Uncertainty Betas and International Capital Flows

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September 12, 2014

Preliminary and Incomplete

Abstract

This paper proposes a novel measure of country risk, 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. In the data, a shock to global volatility reduces the capital inflows from foreigners in the countries with the highest uncertainty betas. At the same time, domestic residents of highest beta countries sell more foreign assets, and thus the effect on net capital flows is subdued. Investment and GDP fall significantly more in these countries than in low uncertainty beta countries. These differences across countries are statistically significant in a large panel of 35 countries over the last 40 years. A simple portfolio choice model illustrates one potential channel that may explain the empirical findings: in the model, a higher volatility beta proxies for a higher expropriation risk of foreigners.

JEL: E32, E44, G12, F32.

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1 Introduction

International capital flows among advanced economies increased dramatically in the last 25 years, with gross flows going up 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 to levels just below their GDP. This paper studies both empirically and theoretically the response of international capital flows to global uncertainty shocks: we uncover a new empirical determinant of international capital flows and provide a simple model to interpret it.

This paper proposes a novel measure of country risk, 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. These uncertainty betas appear related to 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 their cross-country differences. Uncertainty betas therefore potentially gather new information.

In our dataset, 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 from foreigners, and smaller capital outflows from residents, than countries with low past uncertainty betas. As a result, the impact on net capital flows is limited. 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 aggregate uncertainty, when aggregate volatility increases, consumption,

investment, GDP, industrial production, and 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. These differences across countries are statistically significant in a large set of 35 countries over the last 40 years.

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 aggregate stock 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. Inflows decrease in response to a global volatility shock, reaching their minimum after two quarters, while outflows increase at a similar speed in response to a similar shock. In other words, when global volatility rises, foreigners pull their capital out of the high beta countries and the domestic residents of those same high beta countries sell more foreign assets than they buy.

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 capital outflows from the balance of payments confirm the results obtained on net exports. Inflows (outflows) tend to decrease (increase): the results are significant on outflows, inflows, as well as portfolio flows and other flows, which are the most volatile components. Looking across countries, high uncertainty beta countries tend to experience significantly larger falls in capital inflows and large increases in capital outflows than low uncertainty beta countries. Consistent with the literature, consumption, investment and GDP tend to fall significantly when global volatility increases. Looking again across countries, consumption, investment and GDP tend to fall more in high uncertainty beta countries.

To investigate the cause of these cross-country differences and their potential macroeconomic

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impact, we study a simple international portfolio model. In the two-country model, each country has a representative investor and a tree producing dividends. Investors can invest in both the domestic and foreign trees. But a key friction breaks the symmetry between investors. We assume that the foreign investor is exposed to the risk of expropriation when investing in the home tree, whereas home investors are not. Expropriation risk acts like a tax on foreign holdings of the home tree. The tax is a low-probability event, and its magnitude increases with the foreign holdings and aggregate volatility, as governments are likely to face higher incentives to expropriate foreigners in turbulent times and when foreign holdings are sizable.

Expropriation risk is not a mere theoretical concern. Political risk and macroeconomics instability appear as the two major constraints to foreign investment according to a World Bank's survey (World Investment and Political Risk, 2013). A large market of political risk insurance suggests that this concern is real. Political risk insurance represented up to 25% of foreign direct investment for developing economies in 1982. It is down to 14 percent of foreign direct investment, but still accounts for $100 billion of investment insurance issued in 2012. Moreover several firms produce and sell country risk indices to potential investors. The IHS Group, for example, builds quarterly indices of country risk. The first component of each country index corresponds to the likelihood of a 10-percentage-point increase in the rate of capital gains tax for foreign-owned businesses, in line with our model. Expropriation risk, however, can be defined more broadly, including non-tax related policies. Our model translates the general concern for expropriation risk in a simple form.

In the model, dividends, aggregate volatility and the probability of expropriation follow persistent processes but all respond to different and uncorrelated shocks. Because of the key role of heteroscedasticity and non-linearities, we cannot rely on log-linearizations (Rabitsch, Stepanchuk and Tsyrennikov, 2014) and therefore compute the model equilibrium using projection methods. In equilibrium, the model interprets differences in uncertainty betas in terms of differences in expropriation risk. As in the data, an increase in global uncertainty leads to capital flights out of the most exposed countries: the foreigners, who face the expropriation risk, reduce their shares of the domestic tree. The price of the home tree, which falls when the aggregate volatility increases

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or when the probability of expropriation increases, is more volatile than the price of the foreign tree, which is not subject to expropriation risk. High uncertainty beta countries are thus countries with large expected expropriation risk. Countries with higher expected tax rates experience larger portfolio share adjustments and thus larger capital outflows than countries with lower expected tax rates. The model therefore provides a simple qualitative explanation of our empirical findings.

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 market 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, Backus, Henriksen, Lambert and Telmer (2009), Obstfeld, 2012a, 2012b, Forbes and Warnock, 2012, Gourinchas, Rey and Truempler

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[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 shocks can account for about half the variation in economic growth.

(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. Miranda-Agrippino and Rey (2014) study the link between capital flows and U.S. monetary policy. 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 Calvo (1998), Edwards (2002, 2004), Kim and Wei (2002), Choe, Kho and Stulz (2005), Calvo, Izquierdo and Talvi (2006a, 2006b), Fogli and Perri (2006), Albuquerque, Bauer and Schneider (2007), Durdu, Mendoza and Terrones (2009), Milesi-Ferretti and Tille (2011), Rothenberg and Warnock (2011), and Ahmed and Zlate (2012). Our sample encompasses all the sudden stop episodes identified in this literature over the last 30 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 part of a recent set of general equilibrium models of international portfolio allocations, notably Caballero, Farhi and Gourinchas (2008), Mendoza, Quadrini and Ríos-Rull (2009), Gourinchas, Rey, and Govillot (2010), Coeurdacier and Gourinchas (2011), Colacito and Croce (2012), Tille and van Wincoop (2012), Devereux and Sutherland (2012), Maggiori (2012), Heathcote and Perri (2013), Bahmra, Coeurdacier, and Guibaud (2013), Chang, Kim and Lee (2013), Kalemli-Ozcan, Papaioannou and Perri (2013) as well as Coeurdacier, Rey, and Winant (2011, 2013). Our model is simpler than some of those papers and could be extended by adding more assets and more frictions, building on this recent literature. It offers, however, a simple and tractable framework to interpret our empirical results and can be numerically solved rapidly without linearizations.

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 interpolation 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

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[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

standard balance of payments accounting. Gross outflows are defined as net purchases of foreign financial instruments by domestic residents. Gross inflows are defined as net sales of domestic financial instruments to foreign 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 in GDP 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 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 for 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.

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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 foreign assets than they are buying, contributing positively to net inflows. Intuitively, a positive outflow means than money is leaving the foreign country and coming to the home country. Positive inflows means that foreigners are purchasing more domestic assets than they are selling, contributing positively to net inflows. Intuitively, a positive inflow is means that money is flowing into the home country. Up to accounting errors, net inflows are then the sum of gross outflows and gross inflows.

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.

Figure 1 shows the median beta for each country in our sample as well as the the 25th and 75th percentile for the betas of each country. This figure shows that the median beta varies significantly across country. Moreover, it shows that countries like the United States have a beta that varies in a fairly narrow range while countries such as Argentina and Indonesia have much greater variation in their beta.

Figures 2 and 3 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
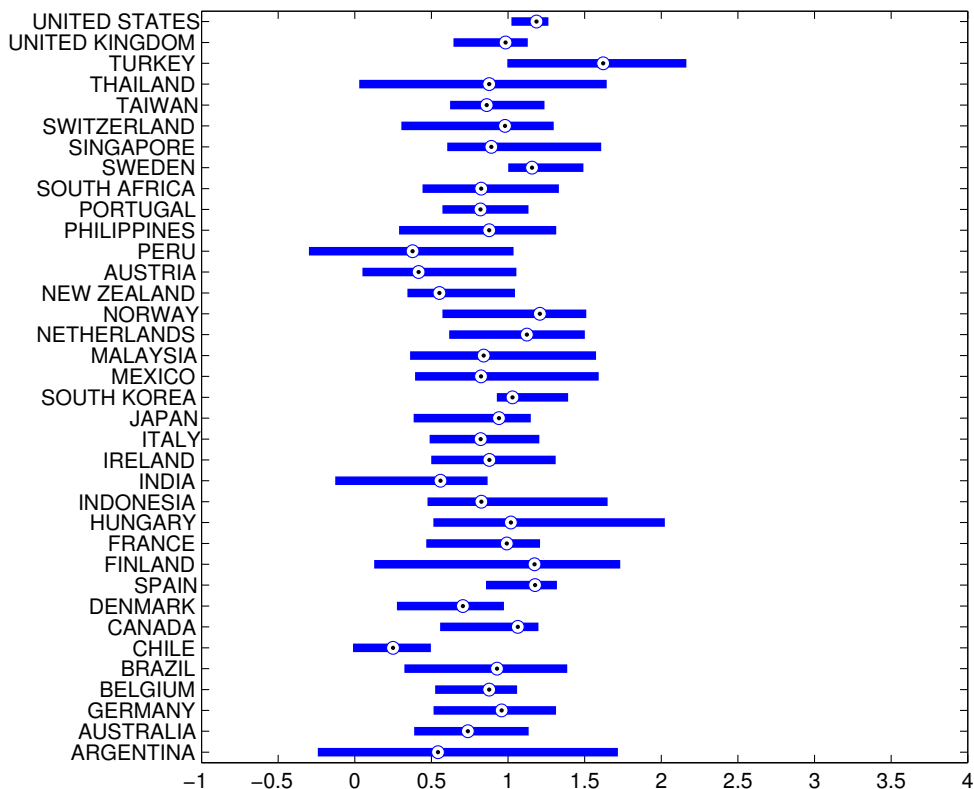
Figure 1: Median Beta — This figure reports the median beta along with the 25th and 75th percentile for each country in the sample.

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.

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:

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

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Figure 2: **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.
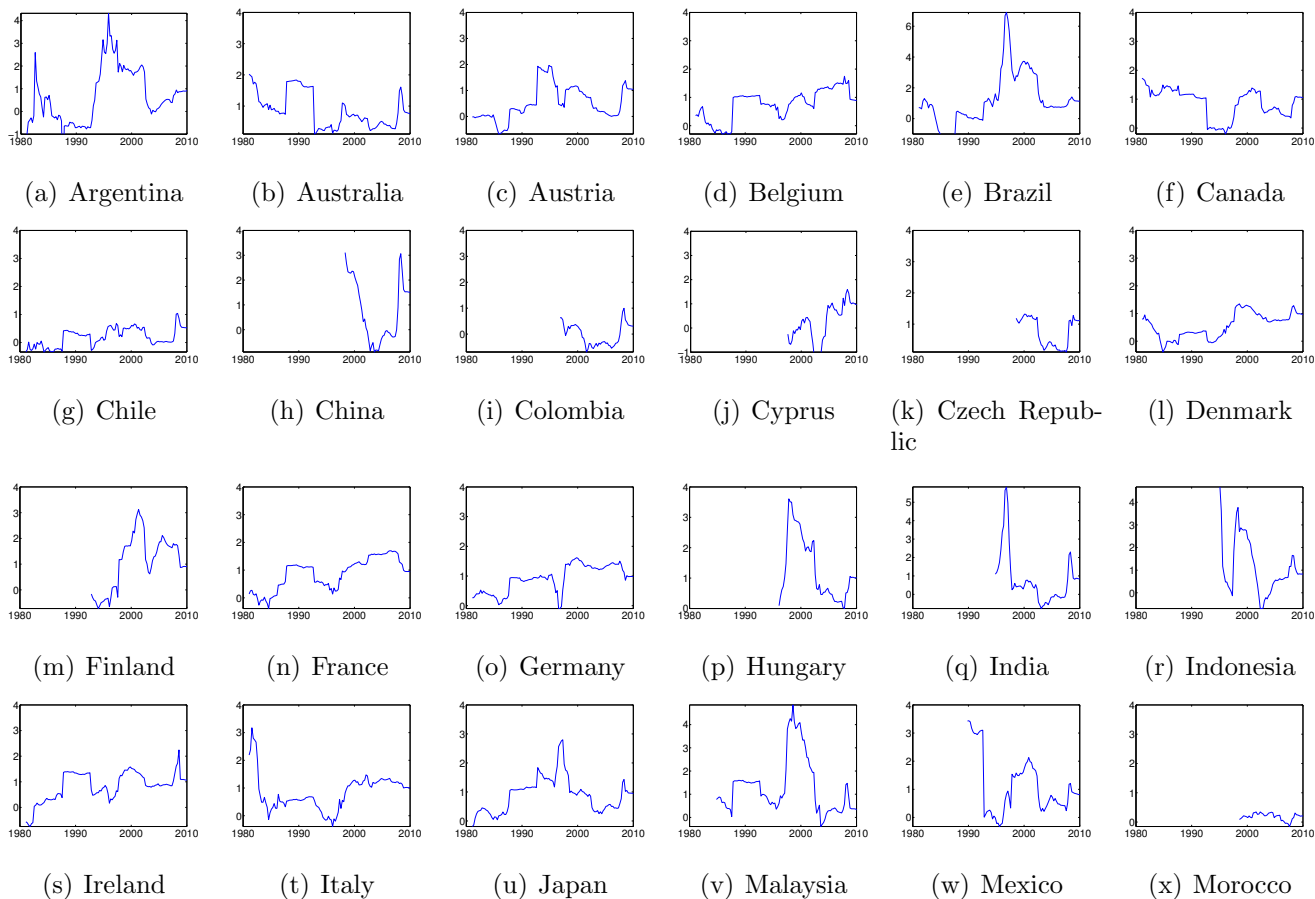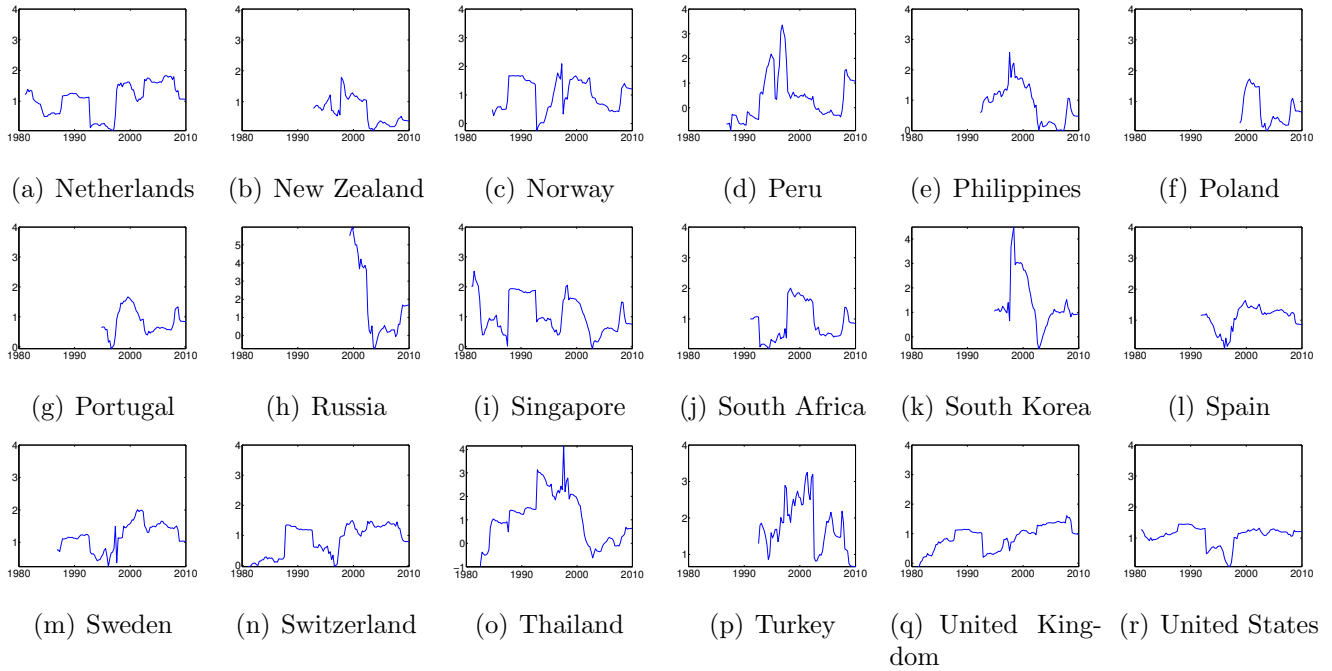
Figure 3: Uncertainty Betas, Cont. — Country-level volatilities are obtained at the quarterly frequency as the standard deviations of daily real stock market returns over one quarter. Likewise, a measure of aggregate volatility is obtained from the MSCI world stock market index. For each country i, uncertainty 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.

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 only a small fraction of the cross-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 potentially bring additional information. We now use this information to study the response of capital flows to global shocks.

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:

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

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.

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 – Portfolios

Following Lustig and Verdelhan (2007) and Gourio et al. (2013), we sort the countries into five portfolios based on their betas in each period and rank them from low to high volatility beta. The first portfolio contains the countries with the lowest volatility betas and the last portfolio includes the countries with the highest volatility betas. Impulse response functions are obtained from one-lag VARs that include each portfolio's macroeconomic time series (denoted x), the 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. The standard errors on impulse response functions are obtained by bootstrapping 1000 times the VAR residuals. 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 4 displays the impulse response for the high minus low portfolio. In the Appendix we

separately display the impulse response for the low and high portfolios. The grey shaded areas indicate 95% confidence intervals. Panel (a) shows that gross outflows increase. Recall that, by convention, positive outflows mean that residents are selling more foreign assets than they are buying, contributing positively to net inflows. The VAR suggests that domestic residents respond to an increase in global uncertainty by selling more foreign assets than they buy in the high beta countries, while they buy more foreign assets than they sell in the low beta countries. Panel (b) shows that gross inflows decline: gross inflows in high beta countries decline while they increase in low beta countries. An increase in global volatility leads foreigners to sell more assets than they buy in the riskier high beta countries while they buy more assets than they sell in the less risky low beta countries. Consequentially the high minus low IRF for gross inflows declines. Panel (c) and (d) show two measures of net capital inflows, the current account and net inflows. As net inflows are defined as the difference of gross outflows and gross inflows it is not surprising that the impulse responses are insignificant for both variables.

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]

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[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

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(a) IRF Gross Outflows   (b) IRF Gross Inflows

(c) IRF Net Inflows   (d) IRF CurrentAccount
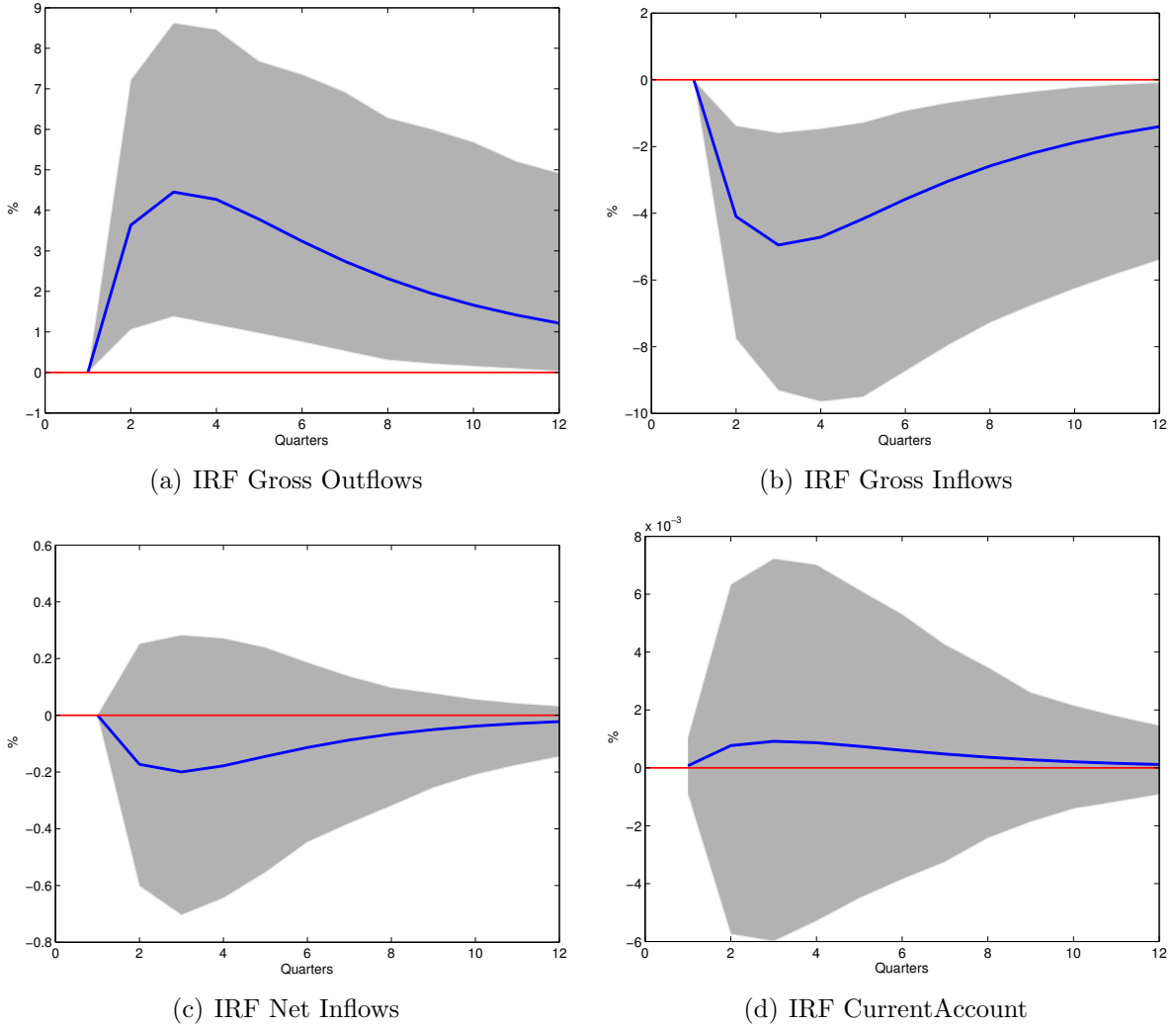
Figure 4: Portfolio VAR – High minus Low — This figure reports the impulse response functions of the current account (where an increase corresponds to capital flights), net inflows, gross outflows and gross inflows. Gross inflows are defined as net sales of domestic financial instruments to foreign residents. 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. The figure reports the differential impulse response functions of high and 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. The grey shaded areas indicate 95% confidence intervals.

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:

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

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we use the simplest measure of volatility.

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 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 their subcomponents).[6] By definition, an increase in global volatility cannot increase (or decrease) net capital inflows in all countries. But high uncertainty beta countries could experience outflows while low uncertainty beta countries experience inflows when global volatility rises. Table 10 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. The results are of the opposite sign when using

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[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 trade in goods and not trade in services. Second, the income of foreign factors of production and unilateral transfers are 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:

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

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.

capital flow data (since net exports are the opposite of net inflows). But these effects are not statistically significant. The impact of volatility shocks are strong and significant on gross inflows and gross outflows but appear to 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:

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

where M denotes different macro quantities such as GDP, and $\Delta^4 = 1 - L^4$ 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] The coefficient 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.

4 A Simple Model of Gross Capital Flows with Expropriation Risk

This section introduces a simple equilibrium model of portfolio choices to interpret the evidence uncovered in the previous section. This evidence requires generating sharp movements in opposite direction of gross inflows (i.e., net sales of domestic assets by foreigners) and gross outflows (i.e., net sales of domestic assets by residents). This is challenging because in general a shock, such as a change in the riskiness of the assets of the two countries, would lead both foreigners and residents to change their portfolio allocation in the same direction. The model reflects our first attempt at breaking this symmetry: we assume that foreigners differ from residents in that they

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[7]Note that the reaction to country-specific ("local") uncertainty shocks is studied in the Appendix (see Table 9) and is consistent with the uncertainty shock literature.

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:

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

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 (opposite of 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.

face expropriation risk. This expropriation risk varies stochastically over time. The model then studies the effect of exogenous changes in the riskiness of different countries on gross international capital flows. We first present the model setup, then discuss briefly the solution method, and finally report some preliminary simulation results.

4.1 Model Setup

The model is an endowment economy with two countries, one representative agent in each country, and a single good (the same good in both countries). A star * denotes a foreign variable. In each country, a tree produces dividends, denoted $\{D_t\}$ for the home tree and $\{D_t^\star\}$ for the foreign tree. Both $\{D_t\}$ and $\{D_t^\star\}$ follow exogenous stochastic processes, with a common stochastic volatility. This aggregate volatility, denoted σ_t^2 follows itself an exogenous autoregressive process. There are no trade costs and no labor income. We denote by P and $P^\star$ the price of one share of the domestic and foreign tree respectively, and by $S^{i,j}$ the number of units of of tree j held by agent i, i.e. the share of tree j owned by i. Hence $S^{f,h}$ is the share of home tree held by the foreign agent.

In each country, the representative agent has standard expected utility preferences. The home representative agent, for example, maximizes:

$$\max_{\left\{C_t, S_{t+1}^{h,h}, S_{t+1}^{h,f}\right\}} E_0 \sum_{t=0}^{\infty} \beta^t \frac{C_t^{1-\gamma}}{1-\gamma}.$$

by choosing (1) how much to consume (C_t) and (2) how many shares of the domestic ($S^{h,h}$) and foreign ($S^{h,f}$) trees to buy, subject to a budget constraint described below. The foreign representative agent solves a similar maximization problem. Thus far, the model describes a classic two-tree portfolio optimization problem with heteroscedasticity.

We depart from the frictionless two-tree portfolio problem by introducing expropriation risk, which takes the form of a stochastic tax on the foreigners' holdings of domestic capital. To keep the model simple, we assume that assets invested in the foreign country are not exposed to any expropriation, and that domestic residents are not subject to expropriation risk either. The proceeds from this tax are used either for government spending, or are rebated as lump-sum transfers

to the domestic agents or even possibly to the foreigners.[8]

The tax rate, denoted τ_t, is assumed to depend on the state of the economy as follows:

$$\tau_t = \left\{ \begin{array}{ll} 0 & \text{with probability } 1 - p_t \\ 1 - \exp^{\left(-\lambda S_t^{f,h} \sigma_t^2\right)} & \text{with probability } p_t \end{array} \right\}.$$

This formula directly builds in two dependencies: aggregate volatility (σ_t^2) and a larger share of home asset held by foreigners $(S_t^{f,h})$ increase the tax rate. Intuitively, times of high uncertainty are either driven by political uncertainty or generate a large uncertainty over economic policies, and a larger share of foreign assets increases the incentives to expropriate. More technically, this formulation implies that the tax rate disappears as the foreigner share goes to zero, and hence helps ensure that the equilibrium does not hit corner solutions. Last, expropriation is a low probability event: the tax rate is zero with probability $1 - p_t$ and strictly positive with probability p_t. The probability of expropriation p_t, drawn at time $t - 1$, follows an autoregressive process. The proceeds from the expropriation are denoted by R_t. They correspond to the product of the tax rate times the tax base, which is itself governed by the shares held times their (cum-dividend) price: $R_t = \tau_t S_t^{f,h} (P_t + D_t)$.

Given these assumptions, the budget constraints of the home and foreign investors are respectively:

$$C_t + P_t S_{t+1}^{h,h} + P_t^\star S_{t+1}^{h,f} = (P_t + D_t) S_t^{h,h} + (P_t^* + D_t^\star) S_t^{h,f} + \alpha_2 R_t,$$

and

$$C_t^\star + P_t S_{t+1}^{f,h} + P_t^\star S_{t+1}^{f,f} = (1 - \tau_t)(P_t + D_t) S_t^{f,h} + (P_t^\star + D_t^\star) S_t^{f,f} + \alpha_3 R_t,$$

where α_2 and α_3 denote the share of expropriation proceeds that are rebated lump-sum to domestic

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[8]In a variant of the model, the transfers to the domestic agents could be set in proportion to their holdings of securities.

and foreign investors respectively. Finally, the market clearing conditions for goods and assets impose that:

$$
\begin{aligned}
S_t^{h,h} + S_t^{f,h} &= 1, \\
S_t^{h,f} + S_t^{f,f} &= 1, \\
C_t + C_t^\star &= D_t + D_t^\star - \alpha_1 R_t,
\end{aligned}
$$

where α_1 denotes the share of expropriation proceeds that is spent by the government.

4.2 Solution, Calibration and Simulation Method

We first describe the system of equations that characterize the equilibrium. We then explain our numerical solution method and our choice for stochastic processes. Finally, we discuss briefly our parameters.

Equilibrium conditions Assuming the existence of an interior solution, the maximization problems of the home and foreign agents imply the following four first-order conditions:

$$
\begin{aligned}
P_t u'(C_t) &= \beta E_t \left[(P_{t+1} + D_{t+1}) u'(C_{t+1}) \right] \\
P_t^\star u'(C_t) &= \beta E_t \left[(P_{t+1}^\star + D_{t+1}^\star) u'(C_{t+1}) \right] \\
P_t u'(C_t^\star) &= \beta E_t \left[(P_{t+1}^\star + D_{t+1}^\star) u'(C_{t+1}^\star) \right] \\
P_t^\star u'(C_t^\star) &= \beta E_t \left[(1 - \tau_{t+1})(P_{t+1} + D_{t+1}) u'(C_{t+1}^\star) \right].
\end{aligned}
$$

The first two equations correspond to the optimal portfolio choice of the home investors, while the last two equations correspond to the optimal portfolio choice of the foreign investor. Those four equations coupled with the feasibility constraints, the clearing market conditions and a budget constraint summarize the model.

Numerical Solution Method   The model is solved using projection methods similar to Judd (1992) and Aruoba, Fernandez-Villaverde and Rubio-Ramirez (2006), following the steps outlined in Rabitsch, Stepanchuk and Tsyrennikov (2014). In simple portfolio models, the only endogenous state variable is the relative wealth of the agents. In our case, because the tax proceeds R_t depend on the foreign-held share of the domestic asset, an additional state variable is necessary to describe the model solution (for instance this share). The method solves for six policy functions, which depend on the two endogenous state variables as well as the exogenous shocks. These shocks are discretized and approximated through Markov chains. We approximate the six policy functions by (tensor of) Chebyshev polynomials. The precise implementation of the projection method is described in the Appendix.

The process for exogenous variables   The dividend dynamics are described by three exogenous state variables (D_t, $D_t^\star$, and σ_t):

$$\begin{pmatrix} D_{t+1} \\ D_{t+1}^\star \end{pmatrix} = \begin{pmatrix} \overline{D} \\ \overline{D} \end{pmatrix} + A \begin{pmatrix} D_t \\ D_t^\star \end{pmatrix} + \sigma_t \varepsilon_{t+1},$$
$$\sigma_{t+1}^2 = \overline{\sigma}^2 (1 - \rho) + \rho \sigma_t^2 + \upsilon_{t+1},$$

where the shocks ε_{t+1} and υ_{t+1} are $i.i.d$ and normally distributed (respectively according to a $N(0, \Sigma)$ and a $N(0, \kappa^2)$ distribution). The law of motion of aggregate volatility does not ensure that σ_{t+1} remains positive; this feature therefore depends on the calibration parameters.

Calibration   Table 4 describes the model parameters. The risk-aversion coefficient is set to 5, while the discount factor is set to 0.9. The autoregressive coefficient of the dividend level is equal to 0.5. The properties of aggregate volatility mimics those of the volatility of world returns used in the previous sections. The expropriation proceeds are mostly wasted (80%), while the rest is rebated to home investors (20%). The elasticity of (one minus) the tax rate to economic uncertainty is set to 10.

Table 4: Calibration

Model parameter	Notation	Value
Risk-aversion	γ	10.0
Discount factor	β	0.99
Average dividend	$\bar{D}$	20.0
Persistence of dividend	a	0.5
Volatility and cross-country correlation	Σ	$\begin{bmatrix} 1.0 & 0.258 \\ 0.258 & 1.0 \end{bmatrix}$
Average volatility	$\bar{\sigma}^2$	0.008
Persistence of volatility	ρ	0.601
Volatility of volatility	κ	0.004
Elasticity of tax rate	λ	10
Lump-sum rebates	$[\alpha_1, \alpha_2, \alpha_3]$	$[0.8, 0.2, 0]$

Notes: The law of motion of dividend is:

$$\begin{pmatrix} D_{t+1} \\ D^\star_{t+1} \end{pmatrix} = \begin{pmatrix} \overline{D} \\ \overline{D} \end{pmatrix} + A \begin{pmatrix} D_t \\ D^\star_t \end{pmatrix} + \sigma_t \varepsilon_{t+1},$$

$$\sigma^2_{t+1} = \bar{\sigma}^2 (1 - \rho) + \rho \sigma^2_t + v_{t+1},$$

where A is a diagonal matrix with a as diagonal values. and where the shocks ε_{t+1} and v_{t+1} are *i.i.d* and normally distributed (respectively according to a $N(0, \Sigma)$ and a $N(0, \kappa^2)$ distribution).

4.3   Simulation Results

We focus our description of the results on the behavior of gross and net capital flows. In the model, the gross capital outflows, defined respectively from the perspective of the domestic or foreign investors are:

$$
\begin{aligned}
GCO &= P_t^* \left(S_{t+1}^{hf} - S_t^{hf} \right) \text{ (Home investor)} \\
GCO^\star &= P_t \left(S_{t+1}^{fh} - S_t^{fh} \right) \text{ (Foreign investor)}
\end{aligned}
$$

For the home investor, capital flows out of the country in order to increase the number of shares of the foreign tree. We assume here that those shares are valued at the beginning-of-period price. Similarly, for the foreign investor, capital flows out of the foreign country in order to increase the number of shares of the home tree. The net capital outflows from the perspective of the domestic investor is the difference $GCO - GCO^\star$. It is naturally the opposite from the perspective of the foreign investor.[9]

In order to understand capital flows and the model mechanism, it is thus necessary to understand the dynamics of these equity shares. Let us start with the corresponding policy functions. Figure 5 reports the shares of the home tree owned by respectively the home and foreign investors as a function of the aggregate volatility level. In a model without expropriation risk (no tax), the home investor owns half of the shares of the home tree, irrespective of the volatility level. In the presence of expropriation risk, home and foreign investors face different expected returns. As aggregate volatility increases, expropriation risk increases because volatility is persistent and the tax is higher in bad times, i.e. in times of high uncertainty. Therefore, as volatility increases, foreigners reduce their holdings of domestic assets, leaving those assets to the domestic investors.

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[9]The gross capital flows differ from the changes in net assets. In the model, the change in foreign assets of the home and foreign investor are respectively equal to:

$$
\begin{aligned}
CFA &= P_{t+1}^\star S_{t+1}^{hf} - P_t^\star S_t^{hf} \text{ (Home investor)} \\
CFA^\star &= P_{t+1} S_{t+1}^{fh} - P_t S_t^{fh} \text{ (Foreign investor)}
\end{aligned}
$$

The net change in foreign assets corresponds to the difference $CFA - CFA^\star$.

(a) Low unconditional expropriation risk   (b) High unconditional expropriation risk
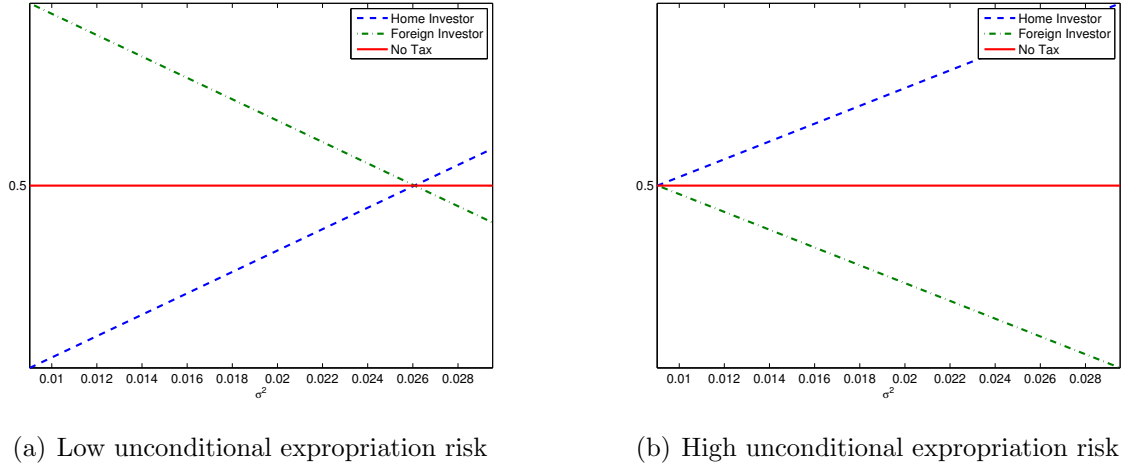
Figure 5: Shares of the Home Tree Owned by the Home and Foreign Investors: This figure reports the shares of the home tree owned by respectively the home and foreign investors as a function of the aggregate volatility level for different sensitivities of the tax rate to economic conditions: $\lambda = 10$ in Panel (a) and $\lambda = 20$ in Panel (b). The model is simulated with the parameters described in Table 4. In the absence of taxes, both investors hold half of the shares.

As a result, an aggregate volatility shock leads to capital outflows out of the expropriation-prone country.

The model interprets differences in uncertainty betas in terms of differences in expropriation risk. In a country without expropriation risk (e.g., the foreign country here), stock prices appear less volatile than in a country with expropriation risk. For example, home stock prices decrease when the expropriation risk increases, whereas foreign stock prices hardly bulge. The same mechanism appears when simulating the model for different parameters, as Figure 5 shows: increasing the sensitivity of the tax rate to the level of aggregate uncertainty (i.e., increasing the parameter λ) leads to larger responses of portfolio holdings and larger domestic price changes. A high volatility beta thus corresponds to a higher level λ of expropriation risk. In the model, the high uncertainty beta country experiences larger capital outflows than the low uncertainty beta one. The model thus offers a potential interpretation to our empirical findings.

The model calibration, however, has several weaknesses. The model does not reproduce fully the equity home bias in the data: while the U.S. stock market represents close to a third of the world stock market, actual U.S. investors tend to allocate more than two-thirds of their assets to U.S. stocks. The model does not reproduce the level of the price-dividend ratio or the average

equity return: while the price-dividend ratio is close to 25 in the data on average, it is equal to 9 in the model. The model does not reproduce the volatility of equity prices or capital flows. For example, the average volatility of U.S. equity returns is 16% in the data, but only 10% in the model. To sum up, the current calibration offers a qualitative but not quantitative interpretation of the data.

4.4 Extensions

We are considering three different extensions. First, the representative investor could be characterized by Epstein-Zin (1989) preferences instead of constant relative risk-aversion. By disentangling the coefficient of risk aversion and the inter-temporal elasticity of substitution (IES) the model could then feature large expected equity returns (due to high risk aversion) and equity drop prices when volatility increases (due to high IES). Second, the model could feature different goods across countries and home bias in consumption (as in Heathcote and Perri (2013)). The introduction of exchange rate risk and home bias in consumption would help the model reproduce the well-known equity home bias. Third, the set of assets traded could include domestic and foreign bonds along the two equity claims. As Coeurdacier and Gourinchas (2011) show, in the presence of exchange rate risk, the introduction of such bonds has a large impact on the optimal portfolio allocation.

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 home and foreign investors behave differently because foreign investors face some expropriation risk. The model is

able to generate qualitatively the heterogeneous effect of uncertainty on capital flows.

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

Appendix A Additional Impulse Response Functions

(a) IRF Gross Inflows

(b) IRF Gross Outflows

(c) IRF Net Inflows

(d) IRF CurrentAccount

Figure 6: Portfolio VAR – High Portfolio — 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 impulse response functions of high 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. The grey shaded areas indicate 95% confidence intervals.

(a) Gross Inflows   (b) Gross Outflows
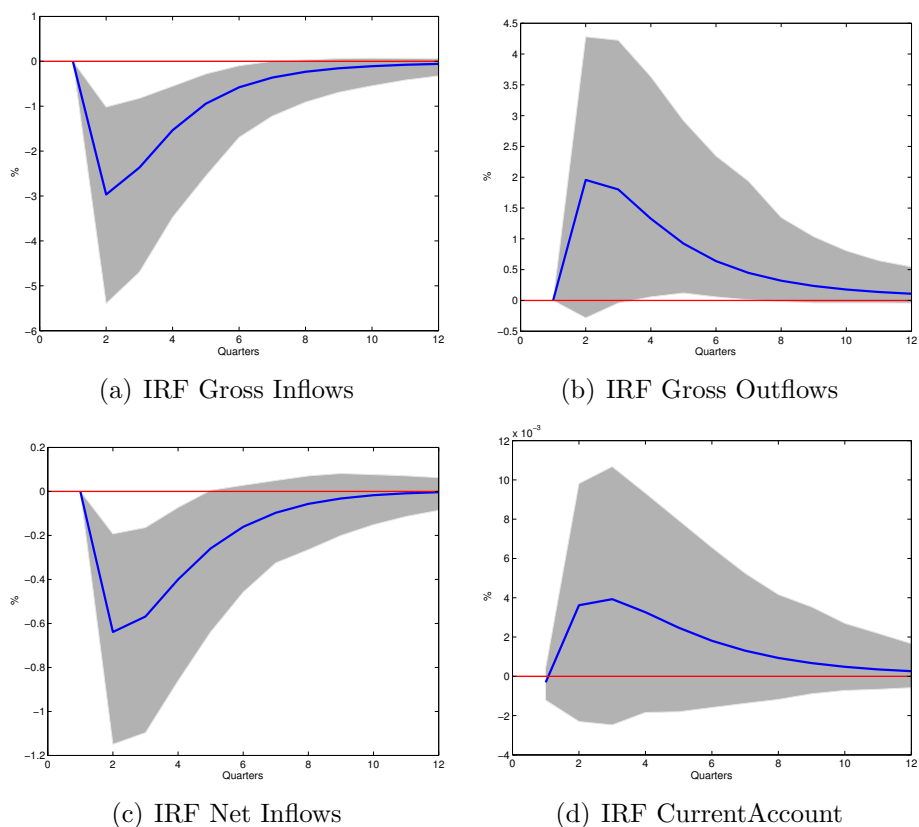
(c) Net Inflows   (d) IRF CurrentAccount
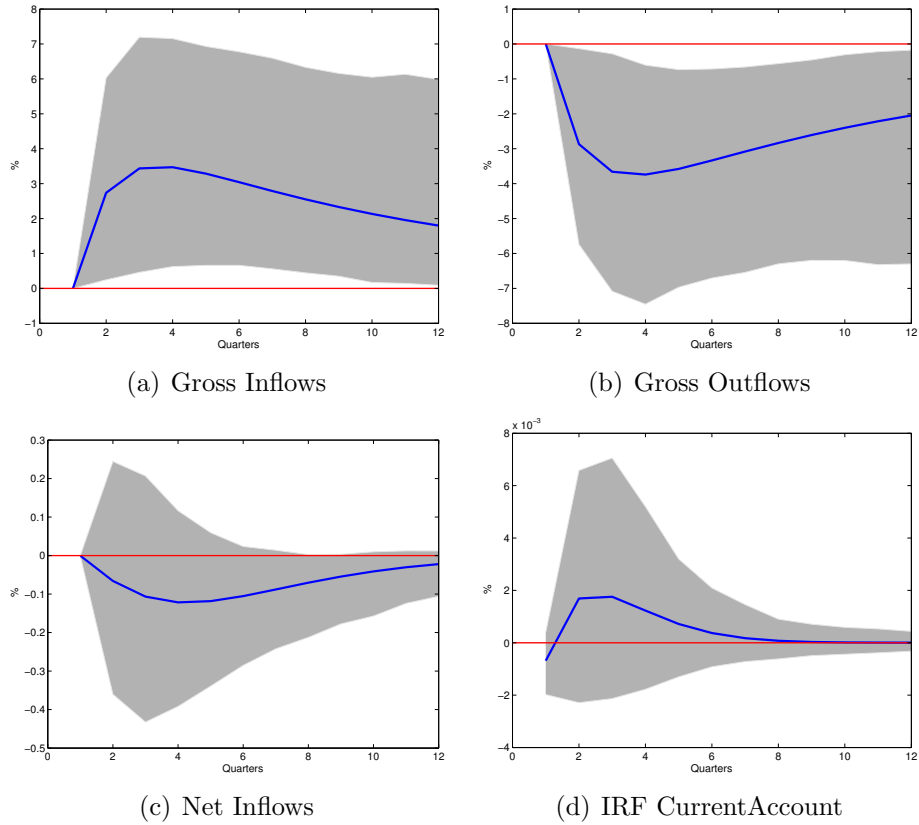
Figure 7: Portfolio VAR – Low Portfolio — This figure reports the impulse response functions of the current account (where an increase corresponds to capital flights), net inflows, gross outflows and gross inflows. The figure reports the impulse response functions of low uncertainty beta countries. In 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. The grey shaded areas indicate 95% confidence intervals.

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.[10] We next verify that our data are consistent with the large literature documenting a negative effect of uncertainty on real economic activity.

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

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.[11] 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 5 presents estimates of the coefficient c from the equation:

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

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 **??** 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.[12] In our data, the correlation between the two series is -0.62. Table 6 presents estimates of a similar equation,

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[11]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.

[12]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.

Table 5: 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:

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

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.

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

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 5, 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 6: 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:

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

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:

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

where Y denotes either gross inflows or gross outflows. Table 7 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 8 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 6 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:

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

Table 7: 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:

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

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 8: 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:

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

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.

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 9) 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 9: 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:

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

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 10: 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:

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

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 11: Data: Starting year by country and data series

Country	NX	UE	IP	Net Inflow	Gross Inflow	Gross Outlfow	GDP	Cons.	Inv.	$\bar{R}^i$
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	2000	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

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Table 12: 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

Appendix C Model Simulations

Appendix C.1 Methodology

Let ω denote the relative wealth and x the expropriation event. Recall that $S^{f,h}$ denote the holdings of foreign household of the domestic asset, σ the stochastic volatility of the dividend process, and p the disaster probability. For each of these variables we first define a discrete grid. All policy functions are approximated at each σ, x, p by

$$f(\omega, S^{f,h}, \sigma, x, p) = \sum_{i=0}^{n_w} \sum_{j=0}^{n_{S^{f,h}}} \phi_{ijp} \Psi_{ij}(w, S^{f,h}) \qquad \text{(Appendix C.1)}$$

where $\Psi_{ij}(k,b) = T_{i-1}(2((\omega-\underline{\omega})/(\overline{\omega}-\underline{\omega})-1)T_{j-1}(2((S^{f,h}-\underline{S^{f,h}})/(\overline{S^{f,h}}-\underline{S^{f,h}})-1), T_l(x) = cos(l\ arccos\ x)$, $l = 0, 1, ..., n_x$ and $x = \omega, S^{f,h}$ generate the Chebyshev polynomials of degree n_x. The higher the degree of the polynomial the more precise is the solution. Let $\underline{\omega}$ denote the lower bound for the share of wealth and $\overline{\omega}$ the upper bound. The bounds for $S^{f,h}$ follow the same notation.[13] While other basis functions can be used Chebyshev polynomials have the useful feature of being orthogonal on $[-1, 1]$ with respect to the inner product defined by the weighting function $(1 - k^2)^{-1/2}$. This makes it feasible to keep the number of unknown coefficients low. The central idea of the collocation method is to pick (collocation) points for $\omega, S^{f,h}, \sigma, x, p$ for which a to be defined residual function $R((\omega, S^{f,h}, \sigma, x, p, \phi) = 0$. Regarding the choice of the collocation points the *Chebyshev Interpolation Theorem* says, see Judd (1992), that the choice of the Chebyshev zeroes is optimal for rapid convergence with an increasing number of collocation points. The zeroes of a Chebyshev polynomial of order N can be found through

$$x_k = cos\left(\frac{(2k + 1)\pi}{2N}\right) \quad \text{for} \quad k = 0, 1, ..., N - 1 \qquad \text{(Appendix C.2)}$$

The policy functions that to be approximated are $P(\omega, S^{f,h}, \sigma, x, p), P^*(\omega, S^{f,h}, \sigma, x, p),$

$C(\omega, S^{f,h}, \sigma, x, p), C^*(\omega, S^{f,h}, \sigma, x, p), S^{h,h}(\omega, S^{f,h}, \sigma, x, p), S^{h,f}(\omega, S^{f,h}, \sigma, x, p), S^{f,h}(\omega, S^{f,h}, \sigma, x, p)$ and $S^{f,f}(\omega, S^{f,h}, \sigma, x, p)$. Each iteration consists of two key steps: First, given the guess for the policy functions and all possible combinations of states tomorrow we solve for the implied relative wealth tomorrow,

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[13] Chebyshev polynomials can also be generated recursively, $T_0(k) = 1$, $T_1(k) = k$, by $T_{n+1}(k) = 2kT_n(k) - T_{n-1}(k)$ for $n = 2, 3, ...$

ω'. Using the guess for the policy functions and ω' we can then compute expectations and solve the for the coefficient ϕ that imply $R((\omega, S^{f,h}, \sigma, x, p, \phi) = 0$. There is a trade of between precision of the solution and computational feasibility. While higher order polynomials allow for highly non-linear policy functions, they lead to a large number of unknown coefficients at the same time which makes the computation of the solution very difficult. In order to ease this problem we therefore start with a low order polynomial for the state variables $S^{f,h}(\omega, S^{f,h}, \sigma, x, p)$. A crucial element to reach convergence is the initial guess for the ϕ coefficients. It is helpful to use the solution of a the model without expropriation risk as initial guess for the model with expropriation risk. Updating of the guess via a Levenberg-Marquardt algorithm and iterating until convergence gives the solution to the model. The Jacobian for the Levenberg-Marquardt method is computed analytically which results in a significant computational speedup compared in comparison to computing it via finite differences. The result of the low order polynomial can be used to increase the order of the polynomials where the additional coefficients are assigned a zero initial guess. The code for this model is implemented in Matlab using mex and C code.