# Currency Crises in Reverse: Do Large Real Exchange Rate Appreciations Matter for Growth?

Bussière, Matthieu and Lopez, Claude and Tille, Cédric

Banque de France, Banque de France, Graduate Institute for International and Development Studies

December 2013

# Currency Crises in Reverse:

# Do Large Real Exchange Rate Appreciations Matter for Growth?*

**Matthieu Bussière♠, Claude Lopez♦, and Cédric Tille♣**

Preliminary version of a paper prepared for the 59th Panel Meeting of Economic Policy, April 2014

**Abstract**

While currency crises have been extensively studied, the opposite phenomenon, large appreciations, has been far less researched, in spite of strong interest in policy circles and in the media. We fill this gap by providing a theoretical analysis and an empirical exploration of large real exchange rate appreciations. We develop a simple model that contrasts the pattern of exchange rate and growth depending on the underlying shock. The model shows that an appreciation stemming from a productivity boom leads to a stronger growth than the same appreciation stemming from a surge of capital inflows. We then use a sample of 30 advanced and 38 emerging market economies, with annual data going back to 1960, and focus on the connection between large appreciations and output growth. Our first empirical finding is that, while countries faced with large real exchange rate appreciations experience significantly lower export growth and higher import growth, this impact on trade flows does not translate into overall output growth. Second, we find supporting evidence for our theoretical patterns in a panel regression, as growth tends to be higher during the appreciation episodes associated with productivity shocks than those associated with surges of capital inflows.

**Keywords:** exchange rate, currency crises, endaka, international trade, international capital flows, lending booms, small open economy macroeconomics.
**JEL classification:** F10, F30, F41.

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* The views presented in this paper are those of the authors and do not necessarily reflect those of the Banque de France or the Eurosystem. We are grateful to Philippe Bacchetta, Christiane Baumeister, Bruno Cabrillac, Menzie Chinn, James Hamilton, Lutz Kilian, Céline Mistretta and Robert Vigfusson for helpful suggestions. We also would like to thank Catherine Martin for outstanding research assistance.
♠ Banque de France, 31 rue Croix des Petits Champs, 75001 Paris; email: matthieu.bussiere@banque-france.fr.
♦ Banque de France, 31 rue Croix des Petits Champs, 75001 Paris; email: claude.lopez@banque-france.fr.
♣ Graduate Institute of International and Development Studies P.O. Box 136, 1211 Genève 21, Switzerland, email: cedric.tille@graduateinstitute.

## 1. Introduction

Currency crises (large real exchange rate depreciations) have figured very prominently on the research agenda of international macroeconomics for several decades. Their adverse effects have been broadly documented, leading academics and policy makers to develop tools to detect when the economy is at risk of a crisis and policies to limit their impact, such as limiting exchange rate movements – a pattern known as "fear of floating" (Calvo and Reinhart, 2002).

In contrast, relatively little is known about the effect of large appreciations, even though concerns about such phenomena are clearly pervasive in the policy debate. Sharp appreciations can lead to a loss in competitiveness and therefore may reduce growth through net trade. This fear has been repeatedly expressed by several policy makers.[1]. While the recent concern about "currency wars" – where the expansionary monetary policy in advanced economies leads to capital flows to emerging markets and an appreciation of their currencies – has been widely noted, the concern is not limited to emerging markets. Japanese policy makers for instance have repeatedly expressed their worries, having experienced several episodes of large real exchange rate appreciations, in the early 1970s in the wake of the Smithsonian Agreement, from 1985 to 1995 after the Plaza Accord, and in the current crisis.[2] The concern is however not universally shared. Paul Krugman (1994) has dubbed it "a dangerous obsession" and argues that "concerns about competitiveness are, as an empirical matter, almost completely unfounded".

This active debate raises the question whether large appreciations indeed have an adverse effect on growth, a point that has not been firmly established. This paper takes a step towards filling the gap. We first provide a theoretical framework that illustrates the joint determination of the real exchange rate and growth, and stresses the how the patterns for these two variables depend on the specific underlying shock. We then assemble a large dataset of 68 countries (30 advanced

[1] Two quotes illustrate these different views. On the one hand, Mishkin (2007) clearly expresses concern about the competitiveness channel (*"An appreciation of the dollar, in turn, restrains exports (because the price of U.S. goods rises when measured in foreign currencies) and stimulates imports (because imports become cheaper in dollar terms). The resulting decrease in net exports implies a reduction in aggregate demand"*). On the other hand, Noyer (2007) brings a more balanced view: *"It is clear that the price-competitiveness of French industries has deteriorated significantly in recent years. Has the euro's appreciation played a role in this? On the one hand, it undoubtedly penalises export sectors whose competitors are located in other monetary areas. But, on the other hand, it benefits those sectors which are large consumers of imported commodities. At this stage, the overall effect on France's growth and external balance is not clearly apparent"*.

[2] There is even a special word in Japanese to refer to a period of strong appreciation ("endaka").

economies and 38 emerging markets), with annual data from 1960 to 2011, and empirically assess the impact of large and sustained appreciation on key macroeconomic variables. Our empirical findings are in lines with the implications from the model.

Specifically, our theoretical analysis considers a simple model with differentiated traded and non-traded sectors, where the economy is subjected to sectoral productivity shocks, shocks to the sectoral allocation of demand, and shocks to the time discount factor. We first consider a simple version with a homogeneous traded good and show that the Home country's real exchange rate appreciates when productivity increases in the Home traded sector, when Home demand shifts towards non-traded goods, and when the propensity to save in the Foreign country increases, a proxy for a surge in capital inflows. A given appreciation can thus be associated with very different growth patterns depending on the nature of the shock. While an appreciation is accompanied by higher growth, this is much more pronounced following a productivity shock than following a capital inflows shock. The pattern is robust to extending the model to include differentiated traded goods, especially for capital inflows shocks. The connection between growth and productivity shocks in the more general model is looser, as productivity now has offsetting effects on the real exchange rate through the terms-of-trade between traded goods (absent in the simple model) and the relative price of non-traded goods.

The main findings from our empirical exercise can be summarized as follows. First, large appreciations are neither uncommon nor limited to emerging economies. We identify 107 episodes among which about 39 took place in advanced economies. Second, the stylized facts show that large appreciations are on average associated with lower exports and higher imports. While this would comfort policy makers worrying about the growth effects of large appreciations, our third result is that the pattern for net trade does not translate into a similar pattern for overall growth. This result therefore puts fears about the growth impact of large appreciations in perspective. Fourth, we document substantial heterogeneity across episodes. In particular, we find empirical evidence that appreciations associated with a productivity shock are characterized by higher output growth than when appreciations are associated with a surge of capital flows (net or gross).

While the stylized facts outlined above point to the absence of any adverse growth effect, we recognize that we cannot limit ourselves to such a broad-brush assessment and undertake a more detailed empirical assessment through a panel analysis. We find that large appreciations tend to be associated with lower growth, but that the effect depends crucially on the underlying shock. In particular, appreciations stemming from productivity growth are more benign than appreciations stemming from surges of capital inflows, in line with our theoretical exercise. We also find that global investors' attitude toward risk, proxied by the VXO index, matter. First, a country faced with a surge of *gross* inflows when investors are relaxed about risk tends to experience lower growth when the surge leads to a large appreciation. Second, a country faced with a surge of *net* inflows when investors are highly concerned about risk tends to experience lower growth, without necessarily facing a large appreciation.

The rest of the paper is organised as follows. Section 2 reviews the relevant literature. Section 3 presents a simple model and contrasts the growth pattern in appreciation episodes depending on the nature of the underlying shock. Section 4 introduces the definition of large exchange rate appreciations, and presents key stylized facts. A panel econometric analysis is undertaken in Section 5. Section 6 concludes and presents possible policy implications.

## 2. Review of the literature

As the exchange rate is a major economic variable, large exchange rate movements have long attracted a lot of attention among policy makers and researchers. However, existing studies have predominantly focused on episodes of weakening currencies, i.e. sharp depreciations, or currency crises. This is understandable given that currency crises generally have powerful adverse effects on growth, as documented by Cerra and Saxena (2008) and Bussière, Saxena and Tovar (2012), among others. Accordingly, statistical tools have been developed to detect currency crises before they strike. Existing approaches include so-called early warning models (Kaminsky, Lizondo and Reinhart, 1998, Goldstein and Reinhart, 2000) and logit models (Frankel and Rose, 1996, Eichengreen, Rose and Wyplosz, 1995, Berg and Pattillo, 1999, Bussière and Fratzscher, 2006).

While the literature on large appreciation is thinner than the one on currency crises, we are by no means the first paper to consider the issue. Kappler et al. (2012) were the first to formally define a large exchange rate appreciation and to look at the effects of such episodes on the current account balance and on real output. They find that large appreciations lead to deterioration of the current account through lower savings and lower exports, the effects being larger in emerging and developing economies. They however find little impact on overall GDP as domestic demand

and net exports move in opposite directions. We build on their work in several ways. First, we do not limit our analysis to countries operating a managed exchange rate. Second, we consider cross-country heterogeneity in addition to average responses, as some countries faced with a large appreciation manage to grow at a robust pace, while others seem to be particularly affected.

Third, we consider the underlying reasons for the appreciation. While nontrivial, such a distinction is important as a given appreciation can be associated with very different movements in growth depending on the driving shock. In particular, we distinguish episodes driven by movements in international capital flows from episodes driven by domestic productivity shocks. Our emphasis on movements in capital flows, which to our knowledge has not been taken previously, fits with a growing emphasis in international economics on "capital flow bonanzas" (Reinhart and Reinhart 2008) and "lending booms" (Gourinchas et al. 2001). Movements in international capital flows can in principle reflect the fundamentals of the particular economy, or global fundamentals. A growing body of literature stresses the prominent role of the later. Forbes and Warnock (2012a,b) argue that episodes of large movements in capital inflows and outflows are associated with changes in global risk, especially for flows in debt instruments, while local fundamentals do not have a robust effect. Ghosh et al. (2012) also document the role of global factors for episodes of large net flows, with local factors playing a secondary (albeit relevant) role. Rey (2013) stresses the relevance of global financial cycles in driving economic conditions, regardless of the exchange rate regime.[3] A prominent study of episodes of large appreciations is Goldfajn and Valdes (1999), who however focus on the persistence and unwinding of episodes where the appreciation is out of line with fundamentals, which is a different focus than ours.

Our paper also relates to other studies on similar issues. Rodrik (2008) focuses on a related (but markedly different) concept, that of undervaluation (and overvaluation). He emphasizes that "*Avoiding overvaluation of the currency is one of the most robust imperatives that can be gleaned from the diverse experience with economic growth around the world, and it is one that appears to be strongly supported by cross-country statistical evidence*", referring to the work of Razin and Collins (1997), Johnson, Ostry, and Subramanian (2007), and Easterly (2005). We differ from Rodrik as we focus on large appreciations and do not refer to a particular benchmark,

[3] Ghosh et al. (2012) however find that surges of capital flows are less frequent and smaller in countries with flexible exchange rates.

therefore abstracting from the question of over- or undervaluation. Our approach is motivated by the considerable uncertainty that surrounds estimates of equilibrium exchange rates -- see for instance the discussion in Bussière et al. (2010).[4]

### 3. A simple model of the real exchange rate

In this section we present a simple model that contrasts the impact of different types of on the real exchange rate, output and the current account. For brevity we focus on the main features and results, and leave more details to the appendix.[5] We first present the building blocks and the solution method. We then derive the analytical solution for a simple combination of parameters, and present numerical results for the more general parametrization.

#### 3.1 Building blocks

Our setup builds on Obstfeld and Rogoff (1996 chapter 4). We consider a general equilibrium model with two countries, Home and Foreign, of sizes *n* and *1-n* respectively. In the Home country, a representative agent of size *n* consumes a basket $C_t$ of traded and non-traded goods, with the former consisting of Home and Foreign produced goods:

$$C_t = \left[\gamma_t^{1/\lambda}\left(C_{T,t}\right)^{(\lambda-1)/\lambda} + \left(1-\gamma_t\right)^{1/\lambda}\left(C_{N,t}\right)^{(\lambda-1)/\lambda}\right]^{\lambda/(\lambda-1)}$$

$$C_{T,t} = \left[\left(n+(1-n)\chi\right)^{1/\theta}\left(C_{H,t}\right)^{(\theta-1)/\theta} + \left((1-n)(1-\chi)\right)^{1/\theta}\left(C_{F,t}\right)^{(\theta-1)/\theta}\right]^{\theta/(\theta-1)}$$

where $t$ denotes time, $C_{T,t}$ and $C_{N,t}$ are the consumptions of traded and non-traded goods, respectively, and $C_{H,t}$ and $C_{F,t}$ are the consumptions of Home traded and Foreign traded goods, respectively. $\gamma_t$ is the time-varying weight of traded goods in the consumption basket, $\lambda$ is the elasticity of substitution between traded and non-traded goods, and $\theta$ is the elasticity of substitution between Home traded and Foreign traded goods. $\chi$ is the degree of domestic bias in traded goods consumption. It lies between zero and one, with zero corresponding to the absence of bias. The consumption baskets of the representative agent of size *1-n* are similar, with asterisks denoting Foreign variables:

[4] A given appreciation does not necessarily coincide with an overvaluation: it could be that the exchange rate is converging towards a new equilibrium, correcting a past undervaluation. Having said that, the definition we use excludes large appreciations that followed a currency crisis: given that such crises are well-known to give rise to an overshooting effect, such episodes would most likely correspond to a correction towards an equilibrium value.

[5] The fully detailed steps of the model solution are available on request.

$$C_t^* = \left[ \left(\gamma_t^*\right)^{1/\lambda} \left(C_{T,t}^*\right)^{(\lambda-1)/\lambda} + \left(1-\gamma_t^*\right)^{1/\lambda} \left(C_{N,t}^*\right)^{(\lambda-1)/\lambda} \right]^{\lambda/(\lambda-1)}$$

$$C_{T,t}^* = \left[ \left(n(1-\chi)\right)^{1/\theta} \left(C_{H,t}^*\right)^{(\theta-1)/\theta} + \left(1-n+n\chi\right)^{1/\theta} \left(C_{F,t}^*\right)^{(\theta-1)/\theta} \right]^{\theta/(\theta-1)}$$

While the weight of traded goods in the overall basket can differ across countries, we assume that the degree of domestic bias in traded consumption is the same in both.

The allocation of consumption reflects the various relative prices, namely the price of Home traded goods $P_{H,t}$ the price of Foreign traded goods $P_{F,t}$ (both prices are the same in the two countries), the price indexes of traded goods $P_{T,t}$ and $P^*_{T,t}$, and the consumer price indexes $P_t$ and $P^*_t$. The price indexes are:

$$P_{T,t} = \left[ \left(n+(1-n)\chi\right)\left(P_{H,t}\right)^{1-\theta} + (1-n)(1-\chi)\left(P_{F,t}\right)^{1-\theta} \right]^{1/(1-\theta)}$$

$$P_{T,t}^* = \left[ n(1-\chi)\left(P_{H,t}\right)^{1-\theta} + \left(1-n+n\chi\right)\left(P_{F,t}\right)^{1-\theta} \right]^{1/(1-\theta)}$$

$$P_t = \left[ \gamma_t \left(P_{T,t}\right)^{1-\lambda} + \left(1-\gamma_t\right)\left(P_{N,t}\right)^{1-\lambda} \right]^{1/(1-\lambda)} \quad ; \quad P_t^* = \left[ \gamma_t^* \left(P_{T,t}^*\right)^{1-\lambda} + \left(1-\gamma_t^*\right)\left(P_{N,t}^*\right)^{1-\lambda} \right]^{1/(1-\lambda)}$$

We define the terms-of-trade as the price of Foreign traded goods to Home traded goods, $T_t = P_{F,t} / P_{H,t}$ and the relative prices of non-traded goods relative to traded goods as $R_t = P_{N,t} / P_{T,t}$ and $R^*_t = P^*_{N,t} / P^*_{T,t}$. The real exchange rate $Q_t = P^*_t / P_t$ reflects the terms-of-trade (in the presence of domestic bias) and the relative prices of non-traded goods:

$$Q_t = \left[ \frac{n(1-\chi) + \left(1-n+n\chi\right)\left(T_t\right)^{1-\theta}}{\left(n+(1-n)\chi\right) + (1-n)(1-\chi)\left(T_t\right)^{1-\theta}} \right]^{1/(1-\theta)} \left[ \frac{\gamma_t^* + \left(1-\gamma_t^*\right)\left(R_t^*\right)^{1-\lambda}}{\gamma_t + \left(1-\gamma_t\right)\left(R_t\right)^{1-\lambda}} \right]^{1/(1-\lambda)}$$

The production of traded and non-traded goods relies on a technology that uses labor with decreasing returns to scale. The total labor supply in the Home and Foreign country are set to $n$ and $1-n$. The outputs of the two sectors in the Home country are $Y_{H,t} = A_{H,t} \left(n - L_{N,t}\right)^{1-\alpha}$ and $Y_{N,t} = A_{N,t} \left(L_{N,t}\right)^{1-\alpha}$ where $L_{N,t}$ denotes the labor input in the non-traded sector, and $A_{i,t}$ is an exogenous productivity term in sector $i = H, N$. The parameter $\alpha$ reflects the degree of returns to scale. The case of $\alpha = 1$ corresponds to an endowment economy, while the case of $\alpha = 0$ corresponds to constant returns to scale. The outputs in the Foreign country are $Y^*_{F,t} = A^*_{F,t} \left(1 - n - L^*_{N,t}\right)^{1-\alpha}$ and $Y^*_{N,t} = A^*_{N,t} \left(L^*_{N,t}\right)^{1-\alpha}$.

Borrowing and lending takes place through a bond denominated in Foreign traded goods, without loss of generality. A unit of bond held between period $t$ and $t+1$ yields an interest rate of $1+r_{t+1}$.

We denote the per capita holdings of bonds by the Home agent at the end of period $t$ by $B_{t+1}$. The intertemporal constraints faced by the Home and Foreign agent are:

$$nP_tC_t + nP_{F,t}B_{t+1} = P_{H,t}A_{H,t}(n - L_{N,t})^{1-\alpha} + P_{N,t}A_{N,t}(L_{N,t})^{1-\alpha} + n(1+r_t)P_{F,t}B_t$$
$$(1-n)P_t^*C_t^* - nP_{F,t}B_{t+1} = P_{F,t}A_{F,t}^*(n - L_{N,t}^*)^{1-\alpha} + P_{N,t}^*A_{N,t}^*(L_{N,t}^*)^{1-\alpha} - n(1+r_t)P_{F,t}B_t$$

where we used the fact that bonds are in zero net supply worldwide. As in each country the consumption of non-traded goods is equal to its supply, we split the constraint in each country between the market clearing condition for the non-traded sector:

$$nC_{N,t} = A_{N,t}(L_{N,t})^{1-\alpha} \quad ; \quad (1-n)C_{N,t}^* = A_{N,t}^*(L_{N,t}^*)^{1-\alpha} \tag{1}$$

and the intertemporal constraint in terms of traded goods:

$$n\left(C_{H,t} + T_tC_{F,t}\right) + nT_tB_{t+1} = A_{H,t}(n - L_{N,t})^{1-\alpha} + n(1+r_t)T_tB_t \tag{2}$$
$$(1-n)\left(C_{H,t}^* + T_tC_{F,t}^*\right) - nT_tB_{t+1} = T_tA_{F,t}^*(n - L_{N,t}^*)^{1-\alpha} - n(1+r_t)T_tB_t \tag{3}$$

The clearing of the market for Home traded goods is written as:

$$nC_{H,t} + (1-n)C_{H,t}^* = A_{H,t}(n - L_{N,t})^{1-\alpha} \tag{4}$$

A similar relation holds for the clearing of the Foreign traded good, but is redundant given (1)-(4). The appendix presents the expressions for (1)-(4) using the expressions for the intratemporal allocation of consumption.

The Home and Foreign representative agents maximize an intertemporal utility of consumption over an infinite horizon:

$$U_t = E_t\sum_{s=0}^{\infty}\left(\beta_{t+s-1}\right)^s \ln\left(C_{t+s}\right) \quad ; \quad U_t^* = E_t\sum_{s=0}^{\infty}\left(\beta_{t+s-1}^*\right)^s \ln\left(C_{t+s}^*\right) \tag{5}$$

where the discount factors $\beta$ and $\beta$* are time varying.

The intertemporal optimization leads to two conditions for each country. The first ones are the Euler conditions for the dynamics of consumption:

$$\left(C_t\right)^{-1} = \beta_tE_t(1+r_{t+1}^C)\left(C_{t+1}\right)^{-1} \quad ; \quad \left(C_t^*\right)^{-1} = \beta_t^*E_t(1+r_{t+1}^{C*})\left(C_{t+1}^*\right)^{-1} \tag{6}$$

where $r_{t+1}^C$ and $r_{t+1}^{C*}$ are the real interest rates in terms of the consumption baskets:

$$1 + r_{t+1}^C = (1+r_{t+1})\frac{P_{F,t+1}}{P_{F,t}}\frac{P_t}{P_{t+1}} \quad ; \quad 1 + r_{t+1}^{C*} = (1+r_{t+1})\frac{P_{F,t+1}}{P_{F,t}}\frac{P_t^*}{P_{t+1}^*} \tag{7}$$

The second set of conditions reflects the optimal allocation of labor across the traded and non-traded sectors:

$$A_{H,t}P_{H,t}(n - L_{N,t})^{-\alpha} = P_{N,t}A_{N,t}(L_{N,t})^{-\alpha} \quad (8)$$
$$A^*_{F,t}P_{F,t}(1 - n - L^*_{N,t})^{-\alpha} = P^*_{N,t}A^*_{N,t}(L^*_{N,t})^{-\alpha} \quad (9)$$

The appendix presents the real interest rates in (6) and the allocations (8)-(9) in terms of relative prices. Note that when Home and Foreign traded goods are perfect substitutes, so that $P_{H,t} = P_{F,t} = P_{T,t} = P^*_{T,t}$ and there are constant returns to scale in production, (8)-(9) imply that the relative price of non-traded goods only reflects relative productivities: $R_t = A_{H,t} / A_{N,t}$ and $R^*_t = A^*_{F,t} / A^*_{N,t}$.

There are three sources of shocks in the model. The first consists of productivity shocks in the traded and non-traded sectors, with exogenous movements in $A_{H,t}$, $A_{N,t}$, $A^*_{F,t}$ and $A^*_{N,t}$. The second are shocks to the allocation of demand between traded and non-traded goods, with fluctuations in $\gamma_t$ and $\gamma^*_t$, a higher value of either denoting a demand shift towards traded goods. The final source of shocks are movements in the discount factors of Home and Foreign agents, $\beta_t$ and $\beta^*_t$. These discount factor shocks can be interpreted as exogenous shifters of international capital flows, as an increase patience of Foreign agents translates into capital flows towards the Home economy.

### 3.2 Solution method

As the model is highly non-linear, we approximate it around a symmetric steady state. In that steady state, where variables are indexed by 0, agents have the same preferences over traded and non-traded goods ($\gamma_0 = \gamma^*_0$), and are equally patient ($\beta_0 = \beta^*_0 = \beta_0$) which removes incentives to save and borrow internationally. In addition no country holds claims on the other ($B_0 = 0$). The Euler conditions (6) imply that the real interest rates are all equal to the inverse of the discount rate.

The baseline steady-state is characterized by the two market clearing conditions for non-traded goods (1), the intertemporal constraints (2)-(3), the market clearing for the Home traded good (4), and the labor allocations (8)-(9). For simplicity, we put restrictions on the productivity levels so that all relative prices are equal to one, consumption is equalized across countries, and the labor allocations reflect the weight of the two sectors in preferences.[6]

[6] Specifically, we have $T_0 = R_0 = R^*_0 = 1$, $C_0 = C^*_0 = R_0 = A_{H,0}\,(n\gamma_0)^{-\alpha}$, and $L_{N,0} = n(1-\gamma_0)$ and $L^*_{N,0} = (1-n)(1-\gamma_0)$.

We express the model in terms of log-linear approximations around the baseline steady state and denote log deviations by hatted values, with for instance $\hat{C}_t = (C_t - C_0)/C_0$. As international bond holdings are zero in the steady state, we scale them by steady state consumption and define: $\hat{B}_t = B_t/(\gamma_0 C_0)$. The approximations of equations (1)-(9) are presented in the appendix.

We consider that the economy is initially in the baseline steady state, and is hit by unexpected shocks. We consider that all shocks follow an autoregressive process:

$$\hat{A}_{H,t} = \rho_T \hat{A}_{H,t-1} + \varepsilon_{TH,t} \; ; \; \hat{A}^*_{F,t} = \rho_T \hat{A}^*_{F,t-1} + \varepsilon_{TF,t} \; ; \; \hat{A}_{N,t} = \rho_N \hat{A}_{N,t-1} + \varepsilon_{NH,t} \; ; \; \hat{A}^*_{N,t} = \rho_N \hat{A}^*_{N,t-1} + \varepsilon_{NF,t}$$
$$\hat{\beta}_t = \rho_\beta \hat{\beta}_{t-1} + \varepsilon_{\beta H,t} \; ; \; \hat{\beta}^*_t = \rho_\beta \hat{\beta}^*_{t-1} + \varepsilon_{\beta F,t} \; ; \; \hat{\gamma}_t = \rho_\gamma \hat{\gamma}_{t-1} + \varepsilon_{\gamma H,t} \; ; \; \hat{\gamma}^*_t = \rho_\gamma \hat{\gamma}^*_{t-1} + \varepsilon_{\gamma F,t}$$

where all the $\rho$'s are between zero and one, the $\varepsilon$'s are iid innovations, and we define $\hat{\beta}_t = (\beta_t - \beta_0)/\beta_0$ and $\hat{\gamma}_t = (\gamma_t - \gamma_0)/(\gamma_0(1-\gamma_0))$.

In the linearized model, the real exchange rate of the Home country reflects the terms-of-trade (to the extent that there is domestic bias in consumption) and the cross-country difference in the relative price of non-traded goods:

$$\hat{Q}_t = \chi \hat{T}_t - (1-\gamma_0)(\hat{R}_t - \hat{R}^*_t) \tag{10}$$

An increase in the relative price of non-traded goods in the Home country leads to a real appreciation through the standard Harold-Balassa-Samuelson effect. As we allow for imperfect substitutability between Home and Foreign traded goods, movements in the term-of-trade also matter, and can offset the usual effect through the relative price of non-traded goods. The output in the Home sectors and the overall Home output, measured in terms of Home traded goods, are written as:

$$\hat{Y}_{H,t} = \hat{A}_{H,t} - (1-\alpha)\frac{1-\gamma_0}{\gamma_0}\hat{L}_{N,t} \quad ; \quad \hat{Y}_{N,t} = \hat{A}_{N,t} - (1-\alpha)\hat{L}_{N,t}$$
$$\hat{Y}_t = \gamma_0 \hat{A}_{H,t} + (1-\gamma_0)\hat{A}_{N,t} + (1-\gamma_0)\left[\hat{R}_t + (1-n)(1-\chi)\hat{T}_t\right] \tag{11}$$

As the analytical solution is quite cumbersome for the general model, we first consider a specific case, before presenting a numerical illustration of the general case.

### 3.3 A simple case

We simplify the model in two ways. First, we consider that Home and Foreign goods are perfect substitutes ($\theta \to \infty$), so that there is a common traded good. The terms-of-trade are then always equal to one, so we lose one endogenous variable as $\hat{T}_t = 0$. We also lose one equation as the market clearing condition (4) corresponds to the sum of (2) and (3). In addition the degree of domestic bias χ is irrelevant. The second simplification is to set the elasticity of substitution between traded and non-traded goods λ equal to one.

It is convenient to first consider the solution in terms of worldwide averages of variables, which we denote by a *w* superscript (for instance: $\hat{C}_t^w = n\hat{C}_t + (1-n)\hat{C}_t^*$). We can show that in worldwide terms consumption reflects the productivity shocks, while the sectoral allocation of output is only driven by demand shocks. The relative price of non-traded good increases when productivity gains are tilted towards the traded sector and when demand shifts towards non-traded goods ($\hat{\gamma}_t^w < 0$):

$$\hat{C}_t^w = \gamma_0 \hat{A}_{T,t}^w + (1-\gamma_0)\hat{A}_{N,t}^w \quad ; \quad \hat{L}_{N,t}^w = -\gamma_0 \hat{\gamma}_t^w \quad ; \quad \hat{R}_t^w = \hat{A}_{T,t}^w - \hat{A}_{N,t}^w - \alpha \hat{\gamma}_t^w$$

We then proceed to the solution of the model in terms of cross-country differences, denoting relative variables by a *d* superscript (for instance: $\hat{C}_t^d = \hat{C}_t - \hat{C}_t^*$). Starting with the solution for the Home country's foreign assets, $\hat{B}_{t+1}/(1-n)$, we can show that the Home country runs a current account surplus when the patience of Home agents increases relative to that of Foreign agents ($\hat{\beta}_t^d > 0$), when productivity gains in the traded sector are tilted in favor of the Home country ($\hat{A}_{T,t}^d > 0$), and when demand in the Home country shift away from traded goods, relative to demand in the Foreign country ($\hat{\gamma}_t^d < 0$):

$$\frac{\hat{B}_{t+1}}{1-n} = \frac{\beta_0}{\alpha + (1-\alpha)\gamma_0}\left[\frac{1}{1-\beta_0\rho_\beta}\hat{\beta}_t^d + \frac{1-\rho_T}{1-\beta_0\rho_T}\hat{A}_{T,t}^d - \frac{1-\rho_\gamma}{1-\beta_0\rho_\gamma}\alpha(1-\gamma_0)\hat{\gamma}_t^d\right] \qquad (12)$$

A current account surplus by the Home country is associated with a shift of its labor force towards the traded sector, a reduction in its overall consumption, and a real appreciation of its currency:

$$\hat{L}_{N,t}^d = -\gamma_0\left[\hat{\gamma}_t^d + \frac{\hat{B}_{t+1}}{1-n}\right] \quad ; \quad \hat{R}_t^d = \hat{A}_{T,t}^d - \hat{A}_{N,t}^d - \alpha\left[\hat{\gamma}_t^d + \frac{\hat{B}_{t+1}}{1-n}\right]$$
$$\hat{C}_t^d = \gamma_0 \hat{A}_{T,t}^d + (1-\gamma_0)\hat{A}_{N,t}^d - \gamma_0 \frac{\hat{B}_{t+1}}{1-n} \qquad (13)$$

In addition to indirect effects through the current account, sectoral productivity differentials directly affect the real exchange rate, and the average productivity gap across countries affects consumption. A shift of demand toward traded goods in the Home country pushes labor into that sector and leads to a real depreciation as it lowers the price of non-traded goods in the Home country relative to the Foreign country.

We illustrate the impact of the various shocks through a numerical example. We set the Home country to be small with $n$ =0.2, assume that traded goods account for 30 % of the total consumption basket in the steady state ($\gamma_0$ = 0.3), that there are decreasing returns to scale ($\alpha$ = 0.25), and set the discount factor $\beta_0$ to 0.95. We set the autoregressive coefficients for all shocks to 0.5.[7]

We present the immediate impact of three different shocks on Home country variables in Figure 1. The first shock is an increase in productivity in the Home traded sector (stripped bars), the second shock is a shift of Home demand towards non-traded goods (grey bars), and the final shock is an increase in the patience of Foreign agents (black bars). The increase in Foreign patience can be interpreted as a capital inflows shock. Another approach to assess the impact of financial conditions on the exchange rate is found in Benigno and Romei (2012) who consider a tightening of borrowing constraints, but abstract from the distinction between traded and non-traded goods. For comparability, the magnitude of each shock set to lead to a unit real appreciation of the Home currency. [8]

The responses of the various variables depend crucially on the nature of the shock. A productivity gain in the traded sector leads agents to postpone consumption, especially of non-traded goods, and accumulate Foreign assets as the real interest rate increases. Labor shifts towards the more productive traded sector and the country experiences an increase in output, entirely driven by the production of traded goods.

A shock to the composition of demand leads to a reduction in overall consumption, which results from offsetting decrease in the consumption of traded goods and increase in the consumption of non-traded goods, which bids up their price. The country experiences an increase in overall output (measured in traded units), albeit smaller than following a productivity gain, with the sectoral composition of output and employment displaying a shift towards the non-traded sector.

[7] Our results are not sensitive to the degree of persistence of shocks.

[8] One may notice that the relative price of non-traded goods in the Home country does not increase equally across all shocks, even though the real exchange rate impact is the same. This simply reflects the fact that the real exchange rate is also affected by the relative price of non-traded goods in the Foreign country.

As traded consumption falls by more than traded output, the country experiences a current account surplus.

A capital inflows shock leads to a sizable current account deficit. Consumption increases across the board, but more so for traded goods. The sectoral composition of output shows a substantial heterogeneity with a shift of labor towards the non-traded sector that leads to a contraction in traded output. While overall output increases, this gain is smaller than following demand or productivity shocks.

Figure 1 illustrates the central result of the model, namely that a given appreciation of the real exchange rate can be associated with sharply different situations. While overall output always increases, it does so by most after a productivity shock and by least after a capital inflows shock. The reaction of the current account differs across shocks, with a surplus after productivity gains in the traded sector and a deficit following a capital inflows shock that fuels a boom in consumption.

### 3.4 The general case

We now turn to the general case where the elasticities of substitution $\theta$ and $\lambda$ can take more general values. As the analytical solution is complex, we focus on a numerical illustration. We keep the same parameters as in the previous section and assume that there is a moderate domestic bias in consumption ($\chi = 0.3$). We consider the same three types of shocks as under Figure 1, and contrast their impact depending on the values of $\theta$ and $\lambda$. As shown below, the shocks do not necessarily lead to a real appreciation, and we thus cannot use the same presentation approach as in Figure 1. We therefore consider unit values for each of the shocks.

The focus of this section is to show how our inferences from the simple model presented above are sensitive to the elasticities of substitution between traded and non-traded goods, and between Home and Foreign traded goods. Figure 2 shows the impact of a unit increase in Home traded productivity on variables in the Home country. In each panel we contrast the impact across different values for $\lambda$ (from 1 to 6, horizontal axis) and $\theta$ (1, 3, 6, and infinity, with four different lines). The simple model presented above corresponds to the left-most point of the thick line.

The main message from Figure 2 is that while the results are not too sensitive to the elasticity of substitution between traded and non-traded goods (the magnitudes of all movements tend to be smaller when traded and non-traded goods are more substitutable), they are very sensitive to the elasticity between Home and Foreign traded goods. The most striking result is for the real exchange rate, as a productivity gain can lead to a real depreciation of the currency when Home and Foreign traded goods are poor substitutes. This can be understood by looking at the equation (10) for the real exchange rate. Higher productivity in the Home traded sector raises the price of Home non-traded goods, which leads to a real appreciation of the currency from the second term in (10). This is the well-known Harold-Balassa-Samuelson effect. The productivity gain also reduces the price of Home-produced traded goods, which is not set by the world market when traded goods are not identical. In the presence of domestic bias in traded consumption this lowers the price of the traded goods basket in the Home country relative to the corresponding basket in the Foreign country. This channel, captured by the first term in (10), lowers the Home consumer price index and leads to a real depreciation. If Home and Foreign traded goods are poor enough substitutes, the terms-of-trade channel dominates and the Home currency depreciates in real terms.

A limited substitutability between traded goods of different origins leads to a higher output gain, higher consumption (as Home traded goods are cheaper), and a smaller current account surplus (or a deficit). The offsetting response of the sectoral output is muted, which along with the larger price movements leads to higher overall output in terms of the Home traded good.

Turning to the consequences of a Home demand shift towards non-traded goods (Figure 3), we see that the sensitivity of the results to the elasticity of substitution between Home and Foreign traded goods is much less pronounced. The results are more sensitive to the elasticity of substitutions between traded and non-traded, with a higher elasticity dampening the movements of the various variables. Only the terms-of-trade are affected by the elasticity of substitution between Home and Foreign traded goods, but this sensitivity is muted when looking at the real exchange rate, which always appreciates following a demand shift by Home agents towards non-traded goods.

The responses to a unit shock in capital inflows, stemming from higher Foreign patience, are displayed in Figure 4. The results are sensitive to the degree of substitutability between different traded goods, but not to the point of reversing the real exchange rate movements, with a depreciation observed for all cases. The real appreciation of the currency is stronger when Home and Foreign traded goods are poor substitutes. The movements of output in all sectors are more muted, and the overall output gain is reduced, and can even turn into a recession if traded and non-traded goods are close substitutes. The consumption boom is more moderate, which translates into a smaller current account deficit.

Contrasting the patterns under a productivity gain with the ones following a capital flows shock, we see that a higher elasticity of substitution actually strengthens the contrast pointed in Figure 1: it leads to a larger real appreciation and lower output gain (or even loss) following a capital flows shock, but raises the output gain following a productivity shock. Appreciations stemming from capital flows shocks are thus clearly less beneficial in terms of output than the ones stemming from productivity gains.

Overall our numerical illustration of the general model reinforces the patterns shown for the simple one. A real appreciation due to a productivity improvement in the traded sector leads to an output boom in that sector and a current account surplus. An appreciation stemming from an increase in Foreign savings by contrast is associated with a credit fuelled consumption boom and a limited increase in overall output as resources shift towards the non-traded sector.

## 4. The impact of large appreciations, capital surge and shock of productivity

This section presents the concepts used in our analysis. We then identify the main stylized facts that emerge from contrasting times of large appreciations with other periods.

### 4.1. Definitions

Our focus is on the relation between large exchange rate appreciations and output, contrasting the pattern between appreciations associated with unusual developments in the financial sector from those associated with a strong increase in domestic productivity.

To do so, we first need to define criteria in order to identify episodes of strong and sustained appreciation as well as strong changes in the financial markets and in terms of productivity.

The limited number of studies of large appreciations does not provide a widely accepted rigorous numerical definition of what constitutes a "large appreciation". Our selection reflects two aspects. First, as we are interested in the aggregate macroeconomic outcome, we focus on effective (rather than bilateral) exchange rates. Second, we define clear thresholds for the exchange rate such that only lasting episodes are selected and not transitory jumps. An episode of large appreciation must meet the following two conditions:

a. The real effective exchange rate remains stronger by at least 10 percent on average for the last three years (t-3) before for the appreciation to be recorded in t. Hence, t corresponds to the end of the three-year phase, such that:

$$\ln[(REER)_t] - \frac{\ln[(REER)_{t-2}] + \ln[(REER)_{t-3}]}{2} \geq 0.1$$

b. There was no depreciation of similar magnitude prior to the appreciation period

$$\ln[(REER)_{t-3}] - \frac{\ln[(REER)_{t-5}] + \ln[(REER)_{t-6}]}{2} \geq -0.1$$

These two criteria are defined in terms of the real exchange rate. We can also add a restriction that focuses our analysis on episodes where the nominal exchange rate moves:

c. The nominal effective exchange rate may be revalued by at least 10 percent or more relative to the average level in the past three years.

$$\ln[(NEER)_t] - \frac{\ln[(NEER)_{t-2}] + \ln[(NEER)_{t-3}]}{2} \geq 0.1$$

These criteria ensure that the identified episode display a large movement in the real exchange rate and that it does not constitute a "catch up" following a large depreciation of the currency.

Table 1 presents the identified episodes. We find 107 such country/time episodes respecting the criteria a and b, and only 43 when the 3 criteria hold, missing some important episodes such as the appreciation of the Yuan in 2008-09 or of the Australian dollar and the South African rand in 2010, among others. As a result, we focus our analysis on real appreciations (criteria a and b). Our definition excludes a number of appreciations that took place just after a currency crisis, such as those observed in Korea and Thailand after the Asian crisis.

Financial market conditions are proxied by large (net and gross) capital inflows. Indeed, swings in international financial markets are a major driver of economic performance in emerging but also advanced economies as the current crisis highlights. For each country, capital inflows are measured as a percentage of GDP. Following Forbes and Warnock (2012), we define a surge in capital inflows (gross or net) as follows:

$$\Delta Inflows_t \geq \overline{\Delta Inflows_t} + \sigma_t \quad \text{with } t = 5, \ldots, T$$

where $\Delta Inflows_t$ is the annual change in capital inflows, $\overline{\Delta Inflows_t} = (1/5)\sum_{i=0}^{4} \Delta Inflows_{t-i}$ is the average change over the previous 5 years, and $\sigma_t = (\sum_{i=0}^{4}(\Delta Inflows_{t-i} - \overline{\Delta Inflows_t})^2)^{0.5}$ is the standard deviation of flows over the same period. A surge episode is thus a situation where the increase in inflows in a year is one standard deviation above the average increase over the five previous years. We consider two types of surge. A "gross surge" is an increase in the growth rate of gross capital inflows, while a "net surge" is an increase in the growth rate of net capital inflows. [9]

We also consider the role of global financial markets conditions, proxied by the VXO measure of risk perception. Specifically, VXO values greater than 25 are generally associated with a large amount of uncertainty, while values below 15 correspond to less stressful, even complacent, times in the markets. In our analysis below, we contrast the impact of appreciations in periods of moderate global risk perceptions (when VXO is lower than 15) from that in periods of high global risk perceptions (when VXO larger than 25).

### 4.2. Descriptive statistics and stylized facts

In order to identify key observed patterns in the relation between large appreciations and output growth, we first use descriptive statistics and event studies to infer overall stylized facts. Table 2 presents the change in GDP, imports, exports, consumption, and investment growth rates as well as in credit to private sector as a percentage of GDP. We contrast the average values of these variables in times of large appreciations where the criteria a and b described above are met (top panel) with their values in times when either of the two criteria is not met (bottom panel). In each panel, we present the values for all countries, before contrasting developed and emerging economies.

Three results stand out. First, international trade flows behave as one could expect. Episodes of large currency appreciations are associated with weaker export growth and higher import growth.

[9] Gross capital inflows are the sum of inflows of direct investment, portfolio inflows, and other inflows. Net capital inflows are the difference between gross capital inflows and gross capital outflows (gross outflows being the sum of direct investment outflows, portfolio outflows, and other outflows).

The annual growth rate of real exports averages 5.2% during a strong appreciation, compared to 6% otherwise. Similarly, large appreciations are associated with stronger growth in imports (8.9% on average against 5.4% in normal times). This first set of results supports the concerns related to the adverse competitiveness effect of large appreciations on net trade, with an appreciated currency reducing exports and boosting imports. Furthermore, the reactions differ across countries: the impact on exports is noticeable for the advanced economies, while the impact of imports is much stronger on emerging economies.

Second, the pattern for net exports does not match the result for overall growth at all. While one may expect the adverse effect of the appreciation on net trade to correspond to weaker GDP growth, this is not the case. Instead, growth is similar on average during episodes of strong appreciation than during normal times (3.3%). Large appreciations are thus associated with other developments that offset the adverse impact on net exports. This is highlighted by our third stylized fact, namely that consumption and investment growth is stronger in times of large appreciations (4.4% and 5.1% respectively) than in normal times (3.7% and 3.3% respectively). A similar pattern is observed for credit growth in advanced economies (but not in emerging ones). Our results clearly underscore that one cannot draw a mechanical link between the impact of appreciations on trade flows on growth. Instead, one needs to assess the underlying drivers of the exchange rate and growth.

The analysis of Table 2 only contrasts the average values of variables across normal times and times of high appreciations. We complement these static results by looking at the evolution of the variables through time. This is done in Figure 5, which shows the dynamics of GDP growth (5.a), as well as real exports, real imports, credit to GDP and the effective real exchange rate (5.b) around the time of large appreciations. The figure reports averages calculated for five types of episodes: (i) no appreciation (white bars), (ii) a strong appreciation (grey bars), (iii) a strong appreciation combined with a productivity increase (black bar), (iv) a strong appreciation combined with a surge of gross capital inflows (vertical stripped bars) and (v) a strong appreciation combined with a surge of net capital inflows (diagonal stripped bars). Based on the definition reported in section 4.1, the time of the appreciation is recorded after a three-year period of sustained increase in REER, as the top panel of Figure 5.b clearly shows. The timing of the shocks, productivity or capital inflows, is more flexible as they can occur contemporaneously (t) or with a lag (t-1). The goal is to capture on-going phenomenon in order to isolate different underlying causes of the strong appreciation. The figure reports the evolution of the variables from three years before (t-3) the strong appreciation to three years after (t+3).

Figure 5.a shows the average patterns of real GDP growth across all countries, as well as separately for advanced and emerging economies. Two key features emerge. First, emerging economies experience, on average, lower growth after a period of large appreciation, unless it is associated with a surge of capital inflows or a productivity shock. By contrast, the negative impact of a large appreciation on advanced economies is temporary (one year), and is followed by a growth recovery. Second, all economies report their best performance (i.e. persistently stronger growth) when a strong appreciation is accompanied by a productivity shock.

Figure 5.b confirms the patterns seen in Figure 2. A large appreciation weakens exports and leads to a clear increase in imports. A strong appreciation combined with higher productivity boosts credit growth within 1 to 2 year after the appreciation, while the presence of a surge strengthens the credit after 2 years.

The patterns presented in this section are consistent with our theoretical findings. However, our analysis only presents broad stylized facts, and does not offer a precise assessment of the role of capital flows surges and productivity on growth. In addition, the average values reported in Table 2 are associated with sizable standard errors, showing that effects are highly heterogeneous. We therefore turn to a more formal assessment of the patterns.

## 5. Evidence from a panel analysis

In this section we refine the analysis using panel regressions. We focus on the determinants of overall GDP growth. Indeed, one potential explanation for the results presented in Table 2, which shows no difference for overall growth between times of large appreciation and other times, may be that these broad stylized facts do not control for the underlying economic shocks. Our econometric analysis allows us to more precisely assess whether different shocks, such as productivity or capital flows, have different implications for overall growth, differences that could be diluted in a broad average analysis.

We use a panel regression analysis and account for countries specificities by including fixed effects to capture the differences in means and by relying on GLS estimators to allow for difference in the variance by relying on GLS estimators.[10] Our most general specification is as follows:

$$y_{it} = FixedEffect_i + \beta_1 y_{i,t-1} + \sum_{j=0}^{1} \beta_{2,j} REER_{i,t-j} + \sum_{j=0}^{1} \beta_{3,j} Dapp_{i,t-j}$$

$$+ \sum_{j=0}^{1} \beta_{4,j} Dprod_{i,t-j} + \sum_{j=0}^{1} \beta_{5,j} Dsurge_{i,t-j}$$

$$+ \sum_{j=0}^{1} \beta_{6,j} Dprod_{i,t-j} * Dapp_{i,t-j} + \sum_{j=0}^{1} \beta_{7,j} Dsurge_{i,t-j} * Dapp_{i,t-j}$$

$$+ \sum_{j=0}^{1} \beta_{8,j} Dprod_{i,t-j} * Dsurge_{i,t-j} + \sum_{j=0}^{1} \beta_{9,j} Dprod_{i,t-j} * Dsurge_{i,t-j} * Dapp_{i,t-j}$$

$$+ \sum_{j=0}^{1} \beta_{10,j} Dsurge_{i,t-j} * DVXO15L_{i,t-j} + \sum_{j=0}^{1} \beta_{11,j} Dsurge_{i,t-j} * DVXO25H_{i,t-j}$$

$$+ \sum_{j=0}^{1} \beta_{12,j} Dsurge_{i,t-j} * DVXO15L_{i,t-j} * Dapp_{i,t-j}$$

$$+ \sum_{j=0}^{1} \beta_{13,j} Dsurge_{i,t-j} * DVXO25H_{i,t-j} * Dapp_{i,t-j} + \varepsilon_{it} \quad (14)$$

where *i* and *t* are indexes of country and time, *y* is the growth rate of GDP, *REER* the growth rate of the real exchange rate (so that an increase denotes an appreciation). The various dummies are defined as follows. Dapp denotes a large appreciation (criteria a and b presented in section 4.1), *Dprod* a productivity increase, Dsurge a capital inflows surge (gross or net depending on the specific regressions), DVXO15L a period where the VXO is below 15, and DVXO25H a period where the VXO is above 25.

$\beta_{2j}$ measures how regular movements of the exchange rate are associated with growth. $\beta_{3j}$ shows whether a large appreciation has an additional effect on growth. $\beta_{4j}$ and $\beta_{5j}$ capture the growth impact of productivity and capital flows, respectively. $\beta_{6j}$ and $\beta_{7j}$ assess whether a large appreciation has a different impact on growth when it is associated with a productivity increase ($\beta_{6j}$) or a capital inflows surge ($\beta_{7j}$). $\beta_{8j}$ shows whether productivity and capital inflows shocks amplify each other, and $\beta_{9j}$ assesses whether that combination changes the growth effect of large appreciations. We can expect the impact of capital flows to differ depending on whether they take place at times of unusually high or low perceptions of risk. This conjecture is assessed by

[10] Endogeneity between GDP and REER may bias these estimates. In an attempt to test the robustness of our findings, we also run instrumental regressions, using lagged REER. The direction (signs of the results) is confirmed but, as expected, the statistical significance is weakened as standard errors are commonly larger with instrumental regressions.

the last four coefficients. $\beta_{10j}$ and $\beta_{11j}$ show whether the impact of capital flows surge is different when perception of risk are unusually low ($\beta_{10j}$) or high ($\beta_{11j}$). Finally, $\beta_{12j}$ and $\beta_{13j}$ assess whether large appreciations have a different impact when they are associated with capital flows surge at times of unusual risk perceptions.

The estimated coefficients and their corresponding p-values are reported in Tables 3 and 4. Table 3 focuses on contemporaneous effects (in the regressions presented in Table 3, $\beta_1 = 0$ and there are no lags of explanatory variables, $j=0$), while we allow for lags in Table 4. In each table, we present specifications of growing complexity. First, we focus on strong appreciation and shocks and abstract from interactions between the various variables (first four columns of coefficients and p-values, $\beta_{1j}$ to $\beta_{5j}$). Second, we allow for differentiated effects of large appreciations when there are productivity or capital flows shocks ($\beta_{1j}$ to $\beta_{7j}$). We next allow for interactions between surge and productivity ($\beta_{1j}$ to $\beta_{9j}$). Fourth, we let the impact of capital inflows to differ in times of unusual risk perceptions ($\beta_{1j}$ to $\beta_{11j}$). Finally we allow the impact of large appreciations to differ in such times ($\beta_{1j}$ to $\beta_{13j}$). For each specification, we estimate two regressions. In the first one surges are measured in terms of gross capital inflows, while they are measured in terms of net inflows in the second one.

The signs and significance of the various coefficients are relatively robust across the different models. Starting with the contemporaneous results of Table 3, five points emerge. First, while a real appreciation is associated with higher growth ($\beta_2$>0), the relation is not monotonous as a strong appreciation has a negative impact on real GDP growth ($\beta_3$ varies from -1.07 and -1.47 depending on the specification considered). Second, growth is boosted in times of high productivity ($\beta_4 > 0$) and capital flows surges ($\beta_5 > 0$), but the impact of the latter is of smaller magnitude. This pattern is in line with the model where growth increases more following a productivity shock than following a capital flows shock. Third, productivity shocks also affect the link between appreciation and growth. While a large appreciation is adverse for growth ($\beta_3 < 0$), this is not the case when the appreciation is accompanied by higher productivity ($\beta_6$ is between 1.38 and 1.46 when considering gross surge in the model and between 1.05 and 1.30 for net surge). By contrast, the effect of surges of capital tends to be smaller, and mostly non-significant ($\beta_7$ lies between 0.87 and 2.02 for gross surge but close to 0 for net surge). While productivity shocks and surge matter (especially for the former), their interaction does not affect growth or the link between growth and appreciation.

The fourth result is that large appreciations associated with capital inflows surges have an adverse effect on growth when they happen in times of unusual risk perceptions, although the exact effect is sensitive to the exact specification considered. When considering surges of gross capital inflows, we observe a sizable negative effect of a large appreciation when investors are unusually tolerant of risk ($\beta_{12}$ = -2.50). When we consider surges of net inflows instead, the adverse effect at times of tolerance for risk is somewhat smaller and non-significant ($\beta_{12}$ = -1.88), but we observe a sizable and significant effect at times of high sensitivity to risk, even when the country is not faced with a large appreciation ($\beta_{11}$ = -1.09). Our analysis thus indicates that when investors are less concerned about the riskiness of their portfolios, countries that are large recipients of gross inflows tend to be faced with reduced growth prospects when their currency appreciates. In times of global crisis, when investors are not tolerant of risk, a country that attracts net foreign inflows (and can thus be seen as a safe haven) tends to suffer.

The final point emerging from our analysis is that growth is more favorable when the country experiences higher productivity than when it is faced with surges of capital flows, even taking the interaction with appreciation into account. Specifically, $\beta_4+\beta_6$ exceeds $\beta_5+\beta_7$ $(+\beta_{10}+\beta_{11}+\beta_{12}+\beta_{13})$. This is in line with our theoretical analysis, which shows that even though a capital flows shock boosts growth, it does so by less than a productivity shock with the same impact on the real exchange rate.

Table 4 presents the results when we include one lag for all variables. While the results are broadly in line with those of Table 3, we also observe some differences, mostly in terms of the impact of large appreciations combined with capital inflows surges at times of unusual attitudes to risk. When we consider surges in gross capital flows, we observe a significant negative effect on growth at times of high tolerance to risk ($\beta_{12,0}$=-2.67), as in Table 3. When considering surges in net flows, we observe a significant adverse effect only at times of limited tolerance for risk. This effect materializes only with a lag and when combined with a large appreciation ($\beta_{13,1}$ =-4.17), whereas we observe even without an appreciation in Table 3. Another difference is that the combination of a net inflows surge, productivity shock, and a strong appreciation boosts growth ($\beta_{9,0}$=4.21), a feature that is not observed in Table 3.

## 6. Conclusion

This paper investigates the connection between strong appreciations and growth. Our main message is that one cannot draw a simple link between the two variables, and instead needs to consider the specific shock behind the exchange rate appreciation.

Using a simple model, we show that appreciations stemming from productivity improvements are associated with a stronger economic performance than appreciations stemming from easier borrowing conditions in world financial markets. We then highlight patterns in a dataset of 68 countries for the period 1960-2011 that are consistent with these theoretical predictions.

We establish three main stylized facts. First, and as expected, large exchange rate appreciations are associated with weaker export growth and stronger import growth, compared to normal times. However, the second result is that this does not translate into a similar pattern for output growth, which is stable in the wake of a large appreciation, suggesting that other factors are sufficiently powerful to offset the effect through trade. Third, there is substantial heterogeneity across appreciation episodes. Appreciations that are associated with a surge in capital inflows are characterized by weaker growth compared to episodes with productivity shock.

A more formal assessment of the impact on growth using panel estimates shows that large appreciations are detrimental, unless they are associated with productivity increases. We also observe that global risk perceptions matter. Surge of gross capital inflows at times of unusual tolerance towards risk have an adverse effect on growth when they lead to a large appreciation. Surges of net inflows in times of stress also lower growth, even when we do not observe a large appreciation.

In terms of policy implications, our analysis shows that policy should not be designed solely in response to exchange rate movements, but instead needs to identify the driving factors. Financial inflows and credit booms emerge as sources of concern. These however are likely to be best dealt with through targeted management of capital flows and credit growth, for instance using macroprudential tools. A policy aimed at the exchange rate, which is merely a consequence of the underlying shocks, could well be too blunt a tool to effectively address legitimate policy concerns.

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## Appendix: complete solution of the model

A.1 Consumption allocation

The allocation of consumption in the Home country is:

$$C_{H,t} = \gamma_t\left(n+(1-n)\chi\right)\left[P_{H,t}/P_{T,t}\right]^{-\theta}\left[P_{T,t}/P_t\right]^{-\lambda} C_t$$
$$C_{F,t} = \gamma_t(1-n)(1-\chi)\left[P_{F,t}/P_{T,t}\right]^{-\theta}\left[P_{T,t}/P_t\right]^{-\lambda} C_t$$
$$C_{N,t} = (1-\gamma_t)\left[P_{N,t}/P_t\right]^{-\lambda} C_t$$

The corresponding relations in the Foreign country are:

$$C^*_{H,t} = \gamma^*_t n(1-\chi)\left[P_{H,t}/P^*_{T,t}\right]^{-\theta}\left[P^*_{T,t}/P^*_t\right]^{-\lambda} C^*_t$$
$$C^*_{F,t} = \gamma^*_t\left(1-n+n\chi\right)\left[P_{F,t}/P^*_{T,t}\right]^{-\theta}\left[P^*_{T,t}/P^*_t\right]^{-\lambda} C^*_t$$
$$C^*_{N,t} = (1-\gamma^*_t)\left[P^*_{N,t}/P^*_t\right]^{-\lambda} C^*_t$$

A.2 Market clearing and intertemporal constraints

Using the intratemporal consumption allocation, the clearing conditions for the non-traded goods (1) are written as:

$$n(1-\gamma_t)\left[\frac{(R_t)^{1-\lambda}}{\gamma_t+(1-\gamma_t)(R_t)^{1-\lambda}}\right]^{\frac{\lambda}{\lambda-1}} C_t = A_{N,t}(L_{N,t})^{1-\alpha}$$

$$(1-n)(1-\gamma_t)\left[\frac{(R^*_t)^{1-\lambda}}{\gamma_t+(1-\gamma_t)(R^*_t)^{1-\lambda}}\right]^{\frac{\lambda}{\lambda-1}} C^*_t = A^*_{N,t}(L^*_{N,t})^{1-\alpha}$$

The Home intertemporal constraint in terms of traded goods (2) is written as:

$$n\gamma_t\frac{\left[\left(n+(1-n)\chi\right)+(1-n)(1-\chi)(T_t)^{1-\theta}\right]^{\frac{1}{1-\theta}}}{\left[\gamma_t+(1-\gamma_t)(R_t)^{1-\lambda}\right]^{\frac{\lambda}{\lambda-1}}} C_t = A_{H,t}(n-L_{N,t})^{1-\alpha} + n(1+r_t)T_tB_t - nT_tB_{t+1}$$

The Foreign intertemporal constraint in terms of traded goods (3) is written as:

$$(1-n)\gamma^*_t\frac{\left[n(1-\chi)+\left(1-n+n\chi\right)(T_t)^{1-\theta}\right]^{\frac{1}{1-\theta}}}{\left[\gamma^*_t+(1-\gamma^*_t)(R^*_t)^{1-\lambda}\right]^{\frac{\lambda}{\lambda-1}}} C^*_t = T_tA^*_{F,t}(n-L^*_{N,t})^{1-\alpha} - n(1+r_t)T_tB_t + nT_tB_{t+1}$$

The clearing of the market for Home traded goods (4) is written as:

$$A_{H,t}(n-L_{N,t})^{1-\alpha}=n\gamma_t\frac{n+(1-n)\chi}{\left[(n+(1-n)\chi)+(1-n)(1-\chi)(T_t)^{1-\theta}\right]^{\frac{\theta}{\theta-1}}}\frac{1}{\left[\gamma_t+(1-\gamma_t)(R_t)^{1-\lambda}\right]^{\frac{\lambda}{\lambda-1}}}C_t$$
$$+(1-n)\gamma_t^*\frac{n(1-\chi)}{\left[n(1-\chi)+(1-n+n\chi)(T_t)^{1-\theta}\right]^{\frac{\theta}{\theta-1}}}\frac{1}{\left[\gamma_t^*+(1-\gamma_t^*)(R_t^*)^{1-\lambda}\right]^{\frac{\lambda}{\lambda-1}}}C_t^*$$

A.3 Real interest rate and labor allocation

Using the intratemporal consumption allocation, the real interest rates in terms of consumption baskets (7) are written as:

$$1+r_{t+1}^C=(1+r_{t+1})\frac{T_{t+1}}{T_t}\left[\frac{\gamma_t+(1-\gamma_t)(R_t)^{1-\lambda}}{\gamma_{t+1}+(1-\gamma_{t+1})(R_{t+1})^{1-\lambda}}\right]^{\frac{1}{1-\lambda}}\left[\frac{(n+(1-n)\chi)+(1-n)(1-\chi)(T_t)^{1-\theta}}{(n+(1-n)\chi)+(1-n)(1-\chi)(T_{t+1})^{1-\theta}}\right]^{\frac{1}{1-\theta}}$$
$$1+r_{t+1}^{C*}=(1+r_{t+1})\frac{T_{t+1}}{T_t}\left[\frac{\gamma_t^*+(1-\gamma_t^*)(R_t^*)^{1-\lambda}}{\gamma_{t+1}^*+(1-\gamma_{t+1}^*)(R_{t+1}^*)^{1-\lambda}}\right]^{\frac{1}{1-\lambda}}\left[\frac{n(1-\chi)+(1-n+n\chi)(T_t)^{1-\theta}}{n(1-\chi)+(1-n+n\chi)(T_{t+1})^{1-\theta}}\right]^{\frac{1}{1-\theta}}$$

The allocations of labor (8)-(9) are written as:

$$A_{H,t}(n-L_{N,t})^{-\alpha}=\left[(n+(1-n)\chi)+(1-n)(1-\chi)(T_t)^{1-\theta}\right]^{\frac{1}{1-\theta}}R_tA_{N,t}(L_{N,t})^{-\alpha}$$
$$A_{F,t}^*(1-n-L_{N,t}^*)^{-\alpha}=\left[n(1-\chi)+(1-n+n\chi)(T_t)^{1-\theta}\right]^{\frac{1}{1-\theta}}\frac{1}{T_t}R_t^*A_{N,t}^*(L_{N,t}^*)^{-\alpha}$$

A.4 Log-linear approximations

In terms of log-linear approximations, we write the market clearing conditions for non-traded goods (1) as:

$$-\gamma_0\hat{\gamma}_t-\lambda\gamma_0\hat{R}_t+\hat{C}_t=\hat{A}_{N,t}+(1-\alpha)\hat{L}_{N,t}\quad;\quad-\gamma_0\hat{\gamma}_t^*-\lambda\gamma_0\hat{R}_t^*+\hat{C}_t^*=\hat{A}_{N,t}^*+(1-\alpha)\hat{L}_{N,t}^*$$

The intertemporal constraints (2)-(3) are:

$$(1-\gamma_0)\hat{\gamma}_t+\hat{C}_t+(1-n)(1-\chi)\hat{T}_t+\lambda(1-\gamma_0)\hat{R}_t=\hat{A}_{H,t}-(1-\alpha)\frac{1-\gamma_0}{\gamma_0}\hat{L}_{N,t}+\frac{1}{\beta_0}\hat{B}_t-\hat{B}_{t+1}$$
$$(1-\gamma_0)\hat{\gamma}_t^*+\hat{C}_t^*-n(1-\chi)\hat{T}_t+\lambda(1-\gamma_0)\hat{R}_t^*=\hat{A}_{F,t}^*-(1-\alpha)\frac{1-\gamma_0}{\gamma_0}\hat{L}_{N,t}^*-\frac{n}{1-n}\frac{1}{\beta_0}\hat{B}_t+\frac{n}{1-n}\hat{B}_{t+1}$$

The market clearing for the Home traded good (4) is:

$$\hat{A}_{H,t} - (1-\alpha)\frac{1-\gamma_0}{\gamma_0}\hat{L}_{N,t} = \theta(1-n)(1-\chi^2)\hat{T}_t$$
$$+ \lambda(1-\gamma_0)\left[(n+(1-n)\chi)\hat{R}_t + (1-n)(1-\chi)\hat{R}_t^*\right]$$
$$+ (n+(1-n)\chi)\hat{C}_t + (1-n)(1-\chi)\hat{C}_t^*$$
$$+ (1-\gamma_0)\left[(n+(1-n)\chi)\hat{\gamma}_t + (1-n)(1-\chi)\hat{\gamma}_t^*\right]$$

The Euler equations (6) are (where $dr_{t+1}^C = r_{t+1}^C - (1-\beta_0)/\beta_0$):

$$\hat{C}_{t+1} = \hat{C}_t + \hat{\beta}_{H,t+1} + \beta_0 dr_{t+1}^C \quad ; \quad \hat{C}_{t+1}^* = \hat{C}_t^* + \hat{\beta}_{F,t+1} + \beta_0 dr_{t+1}^{C*}$$

The real interest rates in terms of consumption baskets (7) are:

$$\beta_0 dr_{t+1}^C = \beta_0 dr_{t+1} + (n+(1-n)\chi)(\hat{T}_{t+1} - \hat{T}_t) - (1-\gamma_0)(\hat{R}_{t+1} - \hat{R}_t)$$
$$\beta_0 dr_{t+1}^{C*} = \beta_0 dr_{t+1} + n(1-\chi)(\hat{T}_{t+1} - \hat{T}_t) - (1-\gamma_0)(\hat{R}_{t+1}^* - \hat{R}_t^*)$$

The labor allocations (8)-(9) are:

$$\hat{A}_{H,t} + \alpha\frac{1}{\gamma_0}\hat{L}_{N,t} = \hat{R}_t + \hat{A}_{N,t} + (1-n)(1-\chi)\hat{T}_t \quad ; \quad \hat{A}_{F,t}^* + \alpha\frac{1}{\gamma_0}\hat{L}_{N,t}^* = \hat{R}_t^* + \hat{A}_{N,t}^* - n(1-\chi)\hat{T}$$

# TABLE AND CHART APPENDIX

**Table 1.** Episodes of appreciation

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Argentina | 1979-1979 | Hong Kong | 1973-1974 | Philippines | 1996-1996 | Latvia | **1998-2000** |
| | 1981-1981 | | 1992-1994 | | 2008-2008 | | 2008-2009 |
| | 1991-1991 | | 1996-**1998** | Poland | **1994-1998** | Lithuania | **1995-2001** |
| | **1999-1999** | Hungary | 1992-1994 | | 2001-2002 | | 2009-2009 |
| Australia | **1973-1974** | | 2002-2004 | | 2006-2006 | Nicaragua | 1986-1987 |
| | **2003-2005** | | 2008-2008 | | **2008-2008** | | 2009-2009 |
| | 2010-2010 | Indonesia | 1977-1977 | Portugal | 1974-1975 | Romania | 1998-1999 |
| Brazil | 1990-1991 | | 2003-2004 | | 1990-1992 | | **2005-2007** |
| | 1997-1997 | | 2006-2007 | Russia | 2004-2008 | Slovak Rep. | **2003-2009** |
| | **2007-2008** | Ireland | **2003-2004** | Singapore | 1975-1975 | | |
| | 2010-2010 | | 2008-2008 | | 2008-2008 | Taiwan | 1974-1974 |
| Canada | **2004-2007** | Israel | 1983-1983 | South Africa | 2010-2010 | | 1982-1982 |
| Chile | **1995-1995** | Japan | **1972-1974** | Spain | 1979-1980 | Venezuela | 1995-1995 |
| | 1997-1997 | | **1977-1978** | | 1989-1990 | | 1997-2001 |
| China | 2008-2009 | | **1986-1988** | Sri Lanka | 2009-2010 | | 2009-2010 |
| Colombia | **1995-1997** | | **1994-1995** | Switzerland | **1973-1976** | | |
| | **2005-2005** | Korea | **2005-2007** | | **1995-1995** | | |
| | **2007-2008** | Malaysia | **1983-1984** | | **2010-2010** | | |

| | | | | | |
|---|---|---|---|---|---|
| Costa Rica | 2010-2010 | Mexico | 1974-1975 | Thailand | **2006**-2007 |
| Czech Rep. | 1996-1996 | | 1991-1993 | Turkey | 1976-1979 |
| | 1998-1998 | | 2000-2002 | | 1989-1990 |
| | **2002-2003** | Netherlands | 2003-2003 | | 2003-2005 |
| | **2006-2009** | New Zealand | 1988-1988 | United Kingdom | **1979-1981** |
| Denmark | 1987-1987 | | **1997-1997** | | **1998-1999** |
| Egypt | 2008-2010 | | **2005-2005** | United States | **1982-1985** |
| Euro Area | **1973-1973** | Norway | 2002-2002 | | **1998-1998** |
| | **1986-1987** | Peru | 1979-1979 | Uruguay | **1992-1995** |
| | **2008-2008** | | 1989-1989 | | **2008-2010** |
| Finland | 1975-1976 | | 1991-1991 | Bolivia | **2009-2010** |
| Germany | **1973-1973** | | 1993-1993 | Estonia | 2008-2008 |
| | | | 2008-2008 | Iceland | 1988-1988 |
| | | | | | **2005-2005** |

Appreciation for criteria a and b, in bold for a,b,c

**Table 2 :** Summary statistics: impact of a strong appreciation

| | GDP | Exports | Imports | Consumption | Investment | Cred_GDP |
|---|---|---|---|---|---|---|
| **In situation of strong appreciation (ab=1)** | | | | | | |
| All countries | | | | | | |
| Mean | 3,3 | 5,2 | 8,9 | 4,4 | 5,1 | 2,3 |
| *Std. dev.* | *4,2* | *7,5* | *12,1* | *6,2* | *7,1* | *11,4* |
| Developed countries | | | | | | |
| mean | 3,1 | 4,6 | 7,7 | 3,6 | 4,9 | 4,6 |
| *Std. dev.* | *3,1* | *7,3* | *11,3* | *2,8* | *6,7* | *14,2* |
| EMEs countries | | | | | | |
| mean | 3,4 | 5,5 | 9,9 | 5,0 | 5,2 | 0,9 |
| *Std. dev.* | *4,8* | *7,7* | *12,7* | *7,8* | *7,3* | *9,1* |

| | GDP | Exports | Imports | Consumption | Investment | Cred_GDP |
|---|---|---|---|---|---|---|
| **Not in situation of strong appreciation (ab=0)** | | | | | | |
| All countries | | | | | | |
| Mean | 3,3 | 6,0 | 5,4 | 3,7 | 3,3 | 1,6 |
| *Std. dev.* | *3,8* | *9,0* | *11,4* | *4,0* | *0,1* | *9,0* |
| Developed countries | | | | | | |
| mean | 3,0 | 5,9 | 5,0 | 3,0 | 2,4 | 2,3 |
| *Std. dev.* | *3,0* | *8,2* | *9,4* | *3,0* | *0,1* | *10,0* |
| EMEs countries | | | | | | |
| mean | 3,6 | 6,1 | 6,0 | 5,2 | 4,5 | 0,7 |
| *Std. dev.* | *4,7* | *10,1* | *14,4* | *5,4* | *0,1* | *7,2* |

**Table 3:** Static regression analysis, coefficients and p-values

| GDP on | gross surge | | net surge | | gross surge | | net surge | | gross surge | | net surge | | gross surge | | net surge | | gross surge | | net surge | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C | **3.06** | *0.00* | **3.06** | *0.00* | **3.11** | *0.00* | **3.09** | *0.00* | **3.13** | *0.00* | **3.10** | *0.00* | **3.15** | *0.00* | **3.12** | *0.00* | **3.15** | *0.00* | **3.12** | *0.00* |
| real exch. | **0.12** | *0.00* | **0.12** | *0.00* | **0.11** | *0.00* | **0.12** | *0.00* | **0.11** | *0.00* | **0.12** | *0.00* | **0.11** | *0.00* | **0.11** | *0.00* | **0.11** | *0.00* | **0.11** | *0.00* |
| app. | **-1.05** | *0.01* | **-1.07** | *0.01* | **-1.44** | *0.00* | **-1.36** | *0.00* | **-1.44** | *0.00* | **-1.33** | *0.01* | **-1.47** | *0.00* | **-1.35** | *0.00* | **-1.46** | *0.00* | **-1.34** | *0.01* |
| productivity | **1.76** | *0.00* | **1.74** | *0.00* | **1.57** | *0.00* | **1.57** | *0.00* | **1.42** | *0.00* | **1.50** | *0.00* | **1.37** | *0.00* | **1.45** | *0.00* | **1.38** | *0.00* | **1.45** | *0.00* |
| surge | **0.70** | *0.00* | **0.69** | *0.00* | **0.61** | *0.01* | **0.64** | *0.01* | **0.49** | *0.04* | **0.59** | *0.02* | **0.64** | *0.09* | **0.75** | *0.04* | 0.53 | *0.17* | **0.73** | *0.05* |
| app.*productivity | | | | | **1.41** | *0.04* | **1.30** | *0.07* | **1.38** | *0.06* | 1.05 | *0.16* | **1.46** | *0.05* | 1.14 | *0.13* | **1.46** | *0.05* | 1.12 | *0.13* |
| app.*surge | | | | | 0.98 | *0.17* | 0.49 | *0.54* | 0.87 | *0.26* | 0.16 | *0.85* | 0.98 | *0.20* | 0.27 | *0.77* | **2.02** | *0.07* | 0.54 | *0.73* |
| surge*productivity | | | | | | | | | 0.69 | *0.21* | 0.31 | *0.60* | 0.64 | *0.25* | 0.28 | *0.63* | 0.63 | *0.26* | 0.23 | *0.70* |
| app*surge*prod. | | | | | | | | | 0.47 | *0.80* | 1.61 | *0.40* | 0.39 | *0.83* | 1.52 | *0.42* | 0.93 | *0.53* | 1.88 | *0.24* |
| surge*vxo15L | | | | | | | | | | | | | -0.07 | *0.86* | 0.02 | *0.97* | 0.12 | *0.78* | 0.18 | *0.69* |
| surge*vxo25H | | | | | | | | | | | | | -0.69 | *0.20* | -0.92 | *0.12* | -0.54 | *0.35* | **-1.09** | *0.08* |
| app*surge*vxo15L | | | | | | | | | | | | | | | | | **-2.50** | *0.05* | -1.88 | *0.27* |
| app*surge*vxo25H | | | | | | | | | | | | | | | | | -1.47 | *0.31* | 1.35 | *0.47* |

Table 3 reports the coefficients and the corresponding p-values when regressing GDP growth on the list of variables listed in the 1st column. With the exception of real exch, which is the 1st difference of exchange rate, these variables are dummies capturing the episodes of interest: app for strong appreciation, productivity for productivity shocks, surge for capital inflows (net and gross) and DVXO for the two levels of VXO considered. The variable "surge" is either gross surge or net surge in the regression. The table reports the results based on the estimation of the full model (last four columns) and 4 restricted versions.

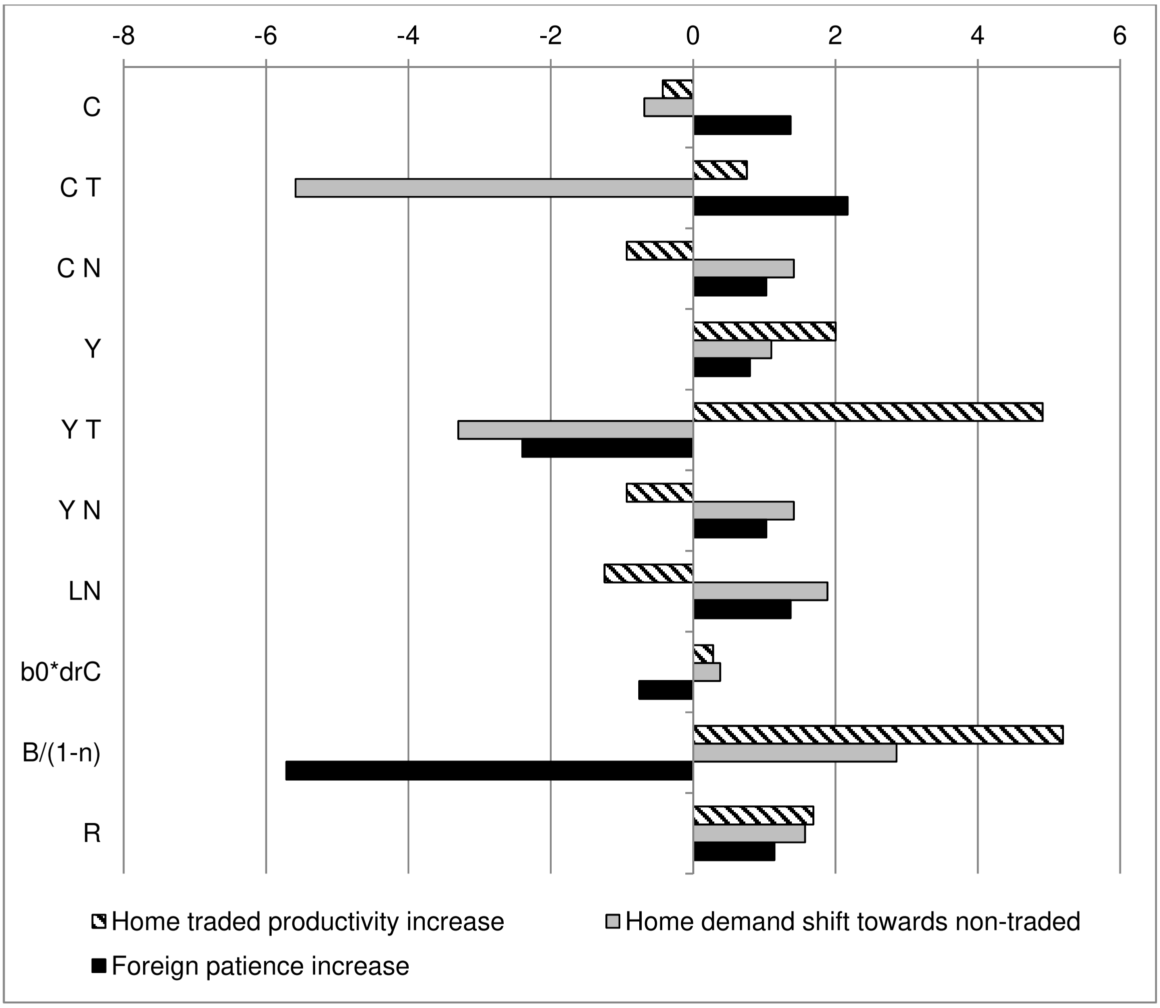
The coefficients in bold are significant at, at least 10%, and the p-values are in italic.

**Table 4:** Dynamic regression analysis, coefficients and p-values

| GDP on | gross surge | | net surge | | gross surge | | net surge | | gross surge | | net surge | | gross surge | | net surge | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GDP(-1) | **0.29** | *0.00* | **0.30** | *0.00* | **0.29** | *0.00* | **0.30** | *0.00* | **0.30** | *0.00* | **0.31** | *0.00* | **0.30** | *0.00* | **0.31** | *0.00* |
| C | **1.79** | *0.00* | **1.80** | *0.00* | **1.82** | *0.00* | **1.80** | *0.00* | **1.79** | *0.00* | **1.76** | *0.00* | **1.80** | *0.00* | **1.76** | *0.00* |
| real exch. | **0.11** | *0.00* | **0.12** | *0.00* | **0.11** | *0.00* | **0.12** | *0.00* | **0.12** | *0.00* | **0.12** | *0.00* | **0.12** | *0.00* | **0.12** | *0.00* |
| real exch.(-1) | **-0.05** | *0.00* | **-0.05** | *0.00* | **-0.05** | *0.00* | **-0.05** | *0.00* | **-0.05** | *0.01* | **-0.05** | *0.01* | **-0.04** | *0.01* | **-0.05** | *0.01* |
| app. | **-1.33** | *0.01* | **-1.28** | *0.01* | **-1.29** | *0.01* | **-1.20** | *0.02* | **-1.30** | *0.01* | **-1.18** | *0.02* | **-1.30** | *0.01* | **-1.20** | *0.02* |
| app.(-1) | 0.32 | *0.51* | 0.28 | *0.56* | 0.30 | *0.54* | 0.25 | *0.61* | 0.25 | *0.61* | 0.22 | *0.65* | 0.27 | *0.59* | 0.21 | *0.67* |
| productivity | **2.01** | *0.00* | **2.02** | *0.00* | **1.94** | *0.00* | **2.10** | *0.00* | **1.95** | *0.00* | **2.13** | *0.00* | **1.95** | *0.00* | **2.11** | *0.00* |
| productivity(-1) | 0.39 | *0.14* | 0.36 | *0.18* | 0.20 | *0.54* | 0.13 | *0.70* | 0.20 | *0.55* | 0.14 | *0.69* | 0.20 | *0.55* | 0.12 | *0.72* |
| surge | **0.66** | *0.00* | **0.67** | *0.00* | **0.61** | *0.01* | **0.72** | *0.01* | **0.96** | *0.01* | **1.07** | *0.00* | **0.86** | *0.02* | **1.04** | *0.01* |
| surge(-1) | **0.92** | *0.00* | **0.66** | *0.00* | **0.79** | *0.00* | **0.51** | *0.03* | **1.04** | *0.01* | 0.45 | *0.16* | **0.96** | *0.02* | 0.32 | *0.33* |
| app.*productivity | **1.16** | *0.10* | 1.17 | *0.12* | 0.85 | *0.23* | 0.61 | *0.41* | 0.84 | *0.23* | 0.56 | *0.46* | 0.78 | *0.27* | 0.53 | *0.48* |
| (app.*productivity)(-1) | 0.22 | *0.81* | 0.52 | *0.57* | 0.42 | *0.67* | 0.91 | *0.37* | 0.49 | *0.63* | 0.99 | *0.33* | 0.41 | *0.68* | 0.99 | *0.33* |
| app.*surge | 0.52 | *0.48* | 0.10 | *0.91* | 0.11 | *0.88* | -0.57 | *0.54* | 0.18 | *0.80* | -0.64 | *0.51* | 1.29 | *0.21* | 0.00 | *1.00* |
| (app.*surge)(-1) | -0.10 | *0.89* | 0.39 | *0.59* | 0.02 | *0.98* | 0.58 | *0.44* | 0.06 | *0.94* | 0.61 | *0.41* | 0.88 | *0.37* | 2.34 | *0.05* |
| surge*productivity | | | | | 0.33 | *0.53* | -0.34 | *0.53* | 0.18 | *0.73* | -0.50 | *0.36* | 0.17 | *0.75* | -0.52 | *0.33* |
| (surge*productivity)(-1) | | | | | **0.85** | *0.07* | 0.92 | *0.05* | **0.83** | *0.09* | **0.85** | *0.07* | **0.83** | *0.09* | **0.86** | *0.07* |
| app*surge*prod. | | | | | 2.04 | *0.37* | 3.39 | *0.14* | 2.33 | *0.31* | 3.77 | *0.11* | 2.89 | *0.14* | **4.21** | *0.03* |
| (app*surge*prod.)(-1) | | | | | -0.57 | *0.80* | -1.18 | *0.59* | -0.39 | *0.86* | -1.02 | *0.64* | 0.13 | *0.95* | -0.50 | *0.77* |
| surge*vxo15L | | | | | | | | | -0.34 | *0.38* | -0.31 | *0.45* | -0.15 | *0.72* | -0.13 | *0.76* |
| (surge*vxo15L)(-1) | | | | | | | | | -0.39 | *0.33* | 0.22 | *0.52* | -0.27 | *0.51* | 0.38 | *0.27* |
| surge*vxo25H | | | | | | | | | -0.78 | *0.17* | -0.89 | *0.15* | -0.68 | *0.26* | -1.07 | *0.11* |
| (surge*vxo25H)(-1) | | | | | | | | | -0.52 | *0.40* | -0.22 | *0.70* | -0.28 | *0.66* | 0.23 | *0.70* |
| app*surge*vxo15L | | | | | | | | | | | | | **-2.67** | *0.08* | -2.50 | *0.19* |
| (app*surge*vxo15L)(-1) | | | | | | | | | | | | | -0.85 | *0.48* | -1.65 | *0.21* |
| app*surge*vxo25H | | | | | | | | | | | | | -1.27 | *0.48* | 0.96 | *0.64* |
| (app*surge*vxo25H)(-1) | | | | | | | | | | | | | -2.13 | *0.22* | **-4.17** | *0.01* |

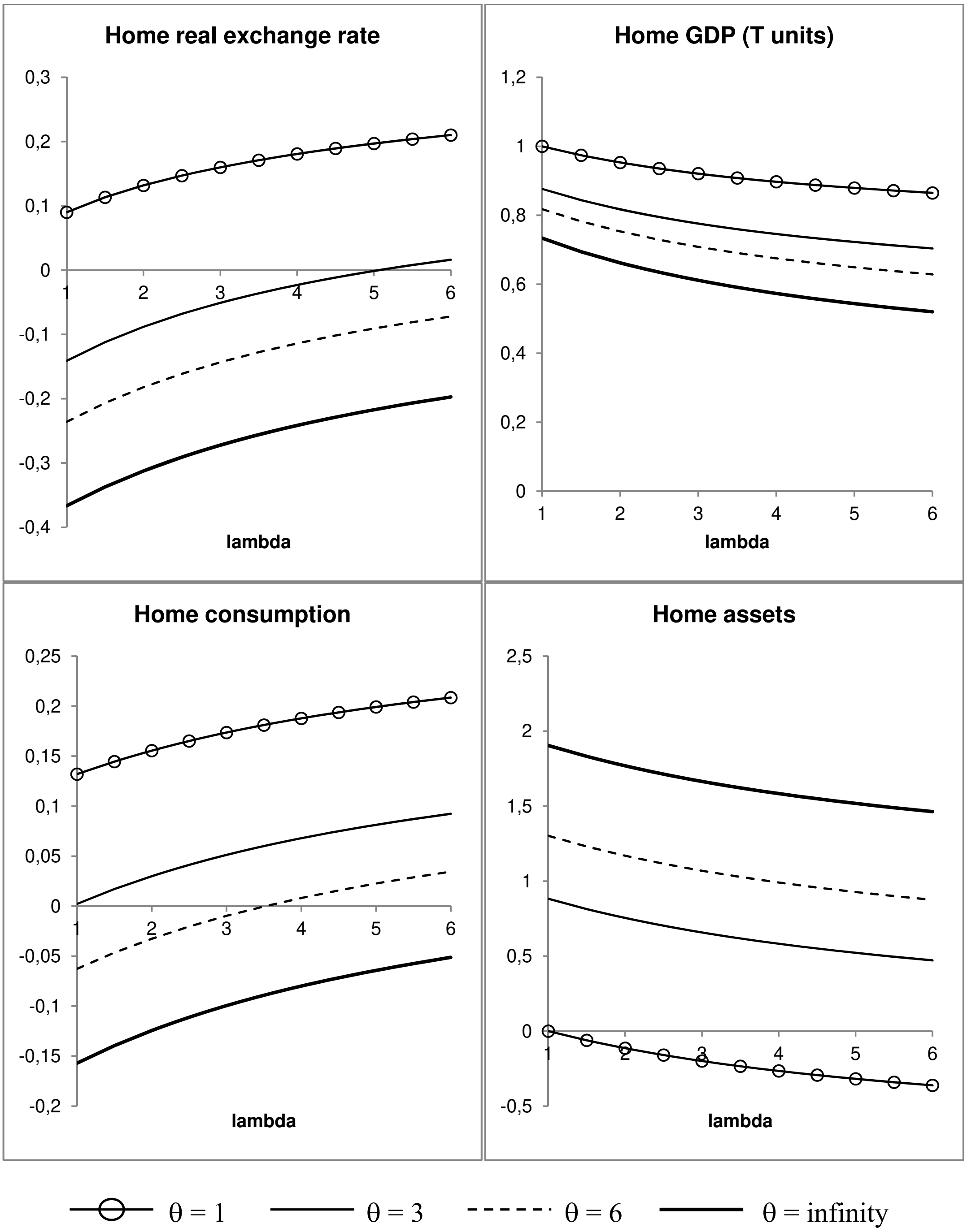
The coefficients in bold are significant at, at least 10%, and the p-values are in italic. See footnote on Table 3 for more information on the variables

**Figure 1: Immediate impact of shocks in the simple model**



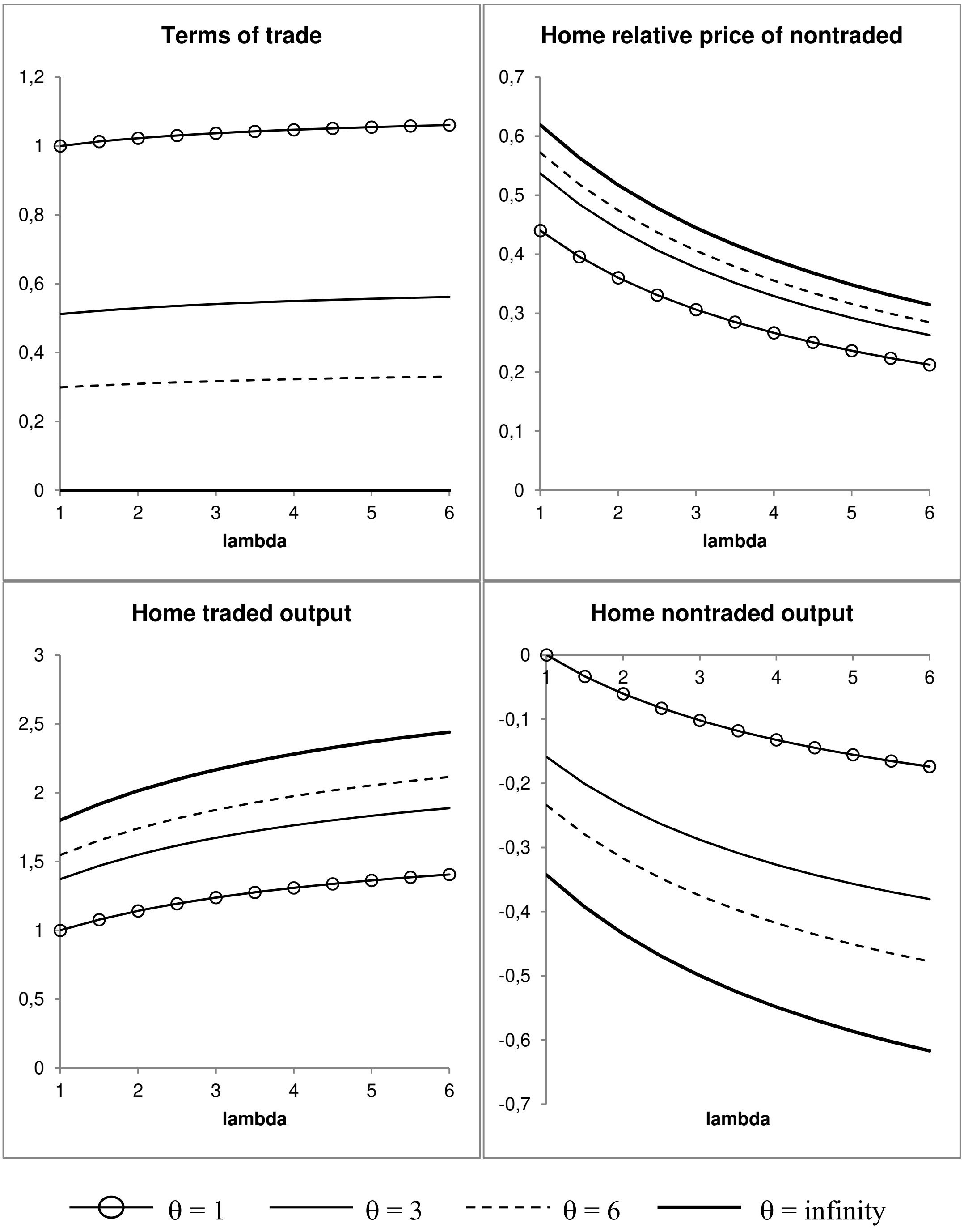

All shocks are parametrized to lead to a unit real appreciation. Coefficients: $\alpha = 0.25$, $n = 0.2$, $\gamma 0 = 0.3$, $\beta 0 = 0.95$, $\lambda = 1$, $\theta$ = infinity, $\rho T = \rho N = \rho b = \rho g = 0.5$

**Figure 2: Increase in Home traded productivity, general model**



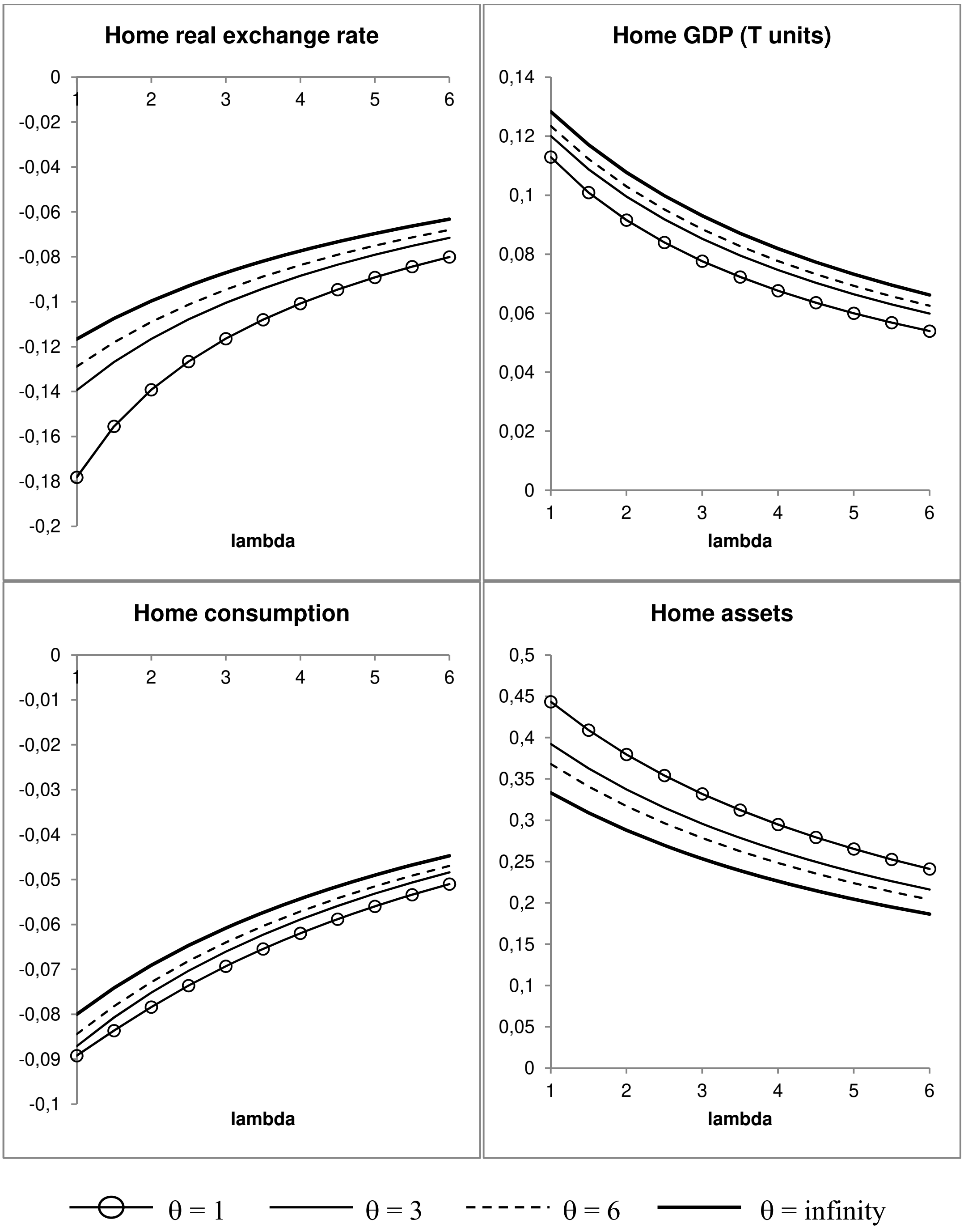

Coefficients: $\alpha = 0.25$, $n = 0.2$, $\gamma0 = 0.3$, $\beta0 = 0.95$, $\chi = 0.3$, $\rho T = \rho N = \rho b = \rho g = 0.5$

**Figure 2 (continued)**



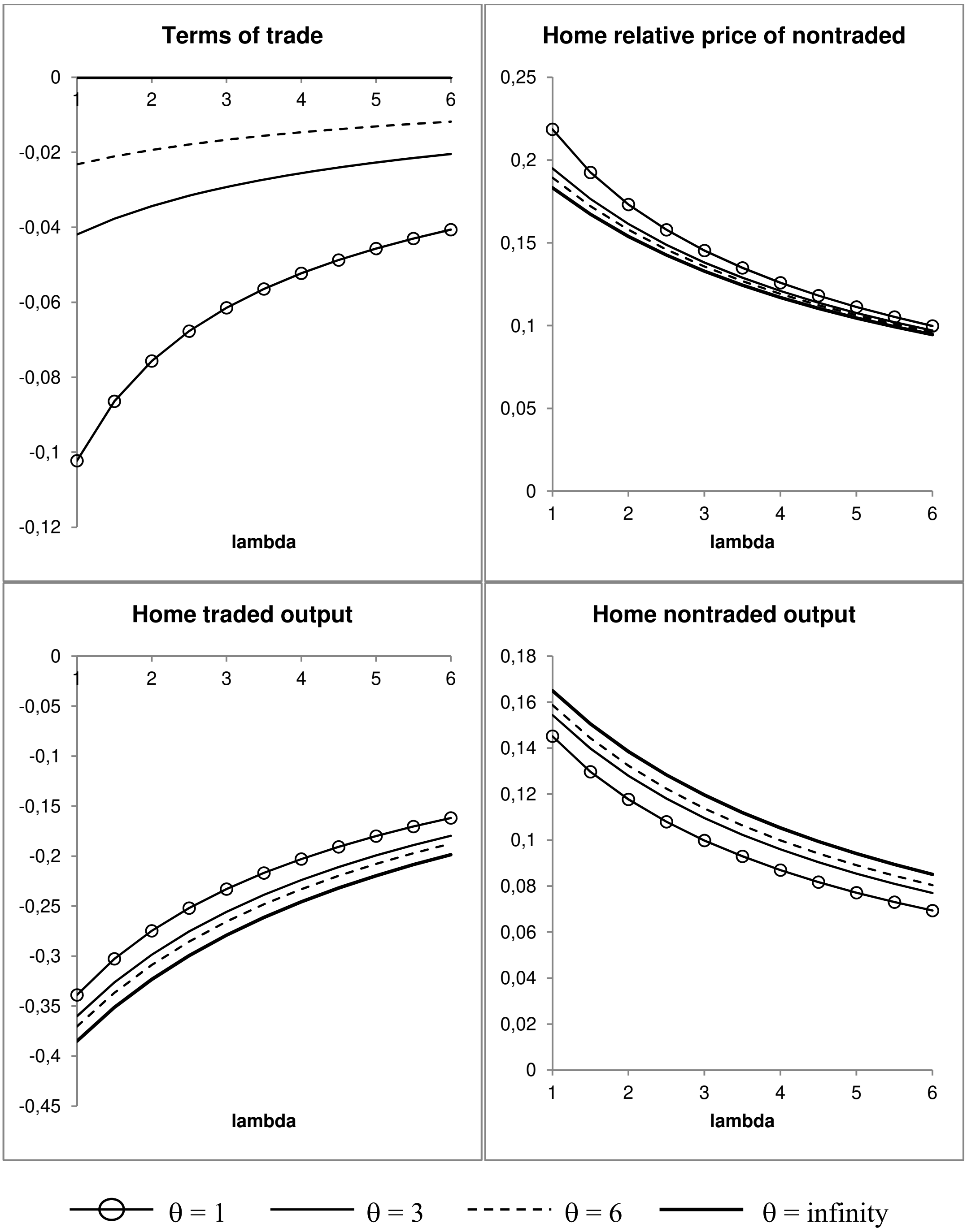

Coefficients: $\alpha = 0.25$, $n = 0.2$, $\gamma0 = 0.3$, $\beta0 = 0.95$, $\chi = 0.3$, $\rho T = \rho N = \rho b = \rho g = 0.5$

**Figure 3: Shift of Home consumption towards non-traded, general model**



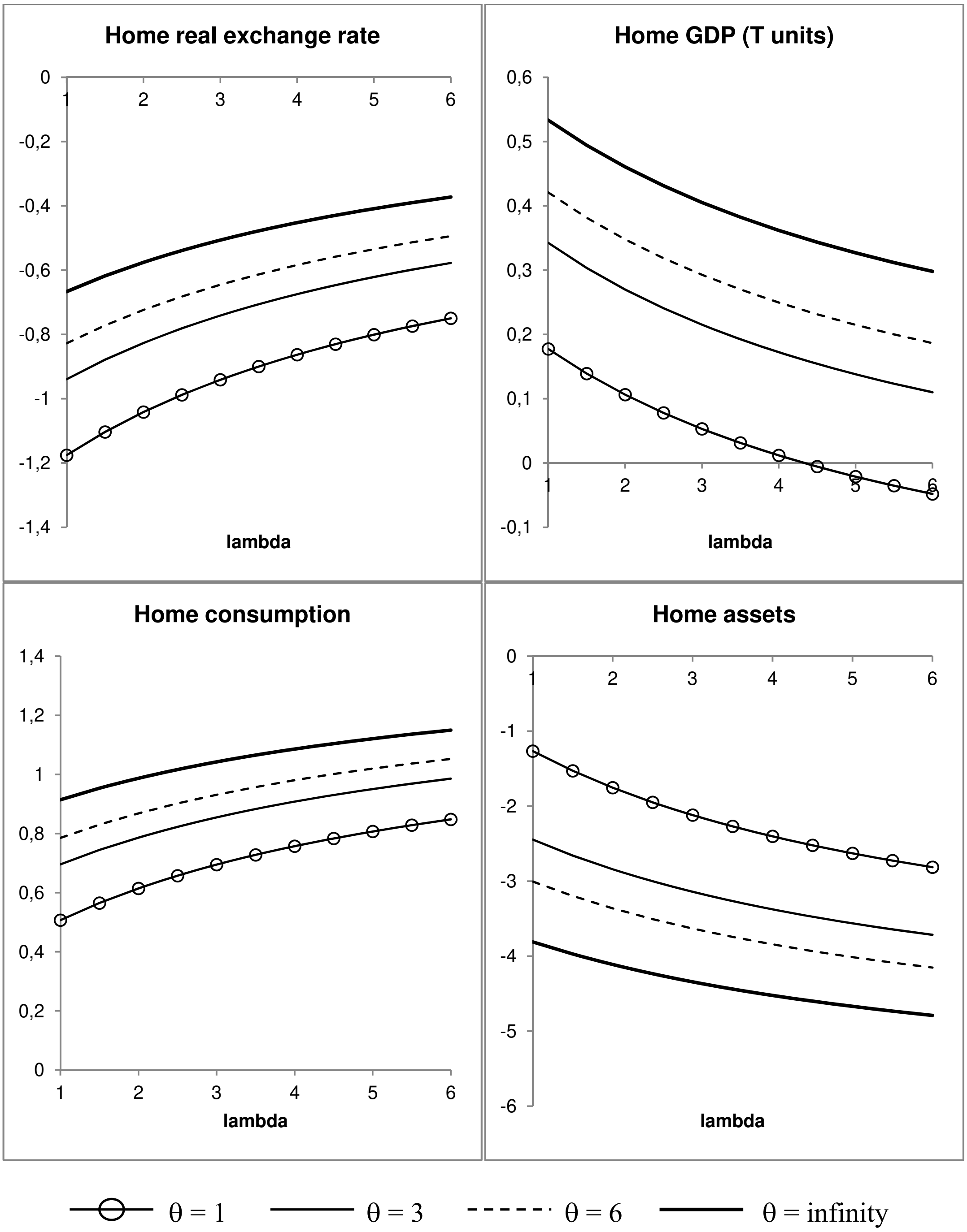

Coefficients: $\alpha = 0.25$, $n = 0.2$, $\gamma0 = 0.3$, $\beta0 = 0.95$, $\chi = 0.3$, $\rho T = \rho N = \rho b = \rho g = 0.5$

**Figure 3 (continued)**



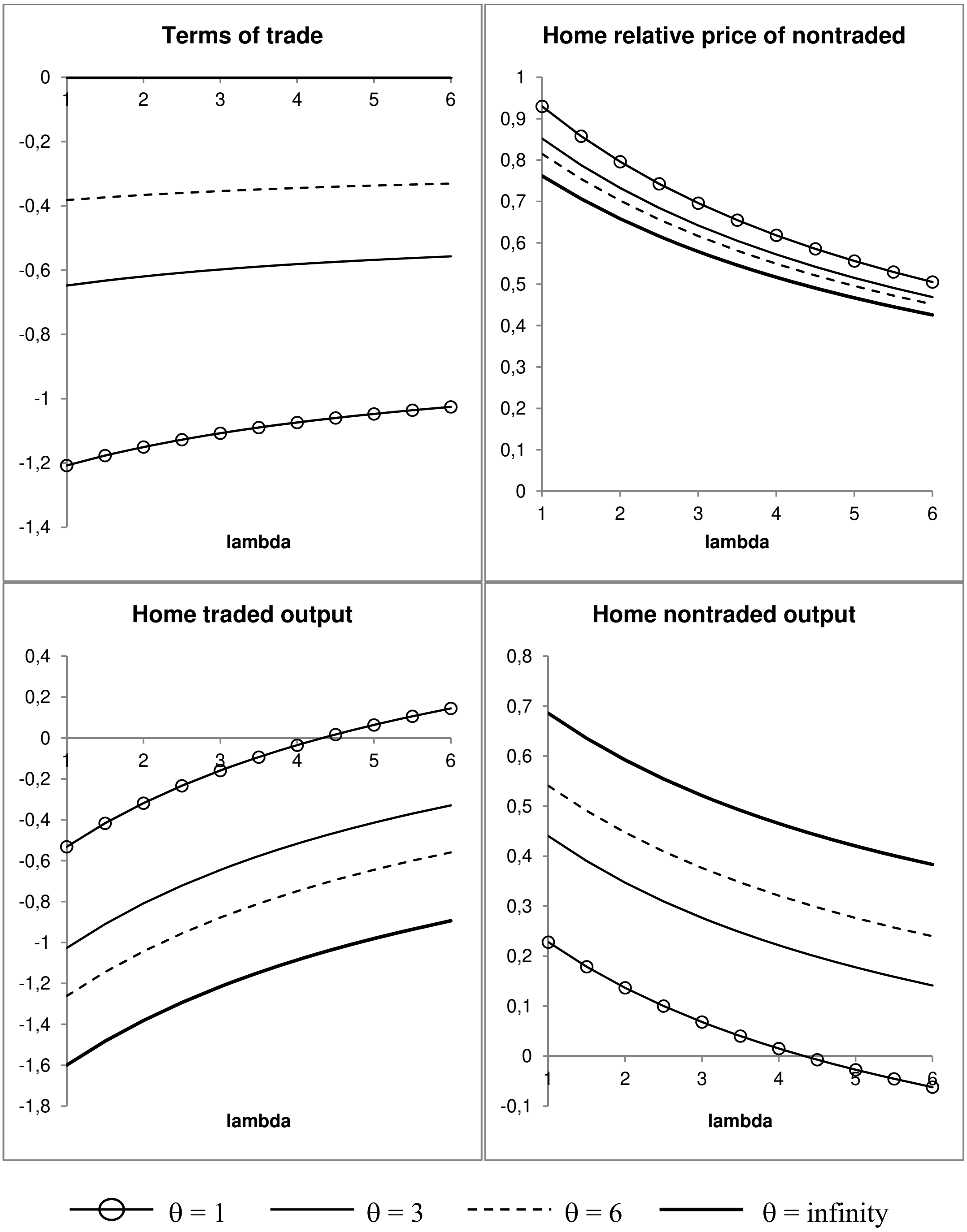

Coefficients: $\alpha = 0.25$, $n = 0.2$, $\gamma0 = 0.3$, $\beta0 = 0.95$, $\chi = 0.3$, $\rho T = \rho N = \rho b = \rho g = 0.5$

**Figure 4: Increase in Foreign patience, general model**




Coefficients: $\alpha = 0.25$, $n = 0.2$, $\gamma 0 = 0.3$, $\beta 0 = 0.95$, $\chi = 0.3$, $\rho T = \rho N = \rho b = \rho g = 0.5$

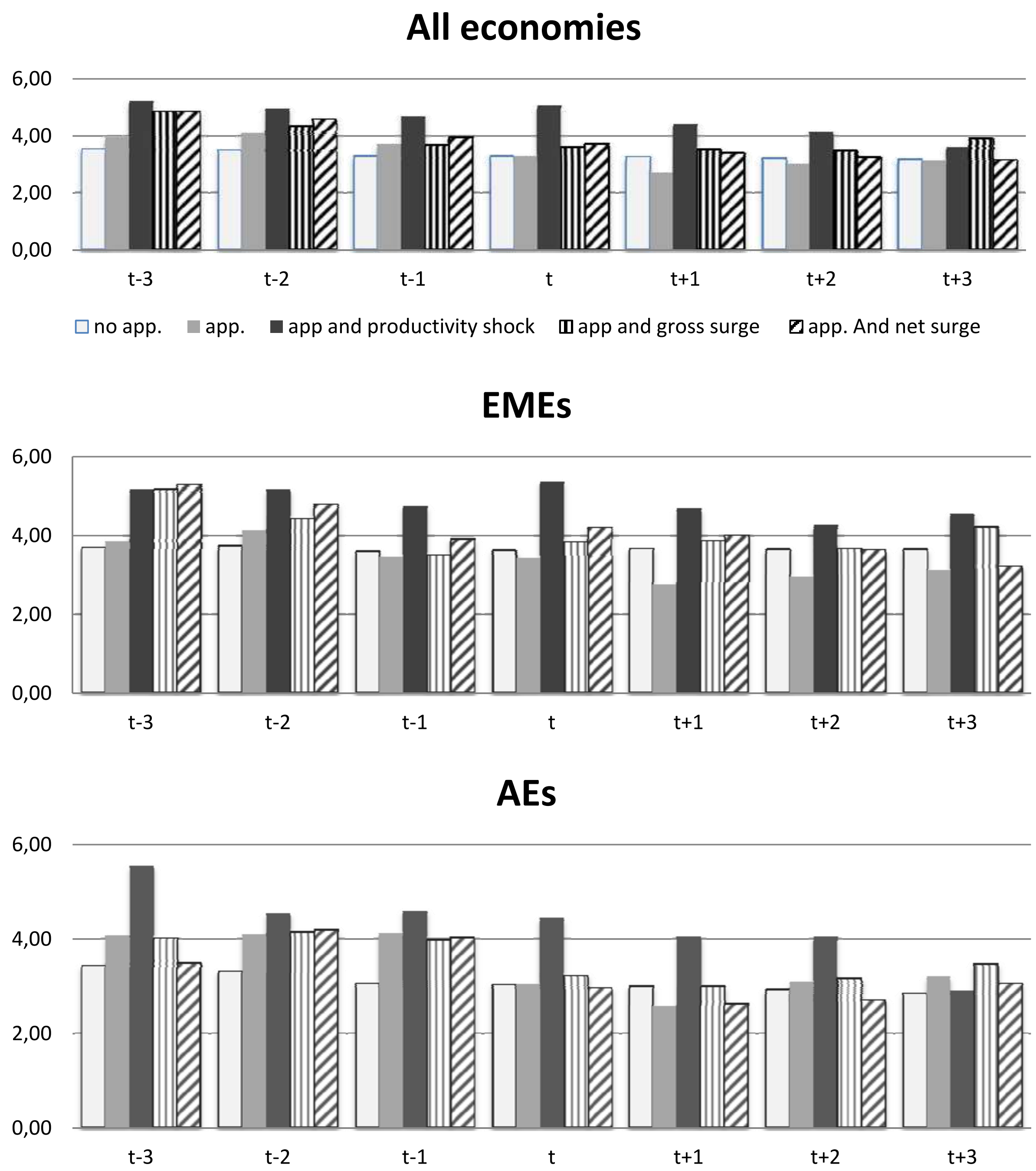
**Figure 4 (continued)**




Coefficients: $\alpha = 0.25$, $n = 0.2$, $\gamma0 = 0.3$, $\beta0 = 0.95$, $\chi = 0.3$, $\rho T = \rho N = \rho b = \rho g = 0.5$

**Figure 5: event-case analysis, average of the variable considered**

**5.a: Impact of a strong appreciation at time t on GDP**




No app stands for no strong appreciation, app. for strong appreciation, app and productivity shock for strong appreciation and a productivity shock, app with gross surge for strong appreciation combined with a gross capital inflows surge and app with net surge for strong appreciation with a net capital inflows surge.

**5.b. Impact of a strong appreciation at time t for all economies on**