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Precautionary Savings and Global Imbalances in World General Equilibrium

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Precautionary Savings and Global Imbalances in World General Equilibrium[*]

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Abstract

In this paper we assess the implications of precautionary savings for global imbalances by considering a world economy model composed by the US, the Euro Area, Japan, China, oil-exporting countries, and the rest of the world. These areas are assumed to differ only with respect to GDP volatility which is calibrated based on the 1980-2008 period. The model predicts a wide dispersion in net foreign asset positions, with the highly volatile oil-exporting countries accumulating very large asset holdings. While heterogeneity in GDP volatility may lead to large imbalances in international investment positions, its impact on current accounts is much weaker. This is because countries are expected to move towards their optimal NFA at a very slow pace.

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I. INTRODUCTION

Precautionary savings are often regarded by policy makers and academics as playing potentially an important role in driving the accumulation of international reserves and sustaining global imbalances. In this paper we develop a world general equilibrium model with heterogeneity across countries in GDP volatility to quantitatively assess the merit of this hypothesis. More specifically, we want to understand how the observed differences in GDP volatility influence the dispersion of net foreign assets and current account imbalances.

To address these questions, we consider a world economy model composed by several countries differing with respect to GDP volatility. Countries receive each period a stochastic GDP endowment which can be either consumed or lent internationally as in Clarida (1990). International borrowing is possible only up to an exogenous limit. The optimal consumption/saving decision is first analyzed in a partial equilibrium setting where the interest rate is fixed exogenously. As long as the interest rate earned on savings is less than the growth-adjusted intertemporal discount rate – condition which is endogenously satisfied in the world general equilibrium – the country exhibits "impatience", so that under perfect foresight it would prefer to front-load consumption by borrowing internationally. In the presence uncertainty, this impatience condition generates instead a finite optimal net foreign asset position (NFA). While impatience pushes the country towards its borrowing constraint, income volatility generates a precautionary motive to save. The optimal level of international asset holdings is the one at which the precautionary motive exactly counterbalances the impatience desire.

We begin by considering a partial equilibrium setting which is useful to understand the structural determinants of the NFA, but is unable to pin down a robust value for its optimal level. This is due to the extreme sensitivity to the interest rate which is unsatisfactorily set exogenously. To avoid this problem, we then solve for the optimal NFA positions in general equilibrium, constraining the world interest rate to clear the market for international assets. We find that the observed heterogeneity in volatilities across countries can produce large NFA imbalances. According to the model, the highly volatile oil exporting countries should accumulate international assets up to several multiples of GDP, while developed economies should borrow a considerable share of GDP. However, the process of convergence towards the predicted optimal international investment positions is extremely slow. Therefore, while heterogeneity in volatilities may sustain a wide dispersion of NFA positions, it can account for only small current account imbalances. This is an interesting result which can inform the debate about the determinants of the accumulation of reserves in emerging markets. Precautionary motives against aggregate risk can very well induce countries to hoard substantial net foreign assets, but they cannot account for large current account surpluses that imply an excessively rapid accumulation.

The finding of a quantitatively small impact of precautionary savings on current accounts requires two caveats. First, the strength of precautionary motives is much stronger for countries close to their borrowing constraints since they cannot easily smooth negative shocks by issuing additional debt. In these circumstances the model implies substantial current account surpluses to move the NFA away from the constraint. The predicted current account surpluses are especially large if there is also the risk of a possible tightening of the international constraint. Second, the limited importance of precautionary savings for current accounts essentially depend on the relative low

risk associated with aggregate GDP fluctuations. As discussed in the literature on the costs of the business cycle pioneered by Lucas (1987), aggregate fluctuations have only mild consequences for welfare. Much stronger precautionary motives are generated by idiosyncratic risk within countries which as shown in Mendoza, Quadrini and Ríos-Rull (2009) and Sandri (2010) can have more sizeable implications for current accounts.

The quantitative analysis of open economies was initially developed under the assumption of perfect foresight or solving for log-linearized models which neglected the role of precautionary motives (Blanchard and Fisher (1989), Mendoza (1991), Backus, Kehoe and Kydland (1992), Baxter and Crucini (1995)). The surge in international reserves in emerging markets over the last few years has however fostered strong interest in precautionary savings. Ghosh and Ostry (1997) show that higher national income volatility generates larger current account surpluses, Durdu, Mendoza and Terrones (2009) use a small open economy model to assess the role of GDP volatility and sudden stop risk for the accumulation of reserves, and Jeanne and Sandri (2010) derive rules of thumb for the optimal level of precautionary savings. We build upon these models, but solve for a world general equilibrium in order to put discipline on the interest rate. Fogli and Perri (2006) and Fogli and Perri (2010) also solve for a general equilibrium setting, but based on only two countries, and show that changes in volatility may produce significant variations in net foreign asset positions. A world general equilibrium approach is also used by Chang, Kim and Lee (2010) who study the importance of country-specific shocks for the dispersion of current accounts, but assume equal volatility across countries.

The structure of the paper is as follows. Section II describes the dynamic stochastic optimization problem and shows how the optimal NFA position varies with the model parameters under a constant exogenous world interest rate. The world general equilibrium solution with endogenous interest rate is presented in section III, where we first solve for the stationary equilibrium and then for the convergence dynamics. Section IV shows that precautionary savings have a larger effect on current accounts for countries close to borrowing constraints or in the presence of higher risk as in the literature on idiosyncratic uncertainty. Section V concludes.

II. Optimal NFA in partial equilibrium

We start by considering the determination of the optimal NFA position using a partial equilibrium setting based on an exogenous interest rate. In each period the economy receives a stochastic GDP endowment Y_t which can be either consumed C_t or saved by accumulating net foreign assets A_t. The country can also borrow internationally but only up to the limit $\underline{A}_t$. The intertemporal budget constraint can be expressed as:

$$A_t = A_{t-1}\overbrace{(1+r)}^{R}+Y_t - C_t \tag{1}$$

where r is the world interest rate. The GDP endowment is subject to stationary fluctuations around a deterministic growth trend G

$$Y_t = P_t Z_t \tag{2}$$
$$P_t = G P_{t-1} \tag{3}$$
$$Z_t = 1 + \rho(Z_{t-1} - 1) + \epsilon_t \tag{4}$$

where P_t and Z_t are respectively the permanent and transitory components of GDP and ϵ_t is a mean zero normally distributed shock with variance σ^2. To reduce the number of state variables, the problem can be normalized by the permanent component of GDP P_t, so that the budget constraint becomes:

$$a_t = a_{t-1} R/G + Z_t - c_t \tag{5}$$

where lower case variables are the upper case ones divided by permanent GDP, e.g. $a_t = A_t/P_t$. Defining $b_t = a_{t-1} R/G$ and assuming a CRRA utility function with risk aversion parameter γ, the dynamic optimization problem of the representative agent can be expressed in recursive formulation as:

$$v_t(b_t, Z_t) = \max_{c_t} \left\{ u(c_t) + \beta G^{1-\gamma} \mathbb{E}_t v_{t+1}(a_t R/G, Z_{t+1}) \right\}$$
$$\text{s.t.} \tag{6}$$
$$a_t = b_t + Z_t - c_t$$
$$\geq \underline{a}$$
$$Z_{t+1} = 1 + \rho(Z_t - 1) + \epsilon_{t+1}$$

with first order condition

$$u'(c_t) = \max \left[\frac{R\beta}{G^\gamma} \mathbb{E}_t u'(c_{t+1}), u'(b_t + Z_t - \underline{a}) \right] \tag{7}$$

We are interested in solving for the optimal net foreign asset position a^*, defined as the level of foreign assets that is expected to be stable, so that if $a_{t-1} = a^*$ (and $Z_t = 1$) then $a_t = a^*$. In order for the target a^* to exist, the impatience condition

$$\frac{R\beta}{G^\gamma} < 1 \tag{8}$$

has to be satisfied.[1] To understand why, consider the case in which $R\beta/G^\gamma = 1$. The first order condition would require in the unconstrained region $u'(c_t) = \mathbb{E}_t u'(c_{t+1})$. Since the expected marginal utility of consumption tomorrow is higher than today due to the presence of uncertainty and the convexity of marginal utility, it would be optimal to permanently increase consumption over time which can be achieved only by constantly increasing the accumulation of foreign assets. In other words, if the representative agent equally values present and future consumption (taking

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[1] See Carroll (2009) for a formal proof of the existence of this target level of savings.

into account the income growth rate and interest rate), it is optimal to postpone consumption and accumulate an infinite buffer of precautionary reserves to smooth future income fluctuations.

Conversely, if the country has a preference to front-load consumption $R\beta/G^\gamma < 1$, there is an optimal finite level of savings at which the impatience motive to borrow exactly offsets the precautionary motive to save. This is because the strength of precautionary motives exponentially increases as a_t shrinks. With assets larger than a^*, the impatience motive overcomes the precautionary motive and the country optimally reduces its NFA. On the contrary, if assets are lower than a^*, the precautionary motive prevails and stimulates the accumulation of additional assets.[2] Since there is no analytical solution for the optimal target a^*, we solve for it numerically in the rest of the paper.

A.   Sensitivity to parameter values

The model is based on seven parameters: the discount factor β, the interest rate R, the GDP growth rate G, the standard deviation of income shocks σ and their persistency ρ, the borrowing constraint $\underline{a}$, and the risk aversion coefficient γ. In our benchmark calibration, we use 3% for the risk free world interest rate, 1% for the annual deterministic growth rate, we set the borrowing constraint at 100% of GDP and the risk aversion coefficient at 2. The income process is estimated on HP-filtered real per capita GDP data from the US between 1980-2008, leading to $\rho = 0.73$ and $\sigma = 1.2\%$. Finally, we set $\beta = 0.99$ which will be required to sustain a 3% world interest rate in the general equilibrium version of the model in section B.

The optimal net foreign asset position predicted by the model is -46% of GDP. However, a^* is extremely sensitive to the parameters controlling the impatience condition. For example, the top left plot of figure 1 shows that very small variations in the world interest rate can lead to substantially different optimal foreign investment positions especially when approaching the impatience limit $R < G^\gamma/\beta$. This is a serious limitation of relying on a partial equilibrium approach to characterize the optimal NFA, since the interest rate is an exogenous parameter. Solving for a world general equilibrium will remove this degree of freedom by pinning down endogenously the interest rate consistent with market clearing. Figure 1 also shows how the optimal NFA increases with the tightness of the borrowing constraint and the persistency and volatility of the GDP process. It is interesting to note the fairly strong responsiveness of a^* to changes in volatility which Fogli and Perri (2006) suggest could help to understand the increasing US international borrowing during the Great Moderation.

Let us finally point out that the sensitivity of the optimal NFA to the interest rate is much weaker if the impatience condition is comfortably satisfied, i.e. if R is substantially below G^γ/β. However, if that was the case, the sensitivity of the NFA to the other parameters would be also greatly reduced, so that given reasonable calibrations of borrowing constraints and GDP volatility

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[2]Note that since the model is non-linear, the target level a^* does not necessarily correspond to the average value of a_t that would be obtained by simulating the model in the presence of shocks. However, under standard calibrations the target a^* and the stochastic average are often fairly close. Furthermore, in this paper we are interested in learning from a normative point of view about the optimal net foreign asset positions that countries should move towards. At this regard, focusing on the concept of target a^* seems particularly appropriate.

Figure 1. a^* as a function of the model parameters
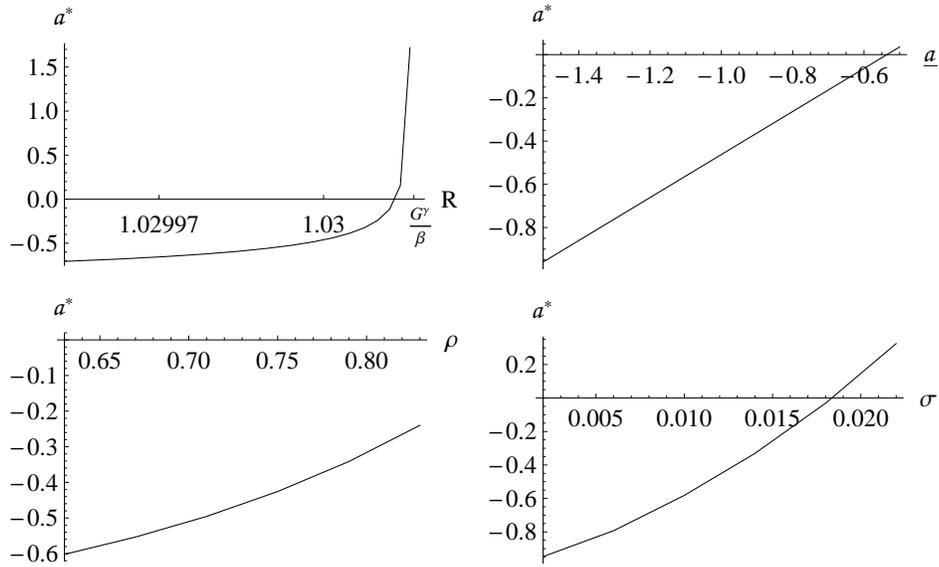
the model would always predict a negative NFA. Since all countries in the world cannot be net debtors, the relevant value for the interest rate has to be fairly close to G^γ/β, where small variations in the model parameters can lead to large swings in the NFA. To better explain these issues, we proceed to characterize the world general equilibrium in the next section.

III. WORLD GENERAL EQUILIBRIUM

The previous section has shown that the optimal NFA predicted by the model is very sensitive to the world interest rate that in a partial equilibrium framework is set exogenously. We now want to solve for a world general equilibrium where the interest rate is endogenously pinned down to clear the international bond market. We consider a world economy populated by six countries/regions facing the same optimization problem as in (6), but differing with respect to GDP volatility.

Solving for this general equilibrium poses some serious technical challenges. Even if we assume that GDP shocks are uncorrelated across countries, the finite number of countries prevents the existence of a stationary equilibrium. Idiosyncratic GDP shocks – which are not washed out by the law of large numbers – would indeed constantly change the aggregate supply and demand for bonds leading to a stochastic world interest rate. This would substantially complicate the solution of the policy functions, since the state space would have to include the NFA positions and GDP transitory components of all countries (or a least knowledge of the stochastic distribution of the world interest rate). To avoid these complexities, we neglect the stochastic nature of the world interest rate.[3] In particular, we are going to solve for the interest rate that clears the international bond market using the net bond supply predicted by the partial equilibrium model. This can be

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[3]This assumption is often used also in the small open economy literature. An exception is the paper by Fernández-Villaverde, Guerrón-Quintana, Rubio-Ramírez and Uribe (2009) which also considers changes in the volatility of the interest rate.

thought as solving for a replicated world economy (i.e. populated by infinite replicas of the six countries/regions that we are considering) in which the law of large numbers prevents idiosyncratic uncertainty to generate aggregate uncertainty.

A. Calibration

We consider a world economy populated by six countries/regions: US, Euro Area, Japan, China, oil exporting countries, and the rest of the world.[4] For each country, we estimate the process in equation 4 using the HP-filtered real per capita GDP series from 1980 to 2008 available in the World Development Indicators database.[5] The country specific estimates for ρ and σ are then aggregated using 2008 GDP weights to construct values for the region of interest. The estimation results are reported in table 1, which shows that advanced economies are more stable, while oil exporting countries are substantially more volatile. Note that using real GDP may actually underestimate the volatility for oil exporting countries, since it ignores oil price fluctuations. If using GDP deflated by CPI as in Bems and de Carvalho Filho (2009), the estimated standard deviation rises to 7.2% while persistency falls to 0.7.[6] We will therefore discuss how the predicted NFA for oil exporters increases under this alternative calibration. Table 1 also includes the 2008 GDP in billions of US dollars which are used to weight each area's demand or supply for international assets to solve for the world market clearing.

Table 1. Regions' specific parameters

Country/Regions	ρ	σ	GDP (USD billions)
US	0.73	0.012	14,400
Euro Area	0.78	0.011	13,600
Japan	0.90	0.009	4,890
China	0.75	0.016	4,530
Oil exporters	0.77	0.032	4,470
Rest of the world	0.73	0.020	18,500

Since the focus of the present paper is on the implications of heterogeneity in income volatility, we assume a common borrowing constraint at 100% of GDP and 1% deterministic growth rate.[7] We set the risk aversion parameter γ to 2 and the intertemporal discount factor β to 0.99 in order to generate an equilibrium world interest rate of 3%.

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[4]The Euro Area includes Austria, Belgium, Cyprus, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, Netherlands, Portugal, Slovak Republic, Slovenia, and Spain. We include among oil exporters all countries with a 2002-2007 average of oil export revenues in non-oil GDP above 10 percent: Algeria, Azerbaijan, Bahrain, Brunei, Ecuador, Gabon, Guyana, Islamic Republic of Iran, Kazakhstan, Kuwait, Libya, Nigeria, Norway, Oman, Qatar, Russian Federation, Saudi Arabia, Sudan, Syrian Arab Republic, Trinidad and Tobago, United Arab Emirates, Venezuela, Yemen

[5]Similar results are obtained if linearly detrending log GDP.

[6]Bems and de Carvalho Filho (2009) study the importance of precautionary savings exclusively for oil exporting countries, while also considering how the optimal amount of net foreign assets is further increased by the exhaustibility of oil reserves.

[7]We could easily relax the former assumption, while assuming heterogeneity in growth rates would imply harder-to-solve dynamics in the world interest rate as the relative size of countries varies over time.

B. Stationary equilibrium

Figure 2 shows in the left plot the optimal NFA level for each region as a function of the world interest rate and in the right plot the world net supply of bonds obtained by aggregating each region's optimal NFA using 2008 GDP weights. As we have learned from the sensitivity analysis in figure 1, the optimal investment position is an increasing function of the interest rate. The elasticity of a^* with R becomes especially high as R approaches the impatience limit G^γ/β. Importantly, a value for the world interest rate fairly close to the G^γ/β limit is required in order to induce any of the regions to hold a positive amount of international assets. Even oil exporting countries which are the most volatile in our sample would indeed prefer to be international borrowers if the interest rate were just 3 basis points below G^γ/β. From the right plot we see that 3% is the value for the world interest rate which allows for market clearing.

Figure 2. a^* as a function of the world interest rate by regions on the left and for the world aggregate on the right.
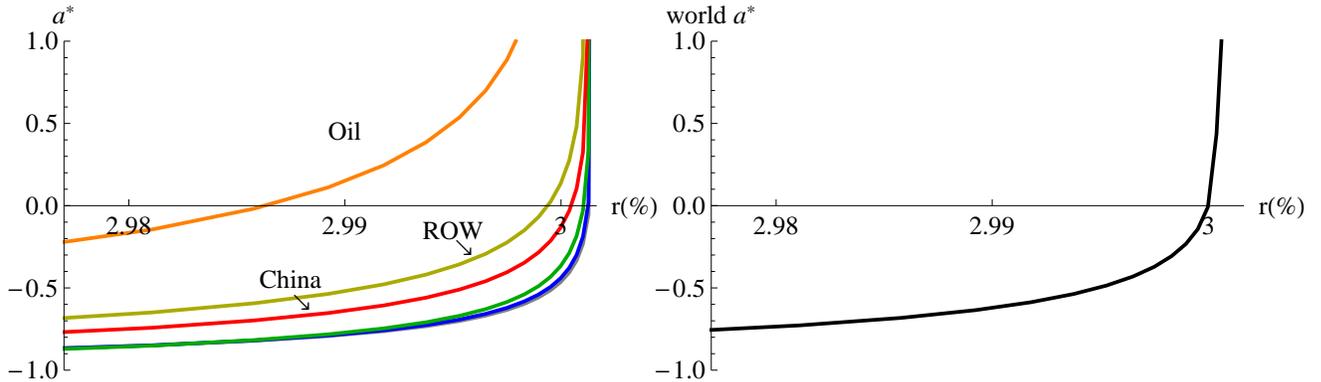

Color legend for left plot: gray US, blue Euro Area, green Japan, red China, orange oil exporters, yellow rest of the world

The predicted optimal NFA positions at the equilibrium world interest rate are shown on the left plot of figure 3. As intuitive, regions with higher volatility are expected to lend to more stable developed economies. But how large is the dispersion of international investment positions caused by the heterogeneity in GDP volatility? Our quantitative exercise reveals that differences in volatility may sustain large global imbalances. Oil exporting countries are expected to accumulate a net foreign asset position of almost three times GDP, while US, Euro Area and Japan borrow more than 30% of GDP. As discussed in the calibration section, if we use GDP deflated by CPI instead of real GDP, the relative volatility of oil exporting countries further increases and the predicted optimal NFA approaches 5 times GDP.

We do not expect a close correspondence of our predicted target NFA positions with actual data, since the model clearly neglects various factors (such as growth differences, demographics, fiscal balances, domestic investment opportunities, etc.) that are likely to affect saving decisions. Furthermore, as discussed in section C, the model predicts very slow convergence towards NFA targets which may have not yet been achieved in the actual world. Indeed, the NFA dispersion predicted by the model is considerably larger than the one observed in 2007, shown in the right

plot of figure 3 using data from Lane and Milesi-Ferretti (2007). The current amount of international assets held by oil exporters and the US debt position appear rather small relative to the model predictions. The predicted investment positions of Japan and China are opposite to the current ones. The discrepancy for Japan could be attributed to the absence of demographic factors in the model. More unclear are the factors behind the accumulation of reserves by China. Precautionary motives are often thought to be playing an important role in driving its hoarding of foreign reserves, but our exercise suggests that the observed level of volatility is not large enough to require a positive NFA. If anything, our calibration exercise neglects China's high growth rate which by strengthening the impatience condition would lead to an optimal large debtor position.[8]

Figure 3. Optimal NFA/GDP (a^*) on the left, and actual NFA/GDP in 2007 on the right
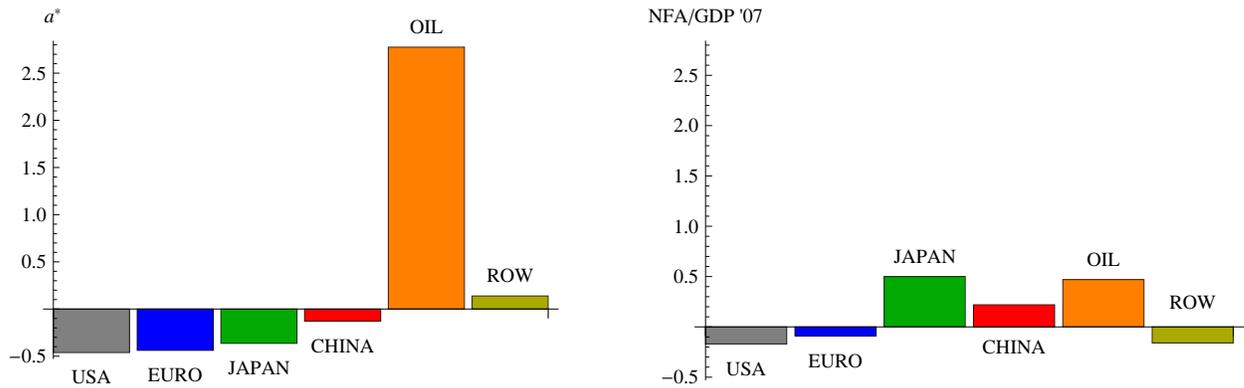
C. Transition dynamics

The model has shown that the observed heterogeneity in GDP volatility across countries can generate large global imbalances. In this section we explore the implications for current accounts. Figure 4 traces on the left plot the dynamics predicted by the model of the net foreign asset position starting from the levels observed in 2007 in the absence of GDP shocks.[9] The process of convergence to the optimal NFA position is extremely slow, with oil exporters, for instance, accumulating after 150 years less than one third of their optimal asset holdings. The extremely slow NFA dynamics translate in very small current accounts.[10] The right plot of figure 4 shows that oil exporters run a current account surplus of only 0.1% of GDP, which finances the deficits of the more developed economies of around 0.03% of GDP. Therefore, while differences in GDP volatility may lead to a wide dispersion of NFA positions, they can not account for large current account imbalances. To understand why, it is useful to consider the left-hand plot in figure 1

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[8]As discussed in Mendoza et al. (2009) and Sandri (2010), the precautionary motives generated by the high idiosyncratic volatility within China (rather than aggregate volatility) may help to account for its large current account surplus. Song, Storesletten and Zilibotti (2009) attribute instead Chinese capital outflows to the declining investment demand from downsizing state-owned enterprises.

[9]We compute the transition dynamics using the market-clearing pattern for the interest rate which is solved with a standard iterative algorithm.

[10]Fogli and Perri (2006) also predict very small current account deficits (around 0.15% of GDP) for the US in response to the reduction in aggregate volatility during the Great Moderation.

which shows how countries' optimal NFA depends on the world interest rate. We observe that the heterogeneity in volatilities generates a fairly wide dispersion in optimal NFA positions for a given interest rate. At the same time, the strong sensitivity of the NFA to r implies that the equilibrium world interest rates is for any country only slightly different from the value consistent with a zero current account and a stable 2007 NFA. For example, in the case of the US a 3.001% interest rate implies an optimal NFA equal to the 2007 value of -17% and thus a zero current account. Since this value is extremely close to the 3% equilibrium interest rate, it only has a very little impact on the Euler equation and consequently on the current account.

Figure 4. NFA and current account (CA) dynamics starting from the 2007 NFA positions
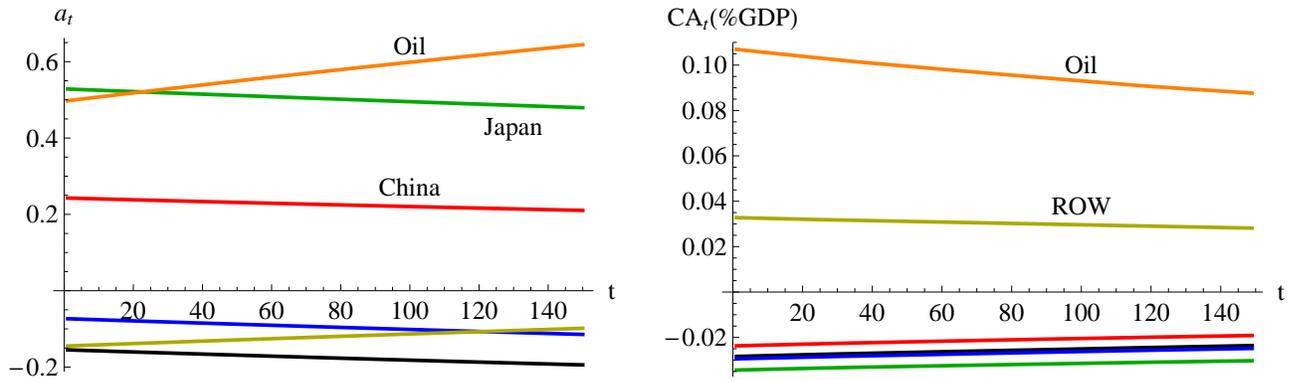
Color legend: gray US, blue Euro Area, green Japan, red China, orange oil exporters, yellow rest of the world

D.   Sensitivity analysis

In this section we study the sensitivity of the optimal NFA and current account dynamics to parameter values. In order to speed up the numerical solution procedure we consider only two regions, by aggregating the US with the Euro zone and Japan, and China with oil exporting countries and the rest of the world. These two regions have respectively weighted means for ρ of 0.78 and 0.74, for σ of 0.011 and 0.021, and a GDP in 2008 of $32,890$ and $27,500$ billions of US dollars. Figure 5 shows the optimal NFA and current account dynamics for these two regions starting from their 2007 international investment positions. The heterogeneity in volatility can again generate a fairly large dispersion in the NFA targets, but only small current account imbalances.

Figure 5. NFA targets and current account dynamics for two regions only.
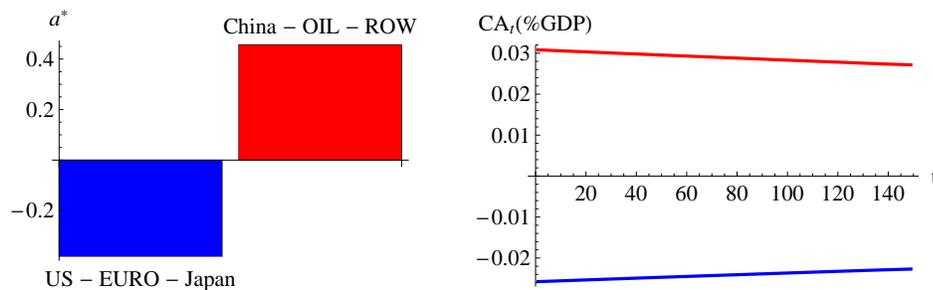
We now want to investigate the robustness of these results to alternative calibrations. Figure 6 shows how the predicted optimal NFA on the left-hand side and the current account dynamics on the right-hand side vary with respect to a particular parameter value. For example, the left plot on the top row shows that the optimal NFA positions are fairly robust to the calibration of the discount factor, which is common across countries and involves a different equilibrium world interest rate. The current account dynamics on the top-right plot are also only moderately affected by a different value for β. The wide dispersion in the NFA targets and small current accounts are equally robust to variations in the world growth rate G and in the tightness of the borrowing constraints $\underline{a}$. Finally, the bottom plots consider the implications of proportionally increasing or reducing by 50% the standard deviation of all countries, whose calibration can somewhat differ depending on how we deflate and detrend GDP series. We observe that NFA and current accounts are only moderately sensitive to these variations in the amount of volatility.

It's important to emphasize that we have considered the sensitivity of our results only to variations in the parameters common to all countries to keep the focus on the paper on heterogeneity in volatility. Variations in a country-specific parameter value can instead have large implications for that country's NFA and possibly for the rest of the world if the country's size is large enough to have implications on the world interest rate. This is particularly so for the parameters β and G which directly affect the impatience condition (8).

IV. WHEN PRECAUTIONARY SAVINGS MATTER FOR CURRENT ACCOUNTS

Our analysis has revealed so far that precautionary savings seem to be of little importance for current accounts. However, this conclusion warrants some qualification. We now discuss two instances in which precautionary motives can in fact generate rapid movements in the NFA and large current accounts.

A. Borrowing constraints

We have until now traced current account dynamics starting from the 2007 NFA positions which for the regional groups we have considered were considerably away from the borrowing limit $\underline{a}$. However, the strength of precautionary motives exponentially increases as the country approaches its borrowing limit, since negative shocks can not be easily offset by issuing additional debt. Figure 7 shows the NFA and current account dynamics of a small open economy (i.e. holding the world interest rate constant at 3%) calibrated with the volatility parameters of the rest of the world in table 1 starting from an initial NFA a_0 closer to the constraint placed at 100% of GDP. We observe that the closer is the country to its borrowing limit $\underline{a} = -1$, the larger becomes the optimal current account surplus. For example, a country with an initial NFA at the constraint $a_0 = -1$ should run a current account surplus of more than one percent of GDP to move rapidly away from the constraint.

Figure 6. Sensitivity of NFA targets and current account dynamics to parameter values.
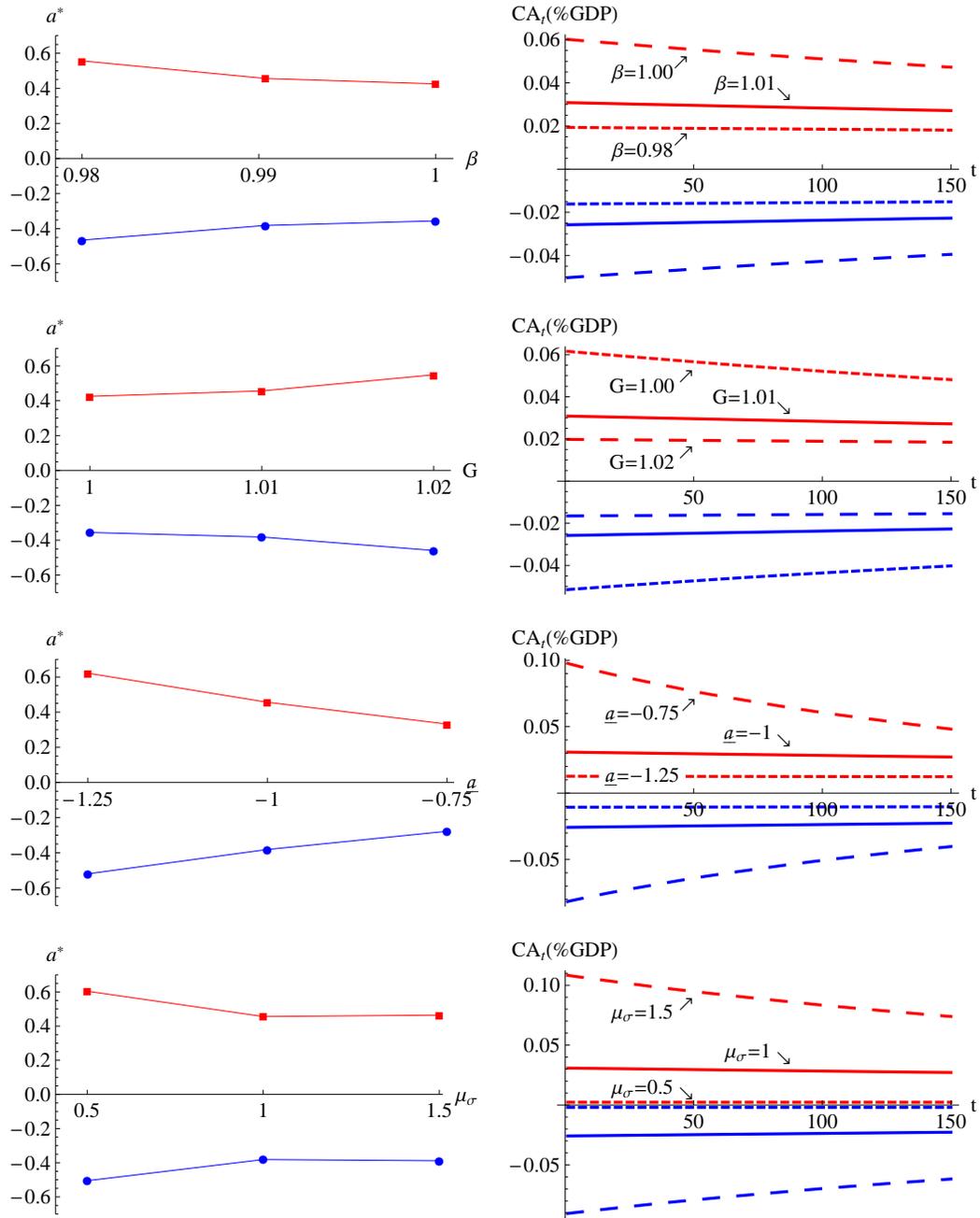
The optimal current account surplus is much larger if the country is also exposed to a possible tightening of the constraint. As an example, we assume that the constraint could tighten to -80% of GDP with 0.1 probability.[11] As figure 8 shows, this risk has the potential to greatly magnify the optimal surplus. The country wants indeed to quickly bring the NFA above -80% of GDP to avoid the abrupt fall in consumption that would be implied by a tightening of the constraint.

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[11]More specifically, we consider a stochastic borrowing constraint $\underline{a}$ with can assume in each period a value of -1 or -0.8, respectively with probability 0.9 and 0.1. We here consider the NFA and current account dynamics conditional on the constraint remaining at -1.
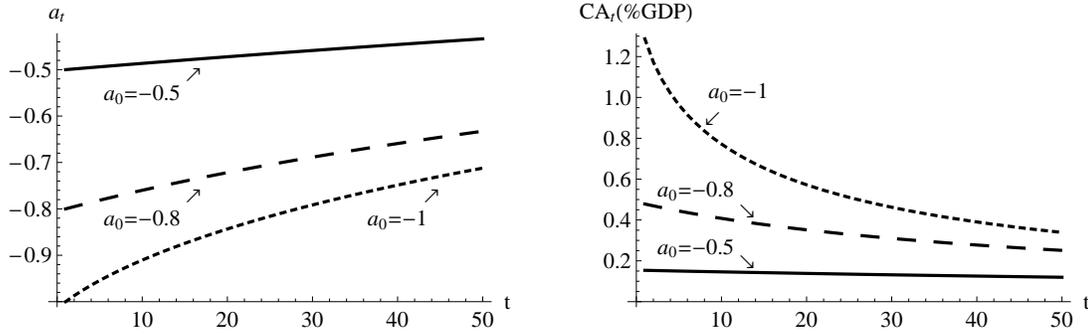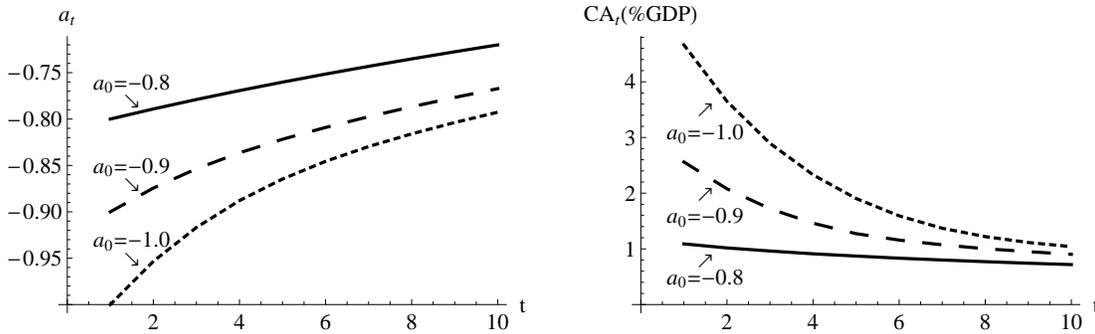
Figure 7. NFA and current account dynamics with an initial NFA a_0 close to the constraint $\underline{a}$=-1

Figure 8. NFA and current account dynamics under a possible tightening of the constraint


Summing up, while precautionary savings have in general little influence on current accounts, this is no longer true for those countries with NFA positions close to their borrowing limits. Since being close to a constraint impairs the ability to smooth negative income shocks by further borrowing, it is optimal to run substantial current account surpluses to improve the NFA fairly quickly. This is particularly important for countries which also face the risk of a possible tightening of the borrowing constraint.

B. Idiosyncratic risk

The bottom plot of figure 6 suggests that the impact of precautionary savings on the current accounts can also be magnified by a proportional increase in GDP volatility across countries. Figure 9 considers a much higher increase in volatility, multiplying the standard deviation of income shocks for each region by $\mu_\sigma = 5$. We observe that this generalized increase in uncertainty leads to a relatively small widening in the dispersions of the equilibrium NFA, but a substantial increase in current account imbalances. For example, the surplus of the "China-Oil-ROW" region increases from 0.03% of GDP as more clearly visible in figure 5, to 1.5% if volatilities are five times larger. But why should we consider much higher volatilities than those estimated on GDP data? Because by focusing on aggregate fluctuations using a representative agent framework we have neglected idiosyncratic risk within countries. Individual income is indeed much more volatile than aggregate GDP, and domestic financial markets and public safety nets allow only for limited risk-sharing. As shown in Mendoza et al. (2009) and

Sandri (2010), precautionary motives in models based on idiosyncratic risk may generate much larger current account imbalances than those we have derived focusing on aggregate volatility.

Figure 9. Optimal NFA and current account dynamics under low ($\mu_\sigma = 1$) and high ($\mu_\sigma = 5$) volatility
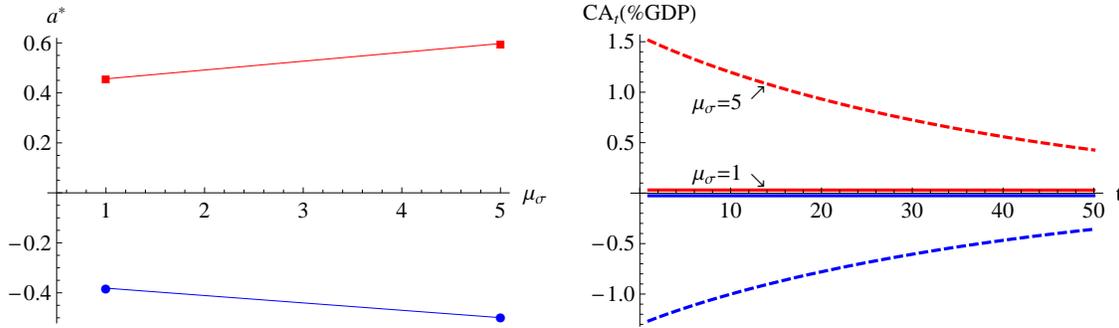
To understand why higher volatilities lead to larger current account imbalances, figure 10 shows how the optimal NFA positions vary with the interest rate. In particular, the left-side plot considers the optimal NFA for each region under the benchmark calibration $\mu_\sigma = 1$ and with standard deviations multiplied by $\mu_\sigma = 5$, and the right-side plot shows the aggregate world NFA. Focusing first on the benchmark calibration $\mu_\sigma = 1$, the relatively low volatilities imply a negative NFA position for both regions as long as the interest rate does not approach the impatience boundary G^γ/β. As explained in section C, the equilibrium world interest rate is thus only marginally different from the values at which countries would want to keep their NFA unchanged. This very small difference leads to a minimal drift in the Euler equation and very gradual movements in the NFA. In the presence of higher volatility $\mu_\sigma = 5$, the countries' optimal NFA positions are instead fairly elastic to the interest rate even at values considerably smaller than the limit G^γ/β. Therefore, the interest rates implying stable NFA are substantially different from the market clearing value. For example, the 2007 NFA for the "China-Oil-ROW" region was at 2.3 percent of GDP. As shown by the dashed-red line on the left-side plot, this value would be optimal and stable if the interest rate were equal to around 2.65%. This is considerably different from the 2.8% equilibrium interest rate on the right-side plot. This larger difference between the equilibrium world interest rate and the interest rates which would keep the NFA constant, generates a stronger drift in the Euler equation and larger current account imbalances.

Figure 10. Sensitivity of the optimal NFA under different volatilities with respect to the interest rate
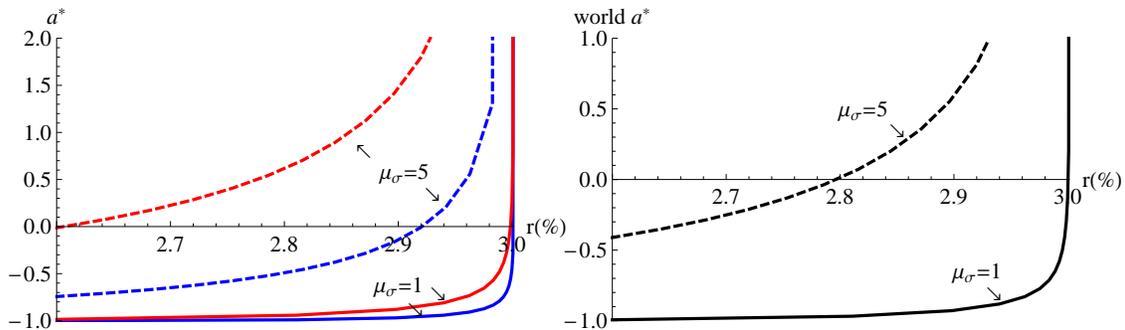
V. Conclusion

In this paper, we have developed a world economy model in which countries differ with respect to GDP volatility. Our quantitative exercise shows that the observed heterogeneity in volatility can lead to a large dispersion of NFA positions. However, the speed of convergence towards the optimal foreign investment positions appears to be very slow, generating only small current account imbalances. These results therefore caution against interpreting large current account surpluses as driven by precautionary motives against aggregate shocks.

Precautionary savings can however have a large impact on the current accounts of countries close to their borrowing constraints. Since the proximity to the constraint limits the possibility to smooth negative shocks by issuing debt, these countries need to run large current account surpluses to improve their NFA position. This is particularly important for those countries subject to a possible tightening of the borrowing constraint which could generate sudden-stop episodes. The relevance of precautionary savings for current accounts can also be substantially increased if focusing on within-country idiosyncratic risk. This requires better cross-country comparable data on household income volatility and the ability of domestic financial markets and fiscal policies to allow for risk-sharing.[12]

An interesting direction of research is to relax the assumption of a single homogenous good, differentiating between domestic and foreign tradable goods as well as between tradable and non tradable goods. It is not obvious a priori whether a lower degree of substitutability between goods would strengthen or reduce the desire to hold foreign assets. On one hand, the limited ability of foreign goods to substitute for domestic products could limit the desired amount of foreign assets. On the other, this lower ability to insure against GDP fluctuations may actually induce to accumulate even more international reserves. Furthermore, the key issue would be how good differentiation interacts with heterogeneity in volatility to change the prediction about the distribution of NFA and current accounts.

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[12]In this regard, it would be interesting to apply the framework developed in the paper to the analysis of imbalances within Europe given the good data coverage.

REFERENCES

Backus, David K., Patrick J. Kehoe, and Finn E. Kydland, 1992, "International Real Business Cycles," *Journal of Political Economy*, Vol. 100, No. 4, pp. 745-775.

Baxter, Marianne, and Mario J. Crucini, 1995, "Business Cycles and the Asset Structure of Foreign Trade," *International Economic Review*, Vol. 36, No. 4, pp. 821-854.

Bems, Rudolfs, and Irineu de Carvalho Filho, 2009, "Current Account and Precautionary Savings for Exporters of Exhaustible Resources," *IMF Working Paper No.09/33.*

Blanchard, Olivier J., and Stanley Fisher, 1989, *Lectures on Macroeconomics* (Cambridge, Massachusetts, London, England: The MIT Press).

Carroll, Christopher D., 2009, "Theoretical Foundation of Buffer Stock Saving," *Unpublished Manuscript, Johns Hopkins University.*

Chang, Yongsung, Sun-Bin Kim, and Jaewoo Lee, 2010, "Accounting for Global Dispersion of Current Accounts," *Working Paper.*

Clarida, Richard H., 1990, "International Lending and Borrowing in a Stochastic Stationary Equilibrium," *International Economic Review*, Vol. 31, No. 3, pp. 543-558.

Durdu, Ceyhun Bora, Enrique G. Mendoza, and Marco E. Terrones, 2009, "Precautionary Demand for Foreign Assets in Sudden Stop Economies: an Assessment of the New Merchantilism," *Journal of Development Economics*, Vol. 89, pp. 194 - 209.

Fernández-Villaverde, Jesús, Pablo A. Guerrón-Quintana, Juan Rubio-Ramírez, and Martín Uribe, 2009, "Risk Matters: the Real Effects of Volatility Shocks," *NBER Working Paper No. 14875.*

Fogli, Alessandra, and Fabrizio Perri, 2006, "The Great Moderation and the U.S. External Imbalance," *Monetary and Economic Studies*, Vol. 24, No. S-1, pp. 209-234.

———, and ———, 2010, "Macroeconomic Volatility and External Imbalances," *Working Paper.*

Ghosh, Atish R., and Jonathan D. Ostry, 1997, "Macroeconomic Uncertainty, Precautionary Saving and the Current Account," *Journal of Monetary Economics*, Vol. 40, No. 1, pp. 121-139.

Jeanne, Olivier, and Damiano Sandri, 2010, "Precautionary Savings in the Open Economy: Exact Solution and Approximate Rules," *Working Paper.*

Lane, Philip R., and Gian Maria Milesi-Ferretti, 2007, "The External Wealth of Nations Mark II: Revised and Extended Estimates of Foreign Assets and Liabilities," *Journal of International Economics*, Vol. 73, No. 2, pp. 223-250.

Lucas, Robert E., Jr., 1987, *Models of Business Cycles* (Basil Blackwell, New York).

Mendoza, Enrique G., 1991, "Real Business Cycles in a Small Open Economy," *American Economic Review*, Vol. 81, No. 4, pp. 797-818.

⎯⎯⎯⎯, Vincenzo Quadrini, and José-Víctor Ríos-Rull, 2009, "Financial Integration, Financial Development, and Global Imbalances," *Journal of Political Economy*, Vol. 117, No. 3.

Sandri, Damiano, 2010, "Growth and Capital Flows with Risky Entrepreneuship," *IMF Working Paper No.10/37.*

Song, Zheng M., Kjetil Storesletten, and Fabrizio Zilibotti, 2009, "Growing like China," *CEPR Discussion Paper No. 7149.*