Uncertainty Betas and International Capital Flows

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Preliminary and Incomplete

Abstract

Motivated by the idea that capital flights are driven by investors' perceptions of a country's riskiness, this paper studies empirically and theoretically the response of capital flows to increases in uncertainty. We propose a novel measure of country riskiness, the uncertainty beta, which is obtained by regressing on a rolling window the realized volatility of a country's stock market return on the world stock market volatility. This measure captures differential exposures to global uncertainty shocks, which is relevant from the point of view of a diversified world investor. We show that shocks to global uncertainty reduce capital inflows in and increase outflows from the countries with the highest uncertainty betas. Moreover, investment, and GDP fall significantly more in these countries. These differences across countries are statistically significant in a large panel of 35 countries over the last 40 years. We illustrate our findings in a tractable macroeconomic model of global capital flows characterized by time-varying uncertainty in investment returns.

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1 Introduction

International capital inflows and outflows among advanced economies increased dramatically in the last 25 years, from around four times the gross domestic product (GDP) of those economies in 1980 to around 20 times their GDP in 2007. Emerging economies experienced a similar increase, albeit starting from lower levels. But in 2008, at a time of great global uncertainty, international capital inflows and outflows among advanced economies collapsed: they were equal to only a fraction of their GDP that year. Such high levels and large volatilities of international capital flows suggest that they play a major role in macroeconomic dynamics. International flows also appear to be driven by the behavior of large, diversified investors who allocate their capital according to risk-based models. It seems natural then to try and understand how the variation of perceived risk leads to capital flows.

In this paper, we study both empirically and theoretically the response of international capital flows to global uncertainty shocks. A recent and growing literature reports that uncertainty shocks affect aggregate consumption, investment, GDP, trade, as well as equity, bond, and currency returns. We add to this literature by uncovering a new empirical determinant of international capital flows — which characterizes the riskiness of a country — and by providing a simple model to interpret it.

Specifically, we propose and construct a novel measure of country riskiness, the volatility beta, which is obtained by regressing on a rolling window the realized volatility of a country's stock market return (calculated using daily data) on the world stock market volatility. This measure captures differential exposures to global uncertainty shocks, which is relevant from the point of view of a diversified world investor. We show that shocks to global uncertainty reduce dramatically capital inflows and outflows in the countries with the highest volatility beta. These differences across countries are statistically significant in a large panel of 35 countries over the last 40 years.

A natural question is what is the ultimate source of volatility betas. In preliminary results, we find that volatility betas are related measures that have been used to forecast the risk of a crisis in a country: debt to GDP ratios, measures of capital account and trade openness, as well as a

measure of democratic accountability, a component of political uncertainty. But these variables do not exhaust all the information contained in uncertainty betas: they actually only account for small fraction of the cross-country differences in uncertainty betas. Uncertainty betas therefore offer novel insights on international capital flows.

In our dataset, we find that past uncertainty betas predict the impact of future uncertainty shocks. When global volatility increases, countries with high past uncertainty betas tend to experience larger decreases in capital inflows and larger increases in capital outflows than countries with low past uncertainty betas. Because uncertainty betas are estimated over rolling windows that do not encompass each global uncertainty shock under study, there is no mechanical look-ahead bias in our results. Uncertainty betas are informative about how countries respond to global shocks, most likely because stock market prices are forward-looking.

The same global uncertainty shocks affect macroeconomic variables: consistent with the literature on the impact of uncertainty, when aggregate volatility increases, consumption, investment, GDP, industrial production, employment, tend to fall. But here again, clear differences across countries appear. We find that all these variables tend to fall more in high uncertainty beta countries, and significantly so for investment and GDP.

In order to establish these results empirically, we pursue two methods: we estimate country-specific VARs and panel regressions. Our VARs are similar to those in Bloom (2009); they contain three variables, a macroeconomic variable, a measure of global volatility, and market returns. The VARs are estimated on monthly and quarterly macroeconomic variables at the country level. Results are reported for each country and for two aggregates of low and high uncertainty betas. Net inflows decrease in response to a global volatility shock, reaching their minimum after two quarters, while net outflows increase at a similar speed in response to a similar shock. The capital flows tend to respond more strongly in high uncertainty beta countries than in low beta ones.

The panel regressions confirm the previous findings: macroeconomic variables tend to respond to global volatility shocks, and more so in high beta countries. Net exports tend to increase significantly when aggregate volatility increases. The result is robust to the inclusion of country

fixed effects and different control variables (e.g. lagged GDP, lagged net exports, stock market returns). Using quarterly measures of net outflows from the balance of payments confirm the results obtained on net exports. Net inflows (outflows) tend to decrease (increase): the results are significant on net outflows, net inflows, as well as portfolio flows and other flows, which are also the most volatile components. Consistent with the literature, consumption, investment and GDP tend to fall significantly when global volatility increases.

The differences across countries appear significant in the panel regressions: high uncertainty beta countries tend to experience larger falls in capital inflows and large increases in capital outflows than low uncertainty beta countries. Again, the panel controls for country fixed effects and lagged variables. Likewise, consumption, investment, and GDP fall more in the same set of high uncertainty beta countries.

To investigate the cause of these cross-country differences and their potential macroeconomic impact, we study a simple international portfolio model. In our model, in each country, output is produced using capital with a common linear technology. But countries differ in their abilities to produce new capital: the law of motion of the capital stock is affected by country-specific capital quality shocks as in Gertler and Kiyotaki (2010). Investment returns are stochastic, and their volatilities exhibit both country-specific and global components. Investors and hand-to-mouth workers populate the world. In each country, a fraction of workers and investors reside and consume. World investors allocate capital across countries according to their perception of risk and capital is reallocated across countries without friction each period. The model abstracts from capital adjustment costs and therefore can be solved relatively easily, without the cross-country distribution of capital becomes as a state variable. The model interprets global uncertainty shocks as increases in the volatility of the investment quality. As in the data, an increase in global uncertainty leads to a decrease in investment and GDP, as well as capital flights out of the most exposed countries.

Our paper is related to different strands of the literature, on closed as well as on open economies. Focusing on closed economies, a recent literature investigates the impact of uncertainty shocks,

following the seminal work of Bloom (2009). Bloom (2013) presents an exhaustive review of the literature on economic uncertainty.[1] Bekaert, Hoerova and Lo Duca (2013) decompose the stock market option-based implied volatility index (VIX) into a proxy for risk aversion and economic uncertainty. They argue that lax monetary policy decreases both uncertainty as well as a risk aversion. Segal, Shaliastovich, and Yaron (2014) decompose uncertainty into "good" and "bad" uncertainty. They argue that "good" uncertainty increases economic activity while "bad" uncertainty predicts lower economic growth. Kelly, Lustig, and van Nieuwerburgh (2013) develop a network model of firm volatility that can generate the observed firm level volatility distribution dynamics in the data. Christiano, Rostagno and Motto (2010) add a financial markets and a banking sector to a standard monetary DSGE model. Shocks to uncertainty generate significant reductions in output. Gabaix (2012) and Gourio (2012) offer potential alternative interpretations of uncertainty shocks in terms of shocks to disaster probabilities.

Focusing on open economies, a recent literature shows that gross outflows and inflows are more informative than net flows (see Lane and Milesi-Ferretti, 2007, Obstfeld, 2012a, 2012b, Forbes and Warnock, 2012, Rey, 2013, and Broner et al., 2013). Notably, Rey (2013) shows that gross outflow and inflows are highly correlated across countries, while net flows are not. Broner et al. (2013) analyze the behavior of gross capital flows over the business cycle and during financial crises. To their work, we had a key, ex ante source of heterogeneity across countries, i.e., their exposure to global uncertainty shocks. Such exposure is relevant for understanding capital flights, and our empirical work therefore builds naturally on the sudden stop literature, notably contributions by Edwards (2002, 2004), Calvo, Izquierdo and Talvi (2006a, 2006b), and Ahmed and Zlate (2012). Our sample encompasses all the sudden stop episodes identified in this literature over the last 30

[1] In Bloom (2009) and Bloom, Floetotto, Jaimovich, Saporta-Eksten and Terry (2012), the combination of economic uncertainty with real adjustment costs induce firms to behave cautiously, implying a drop in economic activity. Gilchrist, Sim and Zakrajsek (2009) provide evidence that increases in uncertainty lead to prolonged declines in investment activity due to increases in financing costs. Arellano, Bai and Kehoe (2012) argue that an increase in risk leads firms to reduce their inputs as financial frictions limit firms' ability to insure against such shocks. Schaal (2012) study uncertainty shocks in a search and matching model of employment, applied notably to the financial crisis of 2007-2009. Bachmann, Elstner and Sims (2010) show that the impact of uncertainty shock is more persistent in the United States than in Germany. Fernández-Villaverde, Guerrón-Quintana, Rubio-Ramirez and Uribe (2011) report that increases in the volatility of real interest rates of small open economics lead to a decline in economic activity. Baker and Bloom (2013) argue that uncertainty shock can account for about half the variation in economic growth.

years. Our uncertainty betas offer an additional country characteristic to assess the likelihood of a sudden stop. Our empirical work extends Gourio, Siemer and Verdelhan (2013) and Carrière-Swallow and Céspedes (2013) by considering the impact of global volatility shocks on capital flows. Our model is simpler than state-of-the-art dynamic stochastic general equilibrium model of international portfolio allocations, notably Gourinchas, Rey, and Govillot (2010), Colacito and Croce (2012), Tille and van Wincoop (2012), Devereux and Sutherland (2012), Bahmra, Coeurdacier, and Guibaud (2013), as well as Coeurdacier, Rey, and Winant (2011, 2013). But the model offers a tractable framework to interpret our empirical results without facing the curse of dimensionality.

The rest of the paper is organized as follows. Section 2 introduces our dataset and uncertainty betas. Section 3 reports the response of capital flows and other macroeconomic variables to global volatility shocks, through VAR and panel tests. Section 4 presents our model. Section 5 concludes.

2 Uncertainty Betas

This section describes the dataset and the construction of uncertainty betas.

2.1 Data

Our dataset includes the following countries: Argentina, Australia, Austria, Belgium, Brazil, Chile, Chine, Colombia, Cyprus, Czech Republic, Finland, France, Germany, Hungary, India, Ireland, Italy, Japan, Malaysia, Mexico, Netherland, New Zealand, Norway, Peru, Philippines, Portugal, Singapore, South Africa, South Korea, Spain, Switzerland, Thailand, Turkey, United Kingdom, and United States. The sample extends at most from January 1970 to April 2011 but some series start later than others. We briefly describe the data sources, starting with the macroeconomic variables before turning to asset prices.

Macroeconomic Data Import, export, international reserves, industrial production, consumer prices, and unemployment series are from the International Monetary Fund's (IMF) International Financial Statistics (IFS). The series are monthly. Daily price indices are obtained by linear in-

terpolation of monthly price indices. Consumption, investment, and GDP are also from the IFS database; those series are quarterly. Capital flows are measured at the monthly and quarterly frequencies. Net international capital flows are usually approximated at the monthly frequency by the amount of net exports. At the quarterly frequency, the financial accounts of the balance of payments offer a more precise description of international capital flows, distinguishing between foreign direct investment, portfolio flows, and the remainder, denoted "other flows." Both monthly and quarterly measures of capital flows are scaled by GDP and lead to similar findings. International capital flows are compiled by Bluedorn, Duttagupta, Guajardo and Topalova (2013) from the IMF balances of payments.[2] gross outflows and gross inflows are actually net items following standard balance of payments accounting. Gross inflows are defined as net sales of domestic financial instruments to foreign residents. Gross outflows are defined as net purchases of foreign financial instruments by domestic residents. Net capital flows are defined as the difference between gross outflows and gross inflows.[3] The series are quarterly, over the 1980–2011 sample. All series are de-seasonalized using the X-12-Arima seasonal adjustment procedure.

The share of short term debt in total debt and the share of manufacturing are obtained from the World Development Indicator (WDI) database of the World Bank. The share of debt in foreign currency is obtained from Lane and Milesi-Ferretti (2001). The index of financial openness, built on the IMF annual reports, is obtained from Chinn and Ito (2006).

Financial Data Nominal exchange rates, expressed in foreign currency per US dollar, and nominal short term interest rates are also from the IFS database. We use Treasury bill rates whenever available, and money market rates otherwise. Real interest rates are obtained as the nominal interest rates minus expected inflation rates, measured as the last 12-month differences in log consumer

[2]The data set is built from balance of payments statistics (version 5), supplemented with other IMF and country sources. The data set does not include the Euro area, but includes its members. It does not report outflows and inflows related to the changes in reserves, but only the net flows. For this reason, they are not included in the subsequent analysis.

[3]By convention, positive outflows mean that residents are selling more assets than they are buying, contributing positively to net inflows, while positive inflows means that foreigners are purchasing more than they are selling, contributing positively to net inflows. Up to accounting errors, net inflows are then the sum of gross outflows and gross inflows.

price indices.

Daily stock market indices, denoted R^m, are from the Morgan Stanley Country Indices (MSCI), Datastream, and Global Financial Data (GFD) stock market databases. Long time series of aggregate daily stock returns Argentina, Brazil, Chile, Colombia, Ecuador, Indonesia, Malaysia, Mexico, Morocco, Nigeria, Peru, Russia, South Africa, South Korea, Thailand, Turkey and Uruguay are from the GFD database.

2.2 Exposure to Global Volatility

Stock market indices deliver a simple measure of each country-specific exposure to global volatility, i.e. the uncertainty betas.

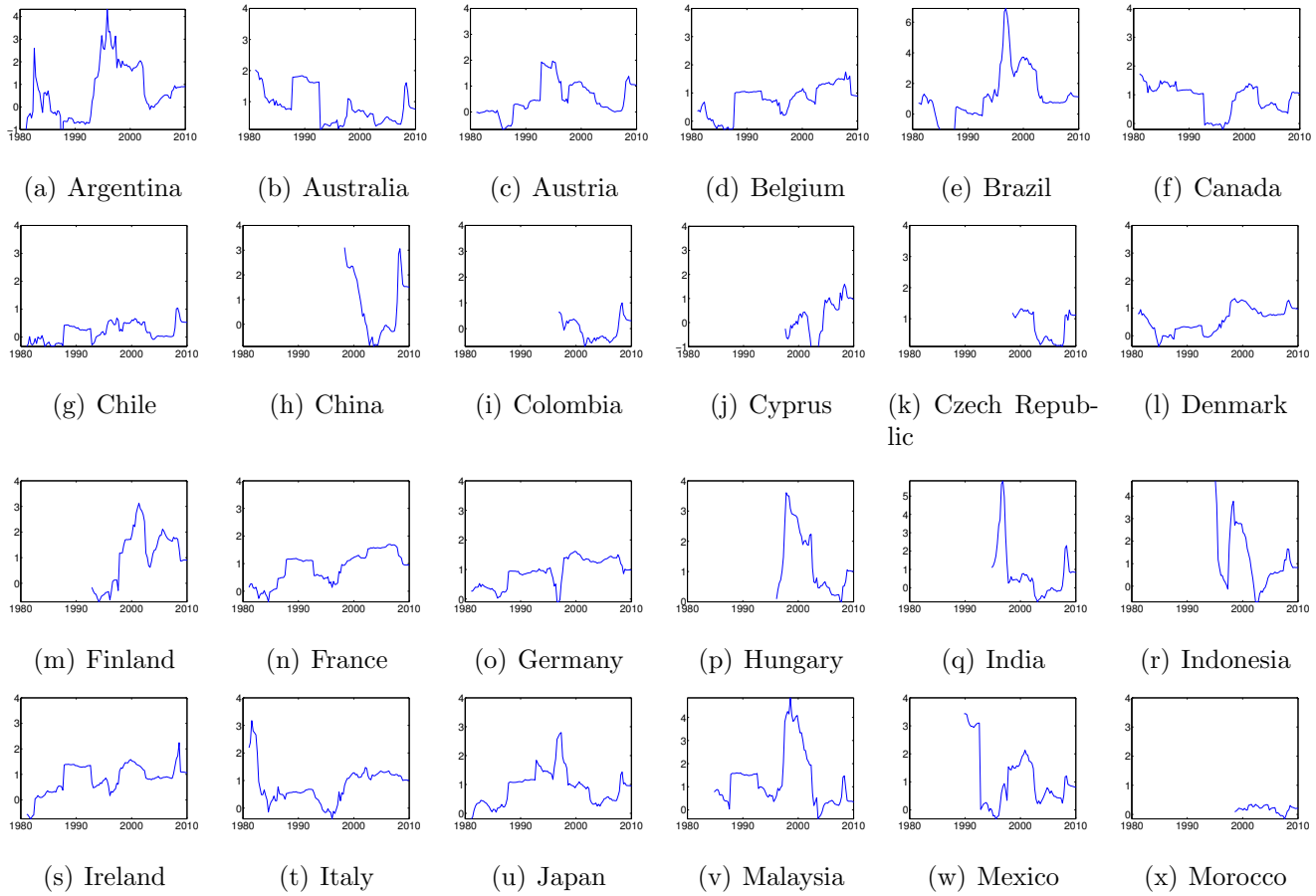
Country Betas Country-level volatilities are obtained at the monthly and quarterly frequencies as the standard deviations of daily real stock market returns over one month or one quarter. Likewise, a measure of aggregate volatility is obtained from the MSCI world stock market index. For each country i, uncertainty betas are then obtained by regressing that country i's stock market volatility on the world stock market volatility:

$$\sigma_t^i = \alpha^i + \beta^i \sigma_t^{World} + \epsilon_t^i.$$

The uncertainty betas, denoted β_t^i, are obtained on rolling window regressions of 20 quarters at the quarterly frequency and 36 months at the monthly frequency. The subscript t on β_t^i indicates that it is obtained on a time window that ends at date t, e.g. from period $t-20$ to t.

Figures 1 and 2 show that uncertainty betas vary significantly across countries and over time. For example, spikes in uncertainty betas for Argentina tend to coincide with the sudden stops of 1980-1982 and 1998–2002. Uncertainty betas for Thailand decline in the late 1990s and early 2000s, a period which coincides with the first constitution to be drafted by a popularly elected assembly in 1997 and open, corruption-free elections in 2001. By comparison, uncertainty betas for the United States appear lower and smoother than for Argentina and Thailand. Our paper, however, does not

provide country-specific event studies for each large variation of uncertainty betas. Instead, we first study the link between uncertainty betas and usual measures of economic and political stability and then turn to the impact of global volatility shocks on international capital flows, conditioning on the level of the uncertainty betas.



(a) Argentina (b) Australia (c) Austria (d) Belgium (e) Brazil (f) Canada

(g) Chile (h) China (i) Colombia (j) Cyprus (k) Czech Republic (l) Denmark

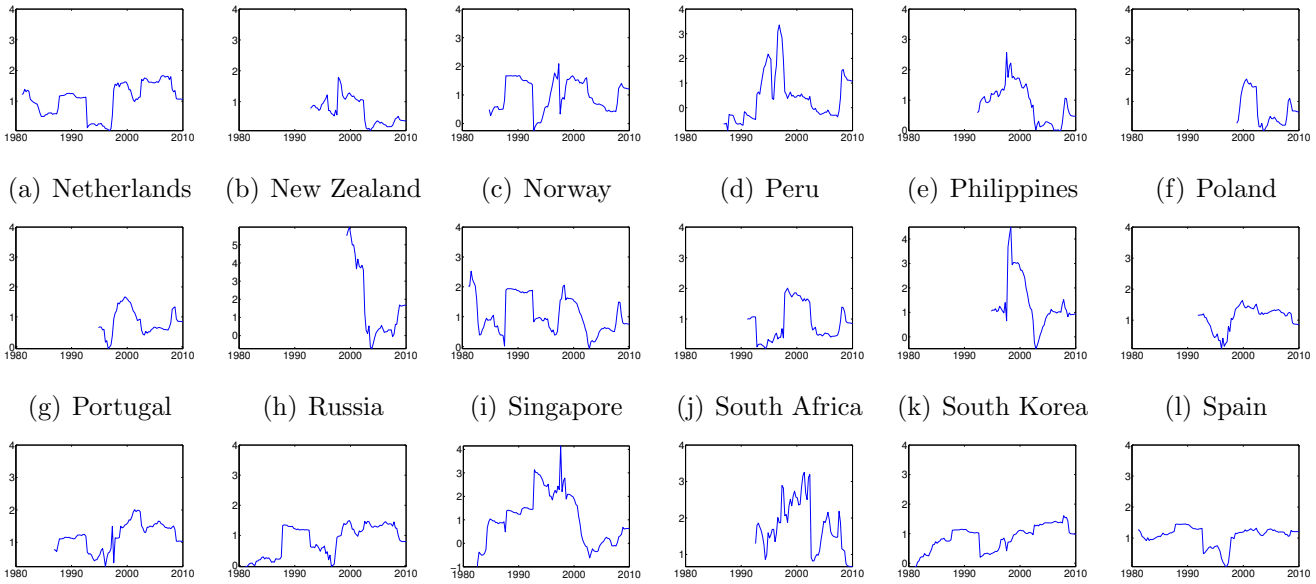
(m) Finland (n) France (o) Germany (p) Hungary (q) India (r) Indonesia

(s) Ireland (t) Italy (u) Japan (v) Malaysia (w) Mexico (x) Morocco

Figure 1: Uncertainty Betas — Country-level volatilities are obtained at the quarterly frequency as the standard deviations of daily real stock market returns over one quarter. Likewise, a measure of aggregate volatility is obtained from the MSCI world stock market index. For each country i, uncertainty betas are then obtained by regressing that country i's stock market volatility on the world stock market volatility. The uncertainty betas, denoted β_t^i, are obtained on rolling window regressions of 20 quarters. The subscript t on β_t^i indicates that it is obtained on a time window that ends at date t, e.g. from period $t-20$ to t.

2.3 Uncertainty Betas and Economic and Political Risk

The uncertainty betas presented in the previous section offer high-frequency measures of exposures to global risk. Such uncertainty betas appear related to the usual measures of economic and political risk in the literature but are not subsumed by them.



(a) Netherlands (b) New Zealand (c) Norway (d) Peru (e) Philippines (f) Poland

(g) Portugal (h) Russia (i) Singapore (j) South Africa (k) South Korea (l) Spain

(m) Sweden (n) Switzerland (o) Thailand (p) Turkey (q) United Kingdom (r) United States

Figure 2: Uncertainty Betas, Cont. — Country-level volatilities are obtained at the quarterly frequency as the standard deviations of daily real stock market returns over one quarter. Likewise, a measure of aggregate volatility is obtained from the MSCI world stock market index. For each country i, uncertainty betas are then obtained by regressing that country i's stock market volatility on the world stock market volatility. The uncertainty betas, denoted β_t^i, are obtained on rolling window regressions of 20 quarters. The subscript t on β_t^i indicates that it is obtained on a time window that ends at date t, e.g. from period $t-20$ to t.

We test the link between uncertainty betas and some measures of economic and political uncertainty in panel regressions. Table 1 reports results from the following panel tests:

$$\beta_t^i = \delta^i + \tau^i X_t^i + \varepsilon_t^i,$$

where β_t^i denotes country i's uncertainty betas and X_t^i is a measure of economic or political risk. Panel I reports results obtained with country fixed effects (δ^i), while Panel II reports results obtained without country fixed effects ($\delta^i = 0$). Economic and political risk are measured by the share of short term debt in total debt (column 1), the ratio of debt to GDP (column 2), a measure of democratic accountability (column 3), trade openness of the country as measured by the sum of exports and imports relative to GDP (column 4), and capital openness, as measured by the Chinn-Ito (2006) index of IMF annual reports on cross-border financial transactions (column 5). All explanatory variables are annual and normalized to have zero mean and variance one. The number of observations in each test because of data availability; for each variable all countries in the sample with available data are included.

Increases in debt to GDP ratios, trade openness, and capital account openness all increase significantly the exposure to global market volatility. A larger share of short term debt, potentially creating roll-over risk, tends to increase the exposure of a country to a global shock but the effect is not significant. With openness comes risk: when economies become more open, their uncertainty betas increase. Higher debt levels, which may be associated with higher default risk, also increase uncertainty betas. In case of a global slowdown, more in-debt economies may be less able to adjust their fiscal policy to smooth out consumption. Democratic accountability decreases uncertainty betas, suggesting that the ability of the political system to respond to a crisis matters. Such interpretations are only tentative as the causality may run in the opposite direction: for example, low uncertainty betas and a low exposure to global volatility shocks may favor a more stable and democratic political system. The correlations between uncertainty betas and measures of economic and political uncertainty do not imply causality.

Those measures of economic and political uncertainty, however, explain little of the cross-

Table 1: Uncertainty Betas and Economic and Political Risk Factors

	(1)	(2)	(3)	(4)	(5)
			Panel I: With Country Fixed Effects		
Short-term debt	0.08				
	(0.12)				
Debt to GDP		0.13***			
		(0.05)			
Democratic accountability			-0.25***		
			(0.08)		
Trade openness				0.35**	
				(0.14)	
Capital openness					0.24***
					(0.06)
Observations	326	461	719	960	931
R-squared	0.13	0.29	0.18	0.16	0.17
			Panel II: Without Country Fixed Effects		
Short-term debt	0.108				
	(0.072)				
Debt to GDP		0.022			
		(0.029)			
Democratic accountability			-0.048		
			(0.046)		
Trade openness				0.058*	
				(0.031)	
Capital openness					0.139***
					(0.043)
Observations	326	461	719	960	931
R-squared	0.006	0.001	0.002	0.003	0.017

Notes: This table reports results from the following panel regressions:

$$\beta_t^i = \delta^i + \tau^i X_t^i + \varepsilon_t^i,$$

where β_t^i denotes country i's uncertainty betas and X_t^i is a measure of economic or political risk. Panel I reports results obtained with country fixed effects (δ^i), while Panel II reports results obtained without country fixed effects ($\delta^i = 0$). Economic and political risk are measured by tthe share of short term debt in total debt (column 1), the ratio of debt to GDP (column 2), a measure of democratic accountability (column 3), trade openness of the country as measured by the sum of exports and imports relative to GDP (column 4), and capital openness, as measured by the Chinn-Ito (2006) index of IMF annual reports on cross-border financial transactions (column 5). All explanatory variables are annual and normalized to have zero mean and variance one. The number of observations in each test because of data availability; for each variable all countries in the sample with available data are included. Robust standard errors are reported in parentheses. Three stars (***) denote significance at the 1% confidence level, while two stars (**) and one (*) star denote significance at the 5% and 10% confidence levels.

country differences in uncertainty betas. Without country fixed effects, the R^2s of the panel regressions are all less than 2%. The uncertainty betas therefore bring additional information. We now use this information to study the response of capital flows to global shocks.

3 The Response of Capital Flows to Global Volatility Shocks

This section first reports the impulse response functions to global volatility shocks and then results from panel regressions. Global volatility shocks tend to decrease international capital inflows and increase capital outflows, and more so in high uncertainty beta countries than in low uncertainty beta ones.

3.1 Impulse Response Functions

Impulse response functions are obtained from one-lag VARs that include each country's macroeconomic time series (denoted x), each country's stock market return, and global stock market volatility:

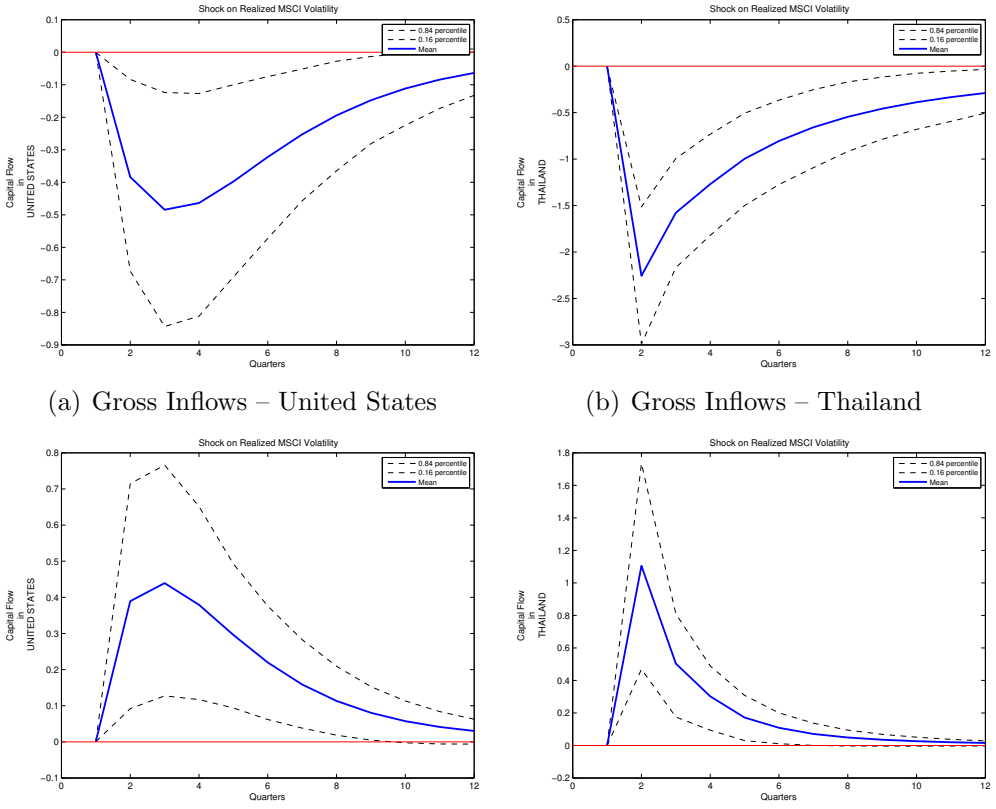
$$\mathbf{Y}_t = \mathbf{c} + \mathbf{A}_1 \mathbf{Y}_{t-1} + \mathbf{e}_t$$

where $\mathbf{Y}_t = [x_t \quad R_t^m \quad \sigma_t^{World}]$. In the main text, the macroeconomic series correspond to the current account, net inflows, gross outflows and gross inflows. All are expressed in percentage of GDP. The Appendix provides additional impulse response functions for other macroeconomic time series like consumption, investment, and GDP; these are expressed in four-quarter log differences to account for their seasonality. VARs are estimated at the country level for countries with at least 15 years of data. The standard errors on impulse response functions are obtained by bootstrapping 1000 times the VAR residuals. Country-specific responses presents 68% confidence level intervals as typically reported in the VAR literature (see, e.g., Caldara and Kamps, 2008).

Structural shocks are obtained through a simple Cholesky decomposition. The order of the variables in the VAR therefore matters: since volatility series appear after market returns, the estimation focuses on a volatility shock that is orthogonal to market returns. Macroeconomic

quantities are allowed to immediately respond to an increase in global stock market volatility.

Figure 3 reports an example of such impulse response functions: the countries are the U.S. (left panel) and Thailand (right panel). In both countries, inflows tend to decrease following a shock on global volatility, while outflows tend to increase. The response of inflows and outflows appear less pronounced in the U.S. than in Thailand, which belongs to the group of high-beta countries more frequently than the U.S. Additional impulse response functions are presented in the Appendix. A similar finding emerges: both current account and net inflows in Thailand show a larger response to an increase in global stock market volatility relative to the United States. This finding is not specific to those two countries: capital flows react differently in low vs high uncertainty beta countries.



(a) Gross Inflows – United States

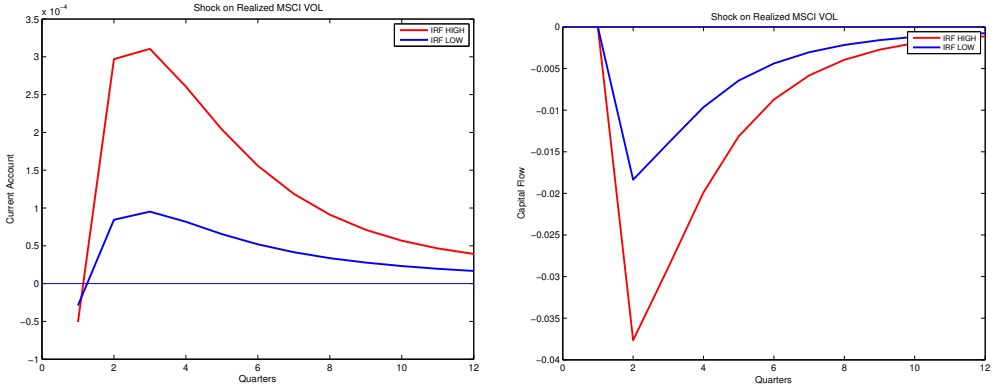
(b) Gross Inflows – Thailand

(c) Gross Outflows – United States

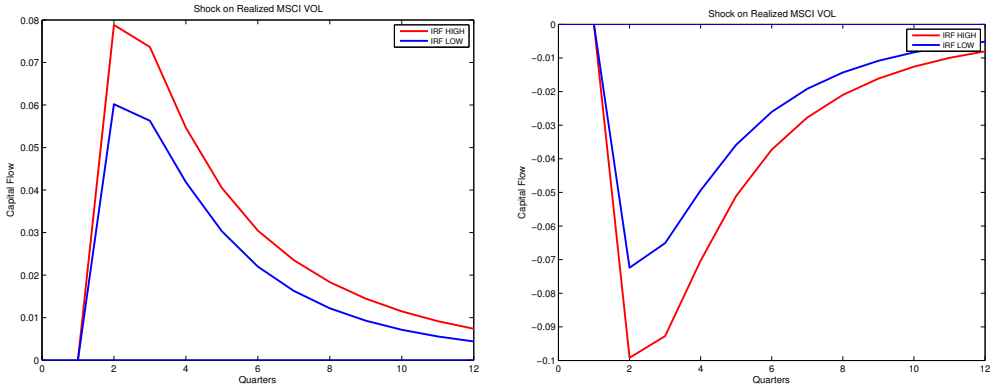
(d) Gross Outflows – Thailand

Figure 3: Impulse Response of Gross Inflows and Outflows in the U.S. and in Thailand — This figure reports an example of impulse response functions. The countries are the U.S. (left panel) and Thailand (right panel). The one-lag VARs include U.S. or Thailand gross outflows (or inflows), U.S. or Thailand's stock market return, and global stock market volatility. Structural shocks are obtained through a simple Cholesky decomposition. The standard errors on impulse response functions are obtained by bootstrapping 1000 times the VAR residuals. Country-specific responses presents 68% confidence level intervals.

In order to summarize the results, Figure 4 reports the average impulse response functions of high vs low uncertainty beta countries. Here again, inflows tend to decrease following a shock on global volatility, while outflows tend to increase. As a result, capital tends to move out of a country in response to a global volatility shock. In a sample that includes all countries and without measurement errors, current account increases in some countries are exactly offset by current account decreases in other countries. This is not true in our dataset which includes only a limited number of countries. A clear difference appears between high and low uncertainty beta countries. Capital flows in high beta countries react more strongly than those in low beta countries. We turn now to panel regressions to show that these differences are statistically significant.



(a) Current Account as % of GDP (b) Net Inflows



(c) Gross Outflows (d) Gross Inflows

Figure 4: Impulse Response of Gross Inflows and Outflows in High- vs. Low-Beta Countries — This figure reports the impulse response functions of the current account (where an increase corresponds to capital flights), net inflows, gross outflows and gross inflows. The figure reports the average impulse response functions of high vs low uncertainty beta countries. In each country, the one-lag VARs include each country's macroeconomic time series, each country's stock market return, and global stock market volatility. Structural shocks are obtained through a simple Cholesky decomposition.

3.2 Panel Regressions with Interaction Effects

To complement the evidence presented in the previous section, we now use quarterly panel regressions with interaction effects to study the differential effect of global volatility shocks on capital flows and real economic activity. Our results demonstrate that high uncertainty beta countries are affected more by shocks to global volatility.[4]

In all that follows, we measure global volatility using the annualized stock return volatility of the MSCI index, calculated using daily data within the quarter. We measure the country riskiness as the uncertainty beta, defined in section 2. By construction the uncertainty beta is predetermined to the global volatility.[5]

Capital Flows As a first step, we study the effect of a global volatility shock on gross capital outflows and inflows in Table 2. Our estimated equation is:

$$Y_t^i = \alpha + \tau^i Y_{t-1}^i + \gamma \sigma_t^w + \zeta X_{t-1}^i + \kappa \beta_{t-1}^i + \psi \sigma_{t-1}^w \beta_{t-1}^i + \varepsilon_t^i,$$

where Y denotes capital outflows, inflows or their subcomponents and X are additional control variables. The table reports the coefficients γ, κ and ψ. Here the key coefficient of interest if ψ, which measures whether countries with higher betas have more pronounced capital outflows when global volatility rises. The variables X are controls (the lagged real stock market return of the country as well as two lags of GDP growth), which are largely irrelevant for the results (as is the inclusion of country fixed-effects).

The main result is that the interaction effect is negative for inflows: hence, countries that have high betas will have more negative inflows when global volatility rises. This is intuitive and

[4]The appendix provides an extensive, complementary empirical analysis of the effect of shocks to country-level ("local") volatility, and documents that net exports (and net capital outflow) rise, while both gross inflow and outflow fall, and economic activity contracts, when local volatility rises. We also used monthly data and found that the results were very similar.

[5]To recap, the uncertainty beta is the regression coefficient of a country's volatility on the world volatility, using the past 20 quarters of data, where volatility is calculated within each quarter using daily data. Rather than using the simple volatility, we experimented with the construction of a global volatility "shock" as the residual of global volatility on its lags and lags of stock returns and economic activity. This has little impact on our results, and hence we use the simplest measure of volatility.

corresponds to foreigners pulling their capital out of the most risky countries in times of crises. This coefficient is driven by private capital flows (so official transactions are not important for this result) and in particular by the category "other inflows".

On the other hand, the interaction coefficient on outflows is positive: when global volatility rises, domestic residents of higher beta countries sell more foreign assets. One potential interpretation is that residents are led to liquidate foreign assets as asset prices and exchange rates movements reduce their wealth. Another potential interpretation is that domestic residents decide to move their wealth holdings home (perhaps because of legal or political constraints). These two effects on inflows and outflows work in opposite directions, leading as we will see to a rather indeterminate aggregate effect.

Finally, we consider the effect of an increase in global volatility on net capital inflows, measured either using the trade balance or capital flows data (including the subcomponents).[6] By definition, an increase in global volatility cannot increase (or decrease) net capital inflows in all countries. But high uncertainty betas could have outflows while low uncertainty betas have inflows when global volatility rises. Table 9 in the Appendix presents the results. The interaction effects are positive for the trade measure: a higher beta implies that an increase in global volatility leads to larger net outflows. But the results are of the opposite sign when using capital flow data (since net exports are the opposite of net inflows). Moreover, these effects are not statistically significant. Hence, at this stage we must conclude that the heterogeneous are extremely strong on gross inflows and gross outflows but cancel out for net inflows.

Real Economic Activity We next study the heterogeneous effects of global volatility on real economic activity. The basic specification is similar to the previous subsection:

$$\Delta^4 M_t^i = \alpha + \tau^i \Delta^4 M_{t-1}^i + \gamma \sigma_t^w + \zeta X_{t-1}^i + \kappa \beta_{t-1}^i + \psi \sigma_{t-1}^w \beta_{t-1}^i + \varepsilon_t^i,$$

[6]The trade balance measure does not correspond exactly to the inverse of net capital inflows for a variety of reasons. First, we only measure goods trade and not service trade. Second, the income of foreign factors of production and unilateral transfers are obviously missing. Last, the current account and the financial account do not match perfectly. In our data, the correlation between the two series is -0.62.

Table 2: Gross Capital Flows and Volatility Shocks: Differences Across Uncertainty Betas

	Capital Flows (1)	Private Capital Flows (2)	FDI Flows (3)	Other Flows (4)	Portfolio Flows (5)
			Panel I: Inflows		
γ	3.65	4.92	-1.49	-4.96	5.07**
	(6.02)	(6.38)	(1.64)	(4.99)	(2.49)
κ	1.68*	1.37	-0.16	1.98**	-0.35
	(0.90)	(0.89)	(0.19)	(0.87)	(0.33)
ψ	-15.09**	-12.64*	1.16	-14.65**	2.70
	(6.89)	(6.83)	(1.50)	(6.42)	(2.38)
Observations	3,406	3,362	3,361	3,385	3,351
R-squared	0.53	0.50	0.23	0.20	0.55
			Panel II: Outflows		
γ	-5.94	-7.56	2.51*	1.83	-4.79**
	(6.05)	(6.01)	(1.50)	(4.91)	(2.51)
κ	-1.99**	-2.59**	0.10	-2.52***	0.16
	(0.93)	(0.98)	(0.23)	(0.75)	(0.27)
ψ	16.73**	17.44**	-1.20	16.06***	-1.14
	(7.07)	(7.37)	(1.69)	(5.65)	(2.58)
Observations	3,399	3,346	3,240	3,335	3,255
R-squared	0.54	0.56	0.20	0.19	0.54

Notes: This table reports results from the following panel regressions:

$$Y_t^i = \alpha + \tau^i Y_{t-1}^i + \gamma \sigma_t^w + \zeta X_{t-1}^i + \kappa \beta_{t-1}^i + \psi \sigma_{t-1}^w \beta_{t-1}^i + \varepsilon_t^i,$$

where Y^i denotes gross capital flows in country i, or their subcomponents, and X^i are additional control variables. Panel I focuses on capital inflows while Panel II focuses on capital outflows. The table reports the coefficients γ, κ and ψ. Column (1) provides the results for gross capital flows, column (2) for gross private capital flows, column (3) for gross foreign direct investment flows, column (4) for gross other flows, and column (5) for gross portfolio investment flows. All explanatory variables are quarterly. The number of observations varies in each regression because of data availability; for each variable all countries in the sample with available data are included. Robust standard errors are reported in parentheses. Three stars (***) denote significance at the 1% confidence level, while two stars (**) and one (*) star denote significance at the 5% and 10% confidence levels.

Table 3: Macro Quantities and Volatility Shocks: Differences Across Uncertainty Betas

	GDP	Investment	Consumption	Industrial Prod.	Unemployment
	(1)	(2)	(3)	(4)	(5)
γ	-1.31	-4.54	-1.76	-10.43**	-15.60**
	(1.70)	(3.18)	(1.61)	(5.18)	(6.05)
κ	0.31	0.70*	0.05	0.51	0.55
	(0.26)	(0.39)	(0.18)	(0.38)	(0.83)
ψ	-2.83**	-8.59***	-0.63	-3.87	-4.78
	(1.28)	(2.78)	(1.47)	(3.27)	(6.79)
Observations	3,598	2,900	2,995	2,505	2,093
R-squared	0.73	0.72	0.76	0.70	0.80

Notes: This table reports the results from the following panel regressions:

$$\Delta^4 M_t^i = \alpha + \tau^i \Delta^4 M_{t-1}^i + \gamma \sigma_t^w + \zeta X_{t-1}^i + \kappa \beta_{t-1}^i + \psi \sigma_{t-1}^w \beta_{t-1}^i + \varepsilon_t^i,$$

where M denotes various macroeconomic quantities and X are additional control variables. The table reports the coefficients γ, κ and ψ. Column (1) provides the results for GDP, column (2) for gross fixed capital formation, column (3) for consumption, column (4) for industrial production and column (5) for the unemployment rate. All explanatory variables are quarterly. The number of observations varies in each regression because of data availability; for each variable all countries in the sample with available data are included. Robust standard errors are reported in parentheses. Three stars (***) denote significance at the 1% confidence level, while two stars (**) and one (*) star denote significance at the 5% and 10% confidence levels.

where M denotes different macro quantities such as GDP. $\Delta^4 = 1 - L^4$ in lag operator notation, is the fourth-quarter difference. Besides GDP, we also consider the effect on investment (gross fixed capital formation, GFCF, which includes residential investment for most countries), as well as consumption, industrial production and (with a flipped sign) the unemployment rate.[7] We see that ψ is always negative, so that higher global volatility leads to larger declines in economic activity where the betas are largest. However, the coefficient is statistically significant only for GDP and investment.

[7]Note that the reaction to country-specific ("local") uncertainty shocks is studied in appendix (see Table 8)) and is consistent with the uncertainty-shock literature.

4 A Simple Model of Capital Flows with Time-Varying Uncertainty

This section introduces a tractable model used to discuss the evidence uncovered in the previous section. Our model studies the effect of exogenous changes in the riskiness of different countries on capital allocation and real economic activity.[8] Specifically, we consider N countries that produce the same good using linear ("AK") technologies. Capital is reallocated without frictions each period. A world investor allocates capital across countries according to his perception of risk.

We first present the model setup, then we discuss how the model can be solved. Last, we discuss some possible extensions.

4.1 Model Setup

Technology In each country $i = 1...N$, output is produced using capital with a *common* linear technology:

$$Y_{it} = A_t K_{it}.$$

Here $\{A_t\}$ is an exogenous stochastic process for productivity. While the assumption of a common productivity is obviously a stark simplification, it allows a clearer exposition of the mechanism, and we believe it has limited effects on our results.

Critically, the technology to produce new capital differs across countries:

$$K_{i,t+1} = e^{\xi_{i,t+1}} \left(K_{i,t}(1-\delta) + I_{i,t} \right),$$

where $\{\xi_{i,t+1}\}$ is an exogenous stochastic process affecting the return to capital, to be discussed below. The investment decision is taken at time t, before the shocks $\xi_{i,t+1}$ are observed. These "capital quality" shocks have been recently used in many papers as a simple way to capture the riskiness of investment and generate significant wealth shocks (see e.g. Gertler and Kiyotaki (2010),

[8] Perhaps the closest antecedent to our framework is Obstfeld (1994), but that paper abstracts from time-varying volatility and focuses on welfare rather than the real economic outcomes.

Gourio (2012)). While our framework abstracts from any capital adjustment cost, it is conceptually easy to incorporate them. The main cost is computational: the cross-country distribution of capital becomes a state variable.

Workers and Investors To keep the model tractable and clear, we focus on the problem of a representative "world investor". This world investor is meant to represent wealthy households and institutions (such as sovereign funds, pension plans, hedge funds, ...) that are large enough to be diversified and have access to international markets. The world investor has Epstein-Zin preferences:

$$V_t = \left((1-\beta)C_t^{1-\gamma} + \beta E_t\left[V_{t+1}^{1-\theta}\right]^{\frac{1-\gamma}{1-\theta}}\right)^{\frac{1}{1-\gamma}},$$

where C_t denotes the world investor consumption, θ is risk aversion, and γ is the inverse of intertemporal substitution. This investor is assumed to have no outside income: he lives off its capital only.[9] We assume that there is a measure one of investors across the world, and a fraction $\pi_i \in [0,1]$ of investors reside in country i. (This is relevant for the construction of capital flows in our model economy.)

For realism, we also incorporate hand-to-mouth workers. These workers receive an income $Y_{it}^W = \phi_i Y_{it} = \phi_i A_t K_{it}$ each period and consume it.[10] Hence, total consumption in country i is the sum of the consumption of the investors and the workers:

$$C_{it} = \pi_i C_t + C_{it}^W = \pi_i C_t + \phi_i A_t K_{it}.$$

Workers' preferences are irrelevant for equilibrium determination.

[9] Since there is only one good in this economy, there is perfect risk-sharing across investors living in different regions and hence perfect aggregation.

[10] Since our technology is capital-only, we need to explain which factors of production generate this income. The simplest assumption is that workers operate a technology that is linear in labor, with externalities produced by the capital: $Y_{it}^W = \psi A_t K_{it} N_{it}$. In equilibrium, $N_{it} = N_i$ and $\phi = \psi N_i$.

Shock structure Our key assumption regards the stochastic process for investment returns. We will assume that for $i = 1...N$:

$$\xi_{it+1} = \mu_{M,i} + \mu_{I,i} v^I_{it+1} + \mu_{A,i} e^{\sigma_t} v^A_{t+1},$$

where v^I_{it+1} is an idiosyncratic shock and v^A_{t+1} is an aggregate shock. These shocks are normally distributed with mean 0, and independent over time and of each other. This specification allows countries to differ in (i) their mean return on capital $(\mu_{M,i})$, (ii) the amount of idiosyncratic risk $\mu_{I,i}$, (iii) their "beta" with respect to the world shock, $\mu_{A,i}$.

The world volatility σ_t it itself stochastic, so that

$$\sigma_{t+1} = (1 - \rho_\sigma)\overline{\sigma} + \rho_\sigma \sigma_t + \sigma_w w^A_{t+1},$$

where w^A_{t+1} is i.i.d. $N(0, 1)$.

Finally, we assume that A_t follows a simple AR(1) process in log:

$$\log(A_t) = \rho \log(A_{t-1}) + \sigma_u u^A_t,$$

where u^A_t is *i.i.d.* and $N(0, 1)$.[11] Finally, note that a sufficient statistic for the current state of this exogenous system is (A_t, σ_t).

Resource constraint and accounting The world is subject only to an aggregate resource constraint:

$$\sum_{i=1}^{N} C_{it} + I_{it} = \sum_{i=1}^{N} Y_{it} + Y^W_{it},$$

which can be rewritten as

$$C_t + \sum_{i=1}^{N} I_{it} = \sum_{i=1}^{N} Y_{it},$$

since $\sum_{i=1}^{N} \pi_i = 1$. Only world investors' decisions affect this resource constraint.

[11] A simple extension is to allow for some correlation between u^A_t, v^A_t and w^A_t.

Net exports of country i are defined as

$$NX_{it} = Y_{it} - \pi_i C_t - I_{it},$$

so that $\sum_{i=1}^{N} NX_{it} = 0$.

4.2 Equilibrium Equations

The representative investor determines the allocation of capital across countries and hence production. Suppose we start the period with $(K_1, ..., K_N)$ as capital allocation and (A, σ) as exogenous shocks. Then world output is simply $\sum_{i=1}^{N} A_t K_{it} = A_t K_t$ where we denote world aggregate capital by K_t. Since capital can be perfectly reallocated this period, the origin of the capital is irrelevant, which shows that the distribution of capital stocks is not a state variable. Rather, the state vector is simply (K, A, σ).

We can then write the Bellman equation of the world investor problem as:

$$\begin{aligned}
V(K, A, \sigma) &= \max_{C, I_1, ..., I_N} \left\{ (1-\beta) C^{1-\gamma} + \beta \mathbb{E}\left[V(K', A', \sigma')^{1-\theta} \right]^{\frac{1-\gamma}{1-\theta}} \right\}^{\frac{1}{1-\gamma}}, \\
s.t. &: \\
K' &= \sum_{i=1}^{N} K_i' = \sum_{i=1}^{N} \left((1-\delta) K_i + I_i \right) e^{\xi_i'}, \\
C &= AK - \sum_{i=1}^{N} I_i.
\end{aligned}$$

We can rewrite this by introducing the fictitious capital stocks $J_i = (1-\delta) K_i + I_i$:

$$\begin{aligned}
V(K, A, \sigma) &= \max_{C, J_1, ..., J_N} \left\{ (1-\beta) C^{1-\gamma} + \beta \mathbb{E}\left[V(K', A', \sigma')^{1-\theta} \right]^{\frac{1-\gamma}{1-\theta}} \right\}^{\frac{1}{1-\gamma}}, \\
s.t. &: \\
K' &= \sum_{i=1}^{N} K_i' = \sum_{i=1}^{N} J_i e^{\xi_i'}, \\
C &= \left(A + 1 - \delta \right) K - \sum_{i=1}^{N} J_i.
\end{aligned}$$

Note that this problem is formally equivalent to a standard portfolio choice problem. We can further simplify by noting that the value function is homogeneous of degree one in K :

$$V(K, A, \sigma) = Kg(A, \sigma),$$

where, with $c = C/K$ and $j_i = J_i/K$:

$$\begin{aligned} g(A,\sigma) &= \max_{c,j_1,...,j_N} \left\{ (1-\beta)c^{1-\gamma} + \beta \mathbb{E}\left[\left(\frac{K'}{K} \right)^{1-\theta} g(A',\sigma')^{1-\theta} \right]^{\frac{1-\gamma}{1-\theta}} \right\}^{\frac{1}{1-\gamma}}, \\ s.t. &: \\ \frac{K'}{K} &= \sum_{i=1}^{N} j_i e^{\xi_i'}, \\ c &= (A+1-\delta) - \sum_{i=1}^{N} j_i. \end{aligned}$$

Denote with $\omega_i = j_i/(A+1-\delta-c)$ the share of wealth (ex-current consumption) invested in country i. Then we have

$$\begin{aligned} g(A,\sigma) &= \max_{c,\omega_1,...,\omega_N} \left\{ (1-\beta)c^{1-\gamma} + \beta(A+1-\delta-c)^{1-\gamma} \mathbb{E}\left[\left(\sum_{i=1}^{N} \omega_i e^{\xi_i'} \right)^{1-\theta} g(A',\sigma')^{1-\theta} \right]^{\frac{1-\gamma}{1-\theta}} \right\}^{\frac{1}{1-\gamma}}, \\ s.t. &: \sum_{i=1}^{N} \omega_i = 1. \end{aligned}$$

The first-order condition with respect to c yields:

$$(1-\beta)c^{-\gamma} = \beta(A+1-\delta-c)^{-\gamma} \mathbb{E}\left[\left(\sum_{i=1}^{N} \omega_i e^{\xi_i'} \right)^{1-\theta} g(A',\sigma')^{1-\theta} \right]^{\frac{1-\gamma}{1-\theta}},$$

and the first-order condition with respect to ω_i yields, for $i = 1...N$:

$$(1-\theta)\beta(A+1-\delta-c)^{-\gamma} \mathbb{E}\left[e^{\xi_i'} \left(\sum_{i=1}^{N} \omega_i e^{\xi_i'} \right)^{-\theta} g(A',\sigma')^{1-\theta} \right] = \chi(A,\sigma),$$

where $\chi(A, \sigma)$ is the multiplier on the constraint $\sum_{i=1}^{N} \omega_i = 1$. Note that

$$R_p(\omega) = \sum_{i=1}^{N} \omega_i e^{\xi_i'}$$

is the analogous to the "portfolio return" of the world investor. This system of equations can be solved numerically using policy function iteration to obtain the policy rules $c(A, \sigma), \omega_i(A, \sigma)$ jointly with the value function $g(A, \sigma)$.[12]

While we have not solved this model yet, we conjecture that an increase in σ would leads to a lower capital stock allocated to countries with high "betas" $\mu_{A,i}$ and hence to lower real investment in these countries. Ceteris paribus, this would lead to lower output in these countries the next period. There would also be a reduction in total world production as investors shift towards lower-mean return and lower risk countries.

Special cases Under some assumptions, this model can be further simplified. First, if the elasticity of intertemporal substitution is unity, then consumption depends only on the current value of A, since the wealth and substitution effect of returns offset perfectly. Second, if A is constant, utility is CRRA ($\theta = \gamma$) and if ξ' are i.i.d. (e.g. because σ is constant), then the optimal portfolio is constant.[13] Third, if A is constant, utility is log, and the ξ' are independent over time (but not identically distributed), then the portfolio depends simply on σ and can be solved in approximate closed form.

Extensions One simple extension is to make the risk aversion of the representative investor stochastic. Higher risk aversion would then be reflected in higher global volatility and would be the driver of our global volatility shock. It is also fairly straightforward conceptually to change the model to a more standard (neoclassical) macroeconomic setup, by introducing Cobb-Douglas production functions, elastic labor supply, and capital adjustment costs. The cost of this is that the

[12] Alternatively, the model can be solved using value function iteration.

[13] If the returns are further normally distributed and we go to continuous time, we get the standard solution ($\omega = \Sigma^{-1} \frac{E(R)}{\gamma}$).

distribution of capital stocks is a state variable, making the computation of equilibria significantly more complicated, but if N is small this can be solved accurately. Another natural extension is to introduce different goods across countries and home bias (as in Heathcote and Perri (2014)).

A more ambitious extension is to introduce portfolio constraints so as to relate more directly to the evidence on gross outflows vs. inflows. A natural starting point would be to assume that domestic agents must hold the capital stock, but can raise debt finance from foreigners. Another important issue is whether the world investor is itself constrained in its leverage.

5 Conclusion

This paper documents that economic uncertainty has a significant impact on international capital flows for a large set of countries. We show that an increase in economic uncertainty increases gross capital outflows and decreases gross capital inflows. The effect on international capital flows is stronger for countries that have a higher exposure to global stock market volatility. Intuitively this means that investors move their funds out of the riskier countries. The heterogenous effect on international capital flows is particularly strong for gross capital inflows and gross capital outflows but only weak for net capital inflows. We then develop a simple model in which a world investor has to optimally allocate resources across countries. The model is able to generate the heterogeneous effect of uncertainty on net capital flows.

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- Supplementary Online Appendix -

NOT FOR PUBLICATION

This appendix presents robustness checks and extensions of the empirical results reported in the paper.

Appendix A Additional Impulse Response Functions

Figure 6 reports impulse response functions of the current account and net capital inflows (both relative to GDP) in the United States and Thailand to a global volatility shock.

Appendix B Country-specific volatility, capital flows, and economic activity

In this section, we study the effect of country-specific volatility on both net and gross capital flows using our quarterly panel data set.[14] We next verify that our data are consistent with the large literature documenting a negative effect of uncertainty on real economic activity.

Appendix B.1 Country-specific volatility and net capital flows

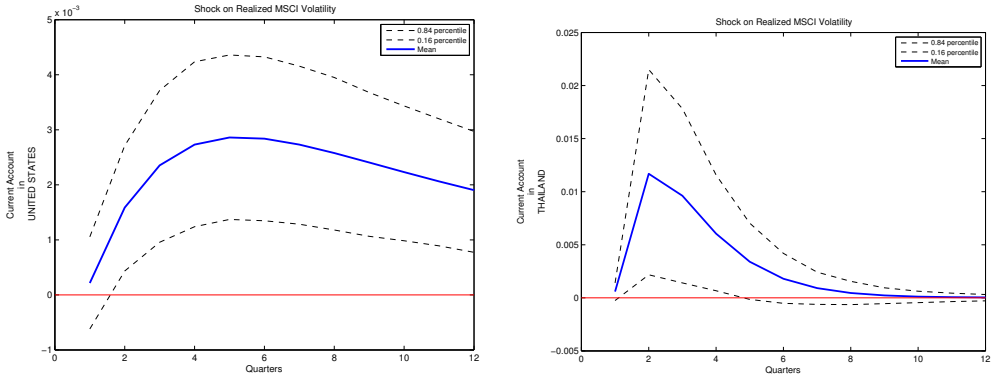
Our measure of volatility is the annualized stock market daily volatility, calculated using daily data within the quarter.[15] We start by studying the trade balance, then turn to net capital inflow (and its broad subcomponents), before going on to gross capital outflows and inflows (and their broad subcomponents). Table 4 presents estimates of the coefficient c from the equation:

$$NX_t^i = \delta^i + \tau^i NX_{t-1}^i + \gamma\sigma_t^w + \zeta X_{t-1}^i + \varepsilon_t^i, \qquad \text{(Appendix B.1)}$$

[14] We also used monthly data for our empirical work, and found that the results were very similar.

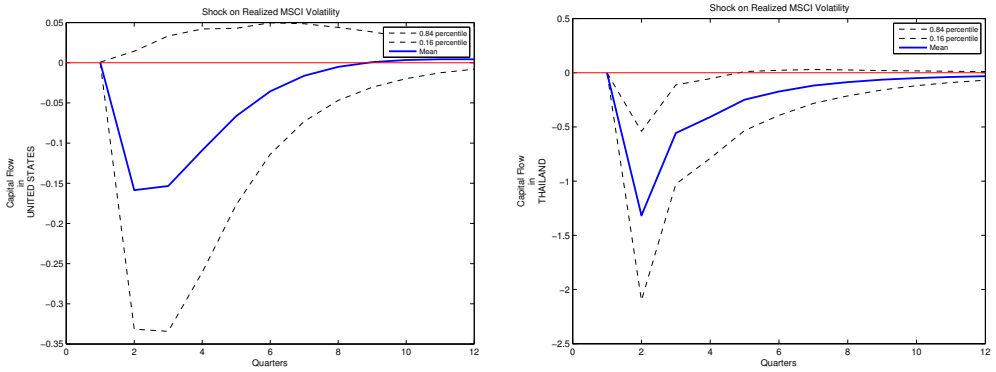
[15] We also experimented with the construction of a volatility "shock", calculated as the residual of volatility on its lags and lags of stock returns and economic activity. This has little impact on our results, and hence we use the simplest measure of volatility.

Figure 5: **VAR Impulse Response – Examples**



(a) Current Account in % of GDP – United States

(b) Current Account in % of GDP – Thailand



(c) Net Inflows – United States

(d) Net Inflows – Thailand

Figure 6: Impulse Response of Gross Inflows and Outflows in the U.S. and in Thailand — This figure reports an example of impulse response functions. The countries are the U.S. (left panel) and Thailand (right panel). The one-lag VARs include U.S. or Thailand gross outflows (or inflows), U.S. or Thailand's stock market return, and global stock market volatility. Structural shocks are obtained through a simple Cholesky decomposition. The standard errors on impulse response functions are obtained by bootstrapping 1000 times the VAR residuals. Country-specific responses presents 68% confidence level intervals.

where NX is the ratio of net exports of goods to GDP. The table reports four versions of this equations, which depend on the set of control X (which is either empty, or includes the lagged real stock market return of the country as well as two lags of GDP growth and an additional lag of NX), and on whether we include country fixed-effects or not. Regardless of the specification, the coefficient c is positive and statistically significant. Since the standard deviation of volatility is about 0.14, a one standard deviation increase in volatility makes NX go up by about 0.4% of GDP, which is economically important. Moreover, during crises, volatility tends to increase by several standard deviations (about 3 during the Fall of 2008 for instance). The natural interpretation of this results is that capital pulls out of the country when it

appears to become more risky. An alternative (not contradictory) interpretation is that the economic contraction leads to reduced demand for imported inputs as well as capital and consumption goods.

Table 4: Net Exports and Volatility

	(1) NXGDP	(2) NXGDP	(3) NXGDP	(4) NXGDP
Volatility	3.43***	2.96**	3.46**	3.32**
	(1.24)	(1.36)	(1.38)	(1.61)
Observations	3,569	3,473	3,569	3,473
R-squared	0.62	0.66	0.67	0.69
Country FE	n	n	y	y
Controls	n	y	n	y
Own Lag	y	y	y	y

Notes: This table reports results from the following panel regressions:

$$NX_t^i = \delta^i + \tau^i NX_{t-1}^i + \gamma\sigma_t^w + \zeta X_{t-1}^i + \varepsilon_t^i,$$

where NX denotes net exports, or it's subcomponents and X are additional control variables. The tables report the coefficient γ. Column 1 includes only the own lag but no fixed effect or controls. Column 2 in addition includes controls. Column 3 includes country fixed effects and own lag but no controls and column 4 includes fixed effects, controls and own lag. All explanatory variables are quarterly. The number of observations varies in each regression because of data availability; for each variable all countries in the sample with available data are included. Robust standard errors are reported in parentheses. Three stars (***) denote significance at the 1% confidence level, while two stars (**) and one (*) star denote significance at the 5% and 10% confidence levels.

Table **??** provides results when we estimate this equation over different subsamples, where we split by country. We find that while these results are true for all countries, the effect is weaker for developed economies and stronger for emerging markets and commodity-producing countries.

Our trade balance measure does not correspond exactly to the inverse of capital inflows for a variety of reasons.[16] In our data, the correlation between the two series is -0.62. Table 5 presents estimates of a similar equation,

$$Y_t^i = \delta^i + \tau^i Y_{t-1}^i + \gamma\sigma_t^w + \zeta X_{t-1}^i + \varepsilon_t^i, \qquad \text{(Appendix B.2)}$$

[16]First, we only measure goods trade and not service trade. Second, the income of foreign factors of production and unilateral transfers are obviously missing. Last, the current account and the financial account do not match perfectly.

where Y denotes net capital inflows, scaled by GDP, and the variables and controls are the same as in the previous table. We obtain a significant negative coefficient, which mirrors the positive coefficient of table 4, though it is somewhat smaller. Moreover, when we estimate this equation separately for the three broad categories of net inflows (FDI, Portfolio and Other), we obtain that portfolio and other flows are the categories that drive the coefficient. Indeed, FDI may react positively to an increase in volatility.

Table 5: Net Capital Inflow and Volatility

	(1) NetInflow	(2) NetInflow	(3) NetFDI	(4) NetFDI	(5) NetOther	(6) NetOther	(7) NetPortfolio	(8) NetPortfolio
Volatility	-1.35*	-2.39*	1.36**	0.28	-2.50**	-2.50	-0.57	-1.63
	(0.77)	(1.29)	(0.55)	(0.70)	(0.90)	(1.29)	(0.79)	(1.14)
Observations	3,241	3,255	3,733	3,733	3,738	3,738	3,599	3,599
R-squared	0.49	0.50	0.26	0.31	0.08	0.11	0.08	0.11
Country FE	n	y	n	y	n	y	n	y
Controls	y	y	y	y	y	y	y	y
Own Lag	y	y	y	y	y	y	y	y

Notes: This table reports results from the following panel regressions:

$$Y_t^i = \delta^i + \tau^i Y_{t-1}^i + \gamma \sigma_t^w + \zeta X_{t-1}^i + \varepsilon_t^i,$$

where Y denotes gross capital inflows, or it's subcomponents and X are additional control variables. The tables report the coefficient ψ. Column 1 and 2provides the results for gross capital inflows, column 3 and 4 for gross foreign direct investment inflows, column 5 and 6 for gross other inflows and column 7 and 8 for gross portfolio investment inflows. The second column for each variable includes country fixed effects. All explanatory variables are quarterly. The number of observations varies in each regression because of data availability; for each variable all countries in the sample with available data are included. Robust standard errors are reported in parentheses. Three stars (***) denote significance at the 1% confidence level, while two stars (**) and one (*) star denote significance at the 5% and 10% confidence levels.

Appendix B.2 Country-specific volatility and gross capital flows

To dig further and understand better the mechanism of capital flows, we decompose the effect of volatility on capital flows by considering gross capital outflows (i.e., net sales of foreign financial instruments by domestic residents; by convention, a positive sign means that residents are selling more assets than they are buying, contributing positively to net inflows) and inflows (i.e., net purchase of domestic financial instruments by foreign residents; a positive sign means that foreigners are purchasing more than they are

selling, contributing positively to net inflows). Up to accounting errors, net inflows are then the sum of gross outflows and gross inflows.

The estimated equations are the same as for net flows:

$$Y_t^i = \alpha + \tau^i Y_{t-1}^i + \gamma \sigma_t^w + \zeta X_{t-1}^i + \varepsilon_t^i, \qquad \text{(Appendix B.3)}$$

where Y denotes either gross inflows or gross outflows. Table 6 presents the coefficient c for inflows (and its subcomponents). The table shows that higher volatility leads to lower gross inflows, i.e. foreigners buys fewer domestic assets. This is intuitive as foreigners try to reduce their exposure to the now-more risky domestic economy. The result holds for private capital flows, and hence is not driven by official transactions. The result is driven by the "other" category. Perhaps more puzzling, table 7 shows that an increase in volatility leads to larger outflows (again, especially in the "other" category), i.e. residents are selling more foreign assets (on net). This contributes to positive net capital inflows as capital pulls in the country. The negative coefficient on net inflows in table 5 arises as the sum of these opposite coefficients, and is much smaller in absolute value. This suggests that gross flows (rather than net) are worthy of study on their own.

Appendix B.3 Country-specific volatility and economic activity

We now briefly verify that our data is consistent with the robust empirical finding that higher uncertainty leads to a contraction of economic activity. We estimate the following equation:

$$\Delta^4 M_t^i = \alpha + \tau^i \Delta^4 M_{t-1}^i + \gamma \sigma_t^w + \zeta X_{t-1}^i + \varepsilon_t^i, \qquad \text{(Appendix B.4)}$$

where $\Delta^4 = 1 - L^4$ in lag operator notation, is the fourth-quarter difference. Besides GDP, we also consider the effect on investment (gross fixed capital formation, GFCF, which includes residential investment for most countries), as well as consumption, industrial production and (with a flipped sign) the unemployment rate. Consistent with the literature, we obtain (in table 8) economically large and statistically highly significant results of a negative effect of volatility on economic activity. Our results extend this literature by considering a broader sample.

Table 6: Gross Inflows and Volatility

	(1) Cap_Inflow	(2) Private_Inflow	(3) FDI_Inflow	(4) Other_Inflow	(5) Portfolio_Inflow
Volatility	-6.75***	-6.00***	-0.47	-8.97***	1.04
	(1.95)	(1.96)	(0.52)	(1.73)	(0.97)
Observations	3,747	3,703	3,702	3,724	3,674
R-squared	0.53	0.50	0.23	0.20	0.54
Controls	y	y	y	y	y
Own Lag	y	y	y	y	y

Notes: This table reports results from the following panel regressions:

$$Y_t^i = \alpha + \tau^i Y_{t-1}^i + \gamma \sigma_t^w + \zeta X_{t-1}^i + \varepsilon_t^i,$$

where Y denotes gross capital inflows, or it's subcomponents and X are additional control variables. The tables report the coefficient ψ. Column 1 provides the results for gross capital inflows, column 2 for gross foreign direct investment inflows, column 3 for foreign direct investment inflows, column 4 for gross other inflows and column 5 for gross portfolio investment inflows. All explanatory variables are quarterly. The number of observations varies in each regression because of data availability; for each variable all countries in the sample with available data are included. Robust standard errors are reported in parentheses. Three stars (***) denote significance at the 1% confidence level, while two stars (**) and one (*) star denote significance at the 5% and 10% confidence levels.

Table 7: Gross Outflows and Volatility

	(1) Cap_Outflow	(2) Private_Outflow	(3) FDI_Outflow	(4) Other_Outflow	(5) Portfolio_Outflow
Volatility	6.44***	5.60***	1.54**	7.50***	-0.42
	(1.85)	(2.51)	(0.65)	(1.48)	(0.92)
Observations	3,710	3,660	3,515	3,641	3,541
R-squared	0.54	0.56	0.21	0.18	0.54
Controls	y	y	y	y	y
Own Lag	y	y	y	y	y

Notes: This table reports results from the following panel regressions:

$$Y_t^i = \alpha + \tau^i Y_{t-1}^i + \gamma \sigma_t^w + \zeta X_{t-1}^i + \varepsilon_t^i,$$

where Y denotes gross capital outflows, or it's subcomponents and X are additional control variables. The tables report the coefficient ψ. Column 1 provides the results for gross capital outflows, column 2 for gross foreign direct investment outflows, column 3 for foreign direct investment inflows, column 4 for gross other outflows and column 5 for gross portfolio investment outflows. All explanatory variables are quarterly. The number of observations varies in each regression because of data availability; for each variable all countries in the sample with available data are included. Robust standard errors are reported in parentheses. Three stars (***) denote significance at the 1% confidence level, while two stars (**) and one (*) star denote significance at the 5% and 10% confidence levels.

Table 8: Macro Quantities and Volatility

	(1) dlog4GDP	(2) dlog4GFCF	(3) dlog4Cons	(4) dlog4IP	(5) dlog4OUR
Volatility	-2.57***	-6.45***	-1.42**	-4.74***	-7.60**
	(0.78)	(2.53)	(0.70)	(1.66)	(3.28)
Observations	3,987	3,130	3,300	2,705	2,334
R-squared	0.67	0.72	0.76	0.70	0.80
Controls	y	y	y	y	y
Own Lag	y	y	y	y	y

Notes: This table reports results from the following panel regressions:

$$\Delta^4 M_t^i = \alpha + \tau^i \Delta^4 M_{t-1}^i + \gamma \sigma_t^w + \zeta X_{t-1}^i + \varepsilon_t^i,$$

where M denotes various macroeconomic quantities and X are additional control variables. The tables report the coefficient ψ. Column 1 provides the results for GDP, column 2 for gross fixed capital formation, column 3 for consumption, column 4 for industrial production and column 5 for the unemployment rate. All explanatory variables are quarterly. The number of observations varies in each regression because of data availability; for each variable all countries in the sample with available data are included. Robust standard errors are reported in parentheses. Three stars (***) denote significance at the 1% confidence level, while two stars (**) and one (*) star denote significance at the 5% and 10% confidence levels.

Appendix B.4 Net capital inflows and volatility shocks

Table 9: Net Capital Inflows and Volatility – Heterogeneous Effect

	(1) NXGDP	(2) NetInflow	(3) NetFDI	(4) NetOther	(5) NetPortfolio
Vol	2.57	-5.54	0.70	-1.57	2.46
	(4.84)	(3.75)	(1.38)	(3.09)	(2.58)
Beta	-0.28	-0.15	-0.08	-0.08	0.38
	(0.50)	(0.37)	(0.21)	(0.43)	(0.38)
InteractBetaVol	3.13	1.80	0.49	-0.44	-4.02
	(4.54)	(3.16)	(1.61)	(3.43)	(2.95)
Observations	3,107	2,950	3,392	3,402	3,277
R-squared	0.66	0.50	0.25	0.08	0.08
Country FE	n	n	n	n	n
Own Lag	y	y	y	y	y
Controls	y	y	y	y	y

Notes: This table reports results from the following panel regressions:

$$Y_t^i = \alpha + \tau^i Y_{t-1}^i + \gamma \sigma_t^w + \zeta X_{t-1}^i + \kappa \beta_{t-1}^i + \psi \sigma_{t-1}^w \beta_{t-1}^i + \varepsilon_t^i,$$

where Y denotes net capital outflows, or it's subcomponents and X are additional control variables. The tables report the coefficients γ, κ and ψ. Column 1 provides the result for net exports, column 2 for net capital outflows, column 3 for net foreign direct investment outflows, column 4 for net other outflows and column 5 for net portfolio investment outflows. All explanatory variables are quarterly. The number of observations varies in each regression because of data availability; for each variable all countries in the sample with available data are included. Robust standard errors are reported in parentheses. Three stars (***) denote significance at the 1% confidence level, while two stars (**) and one (*) star denote significance at the 5% and 10% confidence levels.

Table 10: Data: Starting year by country and data series

	Country	NX	UE	IP	Net Inflow	Gross Inflow	Gross Outlfow	GDP	Cons.	Inv.	R^i
ARGENTINA	213	1992		1985	1993	1993	1993	1990	1993	1993	1983
AUSTRALIA	193	1979	1978		1974	1974	1974	1980	1974	1974	1974
AUSTRIA	122		1974	2010	1974	1974	1974	1980	1988	1988	1974
BELGIUM	124	1992	1983	2000	2002	2002	2002	1980	1980	1980	1974
BULGARIA	918	1993	1991	2000	1994	1994	1994	1999			2000
BRAZIL	223	1989	2001	1985	1990	1990	1990	1995	1995	1995	1980
CANADA	156	1979	1974	2007	1974	1974	1974	1980	1981	1981	1974
CHILE	228	1995	2008		1991	1991	1991	1980	2003	2003	1981
CHINA	924			1991	1998	1998	1998	2000			1993
COLOMBIA	233	1993	2001	1980	1996	1996	1996	1994	2000	2000	1992
CYPRUS	423			1999	2001	2001	2001	1995	1995	1995	1992
CZECH REPUBLIC	935	1992	2005	2000	1993	1993	1993	1994	1996	1996	1993
DENMARK	128	1979	1980	2000	1977	1977	1977	1980	1991	1991	1974
FINLAND	172	1979	1974	1995	1975	1975	1975	1980	1975	1975	1988
FRANCE	132	1979		1974	1978	1978	1978	1980	1974	1974	1974
GERMANY	134	1979	1974	1991	1974	1974	1974	1980	1991	1991	1974
HUNGARY	944	1994	1999	2000	1995	1995	1995	1995	1995	1995	1991
INDIA	534	2003		2005	1996	1996	1996	1996	2004	2004	1990
INDONESIA	536	1989		2000	1983	1983	1995	1997	2000	2000	1990
IRELAND	178	1996	1983	1980	1997	1997	1997	1997	1997	1997	1974
ISRAEL	436	1979		1990	1974	1974	1974	1980	1995	1995	1993
ITALY	136	1979	2004	1974	1980	1980	1980	1980	1991	1991	1974
JAPAN	158	1979	1974	1974	1977	1977	1977	1980	1994	1994	1974
MALAYSIA	548	1990		1990	1999	1999	1999	1988	2005	2005	1977
MEXICO	273	1980	2000	1993	1980	1980	1980	1980	2003	2003	1980
MOROCCO	686	1989			2002	2002	2002	1990			1989

Table 11: Data: Starting year by country and data series

	Country	NX	UE	IP	Net Inflow	Gross Inflow	Gross Outlfow	GDP	Cons.	Inv.	R^i
NETHERLANDS	138	1979		2005	1977	1977	1977	1980	1988	1988	1974
NEW ZEALAND	196				1987	1987	1987	1982	1987	1987	1988
NORWAY	142		1974	1990	1977	1977	1977	1980	1978	1978	1980
PERU	293	1979	2001	1986	1985	1985	1991	1980	1980	1980	1982
PHILIPPINES	566	1979		1985	1979	1979	1983	1981	1998	2008	1987
POLAND	964	1994	2002	2010	1999	1999	1999	1995	1996	1996	1994
PORTUGAL	182	1980		2000	1977	1977	1977	1980	1995	1988	1990
RUSSIA	922	1993	1993	2000	1995	1995	1995	1995	2003	2003	1997
SOUTH AFRICA	199	1979		1990	1985	1985	1985	1980	1974	1974	1978
SOUTH KOREA	542	1979	1999	1980	1976	1976	1976	1980	1974	1974	1984
SPAIN	184	1979	1986	1975	1980	1980	1980	1980	1995	1995	1987
SINGAPORE	576	2002		1983	1986	1986	1986	1985	1975	1975	1974
SWEDEN	144	1979	2001	2000	1980	1980	1980	1980	1993	1993	1982
SWITZERLAND	146	1979	1974		1999	1999	1999	1980	1980	1980	1974
TAIWAN	528		1978	1996	1981	1981	1981		1981	1974	1988
THAILAND	578	1992	2001	1999	1993	1993	1993	1993	1993	1993	1980
TURKEY	186	1986	2005	2005	1987	1987	1987	1987	1998	1998	1989
UNITED KINGDOM	112	1979	1974	1974	1974	1974	1974	1980	1974	1974	1974
UNITED STATES	111	1979	1974	1974	1974	1974	1974	1980	1974	1995	1974