VA deflators are calculated using this data.

Countries and timeframe were selected on the basis of data availability. We increased the timeframe covered by this section of the panel to compensate for the fact that only a relatively small number of countries are available in the GGDC dataset.

2.6 Appendix B: Numerical Approximation

Here we detail our approach to approximating the world economy model.[16] A solution has been found when the conditions for the stationary recursive competitive equilibrium specified in Section 2.1.1 have been satisfied to an acceptable degree of accuracy. We begin by applying a synthesis of the endogenous gridpoint methods introduced by Guerrieri and Lorenzoni (2015) and Korinek and Mendoza (2014) to the household's problem. This involves iterating on the household Euler equation (2.3) to find the optimal policy functions for a given β over a discretised version of the state space. Iterations continue until the absolute difference between policy functions in consecutive iterations is sufficiently small. Then, after recasting the optimal policy function for B over a finer grid we iterate on the probability distribution of countries over states using the formula:

$$m_j(B'(B,\mathbf{y})|\mathbf{y}') = \sum_{\mathbf{y}} m_{j-1}(B,\mathbf{y})pr(\mathbf{y}'|\mathbf{y})$$

where j denotes iteration number and $pr(\mathbf{y}'|\mathbf{y})$ is the probability of $\mathbf{y}_{t+1} = \mathbf{y}'$ when $\mathbf{y}_t = \mathbf{y}$. Iterations continue until the absolute difference between m_j and m_{j-1} is less than 1e-7. If the world bond market clears given $m(B,\mathbf{y})$ then the approximation is complete. Otherwise, we guess a new β and repeat the procedure starting with the household problem.

[16]Matlab code for this algorithm is available on request. Our code is based on the Matlab code accompanying the papers by Korinek and Mendoza (2014) and Guerrieri and Lorenzoni (2015).

In accordance with standard practice, we assess the accuracy of the numerical approximation using the normalised Euler equation error introduce by Judd (1992). In the context of the household problem in our model, this error is given by,

$$EE = 1 - \frac{\left[\beta(1+r)C'(B',\mathbf{y}')^{\zeta}C(B,\mathbf{y})^{-\zeta}\right]^{-\eta}C_T'(B',\mathbf{y}')}{C_T}$$

where $C(B,\mathbf{y})$ and $C_T(B,\mathbf{y})$ are the policy rules for consumption of the composite good and the tradable good respectively, B is bond holdings, $\mathbf{y}$ is the endowment vector and $\zeta = (1-\eta\gamma)/\eta$. Errors are measured in base-10 logarithms so, for example, when EE equals 3 the difference between our approximated household decision and the perfectly model consistent choice is \$1 for every \$1000 spent on tradables consumption. The error is calculated for all states where the borrowing constraint does not bind. In addition to the maximum error over all possible states (Max all), we also report the weighted mean error calculated using probability weights from the model's long-run distribution (Mean ssd). The errors for the model with $\eta = 0.86$ and $\gamma = 4$ are displayed in Table 2.5. Both error measures indicate an acceptable degree of accuracy. Other parameterisations of the model achieve similar levels of accuracy.

Table 2.5: Normalised Euler Equation Errors

	Max all	Mean ssd
EE	-2.23	-4.64

All errors measured in base-10 logarithms.

Chapter **3**

Exchange Rate Flexibility, the International Balance Sheet and Economic Recoveries

The link between exchange rate flexibility, the international balance sheet and economic recoveries is analysed in this paper through the application of OLS and two-stage least squares estimators to a dataset covering 201 recovery episodes occurring between 1971 and 2007. An instrument representing the history of exchange rate regime choice in the years immediately preceding the recovery is used to identify exogenous variation in exchange rate flexibility for the two-stage least squares procedure. Our results suggest that when external foreign currency denominated debt liabilities are relatively large, a pegged regime is associated with significantly faster real GDP growth than a non-pegged arrangement during a recovery. This finding can be rationalised on the basis that when external foreign currency denominated borrowing becomes sufficiently large, the adverse balance sheet effects associated with higher levels of exchange rate flexibility begin to significantly outweigh the beneficial expenditure switching effects.

Since the wake of the 2008-2009 financial crisis there has been a reinvigorated debate over the way in which a country's choice of exchange rate regime influences its ability to recover from a recession. Much of this discussion has focused on whether more flexible regimes aid recovery by allowing exchange rate depreciation to compensate for labour market frictions that slow adjustment. Devaluation is expected to generate expenditure switching effects through which a lower value of the home currency improves the competitiveness of domestically produced goods, thereby boosting net exports and aiding recovery. However, exchange rate movements also impact the valuation of external assets and liabilities denominated in a foreign currency, and the ensuing changes in net worth influence the recovery process as well. Thus, the ability of more flexible regimes to facilitate recovery depends on the extent to which the expenditure switching effects are tempered by the valuation effects. This paper investigates the outcome of this trade-off during economic recovery episodes. Our key finding is that when foreign currency debt is sufficiently large, a pegged exchange rate is associated with a recovery growth rate that is significantly greater (in both statistical and economical terms) than that achieved under a more flexible regime. In other words, our results suggest that when foreign currency debt passes a threshold level, the adverse valuation effects stemming from increased exchange rate flexibility begin to outweigh the beneficial expenditure switching effects, and as a result, a pegged regime aids recovery.

Grounds for our focus on the recovery portion of the business cycle are as follows. An empirical study by Cerra and Saxena (2005) suggests that income levels in countries experiencing frequent recessions exhibit a tendency to fall behind income levels in nations suffering fewer downturns since growth in the early stages of a typical recovery is significantly less than the rate achieved during an average expansion year, and, as the recovery proceeds, growth does not differ significantly from a normal expansion year. Research attempting to identify the determinants of growth during the early stages of a recovery thus has the potential to reveal factors that might influence the international divergence of incomes. We contribute to these efforts by presenting evidence on the link between exchange rate policy and the growth rate of output over the first few years of a recovery.

The link between exchange rate flexibility, the international balance sheet and economic recoveries is analysed in this paper through the application of OLS and two-stage least squares estimators to a sample of 201 recovery episodes over the timeframe running from 1971 to 2007. This sample covers 55 countries spread over the upper and middle income classifications of the World Bank income groupings. Exchange rate flexibility is measured using the de facto exchange rate regime coding system introduced by Klein and Shambaugh (2008). Changes in the history of regime choice in the years immediately before the recovery are used to capture exogenous variation in exchange rate flexibility in the two-stage least squares procedure. The impact of this exogenous variation in exchange rate flexibility on recoveries is estimated for specific characterisations of the international balance sheet. Several measures of the international balance sheet are employed. Debt assets and liabilities are used initially, and then net foreign assets is considered. Measures capturing the foreign currency denominated components of the international balance sheet are the main focus of the estimations.

Our results indicate that when foreign currency denominated debt liabilities are relatively high, a pegged regime is associated with significantly faster growth (of real GDP per capita) than a non-pegged regime in the first two years of the recovery. This disparity is both economically and statistically significant. For instance, the estimations indicate that a country with both net foreign currency denominated debt at the 39th percentile level (foreign currency denominated assets less foreign currency liabilities equals -34 percent of GDP) and a pegged regime experiences a recovery that proceeds 1.1 percentage points faster than that achieved under a non-pegged arrangement in the first post-recession year. Since the average one-year recovery growth rate in the sample is 3.4 percent, the growth boost under a peg is economically large. Put differently, the results suggest that when foreign currency denominated indebtedness becomes sufficiently large the adverse balance sheet effects associated with higher levels of exchange rate flexibility begin to significantly outweigh the expenditure switching effects. Diagnostic testing supports the validity of the IV estimations. Moreover, the estimations are robust to changes in the set of conditioning variables and the use of alternative measures of foreign currency debt.

When considering total debt liabilities (i.e. the foreign and domestic currency denominated components) the nature of the relationship is similar but the degree of statistical precision is weaker. Furthermore, the link between regime choice and recoveries does not appear to be conditional on broader balance sheet measures encapsulating total assets and total liabilities. Thus, our analysis suggests the balance sheet effects stemming from foreign currency debt exposure are most relevant to the link between exchange rate flexibility and recoveries.

Theory Literature There have been considerable efforts in the theoretical literature to understand the shock absorbing capacity of different exchange rate regimes. Friedman (1953) emphasised that the substitutability between exchange rate flexibility and internal price flexibility enables variation in the exchange rate to act as a means of speeding up adjustment to and hence recovery from country specific real shocks in the presence of internal price rigidities. Consequently, a peg would be less proficient at absorbing adverse shocks than a more flexible exchange rate system. The sentiments of Friedman were echoed in the work of Mundell (1968) and Fleming (1962). An extended version of the Mundell-Fleming model introduced by Eichengreen and Sachs (1986) postulated that exchange rate flexibility serves to overcome the constraint imposed by nominal wage rigidity on the adjustment process following a real shock. Specifically, the expenditure switching (from foreign to domestic goods) prompted by an exchange rate devaluation leads to an increase in domestic prices which lowers real wages and in turn, boosts aggregate supply. Ultimately, devaluation is presented as a route to recovery in the aftermath of an adverse shock. More recent work by Broda (2004) and Schmitt-Grohe and Uribe (2011) also assert that nominal exchange rate flexibility is a tool for coping with adverse real disturbances when there are nominal wage rigidities.

While these theories are compelling there is reason to suspect they provide an incomplete insight into the shock-absorbing capabilities of different exchange rate regimes since the implications of changes in the exchange rate extend beyond expenditure switching effects. In the financial accelerator mechanism proposed by Bernanke and Gertler (1989), changes in borrower net worth affect the agency costs of investment, and in turn, this change in the cost of finance influences investment and output. Alternatively, under the accelerator mechanism of Kiyotaki and Moore (1997), changes in the value of collateralisable assets affect borrowing capacity, and in turn, investment and output. Since changes in the exchange rate impact the valuation of foreign currency denominated assets and liabilities, either financial accelerator mechanism gives rise to an additional channel through which exchange rate flexibility can influence an economy's response to a shock. In the presence of an accelerator mechanism, output will be influenced by changes in the value of asset and liability positions stemming from movements in the exchange rate. Therefore, the extent to which an adverse real shock can be overcome through variation in the exchange rate depends on the sum of the expenditure switching and balance sheet effects resulting from an exchange rate depreciation (or devaluation).

There is disagreement in the theoretical literature over the impact of exchange rate movements when these balance sheet effects are taken into account. This literature typically adopts a dynamic general equilibrium model of a small open economy populated by rational agents and subject to nominal rigidities. In addition, capital flows are unrestricted and some form of uncovered interest parity condition is assumed to hold. Consequently, monetary autonomy is foregone under a fixed exchange rate arrangement in these models.

Comments by Cook (2004), Curdia (2008) and Towbin and Weber (2011) attribute the lack of consensus when balance sheet effects enter the discussion to differences in two assumptions. The first difference is whether nominal rigidities are assumed to be present in retail prices or wages, while the second distinction concerns the assumed degree of separation between the agents engaged in borrowing and the agents directly impacted by the nominal price rigidities (i.e. whether the price of borrowers' output is directly subject to nominal rigidities).

Cook (2004) shows that fixed exchange rates are superior to flexible following an adverse shock to the world interest rate when assuming that wages are competitively determined, retail prices are sticky and the entities engaged in foreign currency denominated borrowing are effectively joined with the distributing firms that directly face the nominal rigidities. The expenditure switching effect is counteracted by the balance sheet effect under the flexible exchange rate regime to such an extent that a pegged regime is associated with less post-shock instability. Choi and Cook (2004) also suggest that pegs are more stabilising though in their framework all foreign currency denominated borrowing is undertaken by domestic banks. The decline in aggregate bank net worth following an exchange rate depreciation leads to an increase in the country risk premium which leads to further exchange rate depreciation. Thus, the initial balance sheet effect initiates a feedback loop between the country risk premium and currency depreciation and as a result, the decline in output following a shock to the world interest rate under a flexible regime exceeds the contraction under a peg.

In contrast to these predictions, a flexible regime was shown to be a better shock absorber than a peg by Cespedes, Chang and Velasco (2004) which assumed that wages are sticky, retail prices are competitively determined and the firms engaged in foreign currency denominated borrowing are directly exposed to the nominal wage rigidity. Thus, changing from retail price stickiness to wage rigidity affects the ranking of regimes. A flexible regime was also a better insulator than a peg in the models presented by Gertler, Gilchrist and Natalucci (2003) and Curdia (2008) which both assumed that retail prices are sticky, wages are competitively determined and the firms borrowing in a foreign currency are separate from the firms directly impacted by the nominal rigidities. Furthermore, Devereux, Lane and Xu (2006) showed that a flexible exchange rate regime remains more stabilising than a peg in a model incorporating balance sheet effects even when the expenditure switching effect was limited by a model setup featuring low exchange rate pass-through into imported goods prices.

So far we have considered models that incorporate balance sheet effects by way of a Bernanke and Gertler (1989) style financial accelerator. In a small open economy model featuring nominal wage rigidities, Fornaro (2015) introduces a collateral constraint along the lines of Kiyotaki and Moore (1997) and finds that an exchange rate peg is a less proficient shock absorber than more flexible exchange rate arrangements.

Despite the conflict between the models discussed here, the theory literature does clearly suggest that both balance sheet and expenditure switching effects are important responses to exchange rate movements. It is just the relative magnitude of these effects that differs between models. On the one hand, the sensitivity of the predictions to changes in some contentious assumptions indicates that the role of exchange rate regimes in economic recoveries should first be assessed empirically, as will be done in this paper. That said, by highlighting two important responses to exchange rate movements, the theoretical literature does provide guidance on the mechanisms that must be reflected in our empirical model. More specifically, the theory models suggest that greater exchange rate flexibility entails both expenditure switching and balance sheet effects. The size of the balance sheet effects will depend on the level of foreign currency denominated borrowing. Therefore, the empirical model adopted in this study will assess the impact of different exchange rate regimes on economic recoveries at specific levels of foreign currency denominated debt.

Empirical Literature Moving to the empirics, the account of economic policy during the Great Depression presented by Eichengreen (1992) indicates that departure from the Gold Standard facilitated recovery during the 1930s. Similarly, Eichengreen and Sachs (1985) suggest that increased exchange rate flexibility, in the form of currency devaluation, facilitated recovery during the Great Depression in their study of 10 countries over the time period extending from 1929 to 1935. More specifically, they found that those countries which devalued their currencies sooner achieved a significantly higher level of industrial output by 1935 than the countries which were late to devalue or chose to leave their exchange rates unchanged through 1935. The devaluation was associated with significant improvements in exports and the incentive to invest (the demand side) along with a material decrease in the real wage rate (the supply side). These supply side effects were the subject of a more detailed examination by Bernanke and Carey (1996) in their study of a larger panel of 22 countries over the eight years ending in 1936. Relying on each country's choice of exchange rate policy (abandoned the Gold Standard or remained on gold) as a means of identification, their study presents evidence of a significant inverse link between real wages and output, as well as an upward sloping aggregate supply curve. The authors contend that these results support the view that price changes impact output through their effect on real wages, thus providing an indication that the combination of sticky wages and the adverse demand shocks experienced by adherents to the Gold Standard were the source of the prolonged period of depressed output during the sample period. This finding along with the work of Eichengreen and Sachs suggests that relatively flexible exchange rate arrangements can help overcome the problem of nominal rigidities and in turn, aid an economy in its recovery from a recession.

Additional stylised evidence substantiating the claim that floating exchange rates are associated with more rapid recoveries than pegged regimes is presented by Cerra, Panizza and Saxena (2009) which analysed a panel of 142 countries over the period from 1974 to 2004. In this study the magnitude of the growth advantage was both economically and statistically significant with floats being associated with an increase in growth of about one percentage point compared to a peg during the first recovery year. Comparable findings were obtained in research on the aftermath of economic crises. Guidotti, Sturzenegger and Villar (2005) suggest that floating exchange rates appeared to be superior to fixed regimes during recoveries from sudden stop crises occurring between 1975 and 2002. The statistically significant cumulative growth gain from adopting a float (rather than less flexible arrangements) after each of the first three post-crisis years was 4.2, 8.5 and 5.5 percentage points respectively. Similarly, Tsangarides (2012) found that increased exchange rate flexibility was beneficial for emerging market countries during the recovery from the 2008-2009 financial crisis. Even when allowing for interactions between short term external debt and the exchange rate regime, more flexible arrangements were found to be universally superior. Specifically, the results suggest that pegged regimes recovered from the crisis at a rate that was approximately 1.5 to 2 percentage points slower than under more flexible arrangements.

Further insight is provided by the empirical literature on the shock absorbing capacity of different types of exchange rate regime. Broda (2002) found that fixed exchange rates fared significantly worse than floating in this regard. With a float, an adverse terms of trade shock was associated with both a significant real exchange rate depreciation and a negligible change in GDP. A significant decline in GDP accompanied such a shock under a peg since the real exchange rate was unable to adjust by an adequate amount. However, this significant disparity in GDP performance was not apparent in highly dollarized economies and therefore, the results provide an additional hint that the balance sheet effects, which feature so prominently in the theoretical literature, may be an important factor in ranking alternative exchange rate regimes. Indeed, Towbin and Weber (2012) found the shock absorbing capacity of flexible exchange rates to be better than that of fixed exchange rates when external debt is relatively low but not when it is relatively high. Moreover, the same study also suggests import structure (as measured by the proportion of imports accounted for by raw materials) impacts the insulating capacity of floating exchange rates. That is, when raw materials comprised a large share of imports, a float appeared to outperform a peg in the face of an adverse shock, while at low levels of raw materials imports a peg was superior to a float.

It is apparent that the empirical literature on the subject at hand is in the midst of progressing from a consensus view that greater exchange rate flexibility is better in general during the rebound from a recession to a realisation that perhaps the optimal exchange rate regime for the recovery process depends on the international balance sheet of the country concerned. However, this advance is far from complete since the existing empirical work exhibits several weaknesses, thus signalling the potential for additional contributions to the field.

Firstly, it is possible to improve on the method of exchange rate regime classification adopted in the aforementioned empirical work. Several of the papers used the IMF de jure classification system, which as its name suggests, is based on individual countrys' reports to the IMF regarding the exchange rate regime they have adopted. The reliability of this approach was questioned by Calvo and Reinhart (2002), which presented evidence indicating that a number of countries with IMF de jure floats actually have an exchange rate that behaves in a manner consistent with a peg classification. Therefore, the study by Towbin and Weber (2011) which uses the IMF de jure classifications may well have obtained unreliable inferences since the exchange rate flexibility indicated by an IMF de jure float may in reality be non-existent.

A number of de facto regime classification systems have been put forward to address this weakness of the IMF de jure coding scheme. Some of the studies described above used the de facto coding scheme introduced by Levy-Yeyati and Sturzenegger (2003), which classifies exchange rate arrangements according to exchange rate movement and the variability of international reserves. This approach was criticised by Tavlas, Dellas and Stockman (2008) on the grounds that data on reserves can be 'highly unreliable' [p949] since governments are able to exert influence over their exchange rate by means that are not reflected in this reserve data, while at the same time, reserves can change for reasons unrelated to government efforts to control exchange rates. In particular, Reinhart and Rogoff (2004) note that authorities in numerous countries influence their exchange rate by trading dollar linked domestic debt while others engage in transactions in the forward market or use interest rate policy rather than direct market intervention. Moreover, Bubula and Otker-Robe (2002) mention that reserve data may be misleading due to distortions caused by valuation changes, and what's more, they also assert that simultaneous intervention by another country may lead to a given country's reserve changes being ineffective. These criticisms suggest that the results from the studies relying on the Levy-Yeyati and Sturzenegger (2003) system (Cerra et al. (2009), Towbin and Weber (2011), Broda (2004), and Guidotti et al. (2004)) should be treated with caution. The IMF de facto codings used by Tsangarides (2012) also use data on reserves in the classification process, and thus, the results of that study may also have been adversely effected. At the same time, Tavlas et al. (2008) argues that the IMF de facto approach may suffer from a lack of consistency across countries since the subjective judgement of numerous IMF economists forms part of the classification process. Consequently, disparities between these economists' views regarding the precise characteristics of a particular exchange rate regime may lead to a given country's classification depending on which analyst determines its coding. Finally, the study by Broda (2004) uses the classfication scheme introduced by Ghosh, Gulde, Ostry and Wolf (1997), which is a combination of both de facto and de jure approaches to regime coding. However, a pegged regime that undergoes a one-time change in parity (in a give year) remains a peg under this approach and as a result, the coding scheme may not identify all exchange rate movements that give rise to balance sheet and expenditure switching effects. This deficiency along with those mentioned before indicate that a study using a coding scheme that overcomes these weaknesses, such as the Klein and Shambaugh (2008) system that is used in the present paper, would offer a new insight.

With the exception of the studies investigating the shock absorbing capacity of different exchange rate regimes, there is room to improve on the existing work examining the interactions between external indebtedness and exchange rate flexibility in the recovery process. Moreover, even in the studies considering these interactions, the focus does not extend beyond foreign currency debt to more expansive balance sheet measures such as net foreign assets. That being the case, the present paper, which incorporates broader balance sheet metrics in addition to a more comprehensive analysis of the interactions between external debt and exchange rate flexibility, offers an opportunity to obtain a more thorough understanding of the valuation channels that are so heavily emphasised in the theoretical literature.

This paper is organised as follows. We describe our data and methodology in sections 3.1 and 3.2 respectively. Our results are contained in section 3.3. Section 3.4 concludes.

3.1 Data

3.1.1 The Sample

The data is comprised of 201 recovery episodes spread across 55 countries over the time period extending from 1971 to 2007.[1] While the sample was selected on the basis of data availability, the resulting distribution of income levels (according to the World Bank income groupings) was relatively even with 27 countries being classified as high income and 28 as middle income (13 upper middle income and 15 lower middle income).

The business cycle dating algorithm introduced by Morsink, Helbling and Tokarick (2002) was applied to the annual real GDP per capita series from the Penn World Tables to identify recovery episodes. A given year was classified as a trough if growth in that year was negative and growth in the subsequent year was positive. Similarly, a peak occurred in a year of positive growth that was followed by a year of negative growth. The recoveries took place in the year(s) immediately following a trough. While the use of higher frequency data would have enabled the cycle turning point to be more accurately located, data availability precluded such an approach.

The speed of recovery will be measured using the growth rate of real GDP per capita during the recovery. Although recoveries can also be gauged by the time taken for output to return to the peak achieved before the recession began, that measure will not be used here since its distribution in the sample is poorly suited to regression analysis. Approximately 53 percent of recoveries in the sample regain peak output one year after the trough and consequently, a substantial proportion of the observations exhibit no variation in the variable we are attempting to explain, and as a result, cross-section analysis would be problematic. That said, about 83 percent of sample recoveries regain peak output within three years of the trough and thus, the decision to analyse output growth over the first three years of the recovery implies that our investigation captures the timeframe in which a large majority of the observations in the sample return to peak

[1] A list of the countries is shown in the Appendix in Section 3.6.

output.

A number of data points were excluded from the sample. Firstly, observations with inflation above 40 percent per annum were removed as Reinhart and Rogoff (2004) suggest that the link between exchange rate arrangements and macroeconomic performance begins to breakdown when inflation exceeds this threshold. Secondly, observations with growth of real GDP per capita in the 99th percentile in the first year of the recovery were excluded to avoid the misleading influence that such extreme values may have on the analysis. Thirdly, the developmental level of low income countries was deemed to be insufficient for them to possess a credit allocation mechanism of adequate sophistication for the financial accelerator mechanism to operate, and as a result, one low income country was excluded from the sample. Fourthly, the US was excluded from the sample since the theory models guiding our empirical analysis focus on small open economies. Finally, observations with values of the net foreign currency debt measure in the 1st and 99th percentiles were also excluded.

The main variables of interest (a measure of exchange rate flexibility and gauges of external indebtedness) are described in sections 3.1.2 and 3.1.3. Additional covariates include the amplitude of the recession preceding the recovery, the (log) change in government expenditure, banking and currency crisis dummies, trade and capital account openness measures, the (log) change in the terms of trade, the (log) change in global world exports (i.e. the change in the sum of exports by all countries in the world), the change in the real interest rate, and the change in a political regime index. Detailed definitions of these controls are provided in Appendix B.

3.1.2 Measuring Exchange Rate Flexibility

The de facto exchange rate regime classification was calculated in accordance with the coding scheme introduced by Klein and Shambaugh (2008). In this approach a country-year observation is designated as a peg if the monthly nominal exchange rate (against an appropriate base currency) remains within a ± 2 percent band for the entire year.

Exchange rate movements falling outside this band are coded as non-peg. The nominal exchange rate data used in this process was obtained from the IMF International Financial Statistics database.

A potential concern when using the Klein-Shambaugh measure is whether the band width captures a degree of exchange rate flexibility that is appropriate for the subject of this paper. Klein and Shambaugh address this possibility by noting that the band they recommend is very similar to the requirements placed on historical pegs such as the gold points in the Gold Standard and the bands in Bretton Woods and the EMS. Moreover, assuming the inaccuracy in the choice of band width represents classical measurement error, the instrumental variables technique used in this study should ensure that failure to select the ideal band size will not bias the results.

Since there are three prominent regime classification systems other than the approach chosen here, the grounds for selecting the Klein-Shambaugh scheme will now be explained. The most prominent de facto coding systems were introduced by Levy-Yeyati and Sturzenegger (2003), Shambaugh (2004) and Reinhart and Rogoff (2004).

The Levy-Yeyati and Sturzenegger method was not selected due to its use of potentially misleading international reserves data in the classification process.[2] In contrast, the Klein-Shambaugh method focuses purely on exchange rate movements and is thus not affected by reserves data. It should be noted that using only exchange rate data can lead to instances where a peg classification is attained simply due to a lack of shocks in the foreign exchange market rather than intervention by the monetary authorities. That said, Klein and Shambaugh estimate the probability of such an outcome under some classic floats (USD-DM, USD-JPY, USD-AUD) to be extremely low (less than 1 percent) and therefore, the Klein-Shambuagh scheme should reflect the true intentions of policy for the vast majority of observations.

Furthermore, the Shambaugh and Reinhart-Rogoff systems were deemed to be inap-

[2]Our review of the empirical literature in the introduction discusses the shortcomings of international reserve data.

propriate as they both failed to exhibit a sufficient degree of sensitivity to short run movements in the exchange rate. In the theory models relevant to the subject at hand, a one-off exchange rate devaluation leads to balance sheet and expenditure switching effects, the combination of which has implications for output growth. Consequently, a regime coding scheme that does not provide an indication of when such devaluations take place is not suited to this study. In the Shambaugh (2004) method a given year is classified as a peg if the behaviour of the nominal exchange rate falls into one of two categories: (i) the nominal exchange rate remains within a ± 2 percent band for the entire year; (ii) in 11 out of 12 months in the year there is no change in the exchange rate but in the remaining month there is a movement in the exchange rate of any size. If neither of these conditions is satisfied then the classification is non-peg. Thus, it is apparent that the Shambaugh method fails to bring one-off devaluations to light. In the Reinhart-Rogoff approach, a peg classification is applied when the probability that the absolute monthly change in the nominal exchange rate remains within a one percent band over a rolling five-year window is greater than or equal to 80 percent. Consequently, a one-time devaluation beyond the one percent band may not be lead to a change in the Reinhart-Rogoff classification. Since the Klein-Shambaugh classification changes from peg to non-peg when a one-time devaluation moves the exchange rate outside of the ± 2 percent band, the problem of insensitivity to short-run exchange rate movements is not a feature of that approach.

3.1.3 Measuring the International Balance Sheet

Each of the following metrics play a role in our analysis of the balance sheet effects generated by exchange rate movements. The first measure of each countrys' international balance sheet captures overall external debt exposure and is defined as,

$$\text{Net Debt}_{i,r} = \frac{\text{Debt Assets}_{i,r} - \text{Debt Liabilities}_{i,r}}{\text{GDP}_{i,r}} \tag{3.1}$$

This debt measure and all that follow are measured as at the end of the recession preceding recovery r for country i. GDP in (3.1) is smoothed using a HP filter (with the smoothing coefficient set to 100) to reduce the variability not emanating from changes in debt liabilities or debt assets.

The numerator in (3.1) is comprised of external debt liabilities and debt assets denominated in both domestic and foreign currencies. Net foreign currency denominated debt will be gauged through multiplying debt assets and liabilities by factors produced by Lane and Shambaugh (2010), which reflect the proportion of debt assets and liabilities denominated in a foreign currency. Another variable prepared by Eichengreen, Hausmann and Panizza (2003) named the Original Sin index (OSIN) also measures the proportion of debt denominated in foreign currency but only for the liability side of the external balance sheet.[3] Unfortunately, neither of these datasets cover the complete timeframe being used in the present study (the OSIN data runs from 1993 to 2001 while the Lane-Shambaugh data runs from 1990 to 2004). Eichengreen et al. (2003) present evidence indicating that the OSIN measure has been relatively stable since the 1850s and hence it appears reasonable to use the country average of either of the OSIN or Lane-Shambaugh factors to capture the foreign currency component of external debt. The only exception to this use of country averages of the Lane-Shambaugh factor is for recovery episodes in countries that were members of the European Single Currency and had introduced the Euro, where we use the average of the Lane-Shambaugh factors for the years after the introduction of the Euro in the respective country. The application of the Lane-Shambaugh factors to (3.1) gives,

$$\text{Net Foreign Currency Debt}_{i,r} = \frac{\text{Debt Assets}_{i,r} * \overline{DAFC_i} - \text{Debt Liabilities}_{i,r} * \overline{DLFC_i}}{\text{GDP}_{i,r}} \tag{3.2}$$

where $DAFC_i$ and $DLFC_i$ equal the proportion of assets and liabilities (respectively) denominated in a foreign currency for country i.

Robustness will be assessed through the use of alternative balance sheet measures in which debt exposure is normalised using gross debt. The first of these alternative measures captures total debt liabilities (denominated in both foreign and domestic curren-

[3]This OSIN index will not be used in the net foreign currency denominated debt measure but will instead be used in the debt liability dollarization measure described below.

cies) and is defined as,

$$\text{All Currency Debt Liabilities}_{i,r} = \frac{\text{Debt Liabilities}_{i,r}}{\text{Debt Liabilities}_{i,r} + \text{Debt Assets}_{i,r}} \tag{3.3}$$

The foreign currency component of (3.3) is isolated in the debt liability dollarization measure which is defined as follows,

$$\text{Debt Liability Dollarization}_{i,r} = \frac{\text{Debt Liabilities}_{i,r} * \overline{DLFC_i}}{\text{Debt Liabilities}_{i,r} + \text{Debt Assets}_{i,r}} \tag{3.4}$$

where DLFC is the proportion of debt liabilities denominated in a foreign currency in country i.[4] An additional test of robustness will be conducted through the use of two separate debt liability dollarization measures, one calculated with the OSIN factors, the other prepared with the Lane-Shambaugh factors.

Broader measures of the international balance sheet will also be used. The definition of these variables follow those described above with debt assets and debt liabilities being replaced by total assets and total liabilities respectively. The factors measuring the foreign currency component of these broader balance sheet metrics are all obtained from the Lane-Shambaugh dataset as the OSIN measure only applies to debt and not total assets or total liabilities. The first of these broader measures is net foreign currency assets and is defined as,

$$\text{Net Foreign Currency Assets}_{i,r} = \frac{\text{Total Assets}_{i,r} * \overline{TAFC_i} - \text{Total Liabilities}_{i,r} * \overline{TLFC_i}}{\text{GDP}_{i,r}} \tag{3.5}$$

where TAFC and TLFC equal the proportion of total assets and total liabilities (respectively) denominated in a foreign currency. The second of the broader balance sheet measures is,

$$\text{Total Liability Dollarization}_{i,r} = \frac{\text{Total Liabilities}_{i,r} * \overline{TLFC_i}}{\text{Total Assets}_{i,r} + \text{Total Liabilities}_{i,r}} \tag{3.6}$$

All asset and liability variables used in measuring the international balance sheet were obtained from the External Wealth of Nations (EWN) dataset produced by Lane and Milesi-Ferretti (2004). Definitions of the asset and liability variables are given in the Appendix in Section 3.7.

[4]This approach to measuring debt liability dollarization was based on Berkman and Cavallo (2007).

3.1.4 Descriptive Statistics

Summary statistics for the main variables of interest are presented in Table 3.1. Summary statistics for the remaining variables are provided in the Appendix in Section 3.8.

Table 3.1: Descriptive Statistics

	Mean	Median	St Dev	Max	Min
drgdpc	0.034	0.026	0.028	0.169	0.0001
d2rgdpc	0.057	0.051	0.051	0.299	-0.0768
d3rgdpc	0.079	0.071	0.064	0.281	-0.1720
Klein-Shambaugh regime classification	0.672	1.000	0.471	1.000	0
Regime Record	1.940	2.000	1.838	5.000	0
Net foreign currency debt	-0.311	-0.283	0.260	0.387	-1.498
Net debt	-0.324	-0.298	0.256	0.370	-1.498
DLD (using Lane-Shambaugh index)	0.716	0.769	0.202	0.984	0.141
All currency debt liabilities	0.754	0.786	0.155	0.984	0.264
Net foreign currency assets	-0.120	-0.142	0.421	3.140	-1.484
Net foreign assets	-0.373	-0.356	0.371	1.346	-1.777

Number of observations is 201. drgdpc, d2rgdpc and d3rgdpc measure the (log) growth of real GDP per capita over one-, two- and three-year recovery periods respectively. DLD=debt liability dollarization.

3.2 Methodology

3.2.1 Empirical Model

The following relationship will be estimated to test the predictions of the theoretical literature.

$$g_{i,r} = \alpha + \gamma_1 KS_{i,r} + \gamma_2 ED_{i,r} + \gamma_3 KS_{i,r} * ED_{i,r} + \delta AMP_{i,r} + \beta' Z_{i,r} + \varepsilon_{i,r} \qquad (3.7)$$

where $g_{i,r}$ is the (log) growth of real GDP per capita for country i during recovery r; $KS_{i,r}$ is the Klein-Shambaugh measure of exchange rate flexibility over recovery r; $ED_{i,r}$ is the level of external indebtedness at the end of the final year of the recession preceding recovery r; $AMP_{i,r}$ is the amplitude of the recession preceding recovery r; $Z_{i,r}$ is a vector of control variables detailed in section 3.2.3; and $\varepsilon_{i,r}$ is an error term.

External debt is measured at the end of the recession preceding recovery r to restrict potential endogeneity problems.

Separate estimations of (7) will be conducted for one, two and three year recovery periods. In the two and three year models, the measure of exchange rate flexibility will be the average of the annual exchange rate regime classifications while external debt will continue to be measured at the end of the recession preceding recovery r.

The estimated values of γ_1 and γ_3 offer some insight into the effect of increased exchange rate flexibility on recovery growth at specific levels of external indebtedness. That is, the model specification weighs the ability of a non-pegged regime to overcome the problems stemming from nominal rigidities against the impact of increased exchange rate flexibility on a country's international balance sheet, and in so doing, will evaluate the expenditure switching and balance sheet effects suggested in the theoretical literature. Furthermore, depending on the signs of γ_1 and γ_3, the quotient γ_1/γ_3 may indicate whether a threshold exists at which the direction of the effect of increased exchange rate flexibility on recovery growth changes.

Recession amplitude (AMP) is included to address the threat to identification stemming from the possible link between recession depth and both exchange rate regime choice during the recession and recovery growth. Evidence presented by Klein and Shambaugh (2008), which is discussed in more detail in section 3.2.2, indicates that regime choice before the recovery begins is associated with regime choice during the recovery. At the same time, the theory model presented by Fornaro (2015) gives reason to suspect that exchange rate regime choice will influence the depth of a recession. Moreover, the 'Plucking Model' of Friedman (1988) and the empirical work of Claessens, Kose and Terrones (2011) both suggest the existence of a positive relationship between recession amplitude and recovery growth. In sum, these associations suggest that a failure to control for recession amplitude would lead to omitted variable bias since it is plausible that recession amplitude is associated with both regime choice during the recovery and recovery growth.

Initially (3.7) will be estimated using OLS. The results from these initial estimations should be treated with caution for two reasons. Firstly, the Klein-Shambaugh measure is affected by policy choices which themselves could well have been influenced by the speed of the recovery. Hence, reverse causality presents a plausible threat to identification when using OLS to estimate (3.7). Furthermore, identification of (3.7) relies on the assumption that the measure of exchange rate flexibility is an accurate gauge of the 'true' exchange rate regime in the context of this study. De facto exchange rate regime classification is a controversial issue and thus, although the chosen method appears superior to other available coding systems for the purposes of this study, it is still conceivable that the Klein-Shambaugh approach may not completely capture the variation in the exchange rate that is most relevant for the estimation of (3.7). In other words, there may be measurement error in the exchange rate flexibility metric and consequently, OLS estimation of (3.7) could be biased. These two threats to identification will be addressed using an instrumental variables estimation strategy.

3.2.2 Identification Strategy

The objective when selecting an instrument was to choose a variable that captures the recent history of a country's exchange rate policy. The chosen instrument ('regime record') equals the number of years that a country had a pegged regime (according to the Klein-Shambaugh system) during the five years immediately preceding the recovery. This variable follows the structure of the instrument used by Razin and Rubinstein (2005) but we provide a different justification for instrument relevance.

Loosely speaking, the history encapsulated by the regime record indicates whether a country had a predilection for a particular regime type in the years leading up to the recovery. Thus, identification relies upon this proximate history being able to explain regime choice during the recovery. Evidence regarding the dynamics of exchange rate regime choice presented by Klein and Shambaugh (2008) can be used to more rigorously justify the relevance of this instrument.[5] The estimations of Klein and Shambaugh suggest a survival result which indicates that as the number of years spent in a particular regime increases so does the probability of remaining within that regime for another year. More specifically, the probability of maintaining a one-year old peg for another year was estimated to be 55.9 percent whereas the probability of a five-year old peg lasting another year was 87.7 percent. Similar probabilities were estimated for non-pegged arrangments. In addition to this finding, the study also identified a switching result which indicates that as the time spent in a particular regime increases, the amount of time spent in the subsequent regime decreases. What's more, a relatively short-lived regime was typically followed by a longer time spell in the succeeding regime.

A regime record equal to zero or five indicates that the same regime has been in place for at least five consecutive years and consequently, according to the Klein and Shamabugh survival result there is a high probability that the regime will be in place for another year for such values of the instrument. While this regime persistence could be captured by two dummy variables indicating whether the regime choice for all five years before the recovery was either a float or peg, such an approach would not capture the useful predictive capacity of instances where regime record equals values other than zero or five. This extra variation is particularly informative when regime record equals one. That is, one year out of the five years in the regime record is a peg and the remaining four years are non-pegged. The possible combinations of peg (P) and non-peg (F) over the five-year period with this regime record are,

(a)PFFFF; (b) FPFFF;(c) FFPFF; (d) FFFPF; (e) FFFFP

In combination (a) there is a period of four consecutive non-pegged years immediately prior to the recovery, which indicates a relatively high probability of another year in a peg based on the Klein and Shamabugh survival result. Arrays (b), (c), and (d) represent instances of relatively short peg spells. Based on the switching result it would

[5]This evidence is based on estimations using the same Klein-Shambaugh coding scheme used here.

be reasonable to expect a relatively long non-pegged spell to follow these solitary peg years. Consequently, the switching property suggests that combinations (b), (c), and (d) exhibit characteristics that are supportive of the proposition that there will be a non-peg in the first year of the recovery. Moreover, the survival result also supports the view that there will be a non-peg in the first year of recovery after regime records (b) and (c) since each of these combinations has more than one non-pegged year just before the recovery. Finally, in combination (e) a non-pegged spell of at least four years in length precedes a single pegged year. Klein and Shambugh estimate the proportion of non-pegged spells lasting at least 4 years is about 38 percent and, as a result, it is reasonable to infer that this non-pegged spell is relatively long and, in turn, the switching result suggests that the subsequent pegged spell will be relatively short. While this prediction from array (e) is less helpful in guiding expectations, the other four combinations when regime record equals one provide evidence in favour of a non-peg in the first year of the recovery and thus, a regime record of one is useful in forecasting regime choice.

A simple comparison of the distribution of exchange rate regimes during the first year of the recovery at each level of regime record provides further evidence supporting the assertions of instrument relevance. Table 3.2 contains the average regime choice during the recovery for each value of regime record. There is a very strong association between regime records equal to zero or five and the decision to adopt a non-pegged or pegged regime (respectively) during the first post-recession year. Also, a regime record of one is strongly associated with a float in the recovery year. At the same time, with the exception of the change between regime records equal to one and two, the average regime choice follows a reasonably steady downward path as regime record increases from zero to five. While these observations do suggest instrument relevance they should be treated with caution when viewed in isolation since they are not conditioned upon other variables influencing regime choice. However, the main analysis in section 3.3 comprehensively addresses this issue of instrument strength and ultimately, the diagnostics do not suggest that the regime record instrument is weak (i.e. the inferences we made on the basis of Table 3.2 are sound).

Table 3.2: Regime Distribution

	Average Klein-Shambaugh Classification During Recovery		
Regime Record	1-year	2-year	3-year
0	0.909	0.900	0.901
1	0.765	0.750	0.775
2	0.793	0.776	0.736
3	0.650	0.700	0.700
4	0.409	0.455	0.424
5	0.133	0.155	0.179

Note: Under the Klein-Shambaugh classification system, 1=non-peg and 0=peg. Regime record equals the number of years that a country had a pegged regime - according to the Klein-Shambaugh system - during the five years immediately preceding the recovery.

The same regime record instrument will also be used in the estimations for the two and three-year post recession periods. Table 3.2 also shows the two- and three-year post-recession averages of the exchange rate regime classification for each value of regime record. The stability of these averages over the multiyear recovery periods suggests that the same instrument is relevant for explaining regime choice over the one, two and three-year recovery horizons. This stability offers further support for the assertion that variation in the regime record instrument provides a useful time-specific insight into changes in a country's preferred exchange rate regime. At the same time, the stability also suggests persistence of regime choice once the recovery has begun.

The identification strategy also relies on the assumption that no variables omitted from the empirical model are correlated with both regime record and speed of recovery. The credence of possible threats to this exclusion restriction will be assessed in two ways. The first involves a careful evaluation of the literature to pinpoint variables that have been shown to influence both regime record (through their affect on exchange rate regime choice) and growth during the recovery. Controlling for these variables in the empirical model provides a feasible yet imperfect means of ruling out threats to instrument validity. The second approach to the assessment of instrument exogeneity will involve the application of Hansen's overidentifying restrictions test. Although the benchmark model is not overidentified, it is possible to expand the number of instruments in a manner consistent with the empirical evidence on regime durability, thereby permitting the use of the overidentifying restrictions test. The Klein and Shambaugh study and the work of Husain, Mody and Rogoff (2005) suggests that while regime durability is evident across all countries, the degree of persistence appears to vary with a country's level of development. This observation justifies the interaction of regime record with dummies indicating a country's World Bank income group. The number of instruments will then exceed the number of endogenous variables and in turn, the overidentifying restrictions test can be conducted.

Since the exchange rate regime is also part of an interaction term in (3.7), the model contains two endogenous variables, and thus, at least two instruments are necessary for identification of the benchmark model. The second instrument will be the interaction of regime record and the external debt measure from the structural equation.

3.2.3 Control Variables

The choice of control variables was largely guided by the empirical work described in the literature review along with the work of Cerra and Saxena (2005) on economic recoveries. At the same time, controls were also selected so as to reduce the possibility that there are omitted variables that are correlated with both speed of recovery and regime record. The first control variable is the lagged (log) change in government consumption as a percentage of GDP (ΔGov(-1)) and is intended to capture adjustments in fiscal policy immediately before the recovery. The role of restrictions on capital inflows and outflows in the recovery process is addressed by including the lagged value of the capital account openness index (KAOpen(-1)) introduced by Chinn and Ito (2006) as a second control. The third control is the lagged value of trade openness (TOpen(-1)), which equals the sum of imports and exports as a percentage of GDP. Both capital account and trade openness have been shown to be associated with recovery growth and exchange rate regime choice (see for instance Levy-Yeyati, Sturzenegger and Reggio (2010) for evidence on regime determination) and are thus particularly relevant in this study. Each of these three controls is measured at the end of the recession immediately preceding each recovery to limit potential endogeneity problems.

As in Guidotti et al. (2004), two variables are included to control for shocks during the recovery. The first of these is the (log) change in a terms of trade index (ΔTT) while the second is the (log) change in global world exports (ΔWex). The latter controls for time specific common shocks in a manner that leads to the loss of fewer degrees of freedom than the inclusion of time dummies. The change in the terms of trade index and the growth in global world exports will be measured over the 1-, 2- or 3-year post-recession time periods. The baseline model comprises the main variables of interest described above in addition to the control variables detailed up to this point.

Furthermore, to distinguish between voluntary and forced variation in the choice of exchange rate regime, a currency crisis dummy created by Laeven and Valencia (2008) is also used as a control. This dummy indicates that a currency crisis has taken place when there is a depreciation or devaluation of at least 30 percent in the nominal exchange rate. At the same time, the decline in the value of the currency must also exceed the previous year's depreciation or devaluation by at least 10 percent. The movement in the exchange rate during a currency crisis according to this definition is large enough to move the nominal exchange rate outside of the ± 2 percent band that separates pegged from non-pegged regimes in the Klein-Shambaugh coding system. Due to the potential endogeneity of the currency crisis, the correlation between crisis dummy and exchange rate regime could potentially bias the coefficient estimates for the main variables of interest in model specifications including the crisis indicator. To address this concern, the model will be estimated with and without the crisis dummy to provide a more reliable insight into the impact of controlling for the occurrence of a currency crisis on the main associations being studied. In the multiyear estimations, the dummy will indicate whether a currency crisis occurred at any time during the two or three-year post-recession time periods.

The variables described thus far comprise the baseline model. Some additional variables will also be used to test sensitivity to model specification changes and to further address the possibility that there are omitted variables that are correlated with both regime record and recovery growth. The first addition will be the lagged change in the real interest rate to control for variation in monetary policy during the recession, which could be correlated with regime record. The second addition is a dummy for the occurrence of a banking crisis during the recession preceding the recovery.[6] Finally, the change in the Polity IV political regime index prepared by the Center for Systemic Peace will also be used. In addition to being linked with economic recoveries, the political regime has also been linked with regime choice (see for instance Bernhard and Leblang (1999) and Broz (2002)).

Another concern arises from the choice to only include the exchange rate regime in levels throughout the estimations. This decision implies that the estimated regime coefficient is an average of the impact of a switch in regime and the effect of leaving the regime unchanged during the recovery year(s). As a result, the precise implications of the estimated regime coefficient are unclear. The main concern here is that the impact of increased exchange rate flexibility could be largely driven by the experience of the regime switchers, in which case, an inference that increased exchange rate flexibility in general is beneficial/harmful for the recovery (at a given level of external debt) would be misleading. One way to address this issue would be to include the first difference of the regime variable. However, the relatively small number of switches in the sample combined with the lack of valid instruments for the change in the regime precluded this strategy. As an alternative to this approach, the baseline specification is re-estimated with the observations involving a switch in regime removed from the sample. This strategy will provide an insight into the impact of increased exchange rate flexibility that is not influenced by recoveries involving a change of exchange rate regime. Moreover, changes in the regime point estimates between the full and reduced sample calculations will offer some provisional guidance on the impact of switching the regime during the recovery.

[6] The inclusion of the banking crisis dummy was prompted by the work of Abiad, Dell'Ariccia and Li (2011).

3.2.4 Further Features of the Estimation Process

The first stage of the two-stage least squares process for the exchange rate regime will be estimated using a linear probability model. This contrasts with the empirical literature on the determinants of regime choice which typically uses a non-linear estimation technique such as probit. While the underlying population first stage may in fact be non-linear, Kelejian (1971) showed that the use of a linear first stage estimation technique under such circumstances still gives consistent estimates. Consequently, the IV estimation process used here is theoretically consistent.

Nearly half of the countries in the sample have the same exchange rate regime in all their recovery years and, as a result, the addition of country fixed effects to model (3.7) would remove a significant proportion of the variation in the main variable of interest. As a result, the ability of model (3.7) with country fixed effects to identify the relationship of interest would be severely restricted. Therefore, country fixed effects will not be employed in the baseline empirical model. However, omitting country dummies could lead to autocorrelation in the error terms for each country since a control is not place for potential fixed country specific factors that influence the recovery. To avoid the bias in standard errors resulting from this potential serial correlation, the standard errors will be clustered by country using a cluster method that is robust to arbitrary autocorrelation and heteroskedasticity.[7]

The Angrist and Pischke (2009) first stage multivariate F-test of excluded instruments will be used to address the possibility of weak identification in the two-stage least squares estimations.[8] The same test procedure is also applied to the other endogenous regressor and, as a result, the estimated model has two first stage F-tests, one for each endogenous

[7] This approach draws on the modelling strategy adopted by Acemoglu et al (2003).

[8] In considering the possibility that the exchange rate regime variable is weakly identified, this F-test begins by partialling out the part of the variation in the exchange rate regime that is explained by the fitted values from the first stage regression for the other endogenous regressor (the interaction term). Then the F-test assesses whether the residual remaining after partialling out the other endogenous variable can be explained by the instruments. A failure of the instruments to exhibit such explanatory power is a signal that the model could be weakly identified (i.e. the null of instrument irrelevance is not rejected).

variable. It should be emphasised that a failure to reject the null of instrument irrelevance in this test is not a definitive indicator of instrument weakness and, as will be explained in the results section below, further tests should be conducted to assess instrument relevance when the F-test null is not rejected.

3.3 Results

3.3.1 First Stage Estimates

Table 3.3 shows the first stage estimates based on the net foreign currency debt (NFCD) measure and two sets of conditioning variables. These estimates focus on the first year of the recovery. Columns (1) and (2) contain the reduced form estimates for the exchange rate regime while columns (3) and (4) display the first stage estimates for the interaction term (KS x NFCD). In column (1) the overall association between regime record and exchange rate regime has the expected negative sign while the magnitude of the point estimate is reasonable given the distribution of exchange rate regimes at each level of regime record in the sample in Table 3.2. Similarly, the estimates in column (3) also conform with expectations and they imply an overall inverse link between regime record and the exchange rate regime when NFCD is below the 83^{rd} percentile level or above zero. Specifications (2) and (4) suggest that the addition of a currency crisis dummy does not lead to material changes in the first stage estimates. Furthermore, the Angrist and Pischke multivariate F-test for excluded instruments does not give reason to suspect a weak instrument problem since for each first stage specification this F-statistic is greater than the rule of thumb critical value of ten (i.e. the null of instrument irrelevance is rejected). Taken together, the estimates presented in Table 3.3 suggest the existence of a sound first stage association between the excluded instruments and the endogenous variables.

When using the alternative international balance sheet measures and the multi-year recovery time periods, the first stage estimates are very similar to those discussed here.

Table 3.3: First Stage Estimates

	(1) KS	(2) KS	(3) KS x NFCD	(4) KS x NFCD
Regime record	-0.1378***	-0.1408***	-0.0127**	-0.0112*
	(0.0148)	(0.0148)	(0.0062)	(0.0057)
Regime record x NFCD	-0.0061	-0.0012	-0.1738***	-0.1763***
	(0.0486)	(0.0453)	(0.0274)	(0.0252)
Currency crisis dummy	No	Yes	No	Yes
Angrist-Pischke F-statistic	97.57	100.73	40.49	49.06

Dependent variable specified in column heading. Number of observations is 201 in columns (1)-(4). KS=Klein-Shambaugh regime classification (1=non-peg, 0=peg) for 1-year recovery period. NFCD=Initial net foreign currency debt. See Section 3.1.3 for definitions of external debt measure. *** and ** denote statistical significance at the 1 and 5 percent levels respectively. Standard errors clustered by country shown in parentheses. The baseline set of control variables is used throughout.

For that reason, the reduced form estimates for the remaining balance sheet metrics will not be discussed in detail but the first stage diagnostics will still be included in our second stage results tables.

3.3.2 External Debt: 1-year Horizon

Table 3.4 shows the estimates for the first year of the recovery under the NFCD measure, which captures net foreign currency denominated debt assets as a proportion of (HP-smoothed) GDP. The lower panel of this table contains the estimated partial derivative of recovery growth with respect to the exchange rate regime for various levels of NFCD. The OLS estimates in column (1) suggest that a pegged regime experiences faster recovery growth than a non-pegged regime when net foreign currency debt is sufficiently low.[9] Since the sample average growth rate during the first year of the recovery was 3.4 percent, the point estimates for the exchange rate regime are of an economically meaningful magnitude when NFCD is relatively low. Specifically, according to the OLS estimates in column (1) the difference between recovery growth under pegged and non-pegged regimes is 1 percentage point when NFCD equals -47 percent (25th percentile) and 1.4 percentage points when NFCD is -81 percent (5th percentile). The p-values for these

[9] Since NFCD equals net foreign currency denominated debt assets as a proportion of GDP, when net foreign currency debt decreases there is a relatively higher level of foreign currency denominated debt liabilities.

differences are 3.2 percent at the 25th percentile of the debt measure and 6.8 percent at the 5th percentile.

These OLS estimates may be biased due to reverse causality and/or measurement error. The IV estimates in columns (2) through (5) of Table 3.4 seek to remedy these issues. When using regime record as an instrument for exchange rate regime in column (2) the general nature of the relationship is the same as that obtained with OLS. That is, pegged regimes are associated with significantly faster recoveries than non-pegged arrangements when NFCD is at or below the 49th percentile level (NFCD equals approximately -29 percent). This growth difference is statistically significant with the p-values for the exchange rate regime indicator being 5.7 percent at the 25th percentile of NFCD and 7.6 percent at the 5th percentile. At the same time, this growth disparity between regimes is also economically significant with a peg being linked to a recovery growth rate that is 1.6 percentage points faster than the rebound under a non-peg when NFCD is at the 25th percentile level and 1.9 percentage points faster at the 5th percentile. Thus, the growth difference between exchange rate regimes was larger (in economic terms) in the IV estimations, and consequently, there is an indication that that the OLS estimates were biased toward zero. Similar results were obtained when the currency crisis dummy was included in specification (3), thus providing a hint that the estimated effect of increased exchange rate flexibility is likely to reflect a deliberate rather than forced choice of exchange rate policy. Furthermore, as shown in column (4), when the number of instruments was increased by interacting regime record with indicators for World Bank income groups, the nature of the relationship between exchange rate regime and recovery growth remains the same as in the prior estimations. Moreover, in this overidentified model the p-values for the exchange rate regime indicator are 3.4 percent when NFCD is at the 25th percentile level and 5.1 percent at the 5th percentile level.

The economic magnitude of the recovery growth difference between the two exchange rate regimes remains relatively stable throughout the IV estimations. At the same time, when NFCD is at the 45th, 25th and 5th percentile levels, the growth difference is

Table 3.4: Exchange Rate Flexibility, Net Foreign Currency Debt and Recovery Growth

Dependent variable = 1-year (log) growth of real GDP per capita					
	(1)	(2)	(3)	(4)	(5)
	OLS	2SLS	2SLS	2SLS	LIML
KS	-0.004	-0.012	-0.013	-0.012	-0.013
	(0.006)	(0.011)	(0.011)	(0.011)	(0.011)
KS x NFCD	0.012	0.009	0.010	0.010	0.010
	(0.013)	(0.018)	(0.018)	(0.017)	(0.018)
NFCD	-0.010	-0.007	-0.008	-0.008	-0.008
	(0.009)	(0.012)	(0.012)	(0.012)	(0.012)
ΔGov(-1)	0.040	0.045	0.047	0.046	0.046
	(0.032)	(0.032)	(0.032)	(0.032)	(0.032)
KAOpen(-1)	-0.016***	-0.017***	-0.017***	-0.017***	-0.017***
	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)
TOpen(-1)	0.00006**	0.00006**	0.00005*	0.00006**	0.00006**
	(0.00002)	(0.00003)	(0.00003)	(0.00003)	(0.00003)
ΔWex	0.040	0.033	0.029	0.032	0.032
	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)
ΔTT	0.019	0.022	0.023	0.022	0.022
	(0.022)	(0.022)	(0.023)	(0.022)	(0.022)
Recession Amplitude	0.030	0.036	0.044	0.036	0.037
	(0.023)	(0.023)	(0.030)	(0.024)	(0.024)
Currency Crisis			-0.021**		
			(0.009)		
Intercept	0.032***	0.038***	0.039***	0.038***	0.038***
	(0.007)	(0.009)	(0.009)	(0.009)	(0.009)
Estimated impact of Klein-Shambaugh classification over the distribution of NFCD					
KS+KS x NFCD	-0.014*	-0.019*	-0.021*	-0.021*	-0.021*
(5^{th} percentile of NFCD)	(0.008)	(0.011)	(0.011)	(0.011)	(0.011)
KS+KS x NFCD	-0.010**	-0.016*	-0.018**	-0.017**	-0.017**
(25^{th} percentile of NFCD)	(0.005)	(0.009)	(0.008)	(0.008)	(0.008)
KS+KS x NFCD	-0.008*	-0.015*	-0.016*	-0.015*	-0.016*
(45^{th} percentile of NFCD)	(0.004)	(0.009)	(0.008)	(0.008)	(0.009)
KS+KS x NFCD	-0.007	-0.014	-0.015*	-0.014	-0.015
(65^{th} percentile of NFCD)	(0.004)	(0.009)	(0.009)	(0.009)	(0.009)
KS+KS x NFCD	-0.005	-0.012	-0.014	-0.013	-0.013
(85^{th} percentile of NFCD)	(0.006)	(0.011)	(0.01)	(0.01)	(0.011)
Angrist-Pischke F-stat		97.6, 40.5	100.7, 49.1	28.2, 13.2	28.2, 13.2
OverID test (p-value)				0.37	0.38

N=201 in models (1)-(5). KS=Klein-Shambaugh regime classification (1=non-peg, 0=peg) for 1-year recovery period. NFCD=Initial net foreign currency debt. See Section 3.1.3 for definitions of external debt measure. Definitions of control variables are provided in Section 3.2.3. ***, **, and * denote statistical significance at the 1, 5, and 10 percent levels respectively. Standard errors clustered by country shown in parentheses. The excluded instruments for models (2) and (3) are regime record and regime record x NFCD. The excluded instruments for models (4) and (5) are regime record x World Bank income group interactions and regime record x NFCD x World Bank income group interactions. The null in the overidentifying restrictions test (OverID) is that the instruments are exogenous. Angrist-Pischke F-test null hypothesis is that instruments are weak. Angrist-Pischke F-statistics (a, b) are for (a) KS first stage; and (b) KS*NFCD first stage. Rule-of thumb critical value in F-test is 10. 2SLS denotes two-stage least squares estimator and LIML denotes the limited information maximum likelihood estimator.

always statistically significant at the 10 percent level with p-values for the exchange rate regime regime coefficient often far below this threshold. Therefore, the results in Table 3.4 support the view that the exogenous component of variation in the exchange rate regime is significantly associated with growth during the first year of the recovery when NFCD is sufficiently low.

Turning to diagnostics, the number of instruments used in column (4) is greater than the number of endogenous variables and as a result, the overidentifying restrictions test can be applied to that model. The results of this test fail to indicate that the instruments are not exogenous. In addition, the Angrist and Pischke multivariate F-test for excluded instruments is greater than the rule-of-thumb critical value of ten in all IV specifications in Table 4 (specifications (2)-(5)). Thus, the F-test does not suggest a weak instrument problem in the IV models. Angrist and Pischke (2009) contend that limited information maximum likelihood (LIML) estimation of overidentified models is 'approximately median-unbiased' [p.209] even in the presence of weak instruments and consequently, application of LIML to the IV specification with six instruments provides a further means of investigating the validity of the estimation in column (4). The LIML estimates in column (5) are very similar to those in column (4) and thus, there is additional evidence regarding the robustness of the overidentified two-stage least squares estimates.

Table 3.5 contains the estimates using the net debt (ND) measure, which captures net external debt (denominated in domestic or foreign currency) as a proportion of (HP-smoothed) GDP. These results follow a similar general relationship to that observed with NFCD but the growth difference between regimes tends to be slightly smaller. The similarity of the results across the two debt measures appears reasonable since the median proportion of overall debt liabilities accounted for by foreign currency denominated debt liabilities is approximately 99.9 percent while the average of the same ratio is 93.7 percent. The corresponding median and mean values for debt assets are 100 percent and 94.7 percent respectively. Consequently, the difference between NFCD and ND will tend to be relatively small. Moreover, variation in the foreign currency denominated debt will typically be the major driver of changes in overall debt. That said, even though the difference between the two debt metrics tends to be relatively small, the fact that there is a disparity implies that the ND will be less accurate than NFCD in capturing the currency mismatch that theory suggests is important for comparing the performance of exchange rate regimes. In turn, this minor inaccuracy could explain the tendency toward slightly lower point estimates for the exchange rate regime when using the ND measure.

Throughout the estimations in Table 3.5, the control variables were of the expected sign and in some instances statistically significant. The first stage diagnostics (F-statistic and overidentifying restrictions test) and the LIML estimation in column (5) once again support the validity of the IV estimations when using the ND measure.

3.3.3 External Debt: Multiyear Horizons

Table 3.6 contain the estimates for the 1-, 2- and 3-year horizons when using the NFCD and ND measures. When the horizon is extended to the 2-year post-recession time period, a pegged regime is still associated with faster recovery growth than a non-pegged regime at relatively low levels of NFCD. As Table 3.6 shows, over the 2-year horizon this relationship is statistically significant at the 10 percent level when NFCD is between the 25th and 45th percentile levels. The growth difference between regimes is also economically significant with a pegged regime being associated with an increase in the 2-year recovery growth rate of 2.7 percentage points compared to a non-pegged regime when NFCD is at the 45th percentile. Interestingly, the corresponding growth difference for the 3-year recovery growth rate is also 2.7 percentage points. A similar lack of growth between the 2nd and 3rd post-recession years is also evident at other external debt levels. Thus, it is apparent that the change in the growth difference between regimes when moving from the 1-year to the 2-year horizons is noticeably larger than the corresponding change in the growth difference when moving from the 2-year to

Table 3.5: Exchange Rate Flexibility, Net Debt and Recovery Growth

Dependent variable = 1-year (log) growth of real GDP per capita					
	(1)	(2)	(3)	(4)	(5)
	OLS	2SLS	2SLS	2SLS	LIML
KS	-0.005	-0.014	-0.015	-0.014	-0.014
	(0.006)	(0.012)	(0.011)	(0.011)	(0.012)
KS x ND	0.009	0.002	0.003	0.006	0.006
	(0.014)	(0.018)	(0.019)	(0.017)	(0.018)
ND	-0.005	0.0001	-0.001	-0.002	-0.002
	(0.010)	(0.013)	(0.013)	(0.012)	(0.012)
Estimated impact of Klein-Shambaugh classification over the distribution of ND					
KS+KS x ND	-0.012	-0.016	-0.018	-0.018*	-0.019*
(5^{th} percentile of ND)	(0.008)	(0.01)	(0.011)	(0.01)	(0.01)
KS+KS x ND	-0.009**	-0.015*	-0.017**	-0.016**	-0.017**
(25^{th} percentile of ND)	(0.004)	(0.008)	(0.008)	(0.008)	(0.008)
KS+KS x ND	-0.008*	-0.015*	-0.016*	-0.015*	-0.016*
(45^{th} percentile of ND)	(0.004)	(0.009)	(0.008)	(0.008)	(0.009)
KS+KS x ND	-0.007	-0.015	-0.016*	-0.015*	-0.016
(65^{th} percentile of ND)	(0.005)	(0.01)	(0.009)	(0.009)	(0.01)
KS+KS x ND	-0.006	-0.014	-0.015	-0.014	-0.015
(85^{th} percentile of ND)	(0.006)	(0.011)	(0.01)	(0.01)	(0.011)
Angrist-Pischke F-stat		91.4, 38.6	94.3, 45.9	24.6, 12.5	24.6, 12.5
OverID test (p-value)				0.198	0.208

N=201 in models (1)-(5). KS=Klein-Shambaugh regime classification (1=non-peg, 0=peg) for 1-year recovery period. ND=Initial net debt. See Section 3.1.3 for definitions of external debt measures. The baseline set of controls is used throughout but the coefficients are not reported. Model (3) also includes the currency crisis dummy but the coefficient is not reported. ***, **, and * denote statistical significance at the 1, 5, and 10 percent levels respectively. Standard errors clustered by country shown in parentheses. The excluded instruments for models (2) and (3) are regime record and regime record x ND. The excluded instruments for models (4) and (5) are regime record x World Bank income group interactions and regime record x ND x World Bank income group interactions. The null in the overidentifying restrictions test (OverID) is that the instruments are exogenous. Angrist-Pischke F-test null hypothesis is that instruments are weak. Angrist-Pischke F-statistics (a, b) are for (a) KS first stage; and (b) KS*ND first stage. Rule-of thumb critical value in F-test is 10. 2SLS denotes the two-stage least squares estimator and LIML denotes the limited information maximum likelihood estimator.

the 3-year horizon. Consequently, it appears as though most of the benefits of pegging for countries with relatively low levels of NFCD occur within the first 2-years following the trough of the recession.

The results in Table 3.6 also suggest that the growth difference between regimes over the 2-year timeframe does not vary substantially with changes in the level of ND. Viewed in light of the multiyear estimates under NFCD, this outcome emphasises the importance of the foreign currency denominated component of debt in the determination of balance sheet effects during a recovery.

The first stage diagnostics (F-statistic and overidentifying restrictions test) also support the validity of the multiyear IV estimations. In addition, when the 2- and 3-year specifications were estimated using six instruments (results not reported to save space), the overidentifying restrictions test failed to indicate that the instruments were not exogenous. At the same time, LIML estimations of the overidentified multiyear specifications yielded point estimates that were similar to the overidentified two-stage least squares estimations.

3.3.4 Sensitivity Analysis

Throughout the estimations under NFCD and ND, the control variables were typically of the expected sign and in some instances were statistically significant. In the 1-year results, the point estimates for trade openness were always significant at the 10 percent level or better, while capital account openness was always significant at the 1 percent level. In the multiyear estimations, the change in the terms of trade index was consistently significant at the 5 percent level. These features of the results support the validity of the model specification and in turn, strengthen the reliability of the estimations for the main variables of interest. Nevertheless, further tests of robustness will still be applied.

The robustness of the estimations with NFCD was assessed using two alternative measures of the international balance sheet. These alternatives are two versions of the debt

Table 3.6: Exchange Rate Flexibility and Multiyear Recovery Growth

	(1)	(2)	(3)	(4)	(5)	(6)
	1-year	2-year	3-year	1-year	2-year	3-year
KS	-0.012	-0.022	-0.025	-0.014	-0.027	-0.030
	(0.011)	(0.018)	(0.019)	(0.012)	(0.018)	(0.023)
KS x NFCD	0.009	0.015	0.007			
	(0.018)	(0.037)	(0.046)			
NFCD	-0.007	0.009	0.017			
	(0.012)	(0.030)	(0.038)			
KS x ND				0.002	-0.002	-0.004
				(0.018)	(0.036)	(0.046)
ND				0.0001	0.023	0.034
				(0.013)	(0.028)	(0.033)
Estimated impact of Klein-Shambaugh classification over the distribution of NFCD or ND						
KS+KS x NFCD or ND	-0.019*	-0.034	-0.031	-0.016	-0.026	-0.027
(5th percentile of NFCD or ND)	(0.011)	(0.026)	(0.031)	(0.01)	(0.025)	(0.031)
KS+KS x NFCD or ND	-0.016*	-0.029*	-0.028	-0.015*	-0.027	-0.029
(25th percentile of NFCD or ND)	(0.009)	(0.017)	(0.019)	(0.008)	(0.017)	(0.021)
KS+KS x NFCD or ND	-0.015*	-0.027*	-0.027*	-0.015*	-0.027*	-0.029
(45th percentile of NFCD or ND)	(0.009)	(0.015)	(0.015)	(0.009)	(0.015)	(0.019)
KS+KS x NFCD or ND	-0.014	-0.025*	-0.026*	-0.015	-0.027*	-0.030
(65th percentile of NFCD or ND)	(0.009)	(0.015)	(0.015)	(0.01)	(0.015)	(0.020)
KS+KS x NFCD or ND	-0.012	-0.023	-0.025	-0.014	-0.027	-0.030
(85th percentile of NFCD or ND)	(0.011)	(0.017)	(0.018)	(0.011)	(0.017)	(0.021)
N	201	194	190	201	194	190
Angrsit-Pischke F-stat	97.6, 40.5	81.8, 27.0	106.2, 33.2	91.4, 38.6	75.1, 27.0	100.3, 34.3

Dependent variable: growth in real GDP per capita over timeframe specified in column heading. KS=Klein-Shambaugh regime classification (1=non-peg, 0=peg) for 1-year recovery period. KS=average of one-year Klein-Shambaugh classifications for multiyear estimates. NFCD=Initial net foreign currency debt, and ND=Initial net debt. See Section 3.1.3 for definitions of external debt measures. The baseline set of controls is used throughout but the coefficients are not reported. ***, **, and * denote statistical significance at the 1, 5, and 10 percent levels respectively. Standard errors clustered by country shown in parentheses. The excluded instruments are regime record and regime record x NFCD or ND. Angrist-Pischke F-test null hypothesis is that instruments are weak. Angrist-Pischke F-statistics (a, b) are for (a) KS first stage; and (b) KS*NFCD or KS*ND first stage. Rule-of thumb critical value in F-test is 10. 2SLS estimator used throughout models (1)-(6).

liability dollarization measure, one calculated using the foreign currency factors prepared by Lane and Shambaugh (2010), the other using the OSIN index of Eichengreen et al (2003). These estimations are presented in Table 3.7. The 1- and 2-year results using either version of debt liability dollarization are broadly consistent with the estimations under NFCD. At the 1- and 2-year horizons a pegged regime is linked with faster recovery growth than a non-peg when debt liability dollarization moves above a threshold level (i.e. when foreign currency denominated debt liabilities are a sufficiently large proportion of gross debt). The degree of statistical precision in the IV estimates was slightly higher than under NFCD with the growth difference between regimes at the 1- and 2-year horizons consistently attaining significance at the 5 percent level when using debt liability dollarization. The growth difference between regimes at sufficiently high levels of debt liability dollarization was also economically significant over the 1- and 2-year timeframes. In sum, the robustness of the results is evident from the stability of the general nature of the relationship of interest at the 1- and 2-year horizons when switching to these alternative external debt metrics.[10]

When expanding the set of control variables the relationship between exchange rate regime and growth in the first recovery year is not materially affected. The results for three amendments to the set of conditioning variables are displayed in Table 3.8. The controls include variables which are expected to influence regime choice (which itself is correlated with regime record) and/or recovery growth. Consequently, these supplementary regressions provide further evidence favouring the validity of the estimations.

In addition, the estimations in Table 3.9 show that after removing the country-year observations involving a switch in the exchange rate regime during the recovery, the

[10]Both two-stage least squares and LIML estimation of the overidentified models under debt liability dollarization yielded results that were similar to the just-identified estimates in Table 3.7 (results not reported to save space). Although one of the first stage F-statistics for the overidentified model was less than the rule-of-thumb critical value of 10, the similarity between the overidentified two-stage least squares and LIML estimates suggests that the relatively weaker instrument set in that specification did not generate bias in the point estimates (since LIML is approximately median unbiased even with weak instruments), and consequently, further evidence is provided for the robustness of our main finding. The overidentifying restrictions test was not applied to the overidentified model under debt liability dollarization as the possibility of there being weak instruments in that specification implied that the results of the test could be unreliable.

Table 3.7: Robustness: Alternative Measures of Foreign Currency Debt

Dependent variable = 1-year (log) growth of real GDP per capita				
	(1)	(2)	(3)	(4)
	1-year	2-year	1-year	2-year
	(1)	(2)	(3)	(4)
KS	-0.029**	-0.067***	-0.029*	-0.066**
	(0.013)	(0.025)	(0.015)	(0.029)
KS x DLD1	-0.025**	-0.068***		
	(0.011)	(0.023)		
DLD1	0.020***	0.037**		
	(0.007)	(0.017)		
KS x DLD2			-0.026*	-0.063**
			(0.014)	(0.032)
DLD2			0.025**	0.045
			(0.012)	(0.028)
Estimated impact of Klein-Shambaugh classification over the distribution of DLD1 or DLD2				
KS+KS x DLD1 or DLD2	0.0002	0.013	0.005	0.018
(5^{th} percentile of DLD1 or DLD2)	(0.008)	(0.013)	(0.008)	(0.020)
KS+KS x DLD1 or DLD2	-0.016*	-0.032**	-0.014*	-0.028**
(25^{th} percentile of DLD1 or DLD2)	(0.009)	(0.016)	(0.009)	(0.014)
KS+KS x DLD1 or DLD2	-0.022**	-0.047**	-0.021*	-0.044**
(45^{th} percentile of DLD1 or DLD2)	(0.010)	(0.020)	(0.011)	(0.020)
KS+KS x DLD1 or DLD2	-0.024**	-0.054**	-0.024*	-0.052**
(65^{th} percentile of DLD1 or DLD2)	(0.011)	(0.022)	(0.012)	(0.023)
KS+KS x DLD1 or DLD2	-0.027**	-0.060***	-0.026*	-0.058**
(85^{th} percentile of DLD1 or DLD2)	(0.012)	(0.023)	(0.014)	(0.026)
N	201	194	201	194
Angrist-Pischke F-statistic	24.0, 213.7	24.6, 242.4	20.0, 260.7	20.4, 109.2

KS=Klein-Shambaugh regime classification (1=non-peg, 0=peg) for recovery period specified in column heading. DLD1=Initial debt liability dollarization calculated using Lane-Shambaugh foreign currency factors. DLD2=Initial debt liability dollarization calculated using OSIN index. See Section 3.1.3 for definitions of external debt measures. The baseline set of controls is used throughout but the coefficients are not reported. ***, **, and * denote statistical significance at the 1, 5, and 10 percent levels respectively. Standard errors clustered by country shown in parentheses. The excluded instruments for models (1) and (2) are regime record and regime record x DLD1. The excluded instruments for models (3) and (4) are regime record and regime record x DLD2. Angrist-Pischke F-test null hypothesis is that instruments are weak. Angrist-Pischke F-statistics (a, b) are for (a) KS first stage; and (b) KS*DLD first stage. Rule-of thumb critical value in F-test is 10. 2SLS estimator used throughout models (1)-(4).

Table 3.8: Robustness: Changes to the Set of Conditioning Variables

Dependent variable = 1-year (log) growth of real GDP per capita			
	(1)	(2)	(3)
KS	-0.013	-0.014	-0.008
	(0.012)	(0.012)	(0.008)
KS x NFCD	0.009	0.006	0.018
	(0.018)	(0.018)	(0.012)
NFCD	-0.007	-0.006	-0.017
	(0.012)	(0.012)	(0.010)
Controls	Baseline plus dummy for banking crisis during preceding recession	Baseline plus change in political regime index over the previous five years	Baseline plus change in real interest rate during final year of recession
Estimated impact of Klein-Shambaugh classification over the distribution of NFCD			
KS+KS x NFCD	-0.020*	-0.019	-0.023**
(5^{th} percentile of NFCD)	(0.011)	(0.012)	(0.009)
KS+KS x NFCD	-0.017*	-0.017*	-0.016**
(25^{th} percentile of NFCD)	(0.009)	(0.009)	(0.007)
KS+KS x NFCD	-0.015*	-0.016*	-0.013*
(45^{th} percentile of NFCD)	(0.009)	(0.009)	(0.007)
KS+KS x NFCD	-0.014	-0.015	-0.011
(65^{th} percentile of NFCD)	(0.010)	(0.010)	(0.008)
KS+KS x NFCD	-0.013	-0.014	-0.008
(85^{th} percentile of NFCD)	(0.011)	(0.011)	(0.008)
N	201	191	132
Angrist-Pischke F-statistic	94.1, 40.2	86.7, 39.6	37.2, 40.7

N=201 in models (1)-(3). KS=Klein-Shambaugh regime classification (1=non-peg, 0=peg) for 1-year recovery period. NFCD=Initial net foreign currency debt. See Section 3.1.3 for definition of external debt measure. Coefficients for control variables not reported. ***, **, and * denote statistical significance at the 1, 5, and 10 percent levels respectively. Standard errors clustered by country shown in parentheses. The excluded instruments for models (1)-(3) are regime record and regime record x NFCD. Angrist-Pischke F-test null hypothesis is that instruments are weak. Angrist-Pischke F-statistics (a, b) are for (a) KS first stage; and (b) KS*NFCD first stage. Rule-of thumb critical value in F-test is 10. 2SLS estimator used throughout models (1)-(3).

growth difference between pegged and non-pegged systems remains statistically significant when NFCD is relatively low or when debt liability dollarization is sufficiently high. Although the absolute magnitude of the growth difference between regimes is smaller than with the full sample, it is still economically significant. Thus, the general nature of the relationship between exchange rate regime and recovery growth that was apparent in the full sample is also evident when the observations involving a switch in regime are removed.[11]

Despite this similarity, the changes in the point estimates on removing the switchers are somewhat revealing. Taken together the disparities between the point estimates for the full and reduced size sample give a hint that switching regimes during the recovery year had a more substantial effect on the recovery than leaving the regime unchanged. Moreover, the reduced sample results also allude to the balance sheet effects being larger under a switch since greater exchange rate flexibility is associated with significantly slower recovery growth at lower levels of foreign currency denominated external indebtedness when the switchers are included. That is, the results indicate that the adverse balance sheet effects stemming from increased exchange rate flexibility begin to significantly exceed the expenditure switching effects at higher levels of NFCD (or lower levels of debt liability dollarization) when the switchers are included. At the same time, the average annual increase (i.e. depreciation) in the exchange rate during the recovery year was 13 percent for the countries switching to a new non-peg and 6.5 percent for the countries whose non-peg was in place immediately before the recovery. Thus, the disparity between the post-recession experiences of the switchers and non-switchers relies on the magnitude of the balance sheet effects being more sensitive to exchange rate movements than the expenditure switching effects. Grounds for the differential sensitivities are not readily apparent. The relatively large exchange rate movements experienced by the regime switchers would have led to larger changes in net worth, and as a result, the likelihood of default by public and private entities would have been higher for those

[11] The expanded model specifications used in Table 3.8 were also applied to the sample with regime switchers omitted and the main inferences were unchanged

countries. In turn, the balance sheet effects would appear more severe for the switchers since the valuation effect is correlated with the likelihood or occurrence of default. However, none of the three sovereign debt crises in the sample occurred in the same year as a switch from a pegged to non-pegged regime, and consequently, the balance sheet effects stemming from the greater exchange rate movements experienced by the switchers did not lead to sovereign debt crises during the year of the switch. Alternatively, the larger balance sheet effects under a regime switch may have increased the probability of a debt crisis, and thus, although a debt crisis did not actually occur, the increased probability of one happening may have led to lower recovery growth under a non-pegged arrangement when a switch of exchange rate system took place. Testing this possibility appears infeasible within the econometric framework adopted here, and is thus left to future work.[12]

The estimations in Table 3.9 indicate that when describing the general relationship suggested by this study in quantitative terms, the debt threshold and growth difference based on the sample without the switchers should be used. Consequently, the growth difference between regimes achieves statistical significance (at the 10 percent level) when NFCD is at or below the 39th percentile (net foreign currency denominated debt equals -34 percent of GDP), and when debt liability dollarization is at or above the 28th percentile level (foreign currency denominated debt equals 62 percent of gross debt). At the same time, the growth difference between regimes when net foreign currency debt is at the 39th percentile is 1.1 percentage points, and when debt liability dollarization is at the 28th percentile the growth difference is also 1.1 percentage points.

The results of the sensitivity analysis described here strengthen the general inference that recovery growth under an exchange rate peg is superior to that under a non-pegged regime when external foreign currency denominated debt liabilities are relatively large.

[12] A paper by Razin and Rubinstein (2006), which considers how the probability of a currency crisis influences the relationship between a country's choice of exchange rate regime and economic growth, could be helpful in guiding future that seeks to understand how debt crisis probability affects recovery growth when a switch in exchange rate regimes takes place.

Table 3.9: Robustness: Removing the Regime Switchers

Dependent variable = 1-year (log) growth of real GDP per capita				
	(1)	(2)	(3)	(4)
KS	-0.012	-0.007	-0.029**	-0.021**
	(0.011)	(0.010)	(0.013)	(0.010)
KS x NFCD	0.009	0.012		
	(0.018)	(0.017)		
NFCD	-0.007	-0.007		
	(0.012)	(0.012)		
KS x DLD			-0.025**	-0.019*
			(0.011)	(0.010)
DLD			0.020***	0.016**
			(0.007)	(0.006)
Switchers included?	Yes	No	Yes	No
Estimated impact of Klein-Shambaugh classification over the distribution of NFCD or DLD				
KS+KS x NFCD or DLD1	-0.019*	-0.017*	0.0002	0.002
(5^{th} percentile of NFCD or DLD1)	(0.011)	(0.009)	(0.008)	(0.007)
KS+KS x NFCD or DLD1	-0.016*	-0.013*	-0.016*	-0.011
(25^{th} percentile of NFCD or DLD1)	(0.009)	(0.007)	(0.009)	(0.007)
KS+KS x NFCD or DLD1	-0.015*	-0.011	-0.022**	-0.015*
(45^{th} percentile of NFCD or DLD1)	(0.009)	(0.007)	(0.010)	(0.008)
KS+KS x NFCD or DLD1	-0.014	-0.009	-0.024**	-0.017**
(65^{th} percentile of NFCD or DLD1)	(0.009)	(0.008)	(0.011)	(0.009)
KS+KS x NFCD or DLD1	-0.012	-0.007	-0.027**	-0.019**
(85^{th} percentile of NFCD or DLD1)	(0.011)	(0.009)	(0.012)	(0.009)
N	201	160	201	160
Angrist-Pischke F-statistic	97.6, 40.5	113.5, 112.8	24.0, 213.7	98.0, 799.3

KS=Klein-Shambaugh regime classification (1=non-peg, 0=peg) for 1-year recovery period. NFCD=Initial net foreign currency debt. DLD1=Initial debt liability dollarization calculated using Lane-Shambaugh foreign currency factors. See Section 3.1.3 for definitions of external debt measures. The baseline set of controls is used throughout but the coefficients are not reported. ***, **, and * denote statistical significance at the 1, 5, and 10 percent levels respectively. Standard errors clustered by country shown in parentheses. The excluded instruments for models (1) and (2) are regime record and regime record x NFCD. The excluded instruments for models (3) and (4) are regime record and regime record x DLD1. Angrist-Pischke F-test null hypothesis is that instruments are weak. Angrist-Pischke F-statistics (a, b) are for (a) KS first stage; and (b) KS*NFCD or DLD1 first stage. Rule-of thumb critical value in F-test is 10. 2SLS estimator used throughout models (1)-(4).

3.3.5 Discussion

In sum, these results suggest the existence of an economically and statistically significant relationship between an exogenous component of exchange rate regime variation and recovery growth when external foreign currency denominated debt passes a threshold level. Beyond this threshold pegs appear to grow faster than non-pegs in the first two years of a recovery. What's more, the magnitude of this growth difference between regimes increases as NFCD decreases (or as debt liability dollarization increases). Such an outcome can be explained on the grounds that when external indebtedness passes the threshold level, the adverse balance sheet effects resulting from increased exchange rate flexibility begin to significantly exceed the beneficial expenditure switching effects. Consequently, pegs begin to outperform non-pegs at these relatively higher levels of indebtedness. As the debt measure moves further beyond the threshold, the balance sheet effects become larger and the growth difference between regimes expands.

This outcome can be rationalised using the model presented by Cook (2004), which suggests the adverse balance sheet effects stemming from an exchange rate depreciation exceed the beneficial expenditure switching effects when foreign currency debt is sufficiently large. As a result, a peg is more effective at absorbing a shock to world interest rates than a flexible regime under such configurations of the international balance sheet. This theoretical prediction is reasonably consistent with our results which indicate that increased exchange rate flexibility is associated with significantly slower recovery growth when net foreign currency debt exceeds a threshold level.

The general nature of the relationship is also consistent with the empirical work of Broda (2004) and Towbin and Weber (2011), which suggested that flexible exchange rate arrangements are less proficient shock absorbers when foreign currency denominated debt is relatively high. The remainder of the existing empirical literature suggested that increased exchange rate flexibility universally boosts recoveries and consequently, the results obtained here represent a challenge to these findings. The difference in results may simply reflect the choice in much of this earlier work to use an empirical strategy that did not consider the impact of increased exchange rate flexibility at specific foreign currency debt levels. Alternatively, the disparity could also be a symptom of differences in the model specification, time period being analysed and the exchange rate regime classification methodology being used. Similar conflicts are evident in the literature on the link between long-run growth and the choice of exchange rate regime, where changes in model specification, approach to regime coding and time period being studied often lead to diametrically opposing inferences regarding the impact of exchange rate flexibility.

Further investigation of this contradiction did not yield a clear explanation for the disparity between the results obtained here and those from earlier work. When the baseline specification for this study is re-estimated without the interaction term and with both the interaction term and foreign currency debt level removed, the results suggest an inverse and statistically significant relationship between the Klein-Shambaugh measure of exchange rate flexibility and 1-year recovery growth. Thus, the inclusion of the debt measure cannot explain the contradictory findings. Using the Levy-Yeyati and Sturzenegger (2005) exchange rate regime classification system in these narrowed specifications yields a positive but statistically and economically insignificant coefficient on the regime variable. Thus, while the use of an alternative regime coding scheme leads to different inferences being made, the outcome still does not bear clear similarities to the existing literature. That said, there is a mild hint that regime classification methodology may be responsible for part of the disparity between the results in this study and earlier work.

Finally, the absence of a significant positive association between increased exchange rate flexibility and recovery growth at positive or relatively low levels of net foreign currency debt in this study is somewhat puzzling. It could be the case that the expenditure switching effect is not statistically significant. If this were the case, it would contradict a large portion of the existing empirical work on the link between exchange rate flexibility and economic recoveries.

3.3.6 Total Assets and Total Liabilities

Table 3.10 shows the estimates for the 1-year horizon using the net foreign currency assets and total liability dollarization measures of the international balance sheet.[13] The observations involving a switch in exchange rate regime during the recovery year have been excluded. The estimates suggest that the growth difference between pegged and non-pegged regimes does not exhibit a statistically significant link with either total liability dollarization or net foreign currency assets at the 1-year horizon. The growth difference between regimes may not depend on these broader balance sheet metrics due to the fact that substantial proportions of total liabilities and total assets are comprised of financial derivative, FX reserves, equity and FDI positions. On average these other components of the international balance sheet comprise 47 percent of total assets and 27 percent of total liabilities for the sample studied here. The role that balance sheet components other than debt play in the relationship between exchange rate flexibility and growth may be different to the role played by debt and, as a result, the weakened results observed under net foreign currency assets may be a symptom of this divergence. That is, if the FDI and equity positions led to balance sheet effects of the same nature as debt then the results for net foreign currency assets would be more similar to the estimations with debt.

The control variables for the models displayed in Table 3.10 were of the expected sign and sometimes statistically significant. Moreover, the diagnostic testing and estimation of a multi-instrument version of the model supported the validity of the IV estimations.

[13]The 2- and 3-year results under net foreign currency assets are not used as it appears as though they may be highly sensitive to the addition of a very small number of observations. A small number of observations are omitted from all the 2- and 3-year estimations since the 2- and 3-year averaged exchange rate regime variables are not available for them. These observations are included in the normal 1-year sample as they do possess the 1-year regime. If the 1-year estimations with net foreign currency assets are re-run with these observations omitted then the main relationship of interest is statistically significant whereas the inclusion of the observations yields an association that is statistically insignificant. Consequently, there would be very good reason to doubt the validity of any inferences based on the 2- and 3-year net foreign currency assets estimations using the reduced sized sample and for that reason they are not included in this paper. Our estimations using the debt portion of the balance sheet do not exhibit such material changes when the reduced multiyear sample size is used.

Table 3.10: Exchange Rate Flexibility, Total Balance Sheet and 1-year Recovery Growth

Dependent variable = 1-year (log) growth of real GDP per capita		
	(1)	(2)
KS	-0.010	-0.015
	(0.007)	(0.013)
KS x NFCA	0.005	
	(0.018)	
NFCA	-0.005	
	(0.015)	
KS x TLD		-0.004
		(0.010)
TLD		0.009
		(0.007)
Estimated impact of Klein-Shambaugh classification over the distribution of NFCA or TLD		
KS+KS x NFCA or TLD	-0.013	-0.008
(5th percentile of NFCA or TLD)	(0.012)	(0.008)
KS+KS x NFCA or TLD	-0.011	-0.010
(25th percentile of NFCA or TLD)	(0.008)	(0.007)
KS+KS x NFCA or TLD	-0.011	-0.012
(45th percentile of NFCA or TLD)	(0.007)	(0.007)
KS+KS x NFCA or TLD	-0.010	-0.012
(65th percentile of NFCA or TLD)	(0.007)	(0.008)
KS+KS x NFCA or TLD	-0.009	-0.013
(85th percentile of NFCA or TLD)	(0.008)	(0.010)
N	160	160
Angrist-Pischke F-stat	167.2, 13.9	65.1, 243.6

N=160 in models (1)-(2). Observations involving a change in the exchange rate regime during the recovery year are excluded. KS=Klein-Shambaugh regime classification (1=non-peg, 0=peg) for 1-year recovery period. NFCA=Initial net foreign currency assets. TLD=Initial total liability dollarization calculated using Lane-Shambaugh foreign currency factors. See Section 3.1.3 for definitions of balance sheet measures. The baseline set of controls is used throughout but the coefficients are not reported. ***, **, and * denote statistical significance at the 1, 5, and 10 percent levels respectively. Standard errors clustered by country shown in parentheses. The excluded instruments for model (1) is regime record and regime record x NFCA. The excluded instruments for model (2) is regime record and regime record x TLD. Angrist-Pischke F-test null hypothesis is that instruments are weak. Angrist-Pischke F-statistics (a, b) are for (a) KS first stage; and (b) KS*NFCA or KS*TLD first stage. Rule-of thumb critical value in F-test is 10. 2SLS estimator used throughout models (1)-(2).

The presence of a significant relationship when focusing on foreign currency denominated debt combined with the absence of a significant association under the broader balance sheet measures suggests that foreign currency debt exposure is the most relevant balance sheet metric when considering the impact of a given exchange rate regime on growth during a recovery.

3.4 Conclusion

This study examined the relationship between exchange rate flexibility and growth during economic recoveries. Much attention was given to the role of foreign currency denominated borrowing in this relationship due to the emphasis placed on balance sheet effects in the theoretical literature. Both OLS and two-stage least squares estimation techniques were employed in this endeavour. The IV estimation took advantage of variation in the exchange rate regime emanating from differences in the history of pre-recovery exchange rate regime choices. The use of this exogenous variation addressed the potential reverse causality and measurement error problems originating with the gauge of exchange rate flexibility.

The results highlight a circumstance in which exogenous variation in the exchange rate regime matters for the speed of economic recoveries. Specifically, recovery growth with an exchange rate peg appeared to be significantly higher than under a non-pegged regime when foreign currency denominated debt is relatively large. Moreover, this growth disparity was both economically and statistically significant. The general relationship was apparent with both estimators but the link between the main variables of interest was stronger in both economic and statistical terms when using two-stage least squares. The validity of the IV estimations is supported by the results of thorough diagnostic testing, while the robustness of main relationship of interest was confirmed by subjecting the estimations to changes in the set of conditioning variables and the use of alternative measures of foreign currency denominated debt. In addition, the general relationship was weakened though not to a point of statistical or economic insignificance upon removing the observations involving a change in exchange rate regime during the first recovery year. Taken together, these results challenge much of the existing empirical work on the subject at hand.

The results of this study can be justified on the grounds that when foreign currency borrowing is sufficiently high, the balance sheet effects resulting from exchange rate movements begin to significantly outweigh expenditure switching effects and in turn, a peg will be associated with a faster recovery than a non-pegged arrangement. Although the theoretical literature offers this rationalisation of the main finding of this study, the field would benefit if future empirical work involved a more detailed investigation of the adjustment mechanism through which the balance sheet and expenditure switching effects stemming from exchange rate movements ultimately impact economic recoveries.

3.5 References

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3.6 Appendix A: List of 55 Countries

High Income	Upper Middle Income	Lower Middle Income
Australia	Algeria	Bolivia
Austria	Argentina	Egypt
Belgium	Brazil	El Salvador
Canada	Chile	Guatemala
Czech Republic	Colombia	India
Denmark	Dominican Republic	Indonesia
Finland	Lithuania	Jordan
France	Malaysia	Moldova
Germany	Mexico	Morocco
Greece	Peru	Nicaragua
Hungary	South Africa	Pakistan
Iceland	Uruguay	Papua New Guinea
Ireland	Venezuela, Rep. Bol.	Philippines
Israel		Thailand
Italy		Tunisia
Japan		
Korea, Republic of		
Netherlands		
New Zealand		
Norway		
Portugal		
Singapore		
Slovak Republic		
Spain		
Sweden		
Trinidad and Tobago		
United Kingdom		

Income levels based on World Bank grouping scheme.

3.7 Appendix B: Definitions and Sources of Variables

Variable	Description	Source
Real GDP per capita	PPP converted GDP per capita (chain series) at 2005 constant prices	Penn World Tables 7.0
GDP (current USD)	GDP measured in current US Dollars	World Bank WDI
Nominal exchange rate	Official bilateral exchange rate	IMF IFS
Klein-Shambaugh	Exchange Rate Regime Classification. =1 if non-peg and =0 if peg.	Author's own calculations using IFS data
Debt liabilities	Portfolio debt securities and other investment	Lane and Milesi-Feretti (2007)
Debt assets	Portfolio debt securities and other investment	Lane and Milesi-Feretti (2007)
Total assets	FDI assets+portfolio equity assets+debt assets+derivatives assets+FX reserves	Lane and Milesi-Feretti (2007)
Total liabilities	FDI liabilities+portfolio equity liabilities+debt liabilities+derivatives liabilities	Lane and Milesi-Feretti (2007)
(log) change in government consumption	(log) Change in general government final consumption expenditure as a percentage of GDP	World Bank WDI
Currency crisis dummy	=1 if currency crisis occurs in a given year, 0 otherwise	Laeven and Valencia (2008)
Banking crisis dummy	=1 if banking crisis occurred during recession preceding recovery, 0 otherwise	Laeven and Valencia (2008)
Lagged change in the real interest rate	change in the real interest rate over the final year of the precding recession. Real interest rate equals lending interest rate adjusted for inflation as measured by the GDP deflator.	World Bank WDI

Variable	Description	Source
Recession amplitude	(log) change in real GDP per capita during recession preceding recovery.	Authors's own calculations use PWT data
Change in political regime index	Change in Polity2 regime index over the five years precding the recovery. Polity2 index ranges from -10 (strongly autocratic) to +10 (strongly democratic).	Polity IV database. Centre for Systemic Peace
Trade openness	Exports plus imports as a proportion of GDP (measured in current prices)	Penn World Tables 7.0
Capital account openness	Index measuring presence of multiple exchange rates, restrictions on current and capital account transactions, and the requirement to surrender export proceeds	Chinn and Ito (2006)
Inflation	Annual percentage change in the CPI. For countries with no CPI data available, GDP deflator was used.	IMF IFS
(log) change in global world exports	(log) change in global world merchandise exports (in current US Dollars) over the recovery	World Bank WDI
(log) change in terms of trade	(log) Change in the terms of trade over the recovery. Terms of trade measured using Exports as a capacity to import: the current price value of exports of goods and services deflated by the import price index	World Bank WDI

IMF IFS data was obtained from the Economic and Social Data Service (ESDS).

3.8 Appendix C: Descriptive Statistics

	Mean	Median	St dev	Max	Min
(log) change in government expenditure/GDP	0.012	0.019	0.084	0.362	-0.322
Capital account openness	0.443	0.404	0.343	1	0
Trade openness	66.291	55.007	45.217	369.416	7.180
1-year (log) change in the terms of trade	0.071	0.070	0.111	0.602	-0.372
2-year (log) change in the terms of trade	0.140	0.137	0.146	0.713	-0.424
3-year (log) change in the terms of trade	0.194	0.193	0.190	0.850	-0.507
1-year (log) change in global world exports	0.096	0.091	0.090	0.379	-0.075
2-year (log) change in global world exports	0.201	0.203	0.162	0.708	0.101
3-year (log) change in global world exports	0.285	0.287	0.192	0.877	-0.117
Currency crisis dummy	0.010	0.000	0.100	1	0
Banking crisis during recession	0.124	0.000	0.331	1	0
Change in political regime index	0.550	0	3.064	14.000	-15.000
Change in real interest rate	-0.063	10.254	-0.191	52.200	-41.678
Recession amplitude	0.049	0.024	0.062	0.360	0.0002

N=201 for all variables other than real interest rate where N=132.