International Capital Flows, External Assets and Output Volatility*

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Abstract

Cross-sectional evidence for 119 developing, emerging, and developed countries shows over the last three decades that countries with an on average higher volatility of output growth experience more procyclical capital outflows over the business cycle than those countries with the same growth rate but a more stable output path. This stylized pattern shows up in addition to the recently established fact that countries with higher macroeconomic uncertainty tend to accumulate higher external asset positions. To explain this finding we present an open-economy real business cycle

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model with stochastic growth rates in which higher uncertainty of the expected income stream increases the precautionary savings of households. We show that the combination of income risk and the precautionary savings motive leads to both more procyclical capital outflows in the shorter run and a higher long-run external asset position.

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1 Introduction

A robust stylized fact established in the literature on international capital flows is that the current account and the trade balance are on average countercyclical. That is, times of high output growth are typically also times when the trade balance turns negative and there are net capital flows into the country. The basic open economy model of the business cycle can replicate this phenomenon when output growth is sufficiently positively autocorrelated, so that future income increases by more than today's income. In that case, according to the intertemporal approach to the current account, households' desire to move some of the higher future consumption to the present causes them to borrow against the expected continued increases in income, leading to a decline in the net foreign asset position.[1] Consequently, we should expect a countercyclical relationship between output growth and capital outflows.[2]

In this paper, we uncover a new dimension to this pattern: data from the Penn World Tables on 119 developing, emerging, and developed countries reveal that for countries with a relatively higher volatility of output growth, the trade balance and the current account are less countercyclical. In other words, the more unstable the growth rate of output, the more it responds to unexpected favorable output shocks by exporting on net relatively more capital and goods than more stable countries. The correlation between output growth and capital outflows can then even be procyclical. In the logic of the consumption-smoothing motive within open-economy business cycle models, this pattern is hard to explain. Because only if a higher volatility of output growth were to coincide with a lower autocorrelation of output growth would the consumption-smoothing motive and correspondingly the countercyclicality of external imbalances be lower. However, it turns out that in the data there is no systematic relationship between the volatility and the autocorrelation of output growth, so that this explanation does not apply.

These findings are intricately linked to the empirical observation found in a recent literature that the net foreign asset position of a country is increasing with aggregate uncertainty, which we also find in our data set.[3] This can be theoretically justified as an increase of

[1]The textbook treatment of the approach is found in Obstfeld and Rogoff (1996).

[2]See for example Aguiar and Gopinath (2007) and Uribe and Schmitt-Grohe (2016) for documenting these patterns. In this paper, we go along with these authors and take movements at yearly frequencies to capture business cycle fluctuations. This convention in this literature largely owes to data availability.

[3]We take realized volatility to represent ex-ante uncertainty, which in the long-run should be closely

the precautionary savings in the presence of a higher expected volatility of income. Thus, at the aggregate level, a more volatile growth rate of output increases national savings as households aim at self-insuring against possible negative income shocks, which manifests itself in an increase in the long-run net foreign asset position when output growth becomes more unstable. This dependence emerges from OECD data for industrialized countries, as documented by Fogli and Perri (2015), who use rolling time windows over their sample to capture the time-variation in uncertainty and its effects on foreign assets.

The present paper shows how the long-run level and short-run cyclicality of net external asset positions are linked both in the data and in theory, through their dependence on the volatility on output growth. For our data set, we find that the dependence of the cyclicality of capital flows on the volatility of output growth is robust to controlling for a range of other factors. These factors include political stability, the diversification of a country's productive structure, its access to international financial markets, or its trade openness. Furthermore, we find that net foreign asset positions are higher for countries with on average higher output volatility. Thus we generalize the finding of Fogli and Perri (2015) for the long-run and to developing and emerging markets. Finally, it turns out that it is aggregate savings that increase with a more volatile growth rate of output, while investment does not respond.

For a structural interpretation of the relationship between output volatility and the cyclicality of external assets, we present a small-open-economy model where the growth rate of productivity is stochastic. We take explicit account of the precautionary savings motive, which becomes relevant when asset markets are incomplete, and proceed as Coeurdacier, Rey, and Winant (2011) by approximating the representative household's consumption Euler equations up to second-order to capture behavior towards risk.[4] We then solve the model for the risky steady state based on the implied first-order dynamics of the model. This allows us to endogenously pin down the net foreign asset position, which a first-order approximation of the Euler equations would leave undetermined. The model's state-space representation then allows us to show by simulation how the average riskiness of aggregate output not only affects the magnitude of the steady-state net foreign asset position, but also its cyclical dynamics, that is, the size and sign of the current account response to aggregate shocks. This latter aspect has so far been left unexplored in studies of international capital

related.

[4]See also De Groot (2014) for an application of this approach.

flows and can explain the patterns we have identified in the data.

As mentioned, Fogli and Perri (2015) focus on the time variation of macroeconomic uncertainty and find in OECD data that shocks to volatility lead to changes in net foreign assets of the same sign. They quantitatively explain this dependence in their simulation of a two country real business cycle model with a time-varying volatility of shocks to the level of productivity.[5] By contrast, we focus on the role of long-run uncertainty (as captured by observed volatility) for net foreign assets and also the cyclicality of capital flows.

Our findings add another perspective on the allocation puzzle identified by Gourinchas and Jeanne (2013) for the long-run relationship between productivity growth and capital flows. According to the present-value model of the current account, capital should flow towards fast growing countries. Gourinchas and Jeanne show that, in the data, the opposite is true in the long-run. In our data, this also applies to the short-run when output growth is very volatile: temporarily faster growth leads to capital outflows.

Closely related is also the study by Carroll and Jeanne (2009) who use a model of precautionary saving developed by Carroll (2007) to show that reducing the desired stock of saving in the rest of the world (via reducing the income risk households in the rest of the world face) causes mainly a decline in the world's capital stock outside the U.S. but not necessarily a decline in wealth in the U.S. The authors focus on idiosyncratic unemployment risk and the role of social insurance for the evolution of net foreign assets. In contrast, in this paper the precautionary savings motive is borne by the response to macroeconomic risk from the perspective of a small open economy model.[6]

Other research has focused on particular aspects of precautionary savings in the open economy. The related theoretical literature has so far focused on precautionary savings in the context of sudden stops in capital flows. Durdu, Mendoza and Terrones (2009) assess the optimal level of precautionary assets of a small open economy in response to business cycle volatility and the risk of a sudden stop. They conclude that these risks are plausible explanations of the observed surge in foreign exchange reserves in emerging market countries.[7] Jeanne and Ranciere (2011) show that high levels of international reserves for

[5] Because of the assumed level shocks to productivity, Fogli and Perri (2015) would obtain a procyclical current account, irrespective of the volatility of output growth.

[6] For example Carroll and Weil (1994), Loayza, Schmidt-Hebbel and Serven (2000) or Hausmann, Pritchett and Rodrik (2005) show that national saving rates of faster-growing emerging economies have been rising over time.

[7] Mendoza, Quadrini and Rios-Rull (2009) analyze the role of risk on the savings behavior of countries.

emerging markets can be explained by the attempt to insure against costly sudden stops.[8]

Gurio, Siemer, Verdelhan (2014) find a relationship between stock market volatility and external balances, where the stock market can be seen as an indicator of macroeconomic uncertainty. Their particular focus is on the behavior of international investors, who respond to higher expropriation risks in times of weak economic growth in a country by withdrawing capital.[9]

Sandri (2014) shows that the response of entrepreneurs to higher productivity growth tends to lead to current account improvements. This is driven by firms' need to self-finance investment which leads them to raise savings more than investment in relatively good times, due to a precautionary motive. Instead, our study relies on the role of household savings in generating a procyclicality in the current account and shows that this relationship crucially depends on the average degree of macroeconomic uncertainty that agents face.

The paper proceeds as follows. In the next section, we empirically investigate the procyclicality of the current account and its dependence on macroeconomic volatility. Section 3 develops a small open economy real business cycle model with a stochastic productivity growth rate and other sources of risk, such as spending shocks, to quantitatively confirm how uncertainty leads to precautionary savings and how rising uncertainty can change the sign of the cyclicality of the current account. Section 4 concludes.

2 The procyclicality of the current account

To investigate the procyclicality of the current account and its dependence on macroeconomic volatility we use annual data that cover 119 developing, emerging and industrialized countries over the period 1980 to 2007. The post-1980s period reflects an environment of increased capital mobility due to liberalized capital accounts. The key series are yearly real GDP growth and the stock of net foreign assets, respectively.[10] As our benchmark measure

They show that international financial integration can cause an accumulation of a large level of external liabilities by more financially advanced countries.

[8]However, Jeanne and Ranciere (2011) also argue that it is difficult to explain the build-up in the reserves of emerging-market Asia unless risk aversion and the costs of a sudden stop are high.

[9]We control for political risk in our empirical analysis.

[10]Before the 1980s the dynamics of the net foreign asset positions across countries were essentially flat. Kose et al. (2007) estimate a panel using the same data set on foreign assets and liabilities. They refer to the post-1980 period as the "financial globalization period".

of income uncertainty, we calculate the sample standard deviation of the growth rate of real GDP. Below we also use two alternative measures of income uncertainty. The full data set is listed in the Data Appendix and the countries included are listed in Table (4). The countries are also classified into rich and poor countries according to their per-capita GDP and as large, medium-sized and small countries according to their population.

Most data are taken from the Penn World Tables, and further include savings and investment rates, the trade balance, per capita GDP and the level of real GDP, which is also used to calculate output growth and volatilities. A host of other variables is included as controls, such that the selection of countries in our sample was determined by data availability.

2.1 A first glance at the data

The left panel of Figure (1) shows the cross-sectional correlation of capital outflows, measured by the change in net foreign assets, i.e., the current account, and output growth on the vertical axis and the volatility of output growth on the horizontal axis for the full set of 119 economies over the period 1980 to 2007.[11] The right panel measures capital outflows by the trade balance in deviations from its mean and relates their correlation with output growth to income uncertainty.

While the data features a large dispersion, a simple regression already points at the stylized pattern that we will analyze in more detail below: the correlation between output growth and the change in external balances increases with a higher volatility of output growth. The regression suggests a negative correlation for countries with stable income growth while higher uncertainty leads to a positive correlation. Such a positive correlation means that a higher growth rate is associated with capital outflows. This is the opposite of what the present-value model of the current account would suggest. Since we use country averages of annual growth rates, we confirm also at a short-term frequency what Gourinchas and Jeanne (2012) termed the "allocation puzzle".

The scatter plots and regression lines shown here can only be suggestive of patterns in the data. We now proceed to a more formal econometric analysis of the relationship

[11] We adjust the data on net foreign assets for valuation effects and in order to be consistent with the PPP-adjusted data used below we construct a deflator using the Penn World Tables, as described in the data appendix.

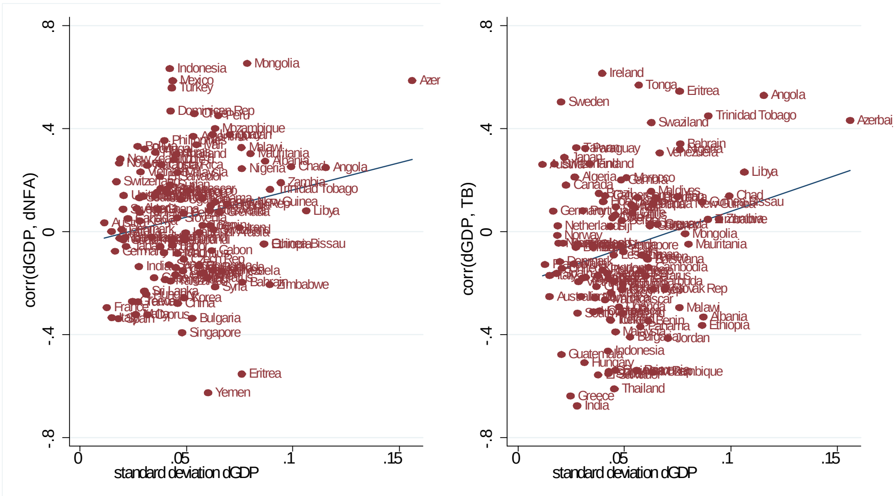

Figure 1: The relationship between the standard deviation of GDP growth (horizontal axis) and the correlations of the change in net foreign assets and the trade balance, respectively, with GDP growth (vertical axes).

between income uncertainty and the correlation between external balances and output growth.

2.2 Regressions

In the following, we present results for several cross-sectional regressions. We start by evaluating the role of income uncertainty by focusing on its effect on savings and investment rates. Then we regress the correlation between capital outflows and output growth on the standard deviation of real GDP growth and a large set of macroeconomic controls that may potentially affect this correlation.[12] We also regress the mean net foreign asset position on the same set of variables. In particular, we start with our baseline specification, which accounts for real GDP per capita, the size of the economy as measured by total GDP, and the average growth rate of GDP.

Real GDP per capita allows to control for differing levels of development across countries. To control for a country's size we include log(GDP). A small open country may be

[12]The cross-sectional analysis captures well the effects of long-run risk, we want to focus on. It also deals with the potential criticism that the results only reflect short-run effects of changes in net foreign assets driven by abrupt reversals in capital flows. The cross-sectional approach circumvents this by using averages over the time period 1980 to 2007.

able to adjust to changes in the macroeconomic environment more quickly and flexibly. However, due to less diversified production, smaller countries may be more vulnerable to real shocks than relatively larger countries and rely more on external adjustment in the aftermath of shocks than larger economies. Thus, the correlation of external balances with income growth should be higher. The average growth rate is added to control for the effects of output growth on income expectations and, hence, on international borrowing and lending. For example, a persistently positive growth rate may raise lifetime income and capital inflows.

In a second step we include further controls, such as the price of investment goods, openness as measured by the sum of exports and imports over GDP, the Chinn-Ito index of capital account openness and the AR(1) coefficient of output growth. The price of investment goods is included in our regression to control for its potentially procyclical effect on real investment, as suggested by Hsieh and Klenow (2007). A higher price of investment should then also be linked to increasing capital inflows to finance the higher investment. In the presence of income uncertainty, trade in goods and services is another channel of international diversification. Furthermore, the trade theory allows factor prices, such as the return on capital, to differ if countries operate under different technologies or degrees of competition. If industrialized countries are closer to the technological frontier, this might be another reason why capital does not necessarily flow from rich to poor countries.[13] To capture these possible effects, we include openness measured as the sum of exports and imports over GDP. To account for different degrees of international capital mobility across developing and industrialized countries, the Chinn-Ito index of capital account openness is added as an additional control variable. The reason for including the AR(1) coefficient as a measure of persistence is, that the intertemporal model of the current account can replicate a procyclical trade balance and current account for lowly autocorrelated shocks to output growth only. Thus, income persistence is an important control variable in order to rule out alternative explanations.

[13] However, the theorem by Stolper and Samuelson (1941) predicts that countries with high trade shares should experience a factor price equalization towards the world average. Thus, trade lowers the relative dispersion in factor prices between industrialized and less developed countries with relatively low levels of technology and might help to attract more capital.

2.2.1 Saving, investment, and income uncertainty

Table (5) shows the results of first regressing savings and investment rates on our baseline specification. For reasons of data availability, the savings and investment regressions are restricted to 87 and 111 countries, respectively.[14] The result of primary interest is that saving is indeed sensitive to income uncertainty, as measured by a higher standard deviation of GDP. This relationship is highly significant and robust to the inclusion of our first set of controls, as shown in column (1) and also together with the additional control variables in column (2). By contrast, investment as a fraction of GDP, however, does not respond significantly to income uncertainty as shown in columns (3) and (4). Notably, we find that the AR(1) coefficient of output growth exhibits no systematic relationship with the standard deviation of GDP and that it cannot explain the variation of savings across countries. This is also the case for the correlation between output growth and external imbalances, as we show below.

2.2.2 Income uncertainty and the procyclicality of capital flows

Having established that aggregate savings respond to macroeconomic uncertainty we now return to the open-economy dimension. In line with the pattern suggested by the scatter plots presented before, we regress the correlation of changes in output growth with either the change in net foreign assets or the trade balance on the standard deviation of income. We include in the regression successively the set of control variables used above and a dummy for the sign of the net foreign asset position.

The baseline results are shown in Table (6). For each variable we present the smaller model with the core variables first, which is then extended to a larger model with additional control variables analogous to the savings and investment regressions presented before. The results are in line with the pattern from the scatter plots. A higher standard deviation of output growth leads to a stronger positive correlation between capital outflows and output growth.

In column (1), GDP per capita and the size of the economy are statistically significant control variables. If we compare two arbitrary countries with the same growth rate and the same size, the country with the higher standard deviation of GDP would exhibit a

[14] Note that the empirical results presented below also hold within the sample of the restricted number of countries for which data on savings and investment are available.

higher correlation between output growth and capital outflows. The results in column (1) suggest capital outflows are countercyclical with a correlation between GDP and capital outflows of -0.63 if we do not condition on uncertainty. If uncertainty is accounted for, average capital outflows can turn from being countercyclical to procyclical if uncertainty is sufficiently large.

Controlling for additional structural characteristics, such as openness, the price of investment, capital account openness, and the AR(1) coefficient of output growth, does not change the positive and statistically significant effect output volatility has on the correlation between capital outflows and output growth.

The level of GDP, its ratio to population and the average growth rate are standard variables to control for the size, the level of development and the convergence process of sample countries. Typically, per-capita GDP soaks up all cross-country differences, thus leaving very little to explain for other variables. For most specifications, we find per-capita GDP and the level of GDP to be significant, although their effect is quantitatively small. The price of investment, a driver for aggregate investment, is not significant. Since we analyze open economies, we have to control for different degrees of openness for capital and trade flows, respectively. Below, we will extend the list of control variables even further.

It is important to note that the estimated constant in columns (1) and (3) is statistically significantly negative. Hence, in the absence of income risk we observe an on average negative correlation between output growth and capital outflows. Uribe and Schmitt-Grohe (2016) show that it is a stylized international business cycle fact that countries with a higher output growth should experience a deterioration of their current account as well as their trade balance. We show that for high output growth volatility, this finding is reversed.

When using the trade balance in deviations from its mean as a measure of external (im)balances, the standard deviation of income also enters positively and significantly throughout the corresponding columns (4) to (6).

In columns (3) and (6) of Table (6) we elicit the effect of income volatility for net debtor and creditor countries, respectively. This specification is motivated by the study of Benhima (2013), who shows that the long-run relationship between capital outflows and productivity growth depends on the sign of the net external position. We find that the effect of income uncertainty does not hinge on the country having on average foreign assets or liabilities.[15]

[15] While we use conventional least-squares to estimate the relationships, the results remain identical

We now show that higher macroeconomic uncertainty is associated with higher long-run net foreign asset positions. Therefore, we relate in column (7) of Table (6) the mean net foreign asset position to income uncertainty.[16] All three control variables enter positively and are statistically significant. Most importantly, income uncertainty remains a statistically significant explanatory variable with a positive effect on mean external assets.[17] This also holds when we regress our core set of controls in column (8).

To shed light on more homogenous sub-groups of countries, we define appropriate dummy variables to separate small and large economies and rich and poor economies, respectively. Our classification of countries is reported in Table (4). Table (7) provides estimates of the baseline regression for different sub-samples of countries. It turns out that the connection between income uncertainty and the growth-outflow nexus as well as the long-run net foreign asset position is particularly strong for relatively smaller and richer economies in our sample.

The saving behavior of households in open economies is not only influenced by macroeconomic determinants, but also by their average human capital endowment, the institutional quality of the economic environment and the stability of the political system. To account for these forces, we estimate separate regressions that contain the set of core explanatory variable and an indicator of the absence of corruption, the political stability and the accumulation of human capital.

Human capital plays an important role for economic growth. A country with more human capital should grow faster and should then also be associated with a higher inflow of international capital to finance the necessary build up of the capital stock. Furthermore, a higher level of human capital provides a better hedge against income uncertainty, since more human capital ensures a more stable income stream.

A lower institutional quality of the economic environment or an unstable political system

once we take account of the bounded nature of the dependent variables and switch to censored regression techniques.

[16]Note that the results do not hinge on expressing net foreign assets and the trade balance, respectively, as a fraction of current GDP. When using initial GDP instead, which is in spirit of Gourinchas and Jeanne (2012), the results remain qualitatively unchanged.

[17]The theoretical section to be presented below suggests that in response to shocks a higher long-run external asset position and higher capital outflows in the presence of higher income growth volatility occur simultaneously. To empirically account for this possibilty, we estimated both regression equations simultaneously using SUR. The results are confirmed within this estimation procedure.

are detrimental to capital inflows, in particular foreign direct investment, and will therefore affect the nexus between growth and capital inflows. In addition, a low institutional quality as such has adverse effects on growth.[18] Finally, political instability and poor institutional quality will increase uncertainty and might cause higher precautionary savings.

The results of this exercise are presented in Table (8). We find that few of the institutional variables enter the regressions significantly. Most importantly, however, the case of the standard deviation of income as a determinant of the correlation between growth and capital outflows and the mean net foreign asset position, respectively, survives once the institutional variables are considered.

To complete this section, we extend the list of control variables. We include the credit-to-GDP ratio to control for financial development. A more financially developed economy might be less credit constrained in times of low growth performance and has better access to international borrowing and lending. To further assess the possibility that a country can insure income risk through the diversification of its export structure, we include a measure of export diversification. For the dynamics of saving and investment, fiscal policy is an important driver. Therefore, we also include the mean and the standard deviation of government consumption relative to GDP. A country might run a sovereign wealth fund in order to save and diversify. We control for this by a separate dummy variable. Another control variable measures the absence of corruption, which also facilitates and efficient channeling of savings. Finally, we control for large financial centers, whose net foreign asset position might behave differently compared to other economies, by using an appropriate dummy variable. Again, the definitions of all variables are given in the appendix.

In addition to the full set of control variables, Table (9) also broadens the measurement of income risk. We not only use our benchmark measure, the standard deviation of income, but also two alternative measures.

International financial markets can be used to insure income risk through borrowing and lending only to the extent this risk is idiosyncratic in nature. We thus use a second measure of income uncertainty, which measure idiosyncratic uncertainty, to corroborate our findings. The idiosyncratic component of income growth is derived by regressing each country's GDP growth rate on a constant and the average growth rate of all countries in

[18] A lower institutional quality of the economic environment or a more unstable political system tend to lower the level of output and reduces the growth rate of the economy, as discussed for example by Easterly (1993).

the sample. The standard deviation of the residual is interpreted as idiosyncratic income uncertainty, $sd(\Delta GDP^{idio})$. The third measure reflects the income risk stemming from a country's average output loss in disaster years, $sd(\Delta GDP^{disa})$, defined as the 10 most deadly country-specific disasters in which the number of casualties is larger than 25.

The results show that all baseline results remain qualitatively unchanged when we add additional controls and use alternative indictors for income risk. All three measures are statistically significant throughout columns (1) to (8).

The next section presents a model that is able to replicate this pattern of precautionary savings and foreign asset accumulation, respectively.

3 Precautionary savings and asset accumulation

In this section, we show why and how income uncertainty may affect the net foreign asset position and the cyclicality of the current account and the trade balance. To this end, we present a simple open-economy real business cycle model where both the level and growth rate of technology, an aggregate spending component, and the world real interest rate are stochastic. The variation in the present value of income that results from these shocks is what drives current account movements.[19] Particularly the ex-ante perceived volatility of income drives the incentives to accumulate precautionary savings to reduce the volatility of consumption.

The next subsection develops the model and derives the representative households' optimality conditions for bond holdings and capital accumulation. Because the environment is not stationary, to find a solution all variables have to be normalized relative to the trending variable, that is technology. In the following subsection we outline the solution method and then focus on the consumption Euler equation for bonds to discuss the various aspects of volatility and covariance that motivate households' consumption smoothing and precautionary savings behavior.

In a subsection on qualitative and quantitative implications, we present the simulation of a calibrated version of the model. First, we focus on the effect of income growth volatility on the net foreign asset position, and second, we discuss the effects on the short-term correlation between output growth and the current account or the trade balance, and how

[19] See for example Hoffmann, Krause and Laubach (2013), who show the importance of trend growth expectations for explaining the U.S. current account vis-à-vis the rest of the world.

it relates to income volatility. We conclude this section with a discussion in a simplified version of the model of how uncertainty affects the reduced-form coefficients in the rational expectations equilibrium.

3.1 Model

Consider a small open economy populated with a continuum of infinitely lived identical households, who maximize expected life-time utility from consumption C_t

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

where $0 < \beta < 1$ is the discount factor, σ is the coefficient of relative risk aversion, and E_0 is the expectations operator, conditional on information available when the household optimizes. Each period, households earn income from their labor endowment and capital. There are two means of intertemporally shifting consumption: investing in the physical capital stock K_t, or in an international real bond B_t that pays an exogenously evolving world real interest rate r_t. The amount of bond holdings corresponds to a country's net foreign asset position. Capital must be non-negative, $K_t \geq 0$, and accumulates according to

$$K_t = (1 - \delta)K_{t-1} + I_t,$$

where $0 < \delta < 1$ is the depreciation rate and I_t is investment. The budget constraint reads

$$(1 + r_t)B_{t-1} + Y_t = C_t + I_t + S_t + B_t, \tag{2}$$

with output Y_t and S_t an aggregate spending shock, possibly capturing changes in government spending. A no-Ponzi game condition is assumed to hold for bonds, ruling out infinite borrowing by selling bonds. Output Y_t is given by

$$Y_t = (LZ_t)^{\alpha} K_{t-1}^{1-\alpha},$$

with Z_t denoting aggregate technology and L fixed labor supply, normalized to one.

Technology Z_t, spending S_t, and the world real interest rate r_t follow stochastic processes. Technology follows

$$\ln Z_t - \ln Z_{t-1} = g_t + \omega_t, \text{ with} \tag{3}$$

$$g_t = (1 - \rho)\, g + \rho g_{t-1} + \nu_t, \tag{4}$$

where the shocks ω_t and ν_t are i.i.d. white noise with variances σ_ω^2 and σ_ν^2, respectively. While ω_t induces level shifts in technology, ν_t temporarily changes its growth rate from its long-run growth rate g, with persistence ρ. Thus ν_t induces a sequence of expected changes to the level of technology. The stochastic processes for S_t and r_t are, respectively,

$$s_t = (1-\rho_s)s + \rho_s s_{t-1} + \varepsilon_t^s,$$

where $s_t \equiv S_t/Z_t$, is defined relative to technology, and $s = S/Z$, and

$$r_t = (1-\rho_r)\, r + \rho_r\,(r_{t-1}) + \varepsilon_t^r.$$

The two innovations ε_t^s and ε_t^r are also i.i.d. white noise shocks with variances σ_s^2 and σ_r^2.

The equilibrium conditions for this economy consist of two consumption Euler equations and two transversality conditions for bonds and capital, respectively, as well as the production function and the budget constraint. The two consumption Euler equations are:

$$C_t^{-\sigma} = \beta E_t\left[C_{t+1}^{-\sigma}\,(1+r_{t+1})\right] \tag{5}$$

and

$$C_t^{-\sigma} = \beta E_t\left[C_{t+1}^{-\sigma}\left(1+r_{t+1}^k-\delta\right)\right], \tag{6}$$

where $r_t^k = (1-\alpha)Z_t^\alpha K_{t-1}^{-\alpha}$ is the marginal product of capital. The transversality conditions rule out a too fast asset accumulation.

Since the economy is non-stationary due to the stochastic growth trend, the equilibrium conditions must be made stationary in order to characterize the rational expectations equilibrium dynamics of the model. This is achieved by expressing the trending variables relative to productivity, Z_t. We define this by lower case letters, i.e., $x_t = X_t/Z_t$ for some variable X_t. Then the stationary Euler equations are

$$c_t^{-\sigma} = \beta E_t\left[c_{t+1}^{-\sigma}\,(1+r_{t+1})\,dz_{t+1}^{-\sigma}\right] \tag{7}$$

and

$$c_t^{-\sigma} = \beta E_t\left[c_{t+1}^{-\sigma}\left(1+r_{t+1}^k-\delta\right)dz_{t+1}^{-\sigma}\right],$$

where $dz_t = Z_t/Z_{t-1}$, while the production function and budget constraint become

$$y_t = k_{t-1}^{1-\alpha}dz_t^{\alpha-1}$$

and

$$\Delta b_t = y_t + (1+r_t-dz_t)\frac{b_{t-1}}{dz_t} - c_t - i_t - s_t, \tag{8}$$

rewritten here in terms of the change Δb_t of the net foreign asset position b_t, in other words, the current account ca_t. The trade balance $TB_t = Y_t - C_t - I_t - S_t$ can be expressed relative to output $tb_t \equiv TB_t/Y_t$ as

$$tb_t = 1 - \frac{c_t}{y_t} - \frac{i_t}{y_t} - \frac{s_t}{y_t}, \tag{9}$$

which corresponds to the treatment of this variable in the data set. Note that for any x_t, we have that $x_t/y_t = X_t/Z_t/(Y_t/Z_t) = X_t/Y$, so that the stationary variables expressed in relative terms move in the same way as the corresponding ratios of the level variables.

The standard procedure to solve such models is to linearize the stationary equilibrium conditions derived above and solve for the rational expectations equilibrium dynamics. In general, this requires the application of numerical methods. Precautionary savings behavior is not captured by this procedure due to the certainty equivalence implied in the linear system. As is well known, this leaves the equilibrium net foreign asset position, $nfa_t \equiv b_t$; indeterminate. Typically, some stationarity-inducing mechanism is assumed that forces the system back to an exogenously given asset position.[20] In the present context, where the very aim is to capture precautionary behavior and to determine the equilibrium stock of savings, these methods are not suitable. The following subsection describes the approach used here as well as the results.

3.2 Solution

To solve the model and find its equilibrium dynamics, we follow Coeurdacier, Winant, and Rey (2011) as well as De Groot (2014) by deriving a second-order Taylor approximation of the two first-order conditions for consumption as a first step. Taking expectations, the optimality conditions then involve variances and covariances of the variables appearing in the Euler equations. Since the solution involves the third derivative of the utility function, the precautionary savings motive can be captured. A crucial step is to take as the expansion point for the approximation of those equations the expected level of consumption and output, rather than the deterministic non-stochastic steady-state levels. Otherwise, the effect of uncertainty on long-run asset positions would be unaccounted for.

The Euler equations and their second-order terms are then approximated linearly and combined with the first-order approximation of the remaining equilibrium conditions. This results again in a linear system, but, due to the procedure explained before, retains a role

[20] See for example the work by Schmitt-Grohe and Uribe (2003).

for uncertainty. The mathematical problem here is that consumption choices are based on perceived volatilities that arise in equilibrium, partly as a result of that very consumption behavior. Therefore, a fixed point problem has to be solved in which the volatility arising in equilibrium is equal to the volatility as perceived by agents when choosing consumption. That fixed point is the rational expectations equilibrium of the approximated system. In the following, we discuss the key equations exhibiting the relevant mechanisms and relegate the details of the solution procedure to an Appendix.

The rationale behind precautionary savings and the cyclicality of consumption can be well understood with the example of the Euler equation for bonds, equation (7). The same considerations apply to the Euler equation for capital. These equations feature the expectation of a product of functions of partly endogenous stochastic variables. The second-order Taylor expansion with the expectations of the variables as expansion points about which the approximation takes place can be written in terms of expected consumption growth as[21]

$$\left(\frac{E_t c_{t+1}}{c_t}\right)^{\sigma} = \hat{\beta}_t \times (1 + E_t r_{t+1}) \left(E_t dz_{t+1}\right)^{-\sigma}, \tag{10}$$

where we define a generalized discount factor

$$\begin{aligned} \hat{\beta}_t \;=\; \beta \Bigg[& 1 + \sigma(\sigma+1)\frac{1}{2}\left(\frac{var_t\left(c_{t+1}\right)}{(E_t c_{t+1})^2} + \frac{var_t\left(dz_{t+1}\right)}{(E_t dz_{t+1})^2}\right). \\ & -\sigma \frac{cov_t\left(c_{t+1}, 1+r_{t+1}\right)}{\left(E_t c_{t+1}\right)\left(1+E_t r_{t+1}\right)} + \sigma^2 \frac{cov_t\left(c_{t+1}, dz_{t+1}\right)}{(E_t c_{t+1})(E_t dz_{t+1})}\Bigg]. \end{aligned} \tag{11}$$

The first part of the approximated Euler equation reveals the familiar effects arising from changed prices of consumption today relative to consumption tomorrow, as given by the interest rate and the growth trend. For a constant discount factor $\hat{\beta}_t$, a higher expected return on bonds induces households to save more and reduce consumption in the current period relative to future periods. By contrast, higher expected productivity growth $E_t dz_{t+1}$ lowers expected growth in consumption relative to technology as households need to save less to keep the level of consumption constant.

In addition, there are the changes in intertemporal trade-offs from risk aversion and the precautionary savings motive, as captured by the generalized discount factor $\hat{\beta}_t$ in equation (11). The covariance terms enter because the correlation of consumption with the return of the savings instrument, in this case bonds, reduces the ability of agents to smooth consumption. The variances of consumption and technology enter because a higher

[21] We ignore terms of order higher than two, reflecting the approximation error.

volatility of relative consumption and income reduces future utility. This leads households to raise marginal utility today, thus to save more and lower consumption.[22] Note that, in all this, variances relative to squared expected values enter, in other words, the squared coefficients of variation govern consumption growth.

In the stochastic steady state, just as for the familiar case of a deterministic steady state, consumption relative to technology $c_t = C_t/Z_t$ is expected to be constant, so that $c = c_t = E_t c_{t+1}$. However, the associated levels of consumption turn out to be different. The steady-state consumption Euler equation for bond holdings is

$$\begin{aligned} 1 &= \beta (1+r) \, dz^{-\sigma} \\ & \times \left[1 + \frac{\sigma(\sigma+1)}{2} \left(\frac{var(c)}{c^2} + \frac{var(dz)}{dz^2} \right) - \sigma \frac{cov(c, 1+r)}{c(1+r)} + \sigma^2 \frac{cov(c, dz)}{cdz} \right]. \end{aligned} \tag{12}$$

First of all, note that $dz^{\sigma} > \beta(1+r)$ since the term in square brackets is generally positive. Since $dc = dz$ in steady state, consumption growth is higher than the discounted return on bonds. Without risk, we would expect the interest rate to rise or consumption growth to drop if savings is unattractive until equality is restored. With risk, households are effectively more patient.

The key mechanism reveals itself best when abstracting from movements in the world real interest rate and capital. Then output is proportional to technology – the driver of fluctuations – and $c = C/Z$ is proportional to C/Y, the consumption to output ratio as measured in the data. Also, $cov(c, 1+r) = 0$. Now compare an economy with a high variance of dz to one with a low variance and realize that the squared growth rate dz^2 is constant. A rise in $var(dz)$ would be associated with a higher discount factor $\hat{\beta}$: all else equal, consumption growth would be expected to increase. However, higher savings in a safer asset must reduce the sum of the variance of consumption and the covariance of consumption with productivity growth. How strongly both fall depends on the specific calibration, discussed below.

From the steady-state equation, a particular variance of technology growth implies a unique level of consumption. The same logic would apply to domestic capital and investment. With consumption, investment and spending given here, we can infer the particular net foreign asset position that is consistent with this level of consumption. In steady state,

[22] See Coeurdacier, Winant, Rey (2011) for a similar discussion for a smaller model without a stochastic growth trend.

when net foreign assets are constant, i.e., $nfa = b = b_t = b_{t-1}$, it must be that

$$\frac{b}{y} = -\frac{1 - a/y}{1 + r - g} g, \tag{13}$$

where absorption is defined as $a = c + i + s$. For c, i, and s at their steady-state values, and given g and $r > g$, the net foreign asset position is determined.[23] A positive amount of international savings, b, finances consumption that is higher than production. Somewhat counter-intuitively, as one might expect risk to have a detrimental effect, higher precautionary savings lead to higher consumption, as agents have higher interest income. A positive b also means that the trade balance $tb = 1 - a/y$ is necessarily negative in steady state.[24]

3.3 Simulations

With the solution describing the dynamic evolution of the economy, we need to assign parameter values to assess in the model the implications of a higher volatility of output growth on consumption, the trade balance, and the net foreign asset position. Here, we follow the literature on emerging market real business cycles, which typically considers yearly frequencies, due to data availability. The long-run, trend growth rate of the economy g is set to a yearly rate of 4 percent, which is the average of the 119 countries in our data set. Time preference, as given by the discount factor β, equals 0.96 at the yearly frequency (see also Obstfeld and Rogoff, 1996). The real interest rate, r, is set to 5 percent, a common value in the real business cycle literature for emerging market economies (see Cicco, Pancrazi and Uribe, 2010 or Obstfeld and Rogoff, 1996). Following Cicco, Pancrazi and Uribe (2010) we set the persistence ρ of deviations of the growth rate g_t from the long-run trend equal to 0.82. The annual depreciation rate of capital is 10 percent, and the intertemporal elasticity of substitution of consumption is set to $\sigma = 1$.

The relationship between the discount factor β, the interest rate r, and the trend growth rate of the economy $dz = 1 + g$ is crucial for the magnitudes and the importance of the precautionary savings motive. As can be seen in equation (12), when $\beta(1 + r)dz^{-\sigma}$ is close to one, the squared coefficients of variation must in steady state be very small. To

[23] Importantly, the condition that the world real interest rate r is larger than the economy's growth trend, $r > g$, ensures that the present value of the resources of the economy is bounded.

[24] In other words, the trade deficit, $tb_t < 0$, must be backed by a positive long-run external asset position $b > 0$, to be able to finance the higher absorption. Durdu, Mendoza and Terrones (2013) provide empirical evidence on this using an error-correction model.

achieve this, the steady-state net foreign asset position must turn out to be quite large, to reduce consumption volatility sufficiently. Therefore, we set the factor $\beta(1+r)$ sufficiently below one to allow the volatility of consumption to be within a plausible range for the output volatility that we consider. Nonetheless, the simulation results below should not be considered a quantitative evaluation of the model. Our focus here is solely on confirming numerically the direction of qualitative effects of differences in output volatilities across countries.

3.3.1 The long-run external asset position

We start with a discussion of the implication of the effect of higher average output growth volatility on the long-run net foreign asset position. Consider the following illustrative calibration: the sample average of the volatility of output growth, $stdev(dY)$, across our 119 countries is about 4.8 percent. We set the standard deviation of the growth rate shock σ_ν equal to 0.007 and level shock σ_ω equal to 0.03, while the standard deviation of the world real interest rate disturbance σ_r is set to 0.05 and of the spending shock σ_s is equal to 0.015, following Cicco, Pancrazi and Uribe (2010). We also use their estimates with respect to ρ^s, which is equal to 0.29, while ρ^r is set at the higher end of their estimates, equal to 0.95. Those values are close to our sample average of the volatility of output, equal to around 4.8 percent. The average volatilities of output have a standard deviation of around 2.4 percent across countries. We therefore show the effects of an increasing output volatility on the long-run consumption and external asset position within this range. It can be seen in Table (1) that a small open economy with a higher output growth volatility experiences a higher long-run external asset position compared to a country with a lower output growth volatility, conditional on the steady-state growth rate. This is in line with one of the stylized facts established in the empirical section.

The table shows two further important implications of higher volatility, consistent with the above discussion of the approximated Euler equation. The higher net foreign asset position is associated with a higher level of consumption, as households receive interest payments on their larger stock of assets. This implies an on average negative trade balance. Furthermore, the volatility of consumption is slightly higher for highly volatile countries, but by much less than the underlying volatility of output growth. This smoothing effect is achieved on the one hand by a somewhat larger fraction of income from abroad that is more stable than domestic income. On the other hand, households increase their consumption by less when output growth rises, due to the precautionary motive mentioned above. A larger fraction of income is saved rather than consumed, as precaution against the more likely future growth revisions. Finally note that the more negative covariation of consumption with productivity growth implies a more positive cyclicality of the trade balance. This implication will be discussed further in the following subsection.

Table 1: Risk and the external position

Output growth volatility $stdev(dy_t)$	low risk 0.024	sample mean 0.048	high risk 0.072
Consumption (c/y)	0.247	0.248	0.250
$stdev(c_t)$	0.098	0.100	0.102
$cov(c_t, dz_t)$	-0.000	-0.001	-0.004
External Assets (b/y)	3.234	3.322	3.472

Notes: The sample mean-risk environment is obtained with the standard deviations described in the text, and scaled proportionately down and up for the low-risk and high-risk environments, respectively, to obtain the required standard deviations of output.

3.3.2 The correlation between output growth and capital outflows

In this section we compare the qualitative predictions of the model regarding the effects of output growth volatility on the correlation between capital outflows and output growth, $corr(\Delta nfa, \Delta y)$, as well as $corr(tb, \Delta gdp)$ at the annual frequency. To do so, we compute model-implied data by simulating 1000 data series for three countries that differ with regard to the volatility of the exogenous shocks. For each country, choosing the volatility of the stochastic disturbances to match the actual average output growth volatility of the country type in question. The different stochastic disturbances are adjusted proportionately, keeping their relative importance unchanged. A full quantitative assessment of the relative magnitudes on the sources of volatility for each country is beyond the scope of this paper. However, when simulating the data series we also account for the country specific underlying growth trend. The results are summarized in table (2).

The numbers in the table are consistent with the empirical relationship established in the paper between output growth volatility and the cyclicality of the trade and of capital flows. The trade balance becomes less countercyclical the higher the standard deviation of output

Table 2: Risk and capital outflows

Output growth volatility $stdev(dy)$	low risk 0.024	sample mean 0.048	high risk 0.072
$corr(\widetilde{tb}_t, dy_t)$	-0.070	-0.044	0.008
$corr(\Delta\widetilde{b}_t, dy_t)$	-0.076	-0.073	-0.055

growth is, and may even turn out procyclical for very high volatilities. Similarly, the current account, i.e., the change Δb in the net foreign asset position b becomes less countercyclical as volatility increases. The more volatile income becomes, the less do households draw on funds accumulated abroad to stabilize their consumption path.

In summary, this section has shown that a simulation of the model is consistent with the empirical results by relating the income volatility to a precautionary savings motive of households. Through this mechanism, households increase their savings to accumulate a buffer stock of foreign assets in the long-run to insure against the presence of higher uncertainty about the future expected income stream in order to keep consumption stable. A higher long-run net foreign asset position requires to accrue in the short-run more net foreign assets so that in the short-run capital outflows occur even when output growth is high. As a result, a more positive relationship between capital outflows and output (growth) at annual frequency occurs as uncertainty increases.

3.4 The mechanism in a simplified model

The preceding discussion has shown how the empirical findings on the cyclicality of the trade balance and the current account can be replicated qualitatively in the simple open-economy model that is analyzed to explicitly allow for the precautionary savings motive. In this section, we dig a little further into the mechanism that brings these effects about, but highlighting how differences in volatility affect the response parameters in a simplified version of the model. This simplified model only features technology shocks and has no capital. Thus all intertemporal reallocation of consumption has to take place via the risk-free bond traded in international markets at a given interest rate r. For simplicity, we also set $\sigma = 1$.

Recall that the solution of the system involves the first-order approximation of the equilibrium conditions of the economy, thus also of the second-order Taylor expansion of the consumption Euler equation. Therefore, equation (10) along with equation (11) becomes

$$\widetilde{c}_t = E_t \widetilde{c}_{t+1} \Gamma_{c,c} + E_t dz_{t+1} \Gamma_{c,dz}, \tag{14}$$

where $\widetilde{x} = \ln(x_t/x)$ and the response coefficients are given by

$$\Gamma_{c,c} = \left[1 + \frac{\beta}{dz} \left(\frac{cov(c,dz)}{dzc} + (1+r)\, 2 \frac{var(c)}{c^2} \right) \right] \tag{15}$$

and

$$\Gamma_{c,dz} = \frac{\beta}{dz} \left[(1+r) \left(1 + \frac{var(c)}{c^2} + 3 \frac{var\,(dz)}{dz^2} \right) + 2 \frac{cov(c,dz)}{cdz} \right]$$

which incorporate both the direct effects of higher growth on consumption as well as the indirect effects through the effect on the variances and covariances. Notably, since a high variance of technology growth lower the variance of consumption and the covariance of consumption and technology, the responsiveness $\Gamma_{c,c}$ of current consumption to higher expected consumption is reduced. In other words, the consumption smoothing motive is weakened after shocks in the presence of high risk.

The remaining equations of the system are the linearized budget constraint and the description of technology, given the processes defined above, that is,

$$c\widetilde{c}_t + \widetilde{b}_t = \widetilde{b}_{t-1} \frac{(1+r)}{dz} - dz_t b \frac{(1+r)}{dz} \tag{16}$$

and

$$dz_t = g_t + \omega_t. \tag{17}$$

The solution to the system involves postulating linear decision rules for consumption and asset holdings, and then determining the coefficients by mapping the assumed decision rule with the system.[25] These rules are

$$\widetilde{c}_t = a_{cb} \widetilde{b}_{t-1} + a_{cg} g_t + a_{c\omega} \omega_t$$

and

$$\widetilde{b}_t = a_{bb} \widetilde{b}_{t-1} + a_{bg} g_t + a_{b\omega} \omega_t$$

Having established the evolution of $\widetilde{c}_t$ and $\widetilde{b}_t$ we can write the remaining variables of interest in linearized form as

$$\widetilde{tb}_t = -c\widetilde{c}_t \text{ and } \widetilde{\Delta nfa}_t = \frac{r}{dz} \widetilde{b}_{t-1} - \frac{rb}{dz} \widetilde{dy}_t - c\widetilde{c}_t. \tag{18}$$

[25] For external assets, $\widetilde{b}_t$, the trade balance, $\widetilde{tb}_t$, and capital flows, $\widetilde{\Delta b}_t$, we define $\widetilde{x} = x_t - x$.

The correlations between the trade balance and capital flows with output growth thus depend on the coefficients that govern the responsiveness of consumption and assets to changes in growth, a_{cg} and a_{bg}.

Finally, to fully solve the model *conditional* moments have to be defined. Since we assume that the shocks are uncorrelated among each other, it follows from (17) and the decision rules that

$$var(c) = a_{cg}^2 \sigma_v^2 + a_{cw}^2 \sigma_w^2 \text{ and } var(dz) = \sigma_v^2 + \sigma_w^2. \tag{19}$$

In other words, these are the one period ahead variances of consumption and output, as perceived by agents in a given period, rather than the unconditional, that is, average, variances. The covariance between output growth and consumption is given by

$$cov(c, dz) = a_{cg} \sigma_v^2 + a_{cw} \sigma_w^2. \tag{20}$$

With these equations at hand, we are able to solve for the stochastic steady state. There are four unknown variables, c, b, $var(c)$ and $cov(c, dz)$, for which we have four equations given by (12), (13), (19) and (20). This fixed point problem can be solved using an iterative non-linear procedure.

Table (3) lists the resulting coefficients:

Table 3: Solutions from simplified model

$\widetilde{c}$	$\widetilde{b}$
$a_{cb} = \frac{\Gamma_{c,c} \frac{(1+r)}{dz} - 1}{\Gamma_{c,c} c}$	$a_{bb} = \frac{1}{\Gamma_{c,c}}$
$a_{cg} = \frac{\Gamma_{c,dz} \rho - \Gamma_{c,c} a_{cb} b \frac{(1+r)}{dz}}{(1 - \Gamma_{c,c} \rho) + \Gamma_{c,c} a_{cb} c}$	$a_{bg} = \frac{a_{cg}(1 - \Gamma_{c,c} \rho) - \Gamma_{c,dy} \rho}{\Gamma_{c,c} a_{cb}}$
$a_{c\omega} = \frac{\Gamma_{c,c} a_{cb} b \frac{(1+r)}{dz}}{\Gamma_{c,c} a_{cb} c - 1}$	$a_{b\omega} = \frac{a_{c\omega}}{\Gamma_{c,c} a_{cb}}$

One can see in the table for example how $\Gamma_{c,c}$ affects the cyclical responsiveness of the net foreign asset position to growth shocks, as given by a_{bg}. Recall from the discussion of equation (15) that a higher volatility of productivity growth reduces that coefficient. This in turn follow from inspection of the steady-state Euler equation (10). Now a lower $\Gamma_{c,c}$ also unambiguously increases a_{bg} : a positive innovation to growth g_t affects foreign assets more strongly when the volatility of output growth (as caused by productivity growth) is high. Another important observation comes from the role of foreign assets for the responsiveness of consumption to growth innovations. The higher the asset position b, all else equal, the smaller will be the response of consumption a_{cg}, as seen in the second row in the column denoted $\tilde{c}$. It may even turn negative, which implies that the response of the trade balance may turn positive.

Having established earlier the relationship between the long-run external asset position and output volatility, we now turn to the business cycle effects. Figure (2) displays impulse response functions for a 0.1 percent innovation to the growth rate of technology in deviations from the steady state, the black solid line in panel (a). The figure demonstrates how risk, as captured by output growth volatility, affects consumption, the trade balance and capital flows over the business cycle. The scenarios only differ in the volatility of output growth, while the underlying growth trend and the innovations to it are the same. The green dashed line reflects the low standard deviation of output growth, in line with the analysis above, the red dot-dashed line shows an environment with average standard deviation, while the blue solid line displays the reaction of the economy for an environment with high volatility.

An innovation to the growth rate leads in all scenarios to an increase in consumption relative to output, as shown in panel (b) of Figure (2). Households in the model perceive themselves as richer even because of the expected continued increase in income, which induces them to borrow to also raise consumption today. This effect is due to the high autocorrelation of output growth mentioned in the introduction. As a consequence, domestic absorption increases and the trade balance in panel c. deteriorates. More international capital flows into the country, shown by the negative response to capital outflows in panel d.

Importantly, figure (2) shows that the magnitude and evolution of the responses depend on the average volatility output growth. The higher the perceived risk in the economy, the more reluctant households are to carry future income into the present, avoiding drawing down on their precautionary savings. This is reflected in the smaller response of consumption under the high volatility scenario. Consequently, the trade balance turns less negative and net capital inflows rise less. The reason for the difference in impulse responses lies in the way that uncertainty shapes the response of the generalized discount factor $\hat{\beta}$ in equation (10). The higher the volatility, the stronger the response of $\hat{\beta}$ to a positive innovation in the growth rate, thus offsetting the incentives to borrow, as mandated by the increase

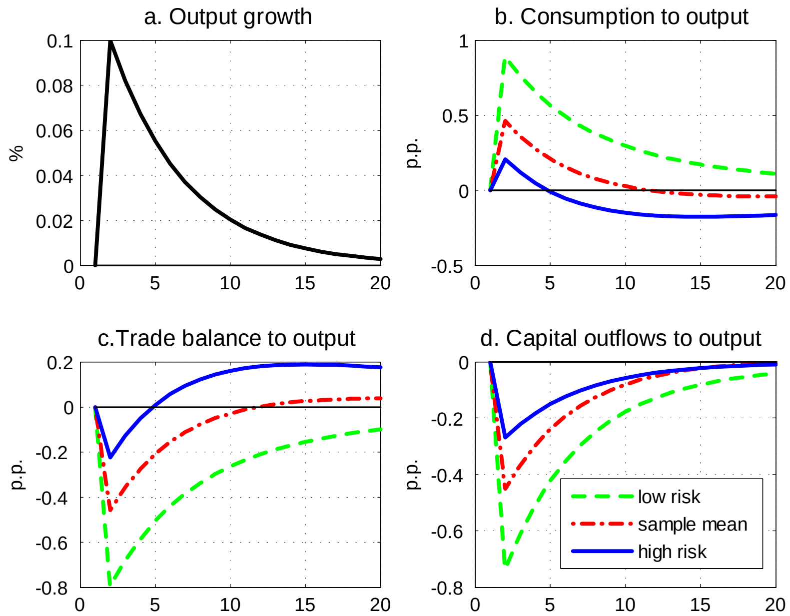

Figure 2: Responses to a positive growth rate shock to productivity for different risk scenarios. *Notes:* The low risk environment is obtained by setting the standard devation of output growth equal to 0.024, the sample mean environment by setting it equal to 0.048 and the high risk environment by setting it equal to 0.072, respectively.

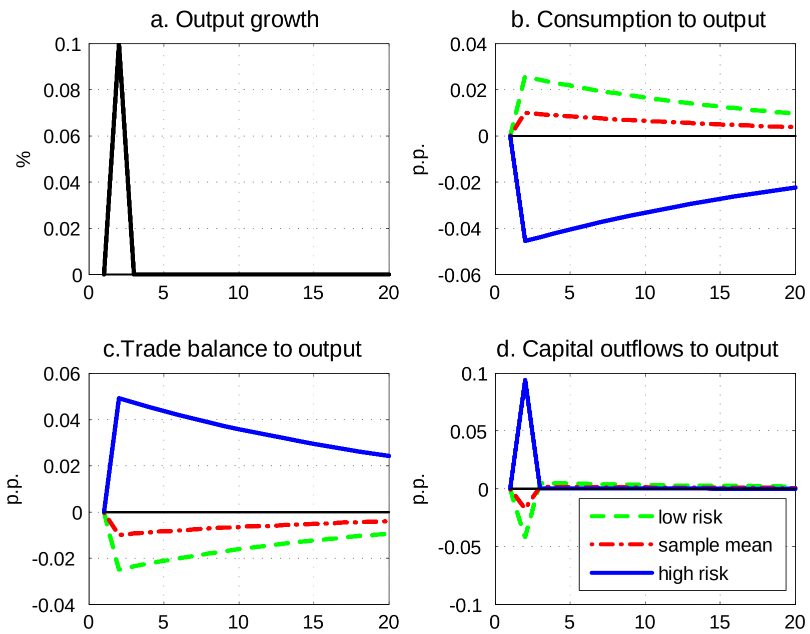

Figure 3: Responses to a positive level shock to productivity for different risk scenarios. *Notes:* The low risk environment is obtained by setting the standard devation of output growth equal to 0.024, the sample mean environment by setting it equal to 0.048 and the high risk environment by setting it equal to 0.072, respectively.

in the expected growth rate $E_t dz_{t+1}$.

Figure (3) shows the response of the economy to a 0.1 percent innovation to the level, not the growth rate, of technology, as shown in panel (a). The responses are distinctly different: depending on the degree of uncertainty, consumption may slightly rise or fall after a one-time shift in technology, as shown in panel *b*. Under low to medium risk, households raise their consumption relative to income, by about 20 percent of the income increase. As risk becomes high, households in fact shift more income into foreign assets. As their consumption drops relative to the higher income, they only increase the level of consumption by about 60 percent. The rest is saved. Most importantly, economies with high output volatility, and thus risk, tend to save more of the windfall gain in productivity, than countries with low output volatility. This also highlights the force working against borrowing when the growth rate increases, as shown in the previous graph.

4 Conclusions

This paper sheds light on the role of output growth volatility for the cyclicality of capital flows and the trade balance, and for the long-run net foreign asset position of a country. It adds to the existing literature by not only showing that average volatility raises the stock of assets abroad, but that it also tends to cause capital and goods outflows to become more procyclical. We show that this patterns holds both in the data and in theory. Our evidence is based on 119 developed, developing, and emerging economies. We control for a variety of additional factors that could plausibly explain the findings.

A stochastic open-economy growth model with its intertemporal optimality conditions for consumption approximated to second order is able to qualitatively replicate these findings. The key mechanism is a precautionary savings motive which induces households to accumulate a larger stock of assets when income is more uncertain. Households respond to favorable growth shocks by using less of an unanticipated increase in income growth for current consumption when growth is perceived to be more unstable.

5 Appendix: Data

Following Gourinchas and Jeanne (2012), all variables are PPP adjusted. Data expressed in current USD, such as data taken from Lane and Milesi-Ferretti's External Wealth of Nations data set are converted into constant international USD, the denomination used by the Penn World Tables (PWT), by dividing them by the deflator Q

$$Q = PI \frac{CGDP}{RGDP},$$

where PI_t is the price of investment goods and $CGDP_t$ and $RGDP_t$ are GDP levels in current and constant international USD, respectively.

The data is annual and covers 119 countries over the period 1980 to 2007. The countries included are listed in Table (4). The countries are also classified as rich countries and poor countries according to their per-capita GDP and as large, medium-sized and small countries according to their population. Details are also given in Table (4).

5.1 Dependent variables

The following data are used to construct the dependent variables:

1. The savings rate (S/GDP) in constant local currency units is taken from the World Development Indicators.

2. The investment rate (I/GDP) in constant local currency units is taken as gross capital formation from the World Development Indicators.

3. The net foreign asset position (NFA) in current USD is taken from the External Wealth of Nations data set, divided by Q_t to obtain constant international USD and expressed in percent of GDP in constant international USD taken from the PWT. The average annual change in net foreign assets is denoted $\Delta \widetilde{nfa}$, the average net foreign asset position is $\widetilde{NFA}$.

4. The trade balance (TB), measured as exports minus imports in current USD, is taken from the PWT and also expressed in percent of (nominal) GDP from the PWT. We use the demeaned trade balance in the estimation ($\widetilde{tb}_t$).

5.2 Explanatory variables

1. Per capita real GDP ($GDPpc$) is taken from the PWT.

2. The level of real GDP (GDP), which is obtained from multiplying $GDPpc$ by the size of the population taken from the PWT. We also employ the average growth rate of real GDP (ΔGDP).

3. The price of investment goods (PI) is taken from the PWT.

4. A measure of openness to trade ($openn$) is constructed as the sum of exports and imports over GDP, both taken from the PWT.

5. The Chinn-Ito index ($chinn - ito$) is used to measure the degree of capital account openness (Chinn and Ito 2008).

6. The persistence of ΔGDP is measured by the country-specific AR(1) coefficient ($AR(1)$) on output growth.

7. The idiosyncratic income risk (ΔGDP^{idio}) is obtained as the residual from a regression of the ΔGDP series on the cross-country average growth rate. Thus, the residual captures the fraction of real growth that is not explained by global growth.

8. The output loss due to natural disasters (ΔGDP^{disa}) is calculated as a country's average output loss in disaster years. Disaster years are the years with the 10 most deadly country-specific disasters, provided that the individual number of casualties is larger than 25. The source of the disaster data is `http://www.emdat.be/country_profile/index.html`

9. The degree of financial development is measured the ratio of credit to GDP ($Credit/GDP$). The data is taken from the World Development Indicators.

10. The mean ($mean\ G$) and the standard deviation ($sd\ G$) of real government consumption are based on the "csh_g" series in the PWT.

11. The diversity of a country's export structure is measured by the export diversification index (exp div index). The index is taken from Ng (2002).

12. A dummy variable (SWF) is one if the country maintains a sovereign wealth fund that belongs to the 30 largest sovereign wealth funds as listed by the Sovereign Wealth Fund Institute and zero otherwise.

13. The institutional quality is measured by the corruption index (*transp*) provided by Transparency International. The index ranges from 0 (highly corrupt) to 10 (highly transparent).

14. Political stability (*polstab*) is measured by the Index on Political Stability and Absence of Violence provided by the Political Risk Services International Country Risk Guide.

15. A dummy indicating financial centers (*FinCenter*) is one for Hong Kong, Ireland, Singapore and the UK and zero otherwise.

16. The average years of schooling (*schooling*) of the population aged 15 and above, averaged over the sample period, is taken from the Barro-Lee database.

6 Appendix: Model

This appendix provides the solution to the model with an endogenous capital stock. Given the discussion of the stochastic steady state in section 3.2 the dynamics of the model are derived.

6.1 Linearized system

In the following we assume that $\sigma = 1$. Note that $\widetilde{x} = \ln(x_t/x)$ while for external assets, $\widetilde{b}_t$, the trade balance, $\widetilde{tb}_t$, and capital flows, $\widetilde{\Delta b}_t$, we define $\widetilde{x} = x_t - x$. We linearize around the stochastic steady state. Using (10) and (11) we have

$$\begin{aligned} & \widetilde{c}_t + E_t(\widehat{1+r_{t+1}})\frac{\beta}{dz}\left[1+\frac{var\,(c)}{c^2}+\frac{var\,(dz)}{dz^2}\right] \qquad (21) \\ = \quad & E_t\widetilde{c}_{t+1}\left[1+\frac{\beta}{dz}\left(\frac{cov\,(c,dz)}{dzc}+(1+r)\,2\frac{var\,(c)}{c^2}-\frac{cov\,(c,1+r)}{c}\right)\right] \\ & +E_t dz_{t+1}\frac{\beta}{dz}\left[(1+r)\left[1+\frac{var\,(c)}{c^2}+3\frac{var\,(dz)}{dz^2}\right]+2\frac{cov\,(c,dz)}{cdz}-\frac{cov\,(c,1+r)}{c}\right]. \end{aligned}$$

At the deterministic steady state, where $1/\beta = (1+r)/dz$, we have $\widetilde{c}_t + \widehat{1+r_{t+1}} = E_t\left[\widetilde{c}_{t+1} + dz_{t+1}\right]$. From the capital and consumption Euler equations (6) it follows that

$$\begin{aligned} & \widetilde{c}_t + E_t(\widehat{r^k_{t+1}})\frac{\beta}{dz}\left[1+\frac{var\,(c)}{c^2}+\frac{var\,(dz)}{dz^2}\right] \qquad (22) \\ = \quad & E_t\widetilde{c}_{t+1}\left[1+\frac{\beta}{dz}\left(\frac{cov\,(c,dz)}{dzc}+\left(1+r^k+\delta\right)2\frac{var\,(c)}{c^2}-\frac{cov\left(c,r^k\right)}{c}\right)\right] \\ & +E_t dz_{t+1}\frac{\beta}{dz}\left[\left(1+\overline{r^k}+\delta\right)\left[1+\frac{var\,(c)}{c^2}+3\frac{var\,(dz)}{dz^2}\right]+2\frac{cov\,(c,dz)}{cdz}-\frac{cov\left(c,r^k\right)}{c}\right] \end{aligned}$$

Again, at the deterministic steady state this would be equal to $E_t(\widehat{r^k_{t+1}}) = E_t(\widehat{1+r_{t+1}})$. Furthermore, from marginal product of capital we have

$$E_t(\widehat{r^k_{t+1}}) = (1-\alpha)\,\alpha dz^\alpha k^{-\alpha}\left(E_t dz_{t+1} - \widetilde{k}_t\right) \text{ and } \widehat{r^k_t} = (1-\alpha)\,\alpha dz^\alpha k^{-\alpha}\left(dz_t - \widetilde{k}_{t-1}\right).$$

Output can be written as

$$\widetilde{y}_t = (1-\alpha)\left(\widetilde{k}_{t-1} - dz_t\right).$$

From the budget constraint it follows that

$$c\widetilde{c}_t + \widetilde{b}_t + k\widetilde{k}_t + \widetilde{s}_t = y\widetilde{y}_t + \widetilde{b}_{t-1}\left(\frac{(1+r)}{dz}\right) - dz_t\frac{b\,(1+r)}{dz} + \widehat{1+r}_t\frac{b}{dz} + \left(\widetilde{k}_{t-1} - dz_t\right)\frac{k\,(1-\delta)}{dz},$$

which becomes

$$c\widetilde{c}_t+\widetilde{b}_t+k\widetilde{k}_t+\widetilde{s}_t=\widetilde{b}_{t-1}\Gamma_{\widetilde{b}}+\widehat{1+r}_t\frac{b}{dz}+\widetilde{k}_{t-1}\Gamma_{\widetilde{k}}-dz_t\Gamma_{dz} \tag{23}$$

where

$$\begin{aligned}\Gamma_{\widetilde{b}} &= \frac{(1+r)}{dz}\\ \Gamma_{\widetilde{k}} &= \frac{(1-\delta)\,k+(1-\alpha)\,dzy}{dz}\\ \Gamma_{dz} &= \frac{(1+r)\,b+(1-\delta)\,k+(1-\alpha)\,dzy}{dz}\end{aligned}$$

Given equations (21)-(23), the relevant linearized system can be summarized by

$$\widetilde{c}_t+E_t(\widehat{1+r_{t+1}})\Gamma_{c,r} = E_t\widetilde{c}_{t+1}\Gamma_{c,c}+E_tdz_{t+1}\Gamma_{c,dz}, \tag{24}$$

$$\begin{aligned}\left(c+\frac{\Gamma_{\widetilde{k}}\Gamma_{r^k,c}}{\Gamma_{r^k}}\right)\widetilde{c}_t+\widetilde{b}_t+\widetilde{s}_t-E_t(\widehat{1+r_{t+1}})\frac{k}{\Gamma_{r^k}} &= \widetilde{b}_{t-1}\Gamma_{\widetilde{b}}+\widehat{1+r}_t\left(\frac{b}{dz}-\frac{\Gamma_{\widetilde{k}}}{\Gamma_{r^k}}\right)\\ &\quad -dz_t\left(\Gamma_{dz}-\Gamma_{\widetilde{k}}\left(1-\frac{\Gamma_{r^k,c}}{\Gamma_{r^k}}\right)\right)\\ &\quad +E_t\widetilde{c}_{t+1}k\frac{\Gamma_{r^k,c}}{\Gamma_{r^k}}-k\left(1-\frac{\Gamma_{r^k,c}}{\Gamma_{r^k}}\right)E_tdz_{t+1},\end{aligned} \tag{25}$$

given

$$\Gamma_{c,r}=\frac{\beta}{dZ}\left[1+\frac{var\,(c)}{c^2}+\frac{var\,(dz)}{dz^2}\right]$$

$$\Gamma_{c,c}=\left[1+\frac{\beta}{dz}\left(\frac{cov\,(c,dz)}{(dz)\,c}+(1+r)\,2\frac{var\,(c)}{c^2}-\frac{cov\,(c,1+r)}{c}\right)\right]$$

$$\Gamma_{c,c,k}=\left[1+\frac{\beta}{dz}\left(\frac{cov\,(c,dz)}{(dz)\,c}+\left(1+r^k+\delta\right)2\frac{var\,(c)}{c^2}-\frac{cov\left(c,r^k\right)}{c}\right)\right],$$

$$\Gamma_{c,dz}=\frac{\beta}{dZ}\left[(1+r)\left[1+\frac{var\,(c)}{c^2}+3\frac{var\,(dz)}{dz^2}\right]+2\frac{cov\,(c,dz)}{cdz}-\frac{cov\,(c,1+r)}{c}\right]$$

$$\Gamma_{c,dz,k}=\frac{\beta}{dz}\left[\left(1+r^k\right)\left[1+\frac{var\,(c)}{c^2}+3\frac{var\,(dz)}{dz^2}\right]+2\frac{cov\,(c,dz)}{cdz}-\frac{cov\left(c,r^k\right)}{c}\right].$$

$$\Gamma_{r^k,c}=\frac{\left(\left[\left(1+r^k+\delta\right)-(1+r)\right]2\frac{var(c)}{c^2}-\frac{cov\left(c,r^k\right)-cov(c,1+r)}{c}\right)}{\left[1+\frac{var(c)}{c^2}+\frac{var(dz)}{dz^2}\right]}$$

$$\Gamma_{r^k,dz}=\frac{\left[\left[\left(1+r^k+\delta\right)-(1+r)\right]\left[1+\frac{var(c)}{c^2}+3\frac{var(dz)}{dz^2}\right]-\frac{cov\left(c,r^k\right)-cov(c,1+r)}{c}\right]}{\left[1+\frac{var(c)}{c^2}+\frac{var(dz)}{dz^2}\right]}$$

and

$$\Gamma_{r^k} = (1-\alpha)\,\alpha dz^{\alpha} k^{-\alpha}$$

$$\Gamma_{\widetilde{b}} = \frac{(1+r)}{dz}$$

$$\Gamma_{\widetilde{k}} = \frac{k\,(1-\delta)+dzy\,(1-\alpha)}{dz}$$

$$\Gamma_{dz} = \frac{b\,(1+r)+k\,(1-\delta)+dzy\,(1-\alpha)}{dz}$$

6.2 Solution to the system

6.2.1 Decision rules

We postulate a linear decision rule around the stochastic steady state which is given by

$$\widetilde{c}_t = a_{cb}\widetilde{b}_{t-1} + a_{cg}g_t + a_{cw}w_t + a_{cr}\widehat{1+r}_t + a_{cs}\widetilde{s}_t, \tag{26}$$

$$\widetilde{b}_t = a_{bb}\widetilde{b}_{t-1} + a_{bg}g_t + a_{bw}w_t + a_{br}\widehat{1+r}_t + a_{bs}\widetilde{s}_t, \tag{27}$$

and

$$\widetilde{k}_t = a_{kb}\widetilde{b}_{t-1} + a_{kg}g_t + a_{kw}w_t + a_{kr}\widehat{1+r_t} + a_{ks}\widetilde{s}_t. \tag{28}$$

Then given (24) and (25) we get a solution to the coefficients on consumption

$$a_{cb} = \frac{\Gamma_{c,c}\Gamma_{\widetilde{b}} - 1}{\Gamma_{c,c}\left(\left(c + \frac{\Gamma_{\widetilde{k}}\Gamma_{r^k,c}}{\Gamma_{r^k}}\right) - k\frac{\Gamma_{r^k,c}}{\Gamma_{r^k}\Gamma_{c,c}}\right)},$$

$$a_{cr} = \frac{\rho^r\Gamma_{c,r}\left(1 - a_{cb}k\frac{\Gamma_{r^k,c}}{\Gamma_{r^k}}\right) - \Gamma_{c,c}a_{cb}\left(\frac{b}{dz} - \frac{\Gamma_{\widetilde{k}}}{\Gamma_{r^k}} + \frac{\rho^r k}{\Gamma_{r^k}}\right)}{\left(k\frac{\Gamma_{r^k,c}}{\Gamma_{r^k}}\rho^r - \left(c + \frac{\Gamma_{\widetilde{k}}\Gamma_{r^k,c}}{\Gamma_{r^k}}\right)\right)\Gamma_{c,c}a_{cb} - (1-\Gamma_{c,c}\rho^r)\left(1 - a_{cb}k\frac{\Gamma_{r^k,c}}{\Gamma_{r^k}}\right)},$$

$$a_{cg} = \frac{\Gamma_{c,dz}\rho\left(1 - a_{cb}k\frac{\Gamma_{r^k,c}}{\Gamma_{r^k}}\right) + \Gamma_{c,c}a_{cb}\left(\Gamma_{\widetilde{k}}\left(1 - \frac{\Gamma_{r^k,c}}{\Gamma_{r^k}}\right) - k\left(1 - \frac{\Gamma_{r^k,c}}{\Gamma_{r^k}}\right)\rho - \Gamma_{dz}\right)}{(1-\Gamma_{c,c}\rho)\left(1 - a_{cb}k\frac{\Gamma_{r^k,c}}{\Gamma_{r^k}}\right) + \left(\left(\widetilde{C} + \frac{\Gamma_{\widetilde{k}}\Gamma_{r^k,c}}{\Gamma_{r^k}}\right) - \rho k\frac{\Gamma_{r^k,c}}{\Gamma_{r^k}}\right)\Gamma_{c,c}a_{cb}},$$

$$a_{cw} = \frac{\left(\Gamma_{\widetilde{k}}\left(1 - \frac{\Gamma_{r^k,c}}{\Gamma_{r^k}}\right) - \Gamma_{dz}\right)\Gamma_{c,c}a_{cb}}{\left(1 - a_{cb}k\frac{\Gamma_{r^k,c}}{\Gamma_{r^k}}\right) + \Gamma_{c,c}\left(c + \frac{\Gamma_{\widetilde{k}}\Gamma_{r^k,c}}{\Gamma_{r^k}}\right)a_{cb}},$$

and

$$a_{cs} = \frac{\Gamma_{c,c}a_{cb}}{(1-\Gamma_{c,c}\rho^s)\left(a_{cb}k\frac{\Gamma_{r^k,c}}{\Gamma_{r^k}} - 1\right) + \Gamma_{c,c}a_{cb}\left(\rho^s k\frac{\Gamma_{r^k,c}}{\Gamma_{r^k}} - \left(c + \frac{\Gamma_{\widetilde{k}}\Gamma_{r^k,c}}{\Gamma_{r^k}}\right)\right)}.$$

For the net foreign assets we have

$$a_{bb} = \frac{1}{\Gamma_{c,c}},$$

$$a_{br} = \frac{\left(a_{cr}\left(1-\Gamma_{c,c}\rho^{r}\right)+\rho^{r}\Gamma_{c,r}\right)}{\Gamma_{c,c}a_{cb}},$$

$$a_{bg} = \frac{\left(a_{cg}\left(1-\Gamma_{c,c}\rho\right)-\Gamma_{c,dz}\rho\right)}{\Gamma_{c,c}a_{cb}},$$

$$a_{bw} = \frac{a_{cw}}{\Gamma_{c,c}a_{cb}},$$

and

$$a_{bs} = \frac{a_{cs}\left(1-\Gamma_{c,c}\rho^{s}\right)}{\Gamma_{c,c}a_{cb}}.$$

For the capital stock it follows

$$a_{kb} = -a_{cb}a_{bb}\frac{\Gamma_{r^k,c}}{\Gamma_{r^k}},$$

$$a_{kg} = \left(\rho - \frac{\Gamma_{r^k,c}}{\Gamma_{r^k}}\left(\rho\left(1+a_{cg}\right)+a_{cb}a_{bg}\right)\right),$$

$$a_{kw} = -a_{cb}a_{bw}\frac{\Gamma_{r^k,c}}{\Gamma_{r^k}},$$

$$a_{kr} = -\frac{\rho^{r}\left(1+a_{cr}\Gamma_{r^k,c}\right)+\Gamma_{r^k,c}a_{cb}a_{br}}{\Gamma_{r^k}},$$

and

$$a_{ks} = -\rho^{s}a_{cs}\frac{\Gamma_{r^k,c}}{\Gamma_{r^k}} - a_{cb}a_{bs}\frac{\Gamma_{r^k,c}}{\Gamma_{r^k}}.$$

With the policy rules in hand we can derive the remaining endogenous variables of interest. To define the conditional moments we need the evolution of the rental rate to capital, which is given by

$$\widehat{1+r_t^k} = -\alpha r^k\left(a_{kb}\widetilde{b}_{t-1} - \left(1-a_{kg}\right)g_t - \left(1-a_{kw}\right)w_t + a_{kr}\widehat{1+r_t} + a_{ks}\widetilde{s}_t\right).$$

6.2.2 The second moments

From the stochastic steady state it follows that we have determine the covariance relationship between consumption and the growth rate of the economy, $cov\left(c,dz\right)$, the world real interest rate, $cov\left(c,1+r\right)$,as well as the rental rate of capital, $cov\left(c,1+r^k\right)$. Furthermore, the variance of consumption, $var\left(c\right)$, and the growth rate, $var\left(dz\right)$, have to be derived.

We therefore define the conditional moments. We assume that the shocks are uncorrelated between each other. The conditional moments are calculated given the impact matrix

$$\mathbf{S}=\begin{bmatrix} a_{bg} & a_{bw} & a_{br} & a_{bs} \\ a_{kg} & a_{kw} & a_{kr} & a_{ks} \\ a_{cg} & a_{cw} & a_{cr} & a_{cs} \\ \alpha r^k\left(1-a_{kg}\right) & \alpha r^k\left(1-a_{kw}\right) & -\alpha r^k a_{kr} & -\alpha r^k a_{ks} \end{bmatrix}$$

and the diagonal variance-covariance matrix

$$\mathbf{\Sigma}=\begin{bmatrix} \sigma_v^2 & 0 & 0 & 0 \\ 0 & \sigma_w^2 & 0 & 0 \\ 0 & 0 & \sigma_\epsilon^2 & 0 \\ 0 & 0 & 0 & \sigma_\varepsilon^2 \end{bmatrix}.$$

Then the conditional moments **CM** are given by

$$\mathbf{CM}=\mathbf{S}\mathbf{\Sigma}\mathbf{S}^{'}$$

We need solutions to the variance $var(c)$, while $var(dz)=\sigma_v^2+\sigma_w^2$. Then

$$var(c) = a_{cg}^2\sigma_v^2+a_{cw}^2\sigma_w^2+a_{cr}^2\sigma_\epsilon^2+a_{cs}\sigma_\varepsilon^2 \quad (29)$$

$$var(dz) = \sigma_v^2+\sigma_w^2 \quad (30)$$

Furthermore we need solutions to the covariances $cov\left(c,\left(1+r^k\right)\right)$, $cov\left(c,(1+r)\right)$ and $cov\left(c,dz\right)$, which are given by

$$cov\left(c,\left(1+r^k\right)\right) = \alpha r^k\left(1-a_{kg}\right)\sigma_v^2+\alpha r^k\left(1-a_{kw}\right)\sigma_w^2-\alpha r^k a_{kr}\sigma_\epsilon^2-\alpha r^k a_{ks}\sigma_\varepsilon^2, \quad (31)$$

$$cov\left(c,(1+r)\right) = a_{cr}\sigma_\epsilon^2, \quad (32)$$

$$cov\left(c,dz\right) = a_{cg}\sigma_v^2+a_{cw}\sigma_w^2. \quad (33)$$

We have 8 unknowns, given by $b, c, r^k, var(c), var(dz), cov\left(c,\left(1+r^k\right)\right), cov\left(c,(1+r)\right)$ and $cov\left(c,dz\right)$, for which we have 8 equations given by (12), the steady-state condition of (6), (13) and (29)-(33). This allows us to solve the system. We are using an iterative non-linear procedure, which enables us to solve this fixed point problem.

Table 4: Countries in the sample.

Albania	S	R	Dominica	S	R	Jordan	S	R	Saudi Arabia	L	R
Algeria	L	R	Dominican Rep	S	R	Kenya	L	P	Senegal	S	P
Angola	S	R	Ecuador	S	R	Korea	L	R	Singapore	S	R
Antigua & Barb	S	R	Egypt	L	R	Lesotho	S	P	Slovak Rep	S	R
Argentina	L	R	El Salvador	S	R	Libya	S	R	Slovenia	S	R
Australia	L	R	Eritrea	S	P	Madagascar	S	P	South Africa	L	R
Austria	S	R	Ethiopia	L	P	Malawi	S	P	Spain	L	R
Azerbaijan	S	R	Fiji	S	R	Malaysia	L	R	Sri Lanka	L	R
Bahrain	S	R	Finland	S	R	Maldives	S	R	Sudan	L	P
Bangladesh	L	P	France	L	R	Mali	S	P	Swaziland	S	R
Belarus	S	R	Gabon	S	R	Malta	S	R	Sweden	S	R
Belize	S	R	Gambia	S	P	Mauritania	S	R	Switzerland	S	R
Benin	S	P	Germany	L	R	Mauritius	S	R	Syria	L	R
Bolivia	S	R	Ghana	L	P	Mexico	L	R	Taiwan	L	R
Botswana	S	R	Greece	S	R	Mongolia	S	R	Tanzania	L	P
Brazil	L	R	Grenada	S	R	Morocco	L	R	Thailand	L	R
Bulgaria	S	R	Guatemala	S	R	Mozambique	L	P	Togo	S	P
Burundi	S	P	Guinea-Bissau	S	P	Netherlands	S	R	Tonga	S	R
Cambodia	S	P	Haiti	S	P	New Zealand	S	R	Trinidad & Tob	S	R
Cameroon	S	P	Honduras	S	R	Nigeria	L	P	Tunisia	S	R
Canada	L	R	Hong Kong	S	R	Norway	S	R	Turkey	L	R
Cap Verde	S	R	Hungary	S	R	Oman	S	R	Uganda	L	P
Chad	S	P	Iceland	S	R	Panama	S	R	UK	L	R
Chile	S	R	India	L	P	Papua NG	S	P	Uruguay	S	R
China	L	R	Indonesia	L	R	Paraguay	S	R	Venezuela	L	R
Costa Rica	S	R	Iran	L	R	Peru	L	R	Vietnam	L	P
Cote d'Ivoire	S	R	Ireland	S	R	Philippines	L	P	Yemen	L	P
Cyprus	S	R	Israel	S	R	Poland	L	R	Zambia	S	P
Czech Rep	S	R	Italy	L	R	Portugal	S	R	Zimbabwe	S	P
Denmark	S	R	Japan	L	R	Romania	L	R			

Notes: The countries are classified by size and level of development. The set of poor (denoted by P) and richer (denoted by R) countries are defined as all countries with average PPP converted to GDP per capita over the period 1980-2007 within the ranges 0-3000 and 3000-25000, respectively. The set of small (S), medium (M) and large (L) countries include countries with 2007 populations of, respectively, less than 20 million, between 20 and 80 million and more than 80 million.

Table 5: Saving, investment and uncertainty

	dependent variable			
	S/GDP		I/GDP	
	(1)	(2)	(3)	(4)
constant	−0.67	−0.60	0.44	0.60
	(0.19***)	(0.30*)	(0.30)	(0.31*)
$sd(\Delta GDP)$	2.39	2.36	−0.40	−0.43
	(0.80***)	(0.85***)	(0.82)	(0.95)
GDPpc	0.00	0.00	0.00	0.00
	(0.00***)	(0.00***)	(0.00)	(0.00)
log(GDP)	0.02	0.03	−0.01	−0.01
	(0.01***)	(0.01***)	(0.01)	(0.01)
mean ΔGDP	0.78	0.70	2.08	1.91
	(0.84)	(0.84)	(10.7*)	(1.19)
log(PI)		−0.02		−0.03
		(0.03)		(0.02*)
open		0.00		0.00
		(0.00)		(0.00)
Chinn-Ito		0.01		−0.00
		(0.01)		(0.00)
AR(1) ΔGDP		−0.02		−0.00
		(0.06)		(0.03)
R^2	0.34	0.35	0.10	0.11
adj. R^2	0.30	0.28	0.06	0.05
obs.	88	87	112	111

Notes: Robust (White) standard errors are given in parenthesis. A significance level of 1%, 5% and 10% is indicated by ***, ** and *, respectively.

Table 6: Baseline results

	dependent variable							
	$corr(\Delta gdp,\widetilde{\Delta nfa})$			$corr(\Delta gdp,\widetilde{tb})$			$mean(\widetilde{NFA})$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
constant	-0.63 (0.31**)	-0.66 (0.45)	-1.11 (0.47**)	0.06 (0.36)	-0.05 (0.50)	0.52 (0.51)	-0.07 (0.02***)	-0.07 (0.02***)
$sd(\Delta GDP)$	2.29 (1.03**)	2.72 (1.01***)	4.48 (1.23***)	4.13 (1.01***)	4.44 (1.04***)	4.49 (1.24***)	0.17 (0.08**)	0.17 (0.08**)
GDPpc	-0.00 (0.00***)	0.00 (0.00**)	0.00 (0.00**)	0.00 (0.00***)	0.00 (0.00**)	0.00 (0.00)	0.00 (0.00***)	0.00 (0.00**)
log(GDP)	0.03 (0.01**)	0.02 (0.01*)	0.03 (0.01**)	-0.02 (0.01)	-0.02 (0.02)	-0.03 (0.02**)	0.00 (0.00***)	0.00 (0.00***)
mean ΔGDP	-2.09 (1.33)	-2.33 (1.27*)	-1.77 (1.25)	-0.47 (1.32)	-0.57 (1.45)	-1.69 (1.47)	0.13 (0.05**)	0.13 (0.06**)
log(PI)		0.03 (0.07)	0.03 (0.06)		0.03 (0.05)	0.04 (0.05)		0.00 (0.00)
open		0.00 (0.00**)	0.00 (0.00**)		0.00 (0.00)	0.00 (0.00)		-0.00 (0.00)
Chinn-Ito		0.02 (0.03)	0.03 (0.02)		0.02 (0.03)	0.02 (0.03)		0.00 (0.00)
AR(1) ΔGDP		0.10 (0.09)	0.08 (0.09)		0.02 (0.10)	0.01 (0.11)		-0.01 (0.00)
$D^{NFA<0}$			0.24 (0.10**)			-0.10 (0.11)		
$D^{NFA<0} \times sd(\Delta GDP)$			-1.77 (1.73)			-2.28 (1.86)		
R^2	0.12	0.16	0.21	0.15	0.16	0.24	0.29	0.31
adj. R^2	0.09	0.09	0.14	0.12	0.10	0.17	0.27	0.26
obs.	119	118	118	119	118	118	119	118

Notes: Robust (White) standard errors are given in parenthesis. A significance level of 1%, 5% and 10% is indicated by ***, ** and *, respectively.

Table 7: Baseline results for small/large and rich/poor countries

	dependent variable					
	$corr(\Delta gdp, \widetilde{\Delta nfa})$		$corr(\Delta gdp, \widetilde{tb})$		$mean(\widetilde{NFA})$	
	(1)	(2)	(3)	(4)	(5)	(6)
D^{small}	-1.19 (0.63*)		0.13 (0.67)		-0.07 (0.02***)	
D^{large}	-1.32 (0.69*)		0.28 (0.74)		-0.07 (0.03***)	
D^{rich}		-0.69 (0.45)		-0.07 (0.52)		-0.07 (0.02***)
D^{poor}		-0.70 (0.47)		-0.02 (0.50)		-0.06 (0.02***)
$sd(\Delta GDP) \times D^{\text{small}}$	2.27 (1.18*)		5.08 (1.10***)		0.16 (0.09*)	
$sd(\Delta GDP) \times D^{\text{large}}$	2.64 (2.00)		2.57 (2.57)		0.20 (0.11*)	
$sd(\Delta GDP) \times D^{\text{rich}}$		3.14 (1.12***)		4.72 (1.24***)		0.26 (0.10**)
$sd(\Delta GDP) \times D^{\text{poor}}$		1.26 (1.91)		3.63 (2.15*)		-0.09 (0.09)
GDPpc	-0.00 (0.00***)	-0.00 (0.00***)	0.00 (0.00*)	0.00 (0.00*)	0.00 (0.00***)	0.00 (0.00**)
log(GDP)	0.05 (0.02**)	0.02 (0.01*)	-0.02 (0.02)	-0.02 (0.02)	0.00 (0.00**)	0.00 (0.00**)
mean ΔGDP	-1.96 (1.37)	-2.66 (1.33**)	-0.81 (1.48)	-0.65 (1.50)	0.13 (0.06**)	0.10 (0.06*)
log(PI)	0.04 (0.07)	0.06 (0.07)	0.02 (0.05)	0.03 (0.06)	0.00 (0.00)	0.00 (0.00)
open	0.00 (0.00**)	0.00 (0.00***)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	-0.00 (0.00)
Chinn-Ito	0.02 (0.03)	0.02 (0.03)	0.03 (0.03)	0.02 (0.03)	0.00 (0.00)	0.00 (0.00)
AR(1) ΔGDP	0.08 (0.09)	0.08 (0.09)	0.02 (0.11)	0.01 (0.11)	-0.00 (0.00)	-0.01 (0.00*)
R^2	0.18	0.19	0.17	0.16	0.31	0.38
adj. R^2	0.10	0.11	0.09	0.08	0.25	0.32
obs.	118	118	118	118	118	118

Notes: Robust (White) standard errors are given in parenthesis. A significance level of 1%, 5% and 10% is indicated by ***, ** and *, respectively.

Table 8: Results with institutional variables

	dependent variable								
	$corr(\Delta gdp, \widetilde{\Delta nfa})$			$corr(\Delta gdp, \widetilde{tb})$			$mean(\widetilde{NFA})$		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
constant	-0.93 (0.48*)	-0.23 (0.55)	-0.48 (0.50)	0.31 (0.52)	-0.85 (0.51)	0.26 (0.60)	-0.07 (0.02***)	-0.06 (0.02***)	-0.07 (0.02***)
$sd(\Delta GDP)$	3.50 (1.13***)	2.41 (1.06**)	2.16 (1.20*)	3.44 (1.21***)	4.63 (1.29***)	2.49 (1.39*)	0.17 (0.07**)	0.17 (0.08*)	0.29 (0.12**)
GDPpc	-0.00 (0.00***)	-0.00 (0.00**)	-0.00 (0.00**)	0.00 (0.00***)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00*)	0.00 (0.00**)	0.00 (0.00**)
log(GDP)	0.03 (0.01*)	0.01 (0.02)	0.02 (0.01)	-0.02 (0.02)	0.01 (0.02)	-0.02 (0.02)	0.00 (0.00***)	0.00 (0.00**)	0.00 (0.00**)
mean ΔGDP	-2.66 (1.30**)	-1.99 (1.65)	-2.59 (1.37*)	0.03 (1.49)	-1.45 (1.74)	-1.13 (1.68)	0.13 (0.06**)	0.13 (0.07*)	0.11 (0.06*)
log(PI)	0.03 (0.07)	0.01 (0.06)	0.01 (0.07)	0.03 (0.06)	0.08 (0.06)	0.03 (0.05)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
open	0.00 (0.00**)	0.00 (0.00*)	0.00 (0.00**)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	-0.00 (0.00)	-0.00 (0.00)	-0.00 (0.00)
Chinn-Ito	0.02 (0.03)	0.02 (0.03)	0.02 (0.03)	0.03 (0.03)	0.03 (0.11)	0.04 (0.03)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
AR(1) ΔGDP	0.08 (0.09)	0.18 (0.10*)	0.08 (0.09)	0.04 (0.11)	-0.06 (0.11)	-0.07 (0.12)	-0.01 (0.00)	-0.01 (0.00)	-0.01 (0.00)
log(transp)	0.17 (0.08**)			-0.20 (0.11*)			0.00 (0.00)		
log (polstab)		-0.06 (0.16)			0.11 (0.20)			0.02 (0.01*)	
schooling			0.00 (0.01)			-0.01 (0.01)			-0.00 (0.00)
R^2	0.18	0.17	0.14	0.20	0.19	0.16	0.32	0.33	0.39
adj. R^2	0.11	0.08	0.06	0.13	0.11	0.08	0.26	0.26	0.33
obs.	116	101	104	113	101	104	116	101	104

Notes: Robust (White) standard errors are given in parenthesis. A significance level of 1%, 5% and 10% is indicated by ***, ** and *, respectively.

Table 9: Results for extended model and alternative uncertainty measures

	dependent variable								
	$corr(\Delta gdp, \widetilde{\Delta nfa})$			$corr(\Delta gdp, \widetilde{tb})$			$mean(\widetilde{NFA})$		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
constant	−1.52	−1.45	−1.13	−1.11	−0.91	−0.67	−0.09	−0.09	−0.10
	(0.60**)	(0.58*)	(0.72)	(0.66*)	(0.68)	(0.67)	(0.03**)	(0.03***)	(0.03***)
$sd(\Delta GDP)$	3.78			3.49			0.09		
	(1.38***)			(1.15***)			(0.05*)		
$sd(\Delta GDP^{idio})$		3.99			2.62			0.09	
		(1.32***)			(1.43*)			(0.05*)	
$sd(\Delta GDP^{disa})$			3.46			3.47			−0.02
			(1.16***)			(0.91***)			(0.05)
GDPpc	−0.00	−0.00	−0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(0.00***)	(0.00***)	(0.00***)	(0.00*)	(0.00**)	(0.00)	(0.00)	(0.00)	(0.00)
log(GDP)	0.03	0.03	0.03	0.01	0.01	0.01	0.00	0.00	0.00
	(0.02*)	(0.02*)	(0.02)	(0.02)	(0.02)	(0.02)	(0.00**)	(0.00**)	(0.00***)
mean ΔGDP	−1.94	−1.97	−1.47	−1.95	−1.85	−2.04	0.06	0.06	0.07
	(1.64)	(1.66)	(1.78)	(1.76)	(1.80)	(1.77)	(0.07)	(0.07)	(0.07)
log(PI)	0.04	0.03	−0.01	0.03	0.03	−0.01	0.00	0.00	0.00
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.00)	(0.00)	(0.00)
open	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(0.00*)	(0.00*)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Chinn-Ito	0.01	0.01	0.02	0.06	0.06	0.08	0.00	0.00	0.00
	(0.03)	(0.04)	(0.05)	(0.03*)	(0.03*)	(0.03**)	(0.00)	(0.00*)	(0.00*)
AR(1) ΔGDP	0.14	0.16	0.12	0.01	0.02	−0.09	−0.00	−0.00	−0.00
	(0.10)	(0.10)	(0.11)	(0.10)	(0.10)	(0.09)	(0.00)	(0.00)	(0.00)
Credit/GDP	−0.00	−0.00	−0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00**)	(0.00*)	(0.00***)	(0.00)	(0.00)	(0.00)
mean G	0.08	0.04	0.01	−0.46	−0.51	−0.60	−0.01	−0.01	−0.01
	(0.16)	(0.17)	(0.21)	(0.15***)	(0.16***)	(0.15***)	(0.00)	(0.00*)	(0.00**)
$sd(G)$	−0.92	−0.86	−1.06	1.74	1.95	2.38	0.01	0.01	0.03
	(0.75)	(0.73)	(0.86)	(0.68**)	(0.73***)	(0.70***)	(0.02)	(0.02)	(0.02)
log(expdiv)	0.21	0.21	0.21	0.32	0.32	0.25	0.01	0.01	0.01
	(0.11*)	(0.11*)	(0.11*)	(0.11***)	(0.11***)	(0.11**)	(0.00***)	(0.00***)	(0.00***)
SWF	−0.07	−0.06	−0.16	−0.10	−0.09	−0.07	0.00	0.00	0.00
	(0.11)	(0.11)	(0.12)	(0.11)	(0.11)	(0.11)	(0.00)	(0.00)	(0.00)
log(transp)	0.28	0.30	0.28	−0.08	−0.09	−0.12	0.00	0.00	0.00
	(0.09***)	(0.10***)	(0.15*)	(0.11)	(0.12)	(0.16)	(0.00)	(0.00)	(0.00)
Fin. Center	−0.04	−0.14	−0.05	0.02	−0.05	−0.24	−0.00	−0.00	0.00
	(0.11)	(0.09)	(0.16)	(0.21)	(0.25)	(0.10**)	(0.00)	(0.00)	(0.00)
R^2	0.21	0.22	0.23	0.38	0.36	0.46	0.39	0.38	0.47
adj. R^2	0.08	0.08	0.07	0.28	0.25	0.34	0.28	0.28	0.36
obs.	103	103	85	103	103	85	103	103	85

Notes: Robust (White) standard errors are given in parenthesis. The dummy D^{NFL} indicates countries with an on average negative NFA position. A significance level of 1%, 5% and 10% is indicated by ***, ** and *, respectively.

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