Do Real Exchange Rate Appreciations Matter for Growth?

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Do Real Exchange Rate Appreciations Matter for Growth?*

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Abstract

While the impact of exchange rate changes on economic growth has long been an issue of key importance in international macroeconomics, it has received renewed attention in recent years, owing to weaker growth rates and the debate on "currency wars". However, in spite of its prevalence in the policy debate, the connection between real exchange rates and growth remains an unsettled question in the academic literature. We fill this gap by providing an empirical assessment based on a broad sample of emerging and advanced economies. We assess the impact of appreciations, productivity booms and capital flow surges using a propensity-score matching approach to address causality issues. We show that appreciations associated with higher productivity have a larger impact on growth than appreciations associated with capital inflows. Furthermore, the appreciation per se tends to have a negative impact on growth. We provide a simple theoretical model that delivers the contrasted growth-appreciation pattern depending on the underlying shock. The model also implies adverse effects of shocks to international capital flows, so concerns about an appreciation are not inconsistent with concerns about a depreciation. The presence of an externality through firms' destruction leads to inefficient allocations. Nonetheless, addressing them does not require a dampening of exchange rate movements.

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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1. Introduction

Policy makers throughout the world have long been wary of real exchange rate appreciations, owing to their effect on growth through reduced price competitiveness in international 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.[1] 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". [2]

This long-standing question has received renewed interest in recent years, with the debate on "currency wars", initiated by Brazil's Finance Minister Guido Mantega in September 2010. Indeed, the Great Financial crisis of 2008-09 has lowered growth rates throughout the world, making policy makers more concerned of the sources of economic growth, and simultaneously led central banks to undertake unprecedented actions whose effect on exchange rates was sometimes substantial, prompting concerns over potential beggar-thy-neighbour effects. Several countries, especially among emerging market economies, expressed concerns regarding surges in capital inflows and the associated real exchange rate appreciations they recorded in the wake of monetary policy decisions in foreign countries.

This active debate raises the question whether appreciations have, indeed, an adverse effect on growth, a point that has not been firmly established. This paper takes a step towards filling the gap by providing empirical evidence and interpreting it through a theoretical framework of the joint determination of the real exchange rate and growth. Both the empirical and theoretical elements stress how the relation between growth and the exchange rate depends on the specific underlying shock.

Our empirical assessment relies on a broad annual sample of 68 countries (30 advanced economies and 38 emerging markets) from 1960 to 2011. We focus on the relation between

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

[2] 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"*.

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. A challenge in evaluating the impact of appreciation on growth is to disentangle the direction of causality. We handle this issue by relying on the propensity-score matching method. While it is commonly used to assess the impact of a public policy in labor economics, its applications in international economics are only few and recent. Our analysis makes three points. First, only advanced economies suffer from an appreciation and this only in the most general case of increase in real exchange rate. Second, both emerging and advanced economies react positively to the combination of appreciation and productivity increase, but the contribution of the appreciation on the enhanced growth rate differs depending on the group of countries considered. Specifically, growth is strengthened in advanced economics growth compared to the case of solely a productivity shock, while it is weakened for the emerging economies. Third, appreciations that are associated with a surge in capital inflows are characterized by weaker growth compared to episodes with productivity shock. Furthermore, emerging economies are sensitive to an appreciation in presence of a surge in capital inflows. Interestingly, focusing on large appreciation episodes does not change these conclusions.

We develop a simple small open economy model in which the pattern of growth and appreciation depends on the underlying shocks, consistent with the empirical results. The model furthermore characterized by asymmetric effects for some shocks, with a recession under any exchange rate movement, and an externality. Policy makers are thus right to be concerned about exchange rate movements, and worrying about an appreciation is not necessarily inconsistent with worrying about a depreciation. The key feature of the model is that firms face idiosyncratic fixed costs, so that in the initial steady state the gross profits of the marginal firm in each sector just covers its fixed costs. Shocks affect gross profits, and we assume that in the short run the firms that cannot cover their fixed cost shut down. In addition, we assume that no firm can be created in the short run.[3] While stark, this assumption captures the fact that it takes more time and resources to establish a new firm than to shut down an existing one. A shock that lowers gross profits in the traded sector reduces the number of traded firms, without any new non-traded firms being created. As individual firms use a technology with decreasing returns to scale, the lower number

[3] For brevity we assume that after one period the number of firms recovers to its initial value. The model could be enriched by allowing for an endogenous number of firms in the long run at the cost of additional complexity.

of firms leads to lower output, as in Bacchetta and van Wincoop (2013). The impact on the number of firms leads to an asymmetry. For instance, and increase in the world interest rate leads to a real depreciation, lowering profits in the non-traded sector. This lowers the number of firms in that sector as well as overall output. The recession following an interest rate increase does not imply that a decrease leads to a boom, to the contrary. A lower interest rate reduces profits and the number of firms in the traded sector. Shocks to interest rates thus lower output regardless of their direction.

The model also exhibits an externality, as under the decentralized allocation agents do not internalize the impact of their decisions on firms' profitability. We assume that the fixed costs faced by firms merely consist of a transfer to the household, and thus do not represent a real cost. A planner is thus not bout by these costs and chooses to offset them through lump sum subsidies. The planner recognizes the cost of lowering the number of firms and thus keeps it at its initial level in both sectors, thereby preventing inefficient recessions. An interesting feature of the model is that the planner's allocation does not dampen the movements in the real exchange rate, which are actually larger than under the decentralized allocation. This indicates that the first best policy cannot simply be implemented by leaning against the wind.

The rest of the paper is organised as follows. Section 2 reviews the relevant literature. Section 3 introduces the definition of exchange rate appreciations and other benchmarks, the propensity matching method and its results. Section 4 presents the theoretical model. Section 5 concludes and discusses possible policy implications.

2. Review of the literature

Numerous papers have been written on the link between exchange rates and growth. A substantial share of these studies focus on episodes of weakening currencies, more specifically 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.

By contrast, Kappler et al. (2012) look at the impact of an *appreciation* on current account balance and on real output. More specifically, they are the first to formally define a large exchange rate appreciation. 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 only large appreciation, but consider such a possibility as a special case of our empirical approach. Second, our method of impact measurement controls for country's specificities, or bias selection. 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 (2012) 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.[4] 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 theoretical contribution is related to the literature that assesses the drivers of real exchange rates. Starting from the textbook Balassa-Samuelson effect, where higher productivity in the trade sector leads to a currency appreciation, the literature has considered the impact of shocks to financial flows, and the presence of externalities.[5] Benigno and Romei (2012) consider financial shocks in the form of a tightening of borrowing constraints. They however abstract from the distinction between traded and non-traded goods. Benigno and Fornaro (2014) develop a model where a real appreciation of the exchange rate leads to a costly externality. Their model

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

[5] Benigno and Thoenissen (2003) show that when traded goods are differentiated, a productivity increase in the traded sector can lead to a real depreciation because of offsetting impacts on the terms-of-trade and the relative price of non-traded goods.

considers endogenous growth in the traded sector. A real depreciation shifts demand away from traded goods, and thus leads to a reduction of productivity growth that is not internalized by agents. While we also consider that exchange rate movements have a costly externality through a destruction of firms, our framework ensures that this is the case for appreciations and depreciations. The impact of exchange rate movements on the number of firms follows from Bacchetta and van Wincoop (2013), who however focus on the issue of multiple equilibria under sticky prices. While the focus on the consequence of real appreciations is relatively recent, an extensive literature has considered the impact of real depreciation. A central mechanism in that line of research is the presence of balance sheet constraints, with a depreciation raising the local currency value of foreign debt and the local cost of imported inputs, as in Cespedes, Chang and Velasco (2004). While our approach differs from their specific modeling, we also consider costs of exchange rate movements through firms' profitability.

3. Growth, appreciations, capital surges, and productivity boom: an empirical assessment

This section presents our econometric analysis of the effects of an appreciation on growth, where we allow for the pattern to vary depending on whether the economy experiences a productivity boom and/or shocks to capital flows. We start by defining our measures of appreciations, productivity and capital flow surges. We then present the method of propensity score matching used in the analysis, before reporting our results.

3.1 Definitions

Our analysis relies on annual data from 1960 to 2011 for a broad sample of 68 countries (30 advanced and 38 emerging).[6] An appreciation episode is defined as a year-to-year appreciation of the real effective exchange rate, which is not preceded by a depreciation over the previous year in order to abstract from episodes of catch-up after a depreciation.[7] The average real appreciation in these episodes amounts to 5.4 percent compared to the previous year. As pointed above, the empirical literature stresses the role of swings in international financial flows as a major driver of economic performance in emerging economies, as well as advanced economies as the current crisis highlights. We consider (gross) capital inflows, measured as a percentage of GDP, and

[6] We decide to use yearly data as quarterly data, especially for capital flows, tend to be noisy and have a limited time span.

[7] We consider the effective rather than the bilateral exchange rate as we are interested in the aggregate macroeconomic outcome.

define a capital “surge” as an annual increase in inflows that is one standard deviation above the average increase over the five previous years, following Forbes and Warnock (2012).[8] In our sample, surge episodes are characterized by increases of gross capital inflows by at least 7 percentage points of GDP over the previous year. We follow a similar approach in defining a productivity increase episode. Specifically, we consider situations where the annual increase in productivity is one standard deviation above the average increase over the five previous years.[9] These definitions enable us to consider three types of appreciation episodes: a sole appreciation, an appreciation combined with a productivity increase, and an appreciation combined with a capital surge. Table 1 reports their incidence. The figures on the diagonal show the total number of episodes (there are for instance 235 cases of productivity increases), and the figures in the lower triangle show the numbers of episode where two out of the three characteristics are observed. There is a reasonable amount of information regarding an appreciation in the presence of a productivity shock (77 observations), or a capital surge (96 observations). Interestingly, there are only a few instances where we observe an appreciation, a capital surge, and a productivity increase simultaneously (16 observations). We therefore ignore the overlap of all three characteristics in our analysis.

3.2. Propensity score matching

Our assessment of the linkages between growth and appreciations cannot merely consist of an examination of the co-movements between these variables. This is because we need to address the main challenge in our exercise, namely endogeneity and selection bias. The selection bias occurs when a real appreciation (the “treatment”) is not randomly allocated across countries, but is instead correlated with other variables. A difference in growth between countries faced with an appreciation (the so-called treated group) and the other countries (the so-called control group) could then be attributable to systematic differences in some variables between the treated and control groups rather than the effect of the treatment itself. A standard approach is to rely on an instrumental variable that affects the appreciation but does not directly affect growth. Controlling for the differences across countries through an effective instrument is however quite difficult, especially in presence of limited amount of data.

[8] Gross capital inflows are the sum of inflows of direct investment, portfolio inflows, and other inflows.

[9] The measure of productivity is the output per person provided by Oxford Economics. We do not report the benchmark as the output is measured in domestic currency: an average across currency would not be useful.

One alternative, commonly used in labor economics and medical research, is the Propensity Score Matching (PSM) approach, as developed in Rosenbaum and Rubin (1983). This methodology has so far only been used in a small number of studies in international macroeconomics, including Glick, Guo, and Hutchinson (2006) who look at currency crises, Das and Bergstrom (2012) who assess capital account liberalization, Forbes, Fratzscher, and Straub (2013) who consider capital control and prudential measures, and Forbes and Klein (2013) who analyze the policy responses to crises. To our knowledge, the method has not been used to assess the linkage between exchange rate movements and growth.

The idea behind the PSM approach is to determine whether a treatment (in our case the three different types of appreciations, with or without productivity increases and capital surges) leads to different outcomes than the absence of treatment, by matching treated observations with control observations that share similar characteristics other than the presence of the treatment. In other words, it constructs a counterfactual for the treatment, based on a set of observable characteristics.

To illustrate the PSM methodology, we denote the indicator treatment for country i by D_i, which is equal to 1 when there is an appreciation (i.e. the treatment) and 0 otherwise. Country i's growth rate is Y_{i0} if the country is in the control group and Y_{i1}, if it is in the treated group, all other characteristics of the country being equal. The treatment effect for country i can be written as $Y_{i1} - Y_{i0}$, where one outcome is observed and the other one is the counterfactual. We are interested in estimating the average treatment (ATT) effect on the treated countries, that is $E[Y_{i1} - Y_{i0}|D_i = 1]$. The challenge is that while $E[Y_{i,1}|D = 1]$ is observed, $E[Y_{i,0}|D = 1]$ is not. The ATT effect can also be written as

$$ATT = E[Y_{i,1}|D = 1] - E[Y_{i,0}|D = 0] - E[Y_{i,0}|D = 1] + E[Y_{i,0}|D = 0]$$

where $E[Y_{i,1}|D = 1]$ and $E[Y_{i,0}|D = 0]$ are observed and $E[Y_{i,0}|D = 1] - E[Y_{i,0}|D = 0]$ is the selection bias. Hence, ATT can only be identified if this selection bias disappears, that is if $E[Y_{i,0}|D = 1] = E[Y_{i,0}|D = 0]$.

The PSM approach addresses this selection problem by pairing each treated observation with control observations that are otherwise similar based on a set of observable characteristics. This requires that the treatment satisfies some form of exogeneity, namely the so-called conditional independence assumption. This assumption states that, conditional on a vector of observable characteristics X, the variable of interest (the growth rate for us) is independent of the treatment status. Conditional on this vector X, the expected growth rate in the absence of an appreciation would then be the same for paired countries, that is $E[Y_{i,0}|D = 1,X] = E[Y_{i,0}|D = 0,X]$, and the bias would disappear. Under this assumption then ATT effect is written as:

$$ATT = E[Y_{i,1}|D = 1,X] - E[Y_{i,0}|D = 0,X]$$

where $E[Y_{i,1}|D = 1,X]$ controls for the relevant set of characteristics X. This set should include variables that are co-determinants of both appreciation and growth, and conditioning on all relevant variables may be a challenge. Rosenbaum and Rubin (1983) and Imbens (2004) show that if the hypothesis of conditional independence hold then all biases due to observable components can be removed by conditioning on the propensity score. Hence, ATT becomes:

$$ATT = E[Y_{i,1}|D = 1,p(X)] - E[Y_{i,0}|D = 0,p(X)]$$

where $E[Y_{i,1}|D = 1,p(X)]$ denotes the fact that we control for the probability of observing the treatment conditional on the set X of variables.

To obtain ATT, we first need to estimates the propensity score to control for the likelihood of receiving the treatment, and then use a matching algorithm to pair the observations based on observable characteristics. We consider four different matching algorithms, all with advantages and drawbacks. The first is the "nearest-neighbor" that pairs each observation in the treated group with the closest observation (in term of propensity score) from the control group. This limits the incidence of "bad matches" at the cost of excluding a lot of potentially useful information. We use this algorithm "with replacement", meaning that the control observations can be used as a match more than once. This choice decreases the bias, increases the average quality of matching, and the results do not depend on the order in which observations get matched. The trade-off is that it increases the estimator variance, if we compare with the alternative of "no replacement". The second matching algorithm is the "five nearest neighbors", which takes five countries instead of one from the control group. This matching trades reduced variance as more information is used to construct the counterfactual, at the cost of some bias as the average match being poorer than in the previous case. The last two matching algorithms, the "kernel" and "local-linear" method, are non-parametric matching estimators that compare the outcome of each treated observation to a weighted average of the outcomes of all control observations, with the highest weight being placed on the control observations with the closest propensity scores to the treated observation. These algorithms have a lower variance as they use more information, at the cost of being more exposed to bad matches.

Applying these matching methods requires that two hypotheses must be satisfied. The first is the conditional independence assumption described above. The second is the common support condition, which ensures that there is sufficient overlap in the characteristics of the treated and untreated groups to find adequate matches.

3.3. Estimation of the impact of appreciations

The explanatory variables considered in the propensity score matching are selected to capture country specificities as well as global conditions. We control for global conditions through the VXO, as a measure of global uncertainty, the log of the commodity price index, and the US interest rate. Country characteristics are captured by changes in real GDP, the ratio of private credit to GDP, and productivity. We also include inflation, the differential between the US and the country interest rate, the level of reserves scaled by GDP, the current account scaled by GDP, the indicator capital account openness by Chinn and Ito (2008, updated in 2013), and a dummy equal to one if the exchange rate is pegged.[10] All variables used in the logit regression are lagged in order to ensure that they are not affected by the treatment.

The propensity score *p(X)* specification that we retain reflects a compromise between the potential influence of a variable on the outcome and its ability to improve the matching. Table 2 reports the logit estimations used to produce the final propensity score specification for the three cases of appreciation (with and without productivity increase and surge). As expected, not all the variables are statistically significant but overall the variables help in capturing the specificities while estimating the PSM, help in the matching, or both.[11]

[10] The IMF and the World Bank are the source of the data with the exception of the data on productivity from Oxford Economics, the Chinn and Ito index from Chinn and Ito (2008, 2013), the Goldman and Sachs commodity index and the VXO from Datastream and the peg dummy is defined as in Shambaugh (2004).

[11] The results are robust to several alternatives based on the list of variables provided, as long as we do not reduce to much the number of treated observations.

As pointed above, our approach requires that the conditional independence condition holds, that is that the value of the various control variables does not significantly differ between the treatment and control groups once the matching is computed. Table 3 assesses this point for the four matching algorithms considered.[12],[13] The p-values reported correspond to the test of mean equality for a variable between the treated and the control group, before the matching (unmatched) and after. We observe that no significant difference remains in the data after any of the four matching procedures. All four matching algorithms are thus clearly suitable for our analysis and perform quite well. Finally, the common support condition of sufficient overlap in the characteristics of the treated and untreated observations also needs to be validated. To do so, the remaining of the analysis focuses on treated observations that have a propensity score between the maximum and the minimum propensity score of the control group.

Having established that all conditions required for the use of our method hold, we now compare the impact of the different appreciations on growth by performing the matches and estimating the ATT effects. The results are reported in Table 4, focusing on the year of the appreciation. Each panel in the table corresponds to one of the four matching algorithms. In each panel, we undertake the analysis for all countries, and then focus on emerging economies (EME) and advanced economies (AE), separately. For each, we consider the three cases of appreciation (sole, with productivity boom, with capital surge) as well as the cases of productivity booms or capital surge that are not accompanied by an appreciation. This allows us to identify the overall impact of the different cases of appreciation, as well as to isolate the impact of the appreciation itself when combined with another change.

While the size of the ATT estimates vary somewhat depending on the algorithms, their direction and statistical strength are quite robust. Four main outcomes can be highlighted. First, an appreciation that is not accompanied by a productivity boom or a capital surge does not have any significant growth impact overall or for emerging economies, but has a negative impact for advanced economies, subtracting between 0.81 and 1 percentage point of growth compared to the control group (depending on the matching algorithm). Second, growth is boosted in countries experiencing an appreciation accompanied by a productivity boom. This is observed across all countries, and is especially pronounced for emerging economies where it adds between 2.28 and

[12] We report the case with only an appreciation but the outcomes are similar for the other cases.

[13] We use the Stata module PSMATCH2, developed by Leuven and Sianesi (2003).

3.03 percentage points to growth. There is also a positive effect in advanced economies, albeit of a smaller magnitude. Third, an appreciation associated with a capital flows surge does not lead have a significant effect on growth, except for emerging economies were it adds up to 1.77 percentage points. The significance of the effect is however sensitive to the matching algorithm considered. Finally, a productivity increase not accompanied by an appreciation clearly boosts growth in all economies, while a capital surge has some positive impact in emerging economies.

Having established the impact of an appreciation combined with a productivity boom or a capital surge, we now turn to the question of the contribution of the appreciation per se. The estimates of the impact of higher productivity and capital inflows in Table 4 tend to be larger in the absence of appreciation. We thus specifically test whether the growth variations observed in presence of an appreciation combined with another change is statistically different from the one observed without an appreciation. The results are reported in Table 5, where negative values indicate that the appreciation per se reduces growth. While the significance of the estimates varies depending on the matching algorithm considered, we observe that in the presence of a productivity boom an appreciation tends to lower growth by up to 0.65 percentage points, especially in emerging economies. By contrast, the appreciation tends to boost growth in advanced economies, by up to 0.52 percentage points. Turning to the impact of an appreciation during a capital flow surge, Table 5 shows that the appreciation has an adverse effect on growth for both emerging and advanced economies, with some sensitivity to the matching algorithm considered.

The final step of our analysis is to assess whether the magnitude of the appreciation matters. Intuitively, the adverse impact of an appreciation can come through a reduced competitiveness of the traded sector. While exporters can handle a moderate appreciation by lowering their profit margin, they may have to cut down on production if the appreciation becomes large. We therefore consider whether our results still hold if we were to consider only episodes of strong appreciations Allegations of currency war and threat of enhanced capital control measures during the post financial crisis period are a natural motivation for this question.

Our definition of a strong appreciation parallels the one of productivity booms and capital flow surges. Specifically, a strong appreciation occurs when the annual increase in the real effective exchange rate is at least one standard deviation above the average increase over the five previous years. We also consider a reference period of three years as a robustness check. Furthermore, a period of strong appreciation cannot be preceded by a depreciation of equal size, to rule out catch up episodes. Quantitatively, large appreciations correspond to an average increase in the real effective exchange rate by 7.33 percent when the reference period is of five years, and by 5.58 percent for the three years reference period.[14] A drawback of considering large appreciations is that the matching process dramatically reduces the number of observations usable in this analysis, which limits our ability to draw conclusions beyond the observed sample.

The resulting ATT estimates are reported in Table 6 and 7, which correspond to Table 4 for the five and three year reference periods respectively. Overall, the pattern is similar to Table 4, with a weakening of some statistical evidence. The Tables make three points. First, a strong appreciation has a negative growth impact in advanced economies, varying from no significant effect using the three years reference period to up to -1.39 percent using the five year period. Second, emerging economies remain sensitive to an appreciation combined with higher productivity, which adds between 1.37 and 3.53 percentage points to growth. By contrast, there is no clear evidence of an impact for advanced economies. Finally, a strong appreciation combined with a capital surge seems to have no growth impact across any of the three groups of countries considered. This robustness analysis shows that focusing on strong appreciation episodes does not change the overall message of our results. Moreover, the enhanced growth rate observed in emerging economies ends up being stronger in presence of a strong appreciation than in presence of an appreciation.

To sum up, our empirical analysis shows that the link between growth and the real exchange rate depends on the underlying shock. An appreciation accompanied by higher productivity is associated to higher growth. For emerging economies, the positive growth primarily reflects the productivity gains, as the appreciation per se tends to lower it. By contrast, an appreciation accompanied by a capital flow surge tends not to be associated with higher growth, and the effect of the appreciation itself is negative. The next section presents a simple model where the link between appreciation and growth depends on the underlying shock, with the possibility of inefficient allocations that a planner would want to correct.

[14] These averages are across the countries and the time period, as a result it is only useful in comparison with the average appreciation reported in the previous section (5.41).

4. A simple model of the real exchange rate

In this section we present a small open economy model that contrasts the impact of productivity and interest rate shocks on the real exchange rate, output and the current account. The model makes three points. First, appreciations stemming from capital inflows surge are associated with weak growth while appreciations associated with productivity shocks are accompanied by high growth, in line with our empirical evidence. Second, the weak growth observed during a capital flow driven appreciation does not imply that a mirroring depreciation is associated with high growth. Instead, the frictions in the model imply that exchange rate movements driven by capital flows shocks are associated with low growth. Third, the model includes an externality that leads to inefficiently low growth following capital flows shocks, thereby justifying policy makers' concerns about both capital flows and sudden stops. For brevity we focus on the main features and results, and leave more details to the appendix.[15] We first present the building blocks and the solution method. We then derive the solution and discuss the results through a numerical illustration.

4.1 Building blocks

We consider a small open economy where a representative agent consumes a basket C_t of traded and non-traded goods:

$$C_t = (\gamma)^{-\gamma}(1-\gamma)^{-(1-\gamma)}(C_{T,t})^{\gamma}(C_{N,t})^{1-\gamma}$$

where t denotes time, $C_{T,t}$ and $C_{N,t}$ are the consumptions of the homogeneous traded and non-traded goods, respectively, and γ is the share of traded goods in the consumption basket. The price of the traded good P_T is exogenously set in the world market, and the consumer price index is $P_t = P_T\,(R_t)^{1-\gamma}$ where $R_t = P_{N,t}\,/\,P_T$ is the relative price of the non-traded good. The allocation of consumption across traded and non-traded goods take the standard form. The real exchange rate is related to R_t, with an increase in the relative price of the non-traded good leading to a real appreciation.

There are $n^T{}_t$ firms producing the traded good and $n^N{}_t$ firms producing the non-traded good at time t. Production uses labor with decreasing returns to scale. The output of individual firms denoted by i in the traded and non-traded sector are $Y_{T,t}(i) \;= A_{T,t}\;(L_{T,t}(i))^{1-\alpha}$ and $Y_{N,t}(i) \;= A_{N,t}$

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

$(L_{N,t}(i))^{1-\alpha}$ respectively, and $A_{k,t}$ is an exogenous productivity term in sector k = T, N. The parameter α 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 total labor input is set exogenously to 1. The assumption of decreasing returns to scale implies that for a given total labor input in a sector, $L_{k,t}$, spread evenly across firms, output is an increasing function of the number of firms in the sector:

$$Y_{k,t} = \int_0^{n_t^k} A_{k,t}(L_{k,t}(i))^{1-\alpha} di = \int_0^{n_t^k} A_{k,t}(L_{k,t} / n_t^k)^{1-\alpha} di = (n_t^k)^{\alpha} A_{k,t}(L_{k,t})^{1-\alpha}$$

Firms in all sectors pay a wage equal to the marginal product of labor. Combining the ensuing labor demand with the technology, we write the profits of individual firms in the traded and non-traded good sectors as:

$$\Pi_{T,t} = \alpha(1-\alpha)^{(1-\alpha)/\alpha}(w_t)^{-(1-\alpha)/\alpha}(R_t^{-(1-\gamma)} A_{T,t})^{1/\alpha} \quad (1)$$

$$\Pi_{N,t} = \alpha(1-\alpha)^{(1-\alpha)/\alpha}(w_t)^{-(1-\alpha)/\alpha}(R_t^{\gamma} A_{N,t})^{1/\alpha} \quad (2)$$

where w is the real wage and profits are measured in units of the consumption basket. The output levels in the two sectors, and the aggregate output (in terms of the consumption basket):

$$Y_{T,t} = n_t^T (1-\alpha)^{(1-\alpha)/\alpha}(w_t)^{-(1-\alpha)/\alpha} R_t^{-(1-\gamma)(1-\alpha)/\alpha}(A_{T,t})^{1/\alpha}$$

$$Y_{N,t} = n_t^N (1-\alpha)^{(1-\alpha)/\alpha}(w_t)^{-(1-\alpha)/\alpha} R_t^{\gamma(1-\alpha)/\alpha}(A_{N,t})^{1/\alpha}$$

$$Y_t = R_t^{-(1-\gamma)}(Y_{T,t} + R_t Y_{N,t})$$

The household can freely lend and borrow from world markets in a bond denominated in the traded good with an exogenous interest rate r_t. The income of the agent is the wage received on the total labor supply and the profits of all firms. The budget constraint for period t is then:

$$C_t + R_t^{-(1-\gamma)} B_t = w_t + n_t^T \Pi_{T,t} + n_t^N \Pi_{N,t} + (1 + r_{t-1}) R_t^{-(1-\gamma)} B_{t-1} \quad (3)$$

The clearing of the non-traded good market is given by:

$$(1-\gamma)C_t = n_t^N (1-\alpha)^{(1-\alpha)/\alpha}(w_t)^{-(1-\alpha)/\alpha}(R_t^{\gamma} A_{N,t})^{1/\alpha} \quad (4)$$

The representative Home household maximizes the following intertemporal utility of consumption:

$$U_t = \sum_{s=0}^{\infty} \beta^s \ln(C_{t+s}) \quad (5)$$

The household maximizes (5) is done subject to the budget constraint (3), taking the value of profits (1)-(2), the real wage and the numbers of firms as given. The ensuing Euler condition is:

$$C_{t+1} = \beta C_t (1+r_t)(R_t / R_{t+1})^{1-\gamma} \tag{6}$$

The last building block of the model is the determination of the number of firms in each sector. We consider that, in the initial allocation, firms face an idiosyncratic fixed cost. Specifically, the $n^T{}_t$'s firm in the traded sector and the $n^N{}_t$'s firm in the non-traded sector face the following fixed costs denominated in units of the consumption basket:

$$Z_T (n_t^T)^{\sigma} \quad ; \quad Z_N (n_t^N)^{\sigma} \tag{7}$$

We assume that these costs do not entail a loss of real resources, but are transferred by firms to the household, and, thus, do not enter the budget constraint (3). Firms in each sector are thus ranked according to their fixed cost. σ captures the sensitivity of the cost to the rank of the marginal firm. The number of firms in the initial allocation is such that the marginal firm in each sector makes zero profits including the fixed cost:

$$Z_T (n_t^T)^{\sigma} = \alpha(1-\alpha)^{(1-\alpha)/\alpha} (w_t)^{-(1-\alpha)/\alpha} (R_t^{-(1-\gamma)} A_{T,t})^{1/\alpha} \tag{8}$$

$$Z_N (n_t^N)^{\sigma} = \alpha(1-\alpha)^{(1-\alpha)/\alpha} (w_t)^{-(1-\alpha)/\alpha} (R_t^{\gamma} A_{N,t})^{1/\alpha} \tag{9}$$

4.2 Solution method

We solve the model in terms of linear log approximations around an initial steady state where the country holds not international bonds, and the world interest rate offsets the discount factor. We set productivity to $\overline{A}$ in both sector, and $Z_T = \alpha\overline{A}(\gamma)^{-\sigma}$ in (7) and $Z_N = \alpha\overline{A}(1-\gamma)^{-\sigma}$ in (8). This parametrization ensures that:

$$\overline{R} = 1 \quad , \quad \overline{n}^T = \overline{L}_T = \gamma \quad , \quad \overline{n}^N = \overline{L}_N = 1-\gamma \quad , \quad \overline{Y}_T = \gamma\overline{A} \quad , \quad \overline{Y}_N = (1-\gamma)\overline{A}$$
$$\overline{C} = \overline{Y} = \overline{A} \quad , \quad \overline{w} = (1-\alpha)\overline{A} \quad , \quad \overline{\Pi}_T = \overline{\Pi}_N = \alpha\overline{A}$$

We consider that, in period 1 (the short run), the economy is hit by a one-period shock in the interest rate or by permanent productivity shocks. From period 2 onwards, the economy reaches a new steady state (the long run).

A central feature of the model is the determination of the number of firms. We follow the model by Bacchetta and van Wincoop (2013) where firms making insufficient profits shut down. Specifically, shocks lead to short run movements in wages, demand and the relative price of the non-traded good, which in turn affect profits. We assume that firms cannot be created in the short run. While this assumption is restrictive, it is motivated by the fact that firm creation is a more costly process than firm destruction. If all firms in a sector make positive the short run profits, the number of firms remains at its initial level. If the shocks lead to lower short run profits, the marginal firms are not able to cover their fixed costs, and we assume that they shut down in the short run. The number of firms in the sector is then given by (8) or (9).

In the long run, we assume that the number of firms in each sector returns to the initial values of γ and 1- γ, so any short run shutdown is temporary. This assumption is done for tractability. Another alternative would be to allow for firm creation and thus let the long-run number of firms be determined by (8) and (9). This alternative, however, raises the complexity of the model. A third alternative would be to assume persistence in the number of firms, so that firms shutting down in the short run never reappear. Such an alternative would however be questionable in the long run.

We start by solving for the long run allocation, conditional on the bond holdings acquired in the short run. Denoting log deviations by hatted values, we write:

$$\hat{C}_2 = \frac{1-\beta}{\beta}\hat{B}_1 + \hat{A}^{agg} \quad , \quad \hat{w}_2 = \hat{Y}_2 = \hat{A}^{agg} \quad , \quad \hat{R}_2 = \frac{\alpha}{\gamma}\frac{1-\beta}{\beta}\hat{B}_1 + \hat{A}^{diff}$$

$$\hat{L}_{N,2} = \frac{1-\beta}{\beta}\hat{B}_1 \quad , \quad \hat{\Pi}_{T,2} = -\frac{1-\gamma}{\gamma}\frac{1-\beta}{\beta}\hat{B}_1 + \hat{A}^{agg} \quad , \quad \hat{\Pi}_{N,2} = \frac{1-\beta}{\beta}\hat{B}_1 + \hat{A}^{agg} \qquad (10)$$

where: $\hat{A}^{agg} = \gamma\hat{A}_T + (1-\gamma)\hat{A}_N$ and $\hat{A}^{dif} = \hat{A}_T - \hat{A}_N$. A productivity increase raises consumption, wages, real output (evaluated at the initial relative prices), and profits, and affects the real exchange rate through the standard Balassa-Samuelson effect. Higher wealth ($\hat{B}_1 > 0$) raises consumption, and leads to a real appreciation that shifts labor towards the non-traded sector and raises profits in that sector relative to the traded sector.

We now turn to the short run allocation. We first solve for the allocation conditional on the short run number of firms in each sector. Using the long-run solution (10), the Euler condition (6), the budget constraint (3), the clearing of the non-traded good market (4) and the fact that the marginal product of labor is equalized across sectors, we write:

$$\hat{C}_1 = -\frac{\beta\gamma}{\gamma+\alpha(1-\gamma)}(\hat{r}_1 + \alpha\hat{n}_1^T) + \hat{A}^{agg} + \alpha\hat{n}_1^{agg} \quad , \quad \hat{w}_1 = \hat{A}^{agg} + \alpha\hat{n}_1^{agg}$$
$$\hat{B}_1 = -\hat{L}_{N,1} = \frac{\beta\gamma}{\gamma+\alpha(1-\gamma)}(\hat{r}_1 + \alpha\hat{n}_1^T) \tag{11}$$
$$\hat{R}_1 = -\frac{\beta\alpha}{\gamma+\alpha(1-\gamma)}(\hat{r}_1 + \alpha\hat{n}_1^T) + \hat{A}^{dif} + \alpha\hat{n}_1^{dif}$$

where: $\hat{n}_1^{agg} = \gamma\hat{n}_1^T + (1-\gamma)\hat{n}_1^N$ and $\hat{n}_1^{dif} = \hat{n}_1^T - \hat{n}_1^N$. The short run profits are given by:

$$\hat{\Pi}_{T,1} = \hat{A}^{agg} - (1-\alpha)\hat{n}_1^{agg} - (1-\gamma)\hat{n}_1^{dif} + \frac{\beta(1-\gamma)}{\gamma+\alpha(1-\gamma)}(\hat{r}_1 + \alpha\hat{n}_1^T)$$
$$\hat{\Pi}_{N,1} = \hat{A}^{agg} - (1-\alpha)\hat{n}_1^{agg} + \gamma\hat{n}_1^{dif} - \frac{\beta\gamma}{\gamma+\alpha(1-\gamma)}(\hat{r}_1 + \alpha\hat{n}_1^T) \tag{12}$$

(12) shows that the profits reflect the shocks and the number of firms in each sector. If the shocks are such that the profits in (12) are positive for an unchanged number of firms, then the number of firms in that sector remains at the initial value. Otherwise, the number of firms adjusts so that the marginal firm makes zero profits:

$$\hat{\Pi}_{T,1} = \sigma\hat{n}_1^T \quad , \quad \hat{\Pi}_{N,1} = \sigma\hat{n}_1^N$$

In general, the solution depends on whether the zero marginal profit constraints are binding or not. For brevity, we illustrate the results by taking three particular cases.

The welfare impact of shocks can be assessed by taking a linear approximation of the utility (5), and using (10) and (11):

$$\hat{U} = \hat{C}_1 + \frac{\beta}{1-\beta}\hat{C}_2 = (1-\beta)^{-1}\hat{A}^{agg} + \alpha\hat{n}_1^{agg}$$

The welfare thus only reflects the productivity shocks and any changes in the number of firms. In particular, a reduction in the number of firms in any sector is welfare reducing. A social planner would thus choose to deliver a lump sum subsidy to firms in the sector facing low profits, paid for by a lump sum tax on the household, in order to prevent the destruction of firms. As the fixed costs faced by firms are only a transfer and do not entail a use of real resources, they are not a constraint for the planner.[16]

4.3 Three specific cases

We first consider the case of a permanent productivity increase in the traded sector, $\hat{A}_T > 0$. (12) shows that profits in both sectors are positive when holding the number of firms to their initial values. There is then no destruction of firms in the short run, and the shock permanently boosts consumption, wages and profits, and appreciates the currency:

$$\hat{C}_1 = \hat{C}_2 = \hat{w}_1 = \hat{w}_2 = \hat{\Pi}_{T,1} = \hat{\Pi}_{N,1} = \hat{\Pi}_{T,2} = \hat{\Pi}_{N,2} = \gamma\hat{A}_T$$
$$\hat{R}_1 = \hat{R}_2 = \hat{A}_T \quad , \quad \hat{B}_1 = \hat{L}_{N,1} = 0 \tag{13}$$

Profits equally rise in the two sectors, but for different reasons. Firms in the non-traded sector benefit from the higher relative price of their output, while firms in the traded sector benefit from their higher productivity, which more than offset their lowered competitiveness relative to non-traded firms.

We next turn to a temporary increase in the world interest rate, $\hat{r}_1 > 0$, a shock that can be interpreted as a sudden-stop of international capital flows. (12) shows that profits are reduced in the non-traded sector if we hold the number of firms unchanged in both sectors:

$$\hat{\Pi}_{T,1}(\hat{n}_1^T = \hat{n}_1^N = 0) = \frac{\beta(1-\gamma)}{\gamma+\alpha(1-\gamma)}\hat{r}_1 \quad , \quad \hat{\Pi}_{N,1}(\hat{n}_1^T = \hat{n}_1^N = 0) = -\frac{\beta\gamma}{\gamma+\alpha(1-\gamma)}\hat{r}_1 \tag{14}$$

It thus cannot be the case that the number of non-traded firms remains constant. Instead, it is given by the zero-profit condition $\hat{\Pi}_{N,1} = \sigma\hat{n}_1^N$. We show in the appendix and in the numerical example below that, in equilibrium, the number of firms in the non-traded sector, the relative price of the non-traded good, consumption and wages all decrease. Labor is reallocated towards the traded sector, but the ensuing increased in traded output is not enough to offset the contraction in non-traded output (due to labor reallocation and the reduction of the number of

[16] We can explicitely solve for the planner's allocation around the steady state, and show that the planner never lowers the number of firms from the steady state values. The planner's allocation is thus the one with constant numbers of firms.

firms), and overall output falls. The contraction of overall output solely reflects the reduction of the number of firms in the non-traded sector.

We finally consider a temporary decrease in the world interest rate, $\hat{r}_1 < 0$, a shock that can be interpreted as a capital inflows surge. (14) shows that profits are reduced in the traded sector if we hold the number of firms unchanged in both sectors. We show below that, in equilibrium, the number of firms in the traded sector, consumption and wages all decrease. The relative price of the non-traded good increases, leading to labor reallocation towards the non-traded sector. The ensuing increased in non-traded output is not enough to offset the contraction in traded output and, overall, output falls. The contraction of overall output solely reflects the reduction of the number of firms in the traded sector.

4.4 Numerical illustration

We illustrate our results with a numerical example. We assume that traded goods account for 30 percent of the consumption basket ($\gamma = 0.3$), that there are decreasing returns to scale ($\alpha = 0.3$), and set the discount factor β to 0.95. We set the sensitivity of the fixed cost to the number of firms σ to unity.

Figure 1 shows the short run impact on Home country variables in response to the three shocks discussed above. The response to a permanent productivity increase in the traded sector is given by the striped bar, the black bars shows the impact of a reduction in the world interest rate, and the dotted bar shows the impact of an interest rate increase. The shocks are parametrized to lead to a unit response in the relative price of the non-traded good. The top panel of Figure 1 presents the main variables, namely the relative price, overall consumption, the current account, and overall output. The bottom panel shows a broader range of variables.

The main message of Figure 1 is that interest rate shocks are contractionnary, regardless of their direction, while a productivity increase raises output. The key reason behind the reduction in overall output in response to interest rate shocks is that these shocks lower profits in a sector (traded for an interest rate decrease, and non-traded for an increase), and lead to the destruction of some firms in the sectors. Because of the decreasing returns to scale in production, shifting the labor input used by the destroyed firms to surviving ones does not generate enough output to replace the foregone one, and overall output falls.

Interestingly, there is a gap between the impacts of interest rate decreases and increases. For instance, output and firm destructions are more acute following a decrease. Even for variables that move in opposite directions across the two shocks, such as the labor input in the non-traded sector, we observe that the effects are of a larger magnitude following an interest rate decrease. This is because $\hat{n}_1^T$ enters (11) and (12) not only in a symmetric manner as $\hat{n}_1^N$ does, but also by affecting the real interest rate expressed in terms of the consumption basket (the $\hat{r}_1 + \alpha\hat{n}_1^T$ term). A fall in the number of traded firms directly reduces the relative price of the non-traded good,[17] which in turn lowers the real interest rate expressed in terms of the consumption basket (equal to $\hat{r}_1 - (1-\gamma)(\hat{R}_2 - \hat{R}_1)$), and thus magnifies the initial shock. A reduction in the number of non-traded firms does not generate such an effect.

As pointed above, a central planner would not allow for the number of firms to decrease, as this lowers welfare and is not strictly speaking necessary because the fixed costs faced by firms only represent a transfer and thus do not entail a real use of resources. The planner's allocation corresponds to $\hat{n}_1^T = \hat{n}_1^T = 0$.

We thus assess how the planner's allocation differs from the decentralized one for the three shocks we consider. There is no discrepancy following an increase in productivity, as this does not lead to any destruction of firms under the decentralized allocation. Figure 2 contrasts the allocations following a decrease in the interest rate, with the shock parametrized to lead to a unit movement in the relative price of the non-traded good under the decentralized allocation. The planner's allocation prevents the reduction in the number of firms in the traded sector. This substantially reduces the contraction in traded output, and avoids the decrease in overall output. The boom in consumption and associated current account deficit are reduced under the planner's allocation. Interestingly, the increase in the relative price of the non-traded good (real appreciation) is higher under the planner's allocation than under the decentralized outcome. Our model thus shows that while relative price movements have detrimental effects under the decentralized allocation, preventing these effects does not imply that price movements should be dampened. A similar pattern is observed in Figure 3 which contrasts the allocations following an

[17] In a steady state where the number of firms can change, the relative price is positively affected by $\hat{n}^T - \hat{n}^N$.

increase in the interest rate. We again see that the planner prevents the reduction in the number of firms in the non-traded sector, thereby limiting the contraction of output in that sector and preventing an overall recession. The decrease in consumption is dampened, but this is not accompanied by a dampening of the current account surplus. In addition, the real depreciation of the currency is larger under the planner's allocation.

4.5 Insights from the theory

Our model delivers an asymmetry between the impact of appreciations and depreciations stemming from shocks to capital flows, as well as an externality that makes the decentralized allocation inefficient in some cases. The asymmetry reflects the fact that shocks to capital flows affect profits in the traded and non-traded sectors differently. They always lead to lower profits and firms' shutdown in one sector. This cannot be offset by firms' creation in the other sector as we assume that creation is not possible in the short run, and we therefore always get a lower number of firms. Combined with decreasing returns to scale, this leads to a contraction in output. Our model can thus delivers adverse effects both of real depreciations, linking with the literature on sudden stops, and appreciations, linking with the recent concerns of policy makers.

An externality is also present in our setting as the fixed costs faced by firms, which drive the movements in the number of firms, do not represent a real cost and thus are ignored by a planner. A planner would always prevent the reduction in the number of firms to support output and welfare. Interestingly, the movement in the real exchange rate is larger under the planner's allocation, despite the fact that this movement is what leads to profits falling in a sector.

A limitation of our model is that it does not deliver any threshold effects where the impacts of small and large shocks differ. For instance, the impact of a 1 percentage point move in the interest rate is simply twice the impact of a 50 basis points move. One could extend the model to allow for such threshold effect, for instance by allowing for the marginal firm in each sector to make positive profits in the steady state. A small reduction in its profits would then not endanger it, while it would have to shut down following a large reduction of profits. Allowing for such threshold effects would, however, make the model substantially more complex.

The model we consider is deliberately kept simple for brevity, and can be extended in many directions. One could include differentiated traded goods, leading to movements in the terms-of-trade. Another extension would be to allow for an endogenous labor supply. Overall output then would not just reflect productivity and the number of firms, thus dampening the contraction following shocks to the interest rate.[18] Finally, we assume that the planner can implement lump sum taxes and subsidies to prevent the numbers of firms from falling. If such subsidies are not feasible, the model could be used to assess whether taxes or subsidies on the consumption of traded or non-traded goods, or on international borrowing, could also keep the numbers firms stable.

6. Conclusion

This paper investigates the connection between exchange rate 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 underlying shock. We first establish three main stylized facts from a broad dataset of emerging and advanced economies. First, exchange rate appreciations are associated with weaker growth only for advanced economies when compared to normal times. Second, both emerging and advanced economies observe enhanced growth when appreciations are accompanied by a productivity increase. Nonetheless, the growth primarily reflects the productivity gain. The appreciation per se reduces growth in emerging economies, but not in advanced economies. Third, appreciations that are associated with a surge in capital inflows are characterized by weaker growth, compared to episodes with a productivity increase. In addition, the impact of the appreciation per se in a capital surge episode is clearly negative. A robustness analysis shows that these results still hold when considering only cases of strong appreciation.

We develop a simple model that generates a pattern of real exchange rate and growth consistent with our empirical findings. In addition, the model also justifies a concern from policy makers about exchange rate movements driven by capital flows surges and sudden stops. Frictions in the sectoral re-allocation of output imply that surges and sudden stops are both associated with a weak output performance. Furthermore, this performance is inefficient and thus justifies a policy

[18] Both features were considered in an early version of the paper, where we assumed constant number of firms. Both features enriched the model, but did not radically alter its predicitions. Given the higher complexity of the solution under differentiated traded goods and endogenous labor supply, we opted to abstract from them for brevity.

response, albeit one that would not dampen the movements in the real exchange rate. By contrast, an appreciation driven by higher productivity generates an efficient response and is of no concern to policy makers.

Our analysis shows that the concern of policy makers about appreciations is well-founded, especially when they are driven by shocks in global financial markets. Our model furthermore shows that being concerned about an appreciation is not inconsistent with being concerned about a depreciation. The proper policy response is however subtle. Exchange rate movements driven by shocks to financial market deliver an inefficient allocation. Yet, the first best allocation does not imply smaller movements in the real exchange rate. A policy aimed at the exchange rate 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 Labor demand

The allocation of consumption by the household between the traded and non-traded goods is $C_{T,t} = \gamma(R_t)^{1-\gamma} C_t$ and $C_{N,t} = (1-\gamma)(R_t)^{-\gamma} C_t$. The optimization by firms leads to the following labor demands for individual firms:

$$L_{T,t}(i) = (1-\alpha)^{1/\alpha}(w_t)^{-1/\alpha} R_t^{-(1-\gamma)/\alpha}(A_{T,t})^{1/\alpha} \quad , \quad L_{N,t}(i) = (1-\alpha)^{1/\alpha}(w_t)^{-1/\alpha} R_t^{\gamma/\alpha}(A_{N,t})^{1/\alpha}$$

The clearing of the labor market implies that:

$$1 = n_t^T L_{T,t}(i) + n_t^N L_{N,t}(i) \qquad \text{(A.1)}$$

A.2 Linearized system

The linearized long run system of equations consists of the profits (1)-(2), the budget constraint (3) with constant asset holdings, the clearing of the non-traded market (4), the labor demand (A.1) and its sectoral equivalents:

$$\begin{aligned}
\hat{\Pi}_{T,2} &= -(1-\alpha)\alpha^{-1}\hat{w}_2 + \alpha^{-1}(\hat{A}_T - (1-\gamma)\hat{R}_2) \\
\hat{\Pi}_{N,2} &= -(1-\alpha)\alpha^{-1}\hat{w}_2 + \alpha^{-1}(\hat{A}_N + \gamma\hat{R}_2) \\
\hat{C}_2 &= (1-\beta)\beta^{-1}\hat{B}_1 + (1-\alpha)\hat{w}_2 + \alpha\gamma\hat{\Pi}_{T,2} + \alpha(1-\gamma)\hat{\Pi}_{N,2} \\
\hat{w}_2 &= \hat{A}^{agg} \\
\hat{C}_2 &= -(1-\alpha)\alpha^{-1}\hat{w}_2 + \alpha^{-1}\hat{A}_N + \gamma\alpha^{-1}\hat{R}_2 \\
\hat{L}_{T,2} &= -\alpha^{-1}(\hat{w}_2 - \hat{A}_T + (1-\gamma)\hat{R}_2) \\
\hat{L}_{N,2} &= -\alpha^{-1}(\hat{w}_2 - \hat{A}_N - \gamma\hat{R}_2)
\end{aligned}$$

The solution of this system conditional on the asset holdings is given by (10).

The linearized short run system of equations consists of the profits (1)-(2), the budget constraint (3) with zero initial asset holdings, the clearing of the non-traded market (4), the labor demand (A.1) and its sectoral equivalents, and the Euler condition (6):

$$\hat{\Pi}_{T,1} = -(1-\alpha)\alpha^{-1}\hat{w}_1 + \alpha^{-1}(\hat{A}_T - (1-\gamma)\hat{R}_1)$$
$$\hat{\Pi}_{N,1} = -(1-\alpha)\alpha^{-1}\hat{w}_1 + \alpha^{-1}(\hat{A}_N + \gamma\hat{R}_1)$$
$$\hat{C}_1 + \hat{B}_1 = (1-\alpha)\hat{w}_1 + \alpha\gamma\hat{\Pi}_{T,2} + \alpha(1-\gamma)\hat{\Pi}_{N,2} + \alpha\hat{n}_1^{agg}$$
$$\hat{w}_1 = \hat{A}^{agg} + \alpha\hat{n}_1^{agg}$$
$$\hat{C}_1 = \hat{n}_1^N - (1-\alpha)\alpha^{-1}\hat{w}_1 + \alpha^{-1}\hat{A}_N + \gamma\alpha^{-1}\hat{R}_1$$
$$\hat{L}_{T,1} = \hat{n}_1^T - \alpha^{-1}(\hat{w}_1 - \hat{A}_T + (1-\gamma)\hat{R}_1)$$
$$\hat{L}_{N,1} = \hat{n}_1^N - \alpha^{-1}(\hat{w}_1 - \hat{A}_N - \gamma\hat{R}_1)$$
$$\hat{C}_2 = \hat{C}_1 + \hat{r}_1 - (1-\gamma)(\hat{R}_2 - \hat{R}_1)$$

This system along with the long run solution (10) leads to the short run solution (11)-(12), conditional on the number of firms in each sector.

If the short run profits (12) are positive when evaluated at $\hat{n}_1^T = \hat{n}_1^N = 0$, the solution entails no movements in the numbers of firms. If $\hat{\Pi}_{T,1} < 0$ when evaluated at $\hat{n}_1^T = \hat{n}_1^N = 0$, then the number of traded firms is given by the zero profit condition: $\hat{\Pi}_{T,1} = \sigma\hat{n}_1^T$. Similarly, if $\hat{\Pi}_{N,1} < 0$ when evaluated at $\hat{n}_1^T = \hat{n}_1^N = 0$, then the number of non-traded firms is given by the zero profit condition: $\hat{\Pi}_{N,1} = \sigma\hat{n}_1^N$.

A.3 Three specific cases.

A temporary increase in productivity raises profits in both sectors without any changes in the number of firms, and thus the solution is given by the expressions above evaluated at $\hat{n}_1^T = \hat{n}_1^N = 0$.

A temporary increase in the interest rate, $\hat{r}_1 > 0$, lowers profits in the non-traded sector when the number of firms is held unchanged, as shown by (14). The number of firms in the non-traded sector is then given by the zero profit condition. The short-run solution is given by:

$$\begin{aligned}
&\hat{n}_1^T = 0 \quad , \quad \hat{n}_1^N = -\Omega^N \Theta \gamma \hat{r}_1 < 0 \\
&\hat{C}_1 = -\Omega^N \Theta(\sigma+1)\gamma \hat{r}_1 < 0 \\
&\hat{w}_1 = \hat{Y}_1 = -\Omega^N \Theta \gamma(1-\gamma)\alpha \hat{r}_1 < 0 \\
&\hat{B}_1 = -\hat{L}_{N,1} = \Theta \gamma \hat{r}_1 > 0 \\
&\hat{R}_1 = -\Omega^N \Theta \alpha(\sigma + (1-\alpha)(1-\gamma))\hat{r}_1 < 0 \\
&\hat{\Pi}_{T,1} = \Omega^N \Theta(\sigma + 1 - \alpha)(1-\gamma)\hat{r}_1 > 0 \\
&\hat{\Pi}_{N,1} = -\Omega^N \Theta \sigma \gamma \hat{r}_1 < 0
\end{aligned}$$

where:

$$\Omega^N = \left[\sigma + (1-\alpha)(1-\gamma) + \gamma\right]^{-1} \quad , \quad \Theta = \beta / (\gamma + \alpha(1-\gamma))$$

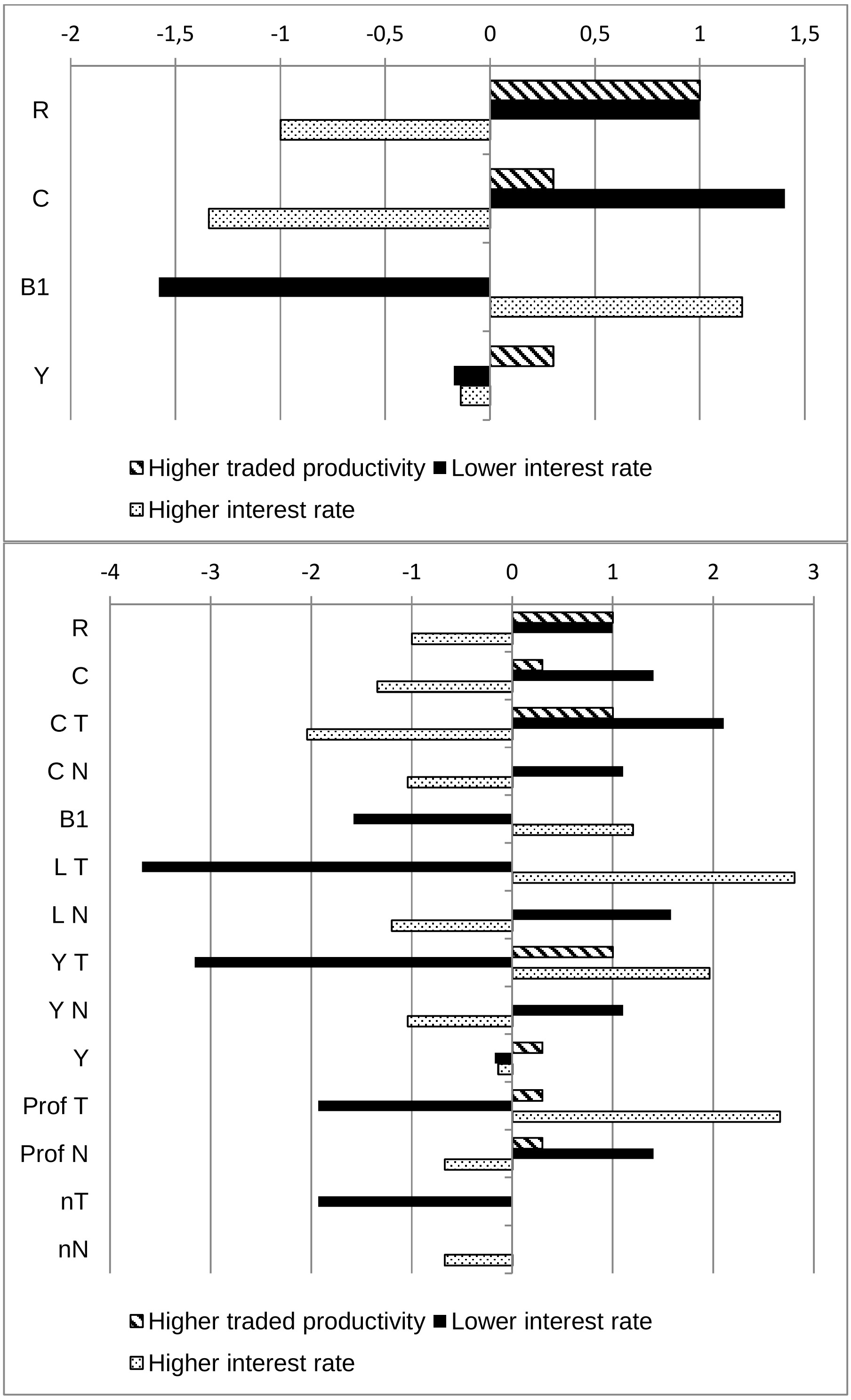
A temporary decrease in the interest rate, $\hat{r}_1 < 0$, lowers profits in the traded sector when the number of firms is held unchanged, as shown by (14). The number of firms in the traded sector is then given by the zero profit condition. The short-run solution is given by:

$$\begin{aligned}
&\hat{n}_1^N = 0 \quad , \quad \hat{n}_1^N = \Omega^T \Theta(1-\gamma)\hat{r}_1 < 0 \\
&\hat{C}_1 = -\Omega^T \Theta(\sigma + 1 - \alpha)\gamma \hat{r}_1 > 0 \\
&\hat{w}_1 = \hat{Y}_1 = \Omega^T \Theta \gamma(1-\gamma)\alpha \hat{r}_1 < 0 \\
&\hat{B}_1 = -\hat{L}_{N,1} = \Omega^T \Theta \gamma(\sigma + (1-\alpha)(1-\gamma))\hat{r}_1 < 0 \\
&\hat{R}_1 = -\Omega^T \Theta \alpha(\sigma + (1-\alpha)\gamma)\hat{r}_1 > 0 \\
&\hat{\Pi}_{T,1} = \Omega^T \Theta(1-\gamma)\hat{r}_1 < 0 \\
&\hat{\Pi}_{N,1} = -\Omega^T \Theta(\sigma + 1 - \alpha)\gamma \hat{r}_1 > 0
\end{aligned}$$

where:

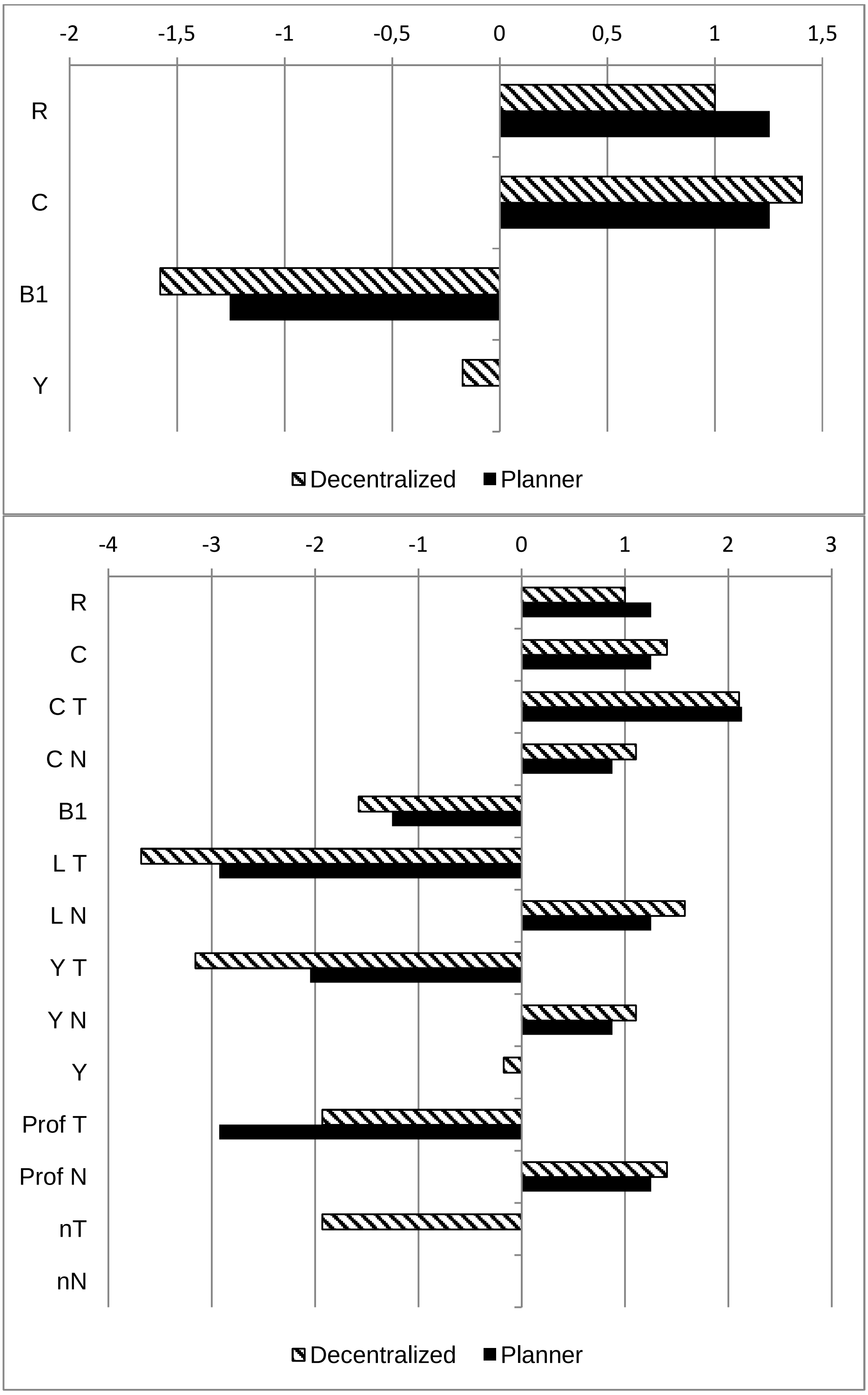
$$\Omega^T = \left[\sigma + (1-\alpha)\gamma + (1-\gamma) - \beta\alpha(1-\gamma)/(\gamma + \alpha(1-\gamma))\ \right]^{-1}$$

Figure 1: Impact on short run variables



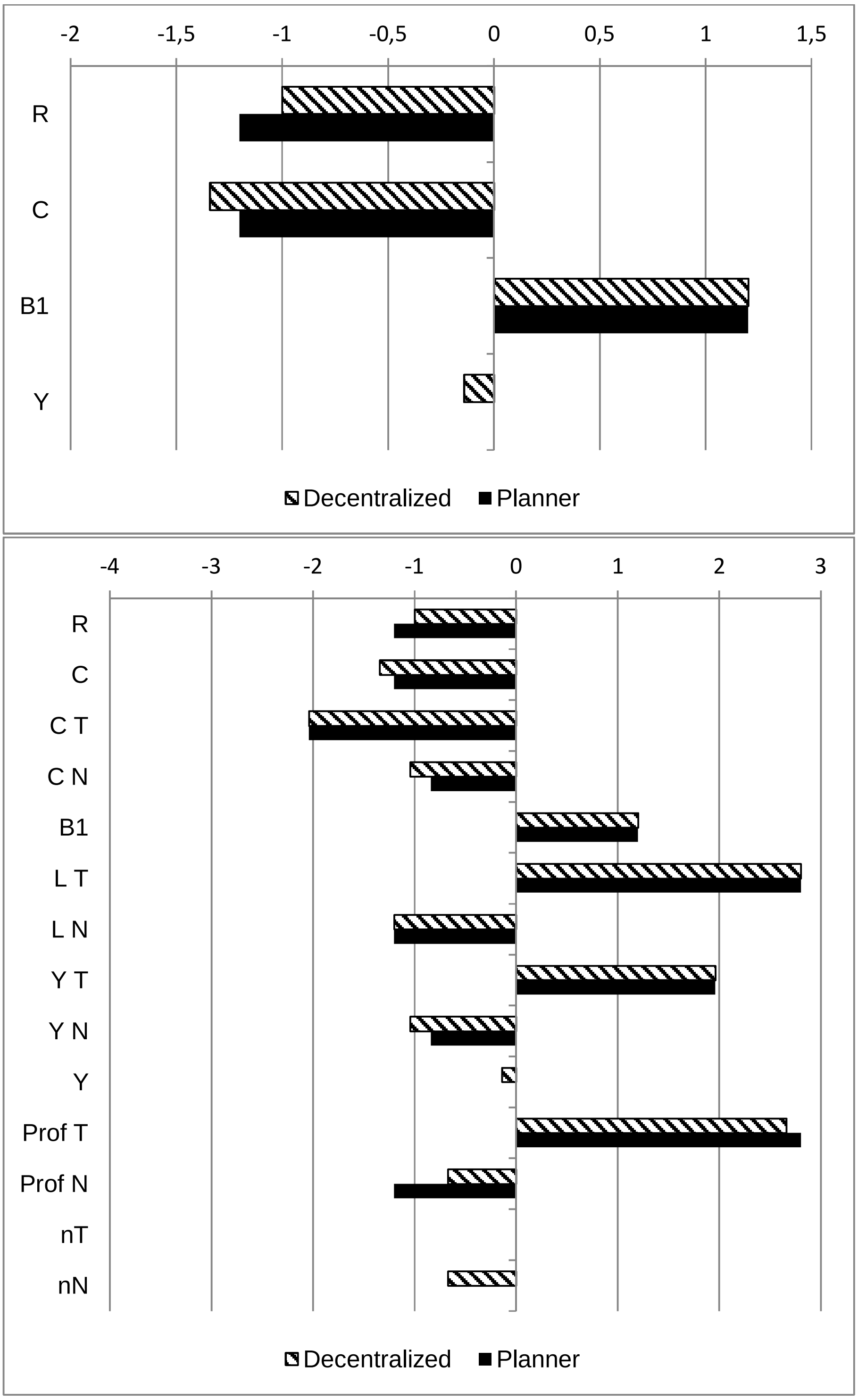
Decentralized allocation. All shocks are parametrized to lead to a unit movement in the relative price of the non-traded good. Coefficients: $\alpha = 0.3$, $\gamma = 0.3$, $\beta = 0.95$, $\sigma = 1$.

Figure 2: Impact of a lower interest rate



The shock is parametrized to lead to a unit movement in the relative price of the non-traded good under the decentralized allocation. Coefficients: $\alpha = 0.3$, $\gamma = 0.3$, $\beta = 0.95$, $\sigma = 1$.

Figure 3: Impact of a higher interest rate



The shock is parametrized to lead to a unit movement in the relative price of the non-traded good under the decentralized allocation. Coefficients: $\alpha = 0.3$, $\gamma = 0.3$, $\beta = 0.95$, $\sigma = 1$.

Table 1: Incidence of the difference changes

	Episodes of		
	Appreciation	Productivity increase	Capital surge
Appreciation	812		
Productivity increase	77	235	
Capital surge	96	45	310
Productivity increase and capital surge	16	na	na

Note: the table presents the number of the various episodes of real appreciations, increases in productivity, and surges in net capital inflows. The numbers along the diagonal show the total number of each episode (for instance there are 235 episodes of productivity increases. The lower triangle shows the number of episodes associated with two developments (there are 96 instances of appreciations accompanied by a capital flow surge). The final line shows the number of episodes where all three developments are observed.

Table 2: Probability of observing the different cases of appreciation

	Appreciation		Appreciation and Prod. Increase		Appreciation and Capital surge	
	Coef.	pval	Coef.	pval	Coef.	pval
VXO	-0,01	0,15	-0,05	0,02	-0,05	0,02
GDP	0,09	0,00	0,05	0,41	0,28	0,17
index commo	0,23	0,08	-0,51	0,06	-0,21	0,42
interest diff.	-0,01	0,45	0,05	0,02	0,01	0,57
inflation	0,02	0,06	-0,04	0,06	-0,01	0,56
KAO	-0,12	0,02	-0,18	0,18	-0,16	0,19
Productivity	-0,05	0,13	-0,13	0,04	-0,18	0,00
_cons	-2,11	0,05	2,10	0,38	0,15	0,91
obs	928		989		818	

Note: the table presents the impact of the various explanatory on the probability of observing a real appreciation, an appreciation associated with higher productivity, and an appreciation associated with a capital flows surge, respectively. The impact is presented through the coefficient and the p-value (a low p-value indicating a significant impact).

Table 3: Conditional independence assumption or sample bias

				Nearest neighbor(1)	Nearest neighbor(5)	kernel	local-linear
		Mean					
		treated	control	p val.	p val.	p val.	p val.
VXO	Unmatched	21,08	22,06	0,11			
	Matched	21,08	20,95	0,81	0,79	0,72	0,81
GDP	Unmatched	3,68	2,96	0,00			
	Matched	3,68	3,87	0,40	0,64	0,91	0,45
index commo	Unmatched	8,08	8,02	0,12			
	Matched	8,08	8,11	0,51	0,72	0,91	0,45
interest diff.	Unmatched	6,67	5,41	0,15			
	Matched	6,67	5,99	0,55	0,24	0,30	0,53
inflation	Unmatched	8,86	6,57	0,03			
	Matched	8,86	7,81	0,44	0,19	0,17	0,39
KAO	Unmatched	0,08	0,06	0,08			
	Matched	0,08	-0,88	0,52	0,97	0,63	0,45
Productivity	Unmatched	1,82	1,67	0,16			
	Matched	1,82	1,88	0,74	0,80	0,74	0,94
			557	335	335	335	335

Note: the table reports the p-value of the test that the variable in the specific column differs between the treatment group and the control group (a high p-value indicates the absence of a significant difference). The p-values are reported before the matching algorithm is applied ("unmatched" rows) and after ("matched" rows). The mean is reported only for the N1 matching algorithm, the mean under other algorithms being very close.

Table 4: Impact of different types of appreciations on growth, ATTs

Panel A : Nearest neighbor(1)					
	Appreciation and				
		Prod. incr.	Capital surge	Prod. incr.	Capital surge
ALL ,treated obs	337	46	46	133	144
ATT	-0,27	1,27 *	0,47	1,94 ***	0,51
se	0,29	0,74	0,73	0,46	0,45
EME, treated obs	150	20	19	60	63
ATT	0,50	3,03 **	0,32	2,83 ***	1,33 *
se	0,62	1,50	1,25	0,75	0,70
AE, treated obs	187	26	27	72	81
ATT	-1,00 **	1,38	-0,23	1,52 ***	0,38
se	0,44	1,00	0,98	0,55	0,54
Panel B : Nearest neighbor(5)					
ALL ,treated obs	335	45	46	130	152
ATT	-0,20	1,64 ***	0,18	1,78 ***	0,72 **
se	0,28	0,56	0,55	0,32	0,35
EME, treated obs	149	20	19	60	62
ATT	0,75	2,54 ***	1,46 *	2,74 ***	1,69 ***
se	0,51	0,89	0,89	0,48	0,54
AE, treated obs	187	26	27	72	81
ATT	-0,81 ***	1,13 *	-0,55	0,88 *	0,01
se	0,29	0,73	0,70	0,53	0,38

Note: the table shows the impact of an appreciation, with or without a productivity increase or a capital surge (first three columns), and of a productivity increase or a capital surge not accompanied by an appreciation (last two columns). Standard errors are bootstrapped (using 500 iterations). *, **, and *** denote significance at the 10, 5, and 1 percent levels, respectively.

Table 4(cont.): Impact of different types of appreciations on growth, ATTs

			Appreciation and							
			Prod. incr.		Capital surge		Prod. incr.		Capital surge	
Panel C : Local-linear										
ALL ,treated obs	337		45		46		130		144	
ATT	-0,24		1,91	***	0,30		2,09	***	0,59	**
se	0,18		0,51		0,45		0,25		0,25	
EME, treated obs	149		20		19		60		62	
ATT	0,66		2,28	**	1,23	*	2,93	***	1,54	***
se	0,35		0,75		0,73		0,41		0,39	
AE, treated obs	187		26		27		72		81	
ATT	-0,90	***	1,37	***	-0,36		0,85	**	-0,20	
se	0,22		0,60		0,60		0,41		0,39	
Panel D : Kernel										
ALL ,treated obs	335		44		46		130		144	
ATT	-0,11		1,99	***	0,36		2,00	***	0,66	**
se	0,21		0,47		0,47		0,28		0,28	
EME, treated obs	148		19		19		60		62	
ATT	0,53		2,70	***	1,77	***	3,13	***	1,77	***
se	0,42		0,70		0,39		0,43		0,47	
AE, treated obs	187		26		27		72		81	
ATT	-0,84	***	1,42	**	-0,28		0,98	***	-0,28	
se	0,23		0,63		0,29		0,33		0,29	

Note: the table shows the impact of an appreciation, with or without a productivity increase or a capital surge (first three columns), and of a productivity increase or a capital surge not accompanied by an appreciation (last two columns). Standard errors are bootstrapped (using 500 iterations). *, **, and *** denote significance at the 10, 5, and 1 percent levels, respectively.

Table 5: Impact of an appreciation

ATT(app+shock)-ATT(shock)

	Panel A : Nearest neighbor(1)		Panel C : Local-linear	
	Prod. increase	Capital surge	Prod. increase	Capital surge
ALL	-0,67 ***	-0,04	-0,18 **	-0,29 ***
EME	0,20	-1,01 ***	-0,65 ***	-0,32 **
AE	-0,14	-0,61 ***	0,52 ***	-0,16 *
	Panel B : Nearest neighbor(5)		**Panel D : Kernel**	
	Prod. increase	Capital surge	Prod. increase	Capital surge
ALL	-0,14 *	-0,54 ***	-0,01	-0,30 ***
EME	-0,20	-0,23	-0,43 ***	0,00
AE	0,25 *	-0,55 ***	0,44 ***	0,00

Note: the table shows the difference between the treatment effect of a shock associated with a real appreciation and the effect of the same shock without an appreciation. Standard errors are bootstrapped (using 500 iterations). *, **, and *** denote significance at the 10, 5, and 1 percent levels, respectively.

Table 6: Impact of different types of strong appreciations on growth, ATTs (5-year benchmark)

	Strong appreciation and					Strong appreciation and				
	nil		Prod. incr.		Capital surge	nil		Prod. incr.		Capital surge
	Panel A : Nearest neighbor(1)					Panel C : Local-linear				
ALL ,treated obs	125		16		15	125		16		15
ATT	-0,53		0,79		-1,05	-0,54		1,26	*	0,01
se	0,47		1,28		1,29	0,36		0,69		0,63
EME, treated obs	53		8		7	53		8		7
ATT	0,43		1,67		0,95	0,54		3,27	***	0,73
se	0,87		2,02		1,64	0,60		1,08		0,87
AE, treated obs	72		8		8	72		8		8
ATT	-1,39	**	-0,76		0,61	-1,12	***	-0,60		-0,35
se	0,58		1,64		1,44	0,29		0,71		0,82
	Panel B : Nearest neighbor(5)					Panel D : Kernel				
ALL ,treated obs	125		16		15	124		16		15
ATT	-0,54	*	1,09		-0,37	-0,299		1,86	***	0,99
se	0,34		1,04		0,88	0,30		0,65		0,69
EME, treated obs	53		8		7	53		8		7
ATT	0,60		3,02	**	0,63	0,638		3,56	***	0,89
se	0,65		1,39		1,05	0,58		0,81		1,01
AE, treated obs	72		8		8	72		8		8
ATT	-1,11	***	-0,59		-0,12	-0,97	***	-0,22		0,14
se	0,38		0,94		0,94	0,28		0,72		0,94

Note: the table is similar to table 4. *, **, and *** denote significance at the 10, 5, and 1 percent levels, respectively.

Table 7: Impact of different types of strong appreciations on growth, ATTs (3-year benchmark)

	Strong appreciation and					Strong appreciation and				
	nil		Prod. incr.		Capital surge	nil		Prod. incr.		Capital surge
	Panel A : Nearest neighbor(1)					Panel C : Local-linear				
ALL ,treated obs	158		23		27	158		23		27
ATT	-0,06		2,05	**	0,13	-0,10		1,60	***	-0,20
se	0,46		1,08		0,98	0,25		0,50		0,45
EME, treated obs	63		11		11	63		11		11
ATT	-0,04		2,04		-0,35	0,87	*	2,37	**	-0,16
se	0,80		1,46		1,65	0,51		1,15		0,75
AE, treated obs	95		12		16	95		12		16
ATT	-0,31		1,10		-0,86	-0,53	**	0,94	*	-0,59
se	0,57		1.25		1,25	0,26		0,57		0,63
	Panel B : Nearest neighbor(5)					Panel D : Kernel				
ALL ,treated obs	158		23		27	158		23		27
ATT	0,04		1,87	***	-0,43	0,21		1,71	***	-0,25
se	0,31		0,76		0,70	0,26		0,45		0,50
EME, treated obs	63		11		11	63		11		11
ATT	0,34		1,37	***	-0,23	1,00	**	2,67	***	0,02
se	0,59		1,33		1,04	0,51		0,81		0,92
AE, treated obs	95		12		16	95		12		16
ATT	-0,57		1,23		-0,72	-0,52	**	0,86	**	-0,40
se	0,37		0,85		0,90	0,26		0,58		0,62

Note: the table is similar to table 4. *, **, and *** denote significance at the 10, 5, and 1 percent levels, respectively.