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RESEARCH ARTICLE

The Macroeconomic Effects of Large Exchange Rate Appreciations

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Abstract Although currency adjustment is often proposed as a policy tool to reduce current account imbalances, there is no consensus regarding the macroeconomic effects. In this paper we study the macroeconomic aftermath of large exchange rate appreciations. Using a sample of 128 countries over the period 1960–2008, we identify 25 episodes of large nominal and real appreciations shocks. We use narrative identification of exogenous appreciation episodes and study the macroeconomic effects in a dummy-augmented panel autoregressive model. Our results indicate that exchange rate appreciations tend to have strong effects on current account balances. Within 3 years after the appreciation event, the current account balance on average deteriorates by three percentage points of GDP. This effect occurs through a reduction of savings without a meaningful reduction in investment. Real export growth slows down substantially, but the output costs are small and not statistically significant. All these effects appear somewhat more pronounced in developing countries.

Keywords Current account adjustment · Global imbalances · Exchange rate adjustment · Real exchange rates

JEL F4 · F31 · F32 · N10 · O16

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The aim of this paper is to provide an empirical backbone to the debate about the macroeconomic effects of large exchange rate adjustments of tightly managed or pegged exchange rate regimes.[1] Using a large cross-country dataset covering the years 1960–2008, we study the effects of large exchange rate appreciations and revaluation shocks. Our main goal is to document the key macroeconomic lessons that can be learned from these episodes. We use a narrative identification strategy to isolate cases when the appreciation was exogenously driven. The historical record indicates that a large exchange rate appreciation leads to a marked deterioration of the current account balance and dampens export growth meaningfully, but the effects on output are minor and statistically insignificant. These effects seem more pronounced in developing countries.

Global imbalances were a prominent trait of the world economy in the past decade. American trade deficits and Chinese surpluses were and remain prominent topics in academic and policy debates. Many economists hold that global imbalances were problematic and were a contributing factor to the global financial crisis (e.g., Obstfeld and Rogoff 2005; Cline and Williamson 2007; Feldstein 2008). However, the role of economic policy in correcting current account imbalances remains debated.[2] One group of economists thinks that large exchange rate adjustments—such as a dollar depreciation and an appreciation of the Chinese renminbi and of other Asian currencies—will eventually play a role in rebalancing the world economy (Obstfeld and Rogoff 2005; Goldstein 2006; Wolf 2009; Subramanian 2010; Ferguson and Schularick 2011). Yet other scholars argue that currency adjustment is not an effective policy tool as elasticities could be low and underlying savings and investment remain unaffected by exchange rate changes (Devereux and Genberg 2007; McKinnon 2007; Qiao 2007). A third group of economists, by contrast, fears that currency adjustment might be all too effective—but mainly in reducing the growth rate of the Chinese and other economies, as China has become a locomotive for developing country growth in the 2000s (Rodrik 2008; Berg and Miao 2010; Garroway et al. 2010).[3]

The main points of disagreement about the macroeconomic effects of exchange rate changes relate to two central issues. First, how effective is exchange rate appreciation in correcting current account surpluses in Asia and deficits in the United States? Second, would such appreciation come with the side effect of reducing growth in developing countries? While these questions open up two different theoretical boxes, they are to some degree open to a joint empirical treatment, which is what we aim to do here.

Despite the large literature dealing with exchange rates and trade elasticities, the number of studies that have specifically analyzed the macroeconomic effects of appreciations is relatively small.[4] Goldfajn and Valdés (1999) have studied large real

[1] We are grateful to two anonymous referees for very helpful comments and suggestions. We also wish to thank, without implicating, Menzie Chinn, Christian Daude, Luiz de Mello and Helen Qiao for their suggestions. All remaining errors are our own.

[2] There is an emerging consensus that global imbalances were closely linked to the 2008 crisis (Bini Smaghi 2008; Caballero and Krishnamurthy 2009; Blanchard and Milesi-Ferretti 2009; Obstfeld and Rogoff 2009), but some authors maintain that the financial crisis was largely unrelated (e.g. Dooley et al. 2009). For an empirical test of the link between imbalances and financial crises see Jordà et al. (2011).

[3] The key argument is that revaluation might put a successful export-led growth model at risk. Similar causes have been named as explaining the "fear of floating" phenomenon (Calvo and Reinhart 2002).

[4] At least outside the narrower context of appreciation pressures in resource rich economies.

effective appreciation episodes from 1960 to 1994 for a broad country sample, but with a focus on the dynamics of appreciation and overvaluation. Eichengreen and Hatase (2007) have analyzed the Japanese revaluation experience with an eye on the policy lessons for China today. A recent study by Eichengreen and Rose (2010) has broadened this approach and is similar to our study in its research objective, but not in the empirical approach. Eichengreen and Rose (2011) examine the macroeconomic impact of exits from pegs that results in exchange rate appreciations. They study 51 cases of exits from fixed exchange rate regimes that went hand in hand with subsequent appreciation. They find no evidence of a generalized growth collapse or a significant fall of the investment rate. Economies marked by rapid consumption, investment, and trade growth—a common pattern in emerging economies—are somewhat more likely to suffer from an economic slowdown in the years after the currency appreciation. Our results also indicate that the negative macroeconomic effects of sharp appreciations are somewhat stronger in emerging economies than in advanced countries.

An extensive literature on current account reversals also speaks to these issues, albeit from the opposite angle. For instance, Milesi-Ferretti and Razin (2000) study episodes of sharp reductions in current account deficits and find that there is no systematic evidence of a growth slowdown—a conclusion that is consistent with ours. More recently, Algieri and Bracke (2011) examined over 70 episodes of substantial and significant current account improvements in industrial and major emerging economies and found a considerable degree of heterogeneity. In a majority of cases current account reversals were accompanied by internal adjustment through a slowdown of domestic demand and did not involve significant exchange rate movement. In emerging market economies, however, the adjustment was accompanied by exchange rate depreciation and slower economic growth. Heterogeneity of macroeconomic adjustments across country groups is a feature that emerges in our broader data set too.

Our approach is the following: we first identify large exchange rate appreciations and revaluations, comprising 10% (or larger) appreciations of the nominal effective exchange rate over a two-year window (or less), that have led to large movements in real exchange rates and we require the appreciations to be sustained in real terms over at least 5 years. From 1960, we identify 25 episodes of large nominal and real appreciations in a sample of 128 countries. We then ask how these events affected the current account balance and output using a dummy variable augmented autoregressive panel model following the methodology pioneered in Cerra and Saxena (2008). We also look at differences between advanced and developing countries in response to these events.

We establish four empirical regularities. First, the current account balance deteriorates strongly in response to appreciation and revaluation shocks. Three years after the strengthening of the exchange rate, the current account balance falls by about three percentage points of GDP as a function of decreased savings with stable investment rates. Second, the effects on output are limited. The negative effect on the level of output amounts to a modest 1% after 6 years. The confidence intervals are wide and the results are statistically insignificant. Third, while aggregate output is not strongly affected, export growth falls significantly after appreciation and revaluation shocks. Finally, most of these effects seem to be more pronounced in developing countries.

Difficulties in disentangling the effects of exchange rate changes from the factors leading to them raise endogeneity issue (Engel 2009). We deal with it through detailed narrative documentation of the individual appreciation episodes[5] and statistical tests for the presence of endogeneity. The narrative approach allows us to differentiate between appreciation episodes that occurred exogenously—in particular, we identify 14 episodes when real exchange rate appreciation was the indirect consequence of the appreciation of the anchor currency in the context of an exchange rate peg—and other episode that might have been partly endogenous responses to economic fundamentals.[6]

The structure of the paper is as follows. Section 1 provides a theoretical and empirical introduction. In section 2, we define the appreciation events we are studying. Section 3 introduces our econometric methodology; section 4 and 5 present the key results and robustness tests. Section 6 summarises the key results of this study and discusses their implication for economic policy.

1 Real Effects of Large Exchange Rate Adjustments

In its simplest form, the idea that large exchange rate movements affect trade and current account balances and can help the global rebalancing process goes back to traditional elasticity models. In this framework, changes in real exchange rates will affect the current account if the Marshall-Lerner condition is fulfilled.[7] However, many empirical studies found relatively low elasticities, at least at short-time horizons (Rose and Yellen 1989; Hooper et al. 2000; Chinn 2004; Chinn and Lee 2009). The literature in the field of new open economy models has also pointed to limited short-run responsiveness of the current account to exchange rate changes (Goldberg and Knetter 1997; Devereux and Engel 2003).[8] All in all, skepticism regarding the role of exchange rates in generating adjustment is widespread and no consensus has been reached to date (Engel 2009).[9] Models incorporating low elasticities, limited pass-through, and imports of intermediate goods yield small adjustment effects (Devereux and Genberg 2007).

The same lack of consensus is representative of discussions surrounding the Chinese case. Devereux and Genberg (2007) develop a general equilibrium model to analyze the impact of an exchange rate appreciation on the current account that

[5] Not dissimilar to the approach taken by Romer and Romer (2010) to identify the effect of tax changes.

[6] For instance, the Malaysian ringgit was managed relative to the Singapore Dollar in the late 1970s. When the Singapore Dollar strengthened against the US dollar in the early 1980s, the Malaysian ringgit appreciated strongly on a trade weighted basis (both in nominal and real terms) for reasons that were by and large unrelated to Malaysia's economic position. We consider this an *exogenous appreciation event*. By contrast, when the German government decided to revalue the Deutschmark in 1970, it is likely that the decision partly reflected the strength of the German economy and the strength of the external position. We consequently treat such an event as at least partly endogenous.

[7] Initially, there might be a J-Curve effect, but eventually the current account would deteriorate.

[8] Chinn and Wei (2008) demonstrate that flexible exchange rate regimes are no more effective in facilitating current account adjustment than fixed regimes.

[9] However, some authors take the opposite position and argue that the "elasticity pessimism" might have gone too far (Obstfeld 2002). In the Asian context, models that show only small adjustment effects (at best) due to sticky prices are also at odds with the rich literature on particularly high pass-through in emerging markets leading to the "fear of floating" phenomenon (Calvo and Reinhart 2002).

generates only small effects. Kwack et al. (2007), Marquez and Schindler (2007), Cheung et al. (2010), Thorbecke and Smith (2010) have also studied Chinese trade elasticities and find relatively small effects from possible renminbi revaluation. However, other recent contributions by Ahmed (2009) and Cline (2010) see greater potential for exchange rate adjustment.

It is clear that exchange rate movements ultimately have to impact savings and investment patterns to be effective in changing the current account. Yet to what extent changes in real exchange rates affect savings and investment remains an open issue. Levy-Yeyati and Sturzenegger (2007) argue that a more depreciated exchange rate leads to lower real wages, inducing firms to increase saving, thereby rising overall saving. Gala (2008) explores the link between depreciated exchange rate changes, depressed real wages and high corporate savings in Asian economies. Similar channels have been analysed by Montiel (2000) and Montiel and Servén (2009). Qiao (2007), by contrast, studies the effect of appreciation on investment. Her model predicts that investment will be dampened by appreciation and thereby possibly causing the current account to improve as appreciation exerts a negative wealth effect. But related empirical evidence remains scarce.[10] To understand how exchange rate changes affect investments and savings determinants, we need to study the impact of exchange rate changes not only on the current account balance, but on savings and investment separately.

The impact of exchange rate changes on economic growth is another field that has attracted considerable attention in the literature. A large empirical literature deals with the growth effects of depreciation events (Edward 1986; Hong and Tornell 2005; Gupta et al. 2007). Bussière et al. (2010) have recently provided new evidence on the output effects of currency collapses that is methodologically similar to ours. However, the role of exchange rate policy and its effects on growth has also been the subject of a more fundamental debate among development economists. At the core of the debate is the question whether the view needs modification that any departures of the real exchange rate from its equilibrium level would harm growth by distorting a key relative price in the economy.[11] A key implication of this traditional "misalignment view" was that undervaluation is equally harmful as overvaluation.

Recent contributions argue that a depreciated real exchange rate can promote economic growth through technology transfers and learning-by-doing externalities (Eichengreen 2008; Aizenman and Lee 2008). The literature on export-led growth has underlined that such ideas are influential for development strategies in large parts of Asia (Dooley et al. 2003). Korinek and Serven (2010) present a model in which real exchange rate valuation improves welfare via positive externalities stemming from investment in the tradables sector. On the empirical side, Rodrik (2008) presents panel regressions that show a correlation of growth rates in developing countries with a measure of real exchange rate undervaluation. Berg and Miao (2010) essentially

[10] Campa and Goldberg (1995, 1999) study the linkage between exchange rate and investment in industry in the US, Canada, UK and Japan. They find that during the 1970s appreciation generated a reduction in capital goods orders, but that the opposite pattern prevailed during the 1980s. Over a sample of Italian manufacturing firms, Nucci and Pozzolo (2001) show that a depreciation of the exchange rate can have positive effects on investment through higher revenues and a negative effect through the cost channel, but the magnitude of these effects varies significantly over time.

[11] For a useful survey see Eichengreen (2008).

confirmed Rodrik's analysis. The authors find empirical evidence that currency overvaluations are negative for growth while undervaluations are positively correlated with growth in developing-countries. Undoing real undervaluation could then be expected to be harmful to economic growth.

Summing up, there is considerable uncertainty about the effects of exchange rate changes. In the remainder of the paper, we subject these positions to an empirical test: we identify large appreciation shocks for a broad country sample and we then estimate their effects on current account balance, saving, investment, external trade and on overall economic growth.

2 Identifying Appreciation Episodes

Our sample consists of annual data for 128 advanced and developing countries for the period 1960–2008. We code an appreciation event for country (i) in year (t) when the following conditions are met. First, we define an appreciation event if the nominal effective exchange rate is revalued by at least 10% or more relative to the average level 2 years before. The two-year horizon allows us to capture not only one-time step revaluations, but also a number of smaller appreciation steps that happen within a short time window. We restrict our analysis to countries that operate fixed exchange rate regimes, i.e. pegs and managed floats, according to the Reinhart and Rogoff (2004) classification (with a few minor modifications detailed in the appendix) as we expect appreciation episodes under floating regimes to be endogenous to economic fundamentals. We define an appreciation event when the nominal effective exchange rate appreciates by 10%, so that

$$\ln\left(NEER\right)_{i,t} - \ln\left(NEER\right)_{i,t-2} \geq 0.1. \tag{1}$$

Second, the nominal appreciation must lead to sustained real appreciation. We therefore require that the real effective exchange rate remains stronger by 10% (or more) on average for 3 years relative to the beginning of the appreciation process,

$$\ln\left(\left(REER_{i,t+1} + REER_{i,t+2} + REER_{i,t+3}\right)/3\right) - \ln\left(REER\right)_{i,t-2} \geq 0.1. \tag{2}$$

We also ensure that the appreciation was not preceded by devaluation of similar magnitude, so that

$$\ln\left(NEER\right)_{i,t-2} - \ln\left(\left(NEER_{i,t-5} + NEER_{i,t-4} + NEER_{i,t-3}\right)/3\right) \geq -0.1. \tag{3}$$

Table 1 lists the resulting appreciation events. In total, we identify 25 large appreciation episodes. Moreover, we found this list of large appreciations to be surprisingly robust to variations in the event definition—such as expanding or shortening the time frame of the appreciation episode from 2 years to 1 or 3 years, relaxing or strengthening the criteria for previous devaluations.

We then collected detailed historical information on each of these events. This allowed us to classify the events into two different groups. The first group consists of appreciation events that occurred *without* an active policy decision to alter the parity on part of the authorities in the concerned country. Typically, such cases relate to the appreciation of the anchor currency in a peg against key trading partners leading to

Table 1 Appreciation events

Country	Period		Δ NEER	Δ REER	Description
Australia[a]	1971	1973	10.20 %	10.30 %	After the breakdown of the Bretton Woods system, the depreciation of the US dollar led to the appreciation of the Australian dollar which was pegged to the British pound.
Sweden[a]	1977	1979	10.80 %	11.30 %	From 1977 to 1991, the Krona was pegged to a trade-weighted basket of foreign currencies. The appreciation of European currencies indirectly triggered the appreciation of the Krona on a nominal and real effective basis.
Ireland[a]	1978	1980	12.90 %	22.00 %	Ireland joined the European Exchange Rate Mechanism (ERM) in 1979. The appreciation of European currencies in the late 1970s triggered appreciation on a trade-weighted basis.
Malaysia[a]	1978	1980	20.30 %	16.50 %	From September 1976 to the end of 1984, the Malaysian National Bank stabilized the exchange rate against the Singapore dollar. The rise in the Singapore dollar triggered the appreciation of the currency.
Algeria[a]	1980	1982	17.20 %	28.00 %	The exchange rate of the Algerian dinar was pegged to a basket of currencies with a large U.S. dollar weight. Dollar strength during the early 1980s led to a strong appreciation of the dinar on a trade-weighted basis.
Singapore[a]	1980	1982	12.90 %	12.40 %	From 1973 to 1985, Singapore pegged the value of Singapore Dollar against a basket of currencies with a large US dollar weight. The trade-weighted appreciation resulted from dollar strength.
Belize[a]	1981	1983	13.70 %	16.00 %	The Belizean currency was pegged to the US dollar. The appreciation was triggered by dollar strength at the beginning of the 1980s.
Algeria[a]	1982	1984	16.60 %	11.70 %	The appreciation of the U.S. dollar during the first half of the 1980s led to a strong rise in the real value of the Algerian dinar on a trade-weighted basis relative to European trading partners.
Ivory Coast[a]	1983	1985	16.60 %	26.40 %	The currency appreciated on a trade-weighted basis as a consequence of the appreciation of the anchor currency (French Franc) against the US Dollar.
Cameroon[a]	1984	1986	11.80 %	21.20 %	The currency appreciated on a trade-weighted basis as a consequence of the appreciation of the anchor currency (French Franc) against the US Dollar.
Ivory Coast[a]	1985	1987	30.20 %	27.00 %	The currency appreciated on a trade-weighted basis as a consequence of the appreciation of the anchor currency (French Franc) against the US Dollar.
Spain[a]	1986	1988	10.40 %	19.00 %	The peseta was managed vis-à-vis to other ERM currencies whose appreciation against the dollar, triggered appreciation on a trade-weighted basis.

Table 1 (continued)

Country	Period		Δ NEER	Δ REER	Description
Singapore[a]	1988	1990	12.00 %	17.00 %	Trade-weighted appreciation as a function of strength of the main anchor currency.
Spain[a]	1988	1990	13.40 %	11.20 %	Appreciation was triggered by the appreciation of European currencies against the dollar in the late 1980s.
Germany	1968	1970	10.70 %	12.90 %	Under the Bretton Woods system, the rate of the DM was amended in October 1969. The DM was revalued.
Japan	1970	1972	14.40 %	24.00 %	The exchange rate of the yen was maintained at Yen 360 per USD from 1949 to 1971. After the United States devalued, the Yen was revalued to 308 per USD.
Switzerland	1971	1973	10.20 %	20.60 %	After the demise of the Bretton Woods system, the Swiss franc was revalued twice in 1971.
Switzerland	1974	1976	22.40 %	13.00 %	The Swiss National Bank de facto managed a sustained exchange rate appreciation against dollar and DM,
Japan	1975	1977	14.70 %	20.90 %	The Bank of Japan managed the appreciation of the yen against the dollar.
Romania	1980	1982	47.50 %	35.40 %	At the beginning of the 1980s, several step appreciations of the commercial exchange rate were taken.
Taiwan	1986	1988	13.90 %	11.40 %	In 1987, the exchange rate regime was changed towards a more market determined rate, leading to an appreciation on a trade-weighted basis.
Chile	1992	1994	29.80 %	15.00 %	The central bank revalued the "central parity" of the currency. It was also decided to widen the bands from ±5 % to ±10 %.
Colombia	1993	1995	11.20 %	30.60 %	The central bank revalued the "central parity" of the currency.
Czech Republic	2001	2003	11.20 %	16.40 %	The appreciation was linked to the introduction of a new exchange rate regime framework (with a crawling band and Central Bank interventions).
Colombia	2004	2006	10.00 %	23.00 %	The central bank revalued the "central parity" of the currency.

[a] denotes indirect appreciation events as detailed in the text. All other cases involve active parity adjustments by national authorities. Sources: see appendix

nominal and real appreciation of a country's currency on a trade-weighted basis. In other cases, the countries actively adjusted their nominal exchange rates, so that the appreciation is potentially endogenous to economic fundamentals as discussed below. An example here would be the Bundesbank's consent to a revaluation of the Deutschmark in the late 1960s and early 1970s in response to fears about imported inflationary pressures.

A crucial issue for studying the economic effects is that decision to adjust the parity and revalue is typically not random. The economic variables of interest—such

as the current account balance—can be expected to play an important role for the decision to change the exchange rate. Our analysis needs to address this problem. We propose two ways to deal with the issue. First, on the basis of our detailed narrative of the appreciation events we are able to identify 14 cases of indirect appreciations, i.e. cases where the nominal and real appreciation were "mechanistic" consequences of the appreciation of the anchor currency. We argue that such instances of appreciation by the (typically larger) anchor currency are by and large exogenous.

Second, we run a number of statistical tests to gauge the potential endogeneity problems. In Table 2 we show the results of panel logit regressions relating the probability of appreciation episodes to lagged growth and current accounts. We run separate analysis both for the small sample of indirect appreciation episodes (where no active policy decision was taken) and the large sample of all appreciations, including active revaluations. We test whether strong growth or high current account surpluses increase the probability of an appreciation event in a significant way. We also interact the two using rolling 3-year moving averages that exclude the initial year when appreciation started. While there are reasons to believe that active policy steps to revalue the currency become more likely with good economic fundamentals, it is equally conceivable that countries with good fundamentals resist exchange rate adjustment for many years and that countries with bad fundamentals can also be affected by exogenous appreciation shocks linked to movements in their anchor currency.

The results presented in Table 2 gives us an idea about the potential endogeneity problems of the two samples. For our small sample of indirect appreciations there is no evidence that appreciation is linked to economic fundamentals in the preceding years. All individual lags are insignificant. Looking at them jointly, we cannot reject the hypothesis that all lags are equal to zero. We obtain similar results for the current account. In regression (3) we interact growth and current account balance, but fail to find evidence for significant effects. Also for the large sample, the lags remain individually and jointly insignificant, but the coefficient estimates increase somewhat. We interpret this as an indication that caution is needed in the causal interpretation of our results, in particular in the case of the larger sample. But all in all we come away confident that the exogeneity assumptions behind our analysis hold up relatively well. In any case, we cannot reject the hypothesis that appreciation events are unrelated to previous trends in growth and external balances in both the restricted and the larger sample.

3 Econometric Methodology

In the following, we estimate the macroeconomic impact of appreciation episodes. We broadly follow the methodology introduced by Cerra and Saxena (2008) and extended by Bussière et al. (2010) in their study of the macroeconomic effects of devaluations.[12] Revisiting the literature on the contractionary effects of devaluations

[12] More generally, there is a large literature on the contractionary effects of devaluation, mostly in a developing country context, which we will not recall here (see for instance Krugman and Taylor 1978; Shi 2006, etc.). Some channels emphasised in this literature (beyond those discussed below for elasticity's and real balance effects) have been symmetrically used in this paper for the analysis of appreciations.

Table 2 Exogeneity tests

Panel-Logit regression sample		(1) indirect events	(2) indirect events	(3) indirect events	(4) all events	(5) all events	(6) all events
Dependent variable: revaluation event (0/1)							
Real growth							
	dy_{t-1}	0.948			1.787		
		(7.197)			(5.094)		
	dy_{t-2}	6.385			5.932		
		(8.108)			(4.501)		
	dy_{t-3}	5.993			2.795		
		(7.303)			(4.33)		
3-year mov. av.				1.275			3.011
				(3.491)			(2.461)
Current account/GDP							
	$cagdp_{t-1}$		0.0401			−0.0106	
			(0.073)			(0.051)	
	$cagdp_{t-2}$		0.0298			0.0527	
			(0.095)			(0.057)	
	$cagdp_{t-3}$		−0.0255			−0.000791	
			(0.076)			(0.037)	
3-year mov.av.				−0.0105			−0.00925
				(0.0182)			(0.0144)
Growth*Current account/GDP				0.0834			0.183
3-year mov.av.				(0.279)			(0.197)
Constant		1.266*	1.433*	−3.303***	0.620	0.497	−2.830***
		(0.725)	(0.767)	(0.383)	(0.657)	(0.745)	(0.214)
Test for all lags =0,$\chi 2$		2.028	1.189		4.966	2.217	
p-value		0.567	0.756		0.174	0.529	
Sum of lag coefficients		13.33	0.0444		10.51	0.0413	
SE		10.04	0.0533		5.409	0.0316	
Time-effects		Yes	Yes	Yes	Yes	Yes	Yes
Observations		5 392	3 450	3 628	5 392	3 450	3 628
Number of countries		127	128	123	127	128	123

Standard errors in parentheses: *denotes significance at 90 % level; **at 95 % level; ***at 99 % level

is beyond of the scope of this paper. Yet we think that of the channels and methods pioneered in this literature can be studied symmetrically in the appreciation case. Bussière et al. (2010) use both static and dynamic panel analysis. In the static model, growth is regressed on a number of variables in a first attempt to determine the average behaviour of output following a currency crash. The dynamic model builds on a univariate autoregressive fixed-effects estimation. From this one can derive

impulse-responses that display an estimate of the total effect of a currency change over time. The dummy augmented panel autoregressive model we use takes the following form:

$$x_{it} = \alpha_i + \lambda_t + \sum_{j=1}^{p} \beta_i x_{it-j} + \sum_{s=0}^{q} \delta_s E_{it-s} + \varepsilon_{it}. \quad (4)$$

The dependent variable x_{it} is the macroeconomic variable of interest. Period and time effects capture cross-sectional and time-specific heterogeneity in the evolution of x_{it}. They are given by α_i and λ_t, respectively. Inertia, i.e. serial correlation, is modelled through the inclusion of lagged variables of x_{it}. Large appreciation events enter the equation through current and lagged values of the dummy variable E_{it}. Finally, ε_{it} denotes unsystematic error in the evolution of the left hand side variable. The model is estimated for each of the variables of interest by OLS. White standard errors that are robust to observation specific heteroskedasticity in the disturbances are used for inference. The lag length of the endogenous variable and the dummy variable is set to four for all model specifications. First, a common lag length facilitates comparison of impulse response functions across different estimation setups by assuring that lagged influences from the endogenous variables and the event dummies are captured equally across models. Second, four lags of both the endogenous variable and the event dummy turned out to be sufficient for capturing the relevant dynamics. Shorter lag lengths typically did not capture all relevant delayed effects.

For robustness purposes, we work with the two different appreciation event definitions that we discussed above. Our small sample consists of 14 instances of large appreciations that occurred without active policy changes on the part of the country. In our large sample, we additionally include a roughly equal number of large appreciations that reflect active policy decision by the countries' authorities. Our strategy therefore builds on two pillars. First, we took great care to study the history of each individual appreciation episode. In our sample of indirect appreciation events we included only appreciation shocks that were linked to changes in the value of the anchor currency and appeared exogenous to economic trends in the country that operated the peg. Second, our statistical tests above returned no major hints of serious violations of the exogeneity assumption also for the larger sample, although careful interpretation is always warranted. In a last step, we also lowered the threshold value to 5 per cent nominal and real appreciation as part of our robustness tests. This yielded a total of 65 events. The dynamic responses reported below turned out to be qualitatively similar to our original event definition, but the estimates were unsurprisingly somewhat less precise.[13]

However, in light of the importance of the question, we need to be aware of the potential biases introduced to our analysis, which will help to guide the interpretation. A simultaneity bias could arise when the contemporaneous exchange rate event E_{it} is determined simultaneously along with the left hand side variable x_{it}. For instance, if revaluation becomes more likely with strong growth or with an increasing current

[13] Detailed results are available upon request. We thank an anonymous referee for the suggestion to test the robustness of our results to a lower event threshold definition.

account surplus, then E_{it} and the error term of equation 5 are correlated and OLS-based estimates of δ_0 will be biased. The size and direction of the bias generally depend on the covariance between x_{it} and the error term that governs the law of motion of E_{it}. At least for the direction of the bias we can give an intuition for the potential effect.

Consider the finding that a strong and sustained exchange rate appreciation deteriorates the current account (detailed results are presented below). By assuming that the exchange rate event is exogenous, we attribute the adjustment of the current account to the impact of the event. However, if the occurrence of a period of currency appreciation is a result, rather than a cause, of the deteriorating current account, then the impact of the exchange rate event would be due only to the lagged effects of E_{it} in equation 5. In this case, the estimated downward adjustments of the current account as shown in the figures below may be too strong. Yet from an economic point of view, it seems rather unlikely that appreciation is a function of a *deteriorating* current account. If anything, the opposite would be expected.

We present our estimation results as responses of the current account and output growth to contemporaneous and lagged impulses from the appreciation event. As discussed above, we also model the effect on aggregate saving and investment. These impulse responses are shown with 68% confidence intervals based on stochastic simulations of the estimated coefficient uncertainty. In the figures below we present the mean response together with bands that show the mean response ± one standard deviation. We will refer to responses as significant in statistical terms if the 68% confidence intervals do not encompass the zero line.[14] In the following discussion, we focus on the effect of appreciation shocks on the post-event trend of the macroeconomic variables under study, but also refer to the resulting level effects for clarification.

4 The Macroeconomic Effects of Large Appreciations

We start with the large sample of appreciation events, which we corroborate later with the smaller set of indirect appreciation shocks. Figure 1 shows the impulse response functions for all 25 appreciation events that we identified across all countries. A number of interesting insights emerge from the estimated impulse responses.

First, the immediate output responses seem *positive*, i.e. output growth accelerates, but they turn negative after about 3 years. After 6 years, the reduction in output growth accumulates to an output loss of about 1% in levels. However, wide confidence intervals imply that these losses are insignificant in statistical terms. In light of the time span and possible margins of error, these results provide only weak support for the idea that large appreciation shocks lead to pronounced output losses. By contrast, the impact of appreciation events on the current account is much stronger. The current account balance deteriorates persistently after an appreciation event. The main effect materialises after 3 years when the current account balance (as ratio of GDP) is almost three percentage points lower than before.

[14] Our main conclusions do not change if we use 90% confidence intervals. Detailed results are available upon request.

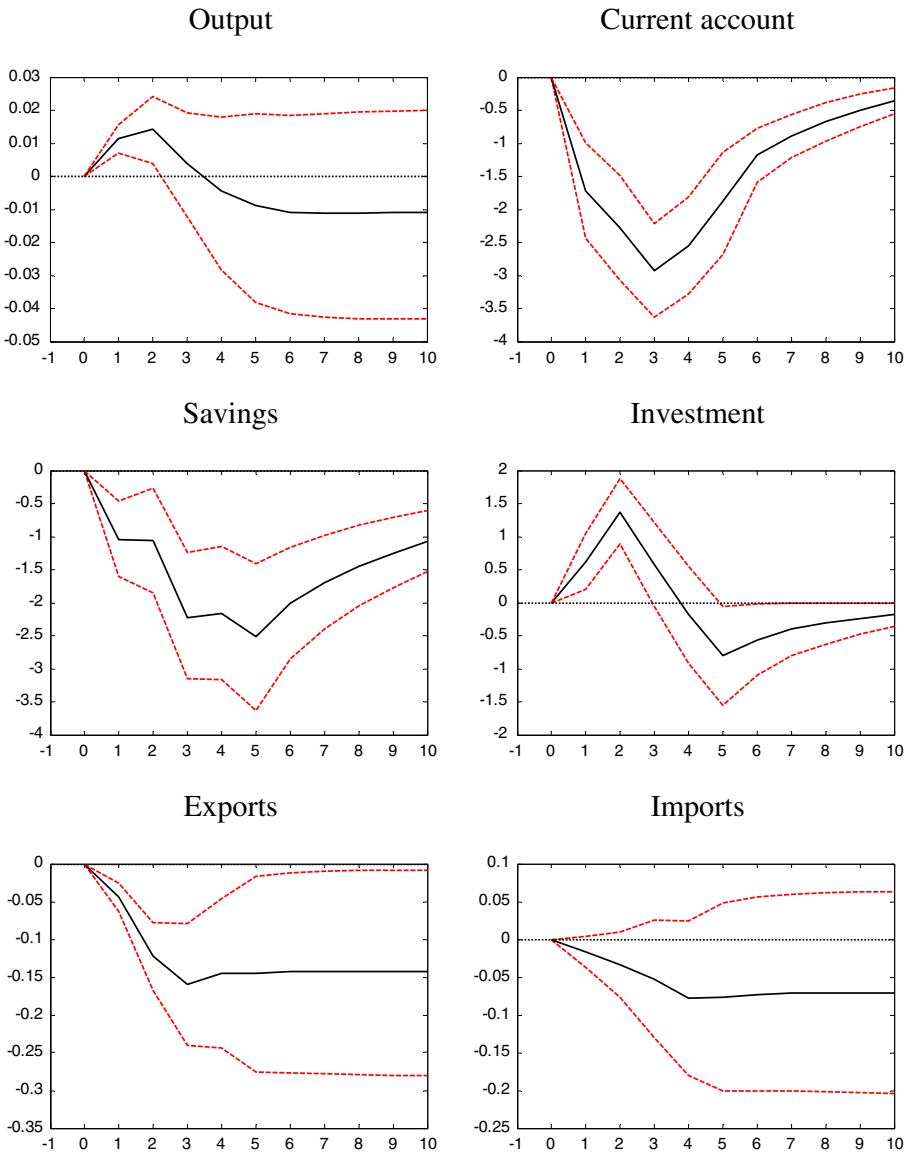

Fig. 1 Impulse responses: all countries, all events

Does the deterioration of the current account balance reflect a fall in savings or an increase in investment? The impulse response of the current account is a reflection of the savings and investment responses which are shown in the lower part of Fig. 1. The estimation yields an interesting picture. The sharp decline in the current account balance after appreciation is a function of falling saving and increasing investment (at least in the first years after the appreciation impulse). It is clear from the data that the impulse response of savings dies out only slowly. Even after 10 years aggregate saving remains significantly below its pre-appreciation level. Investment first jumps

after appreciation, but turns negative after 3 years, thus compensating part of the longer-term savings effect on the current account. From an econometric perspective, it is worth to mention that the estimated responses of the current account, saving and investment are considerably more precise than the estimated responses for output. They are also statistically significant as the error bands are narrow and do not breach the zero line.

The reaction of (real) exports and imports diverges strongly after appreciation. As can be seen from the lowest panel in Fig. 1, imports are by and large unaffected by appreciation, but export growth falls sharply in the first 3 years. The losses accumulate to about 15 % (relative to trend) in the first 3 years, but stabilise afterwards. Correct interpretation of these level effects is crucial. They do not imply an outright decline in the level of real exports, but a significant reduction relative to the pre-event trend which results in a roughly 15 % lower level after 3 years. Yet the strong slowdown in export growth does not leave a strong imprint on overall output. Domestic demand becomes the beacon of growth.

To summarise Fig. 1, the results provide evidence of a negative and significant impact of appreciation events on the current account. This effect is due to the negative reaction of domestic savings. Looking at this through the lenses of foreign trade transactions, it becomes clear that export growth decelerates sharply while imports remain by and large unaffected. However, these dynamics leave a lesser imprint on overall output. The mean output response is negative for horizons above 3 years but insignificant from a statistical point of view. Proponents of appreciation as a remedy for global imbalances will take these results as supportive for their position. Large appreciation shocks do not meaningfully reduce domestic investment or affect economic growth but help rebalance the economy. Domestic absorption rises as a result of lower savings. Whether the decline in savings reflects mainly a decline in corporate or household savings, will be an interesting topic for further research.

In Fig. 2, we show the estimated impulse responses from our small sample of indirect appreciations, i.e. nominal and real effective appreciations that resulted from an appreciation of the anchor currency in the peg. Reassuringly, the results are very similar so that our key finding seem robust to endogeneity concerns. Appreciation shocks lead to a visible deterioration of the current balance, driven by a strong effect on savings. Export growth decelerates sharply while imports perform relatively better. With regard to output, the estimated effects are similar to those reported above for the broader sample of appreciation events. The mean response of output shows a cumulative loss of about 2%. While this effect seems permanent, it appears relatively small and statistically not different from zero.

Table 3 summarizes the key results of our analysis showing the estimated mean level effects in the first 5 years after appreciation and revaluation shocks for all countries. Output levels are initially rising, but after 5 years the cumulated effect is marginally negative (output levels are less than 1% lower relative to trend). However, the current account deteriorates meaningfully (by about 2–3 percentage points relative to GDP), and export losses accumulate to close to 15 % over 5 years. Investment is only marginally affected, while savings fall by about 2.5 pp relative to GDP. If we restrict our analysis to the smaller sample of indirect appreciation shocks, the results are very similar, albeit the current account deterioration and the slowdown in export growth appear somewhat more pronounced.

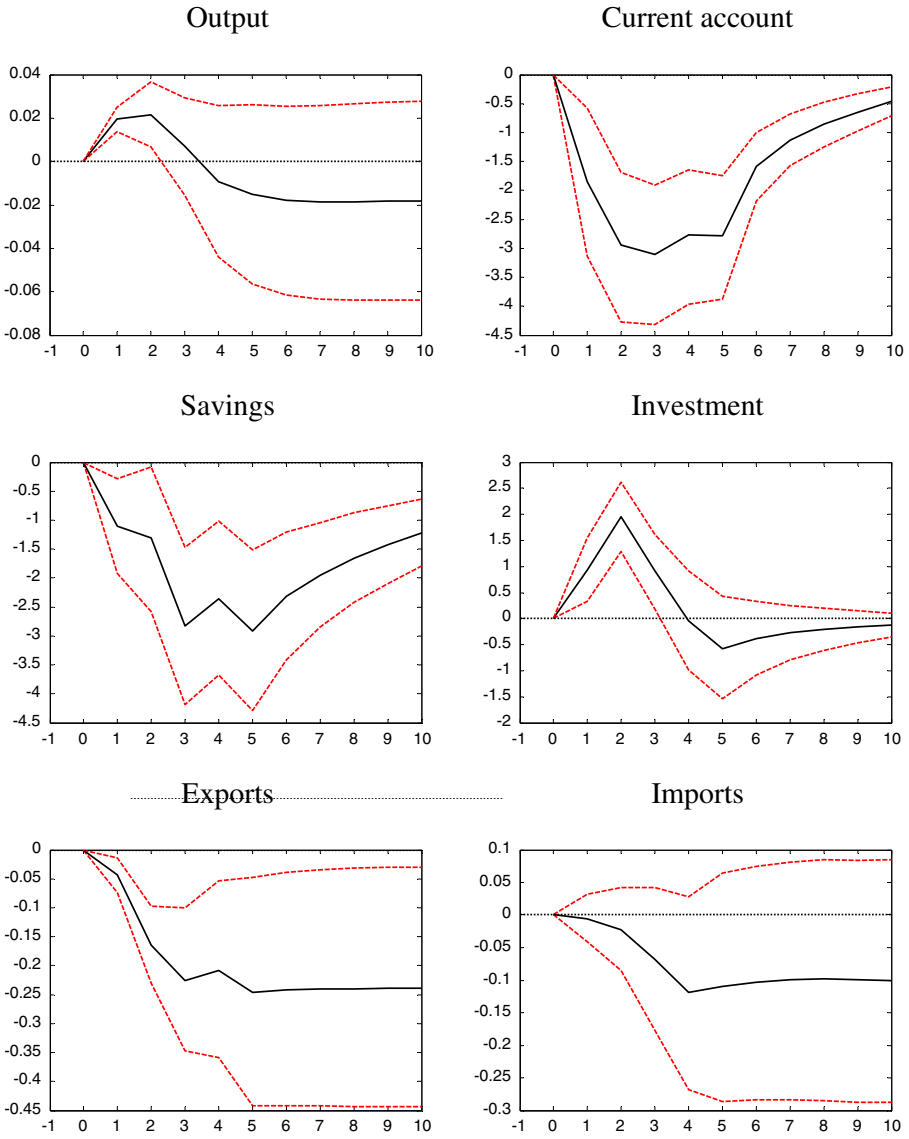

Fig. 2 Impulse responses: all countries, indirect events only

5 Effects in Developing and Advanced Economies

In the next step of our empirical analysis, we split our sample in an attempt to potentially uncover different dynamics for developing and developed countries.[15] As discussed above, a growing literature argues that the real exchange rate plays a central role for the economic development of poor countries, e.g. through positive

[15] We classify all those countries as developing that had a PPP adjusted income of less than one third of the US level in the year 1980.

Table 3 Mean level effects after appreciation (all countries)

Years after appreciation	1	2	3	4	5
Full sample					
Output	0.011**	0.014	0.004	−0.005	−0.009
Current account/GDP	−1.721**	−2.284***	−2.929***	−2.548***	−1.876**
Investment/GDP	0.618	1.373**	0.584	−0.175	−0.792
Savings/GDP	−1.050*	−1.058	−2.222**	−2.159**	−2.512**
Real exports	−0.044***	−0.122***	−0.160**	−0.145	−0.145
Real imports	−0.016	−0.033	−0.053	−0.078	−0.077
Indirect appreciations sample					
Output	0.019***	0.022	0.007	−0.009	−0.015
Current account/GDP	−1.849	−2.947**	−3.102**	−2.771**	−2.787**
Investment/GDP	0.923	1.948***	0.91	−0.041	−0.577
Savings/GDP	−1.101	−1.307	−2.832**	−2.358*	−2.912*
Real exports	−0.041	−0.162**	−0.224*	−0.204	−0.242
Real imports	−0.005	−0.023	−0.068	−0.119	−0.110

Cumulative log-level change for output, exports and imports. Percentage point change over GDP for current account, investment and savings. *denotes significance at 90 % level; **at 95 % level; ***at 99 % level

externalities from exports of manufactured goods. This sets developing countries apart from advanced economies and calls for a disaggregated analysis. As above, we start with the broad event definition, but also corroborated our results with the purely indirect appreciation episodes.[16] For developing countries (Fig. 3), the estimated event responses of the key variables are qualitatively the same as for the entire sample: strong and significant current account responses and an indeterminate impact on economic growth. What differs somewhat is the size of the effects. Current account deterioration and the decrease in the saving rate are greater than 4 percentage points at peak, hence much more pronounced and also more persistent. Export losses are almost twice as large in levels while the import response is large but with wide confidence intervals. We also find evidence that output losses are somewhat higher. They amount to about 2 per cent over 10 years, but remain statistically insignificant. Our estimations also show a more volatile path of the investment rate than in the full country sample.

For advanced economies (Fig. 4), output effects of appreciation shocks are also not significantly different from zero and the current account response is considerably milder owing to a more short-lived impact on export growth. Large exchange rate appreciations have only short (if any) effects on the external balance. Our estimations show a significant response only at the three-year horizon. We find an interesting difference here as the savings decline is actually more abrupt than in the developing

[16] We also tested the robustness of these results to a change in the event definition. The results for the indirect events are not reported here but available from the authors upon request. The robustness check yielded very similar responses of the variables in the system.

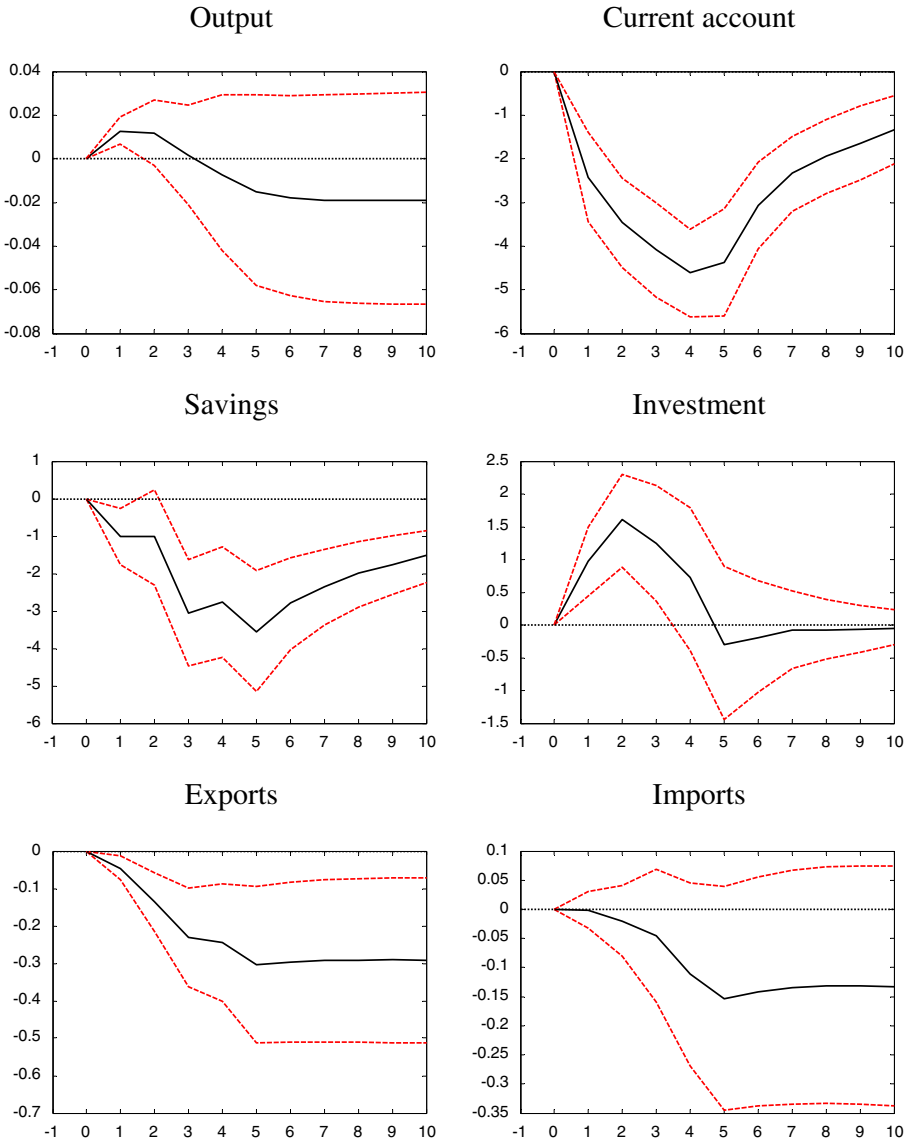

Fig. 3 Impulse responses: developing countries, all events

country sub-sample. But it goes hand in hand with a decline in investment so that the overall savings-investment balance is not strongly affected. However, a smaller number of observations in the advanced country sample lowers the precision of the estimated coefficients and renders most impulse response functions insignificant.

All in all, we think that the evidence we find is sufficiently strong to justify the idea that the macroeconomic effects of appreciation shocks differ between developed and developing countries. The differential effects appear particularly pronounced with regard to the external balance that deteriorates more persistently in developing

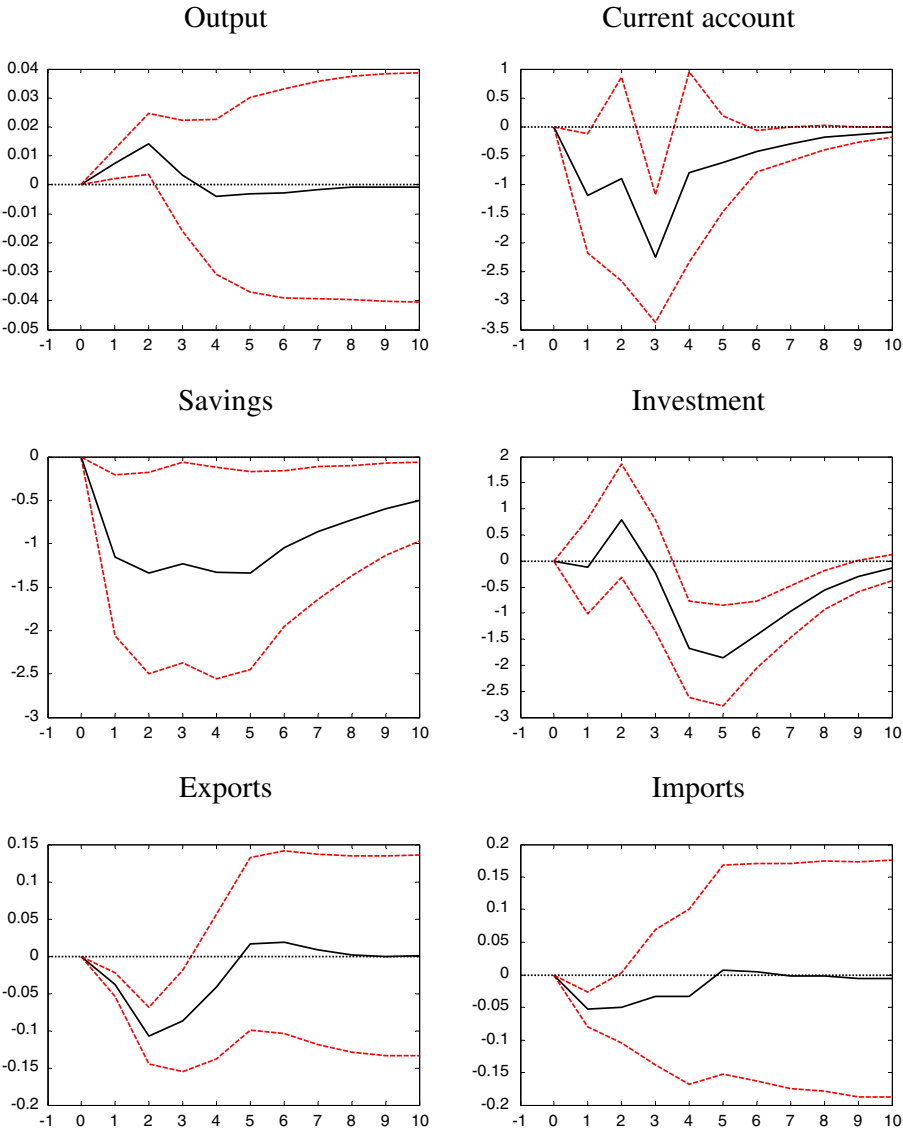

Fig. 4 Impulse responses: advanced countries, all events

countries. Export growth takes a stronger hit in developing countries, but is counterbalanced by stronger domestic growth. The growth response also differs between advanced and developing economies. While not statistically significant, the estimates suggest a stronger impact of appreciation on growth in developing countries. The growth path of a typical advanced country is hardly affected by appreciation. In developing countries, appreciation episodes lead to output losses more often. Testing formally for the equality of coefficients in the subsample regressions for advanced and developing countries, we find that the difference between the responses is statistically significant in the case of the current account, investment, and foreign

trade. By contrast, for growth, savings and investment the different responses between the two country groups do not pass the significance test.[17]

Table 4 summarizes our empirical findings with regard to different event responses in developing and advanced economies. Across the variables studied here, the macroeconomic effects of appreciation and revaluation shocks appear stronger in less developed countries than in developing countries. The current account correction is more pronounced as is the decline in savings which is about twice as strong as in advanced economies. The behaviour of export and import growth also differs between both groups, with developing countries' exports exhibiting a much stronger sensitivity to exchange rate appreciation. However, according to our estimates here the investment dynamic remains by and large unaffected and the output effects in developing countries remain small and statistically insignificant. Overall, the previous conclusion that the economic effects of appreciation shocks are somewhat stronger in developing countries is clearly confirmed.

6 Conclusion

The macroeconomic effects of exchange rate changes are likely to remain a contentious issue in international economics. While the debate about global rebalancing has gained traction after the financial crisis of 2008–09, the wisdom of using exchange rates as an adjustment tool remains debated. This partly reflects long-standing disagreement in the profession about the determinants of current account balances. Until recently, scepticism with regard to the effects of (even large) exchange rate adjustment on global current account balances has been widespread. Other recent contributions by Ahmed (2009), and Cline (2010), however, have struck a little more optimistic tune towards the effects of exchange rate changes.

In this paper, we have studied the empirical record of almost 50 years of international economic history. Using data for 128 countries between 1960 and 2008, we have found 25 episodes of large sustained exchange rate revaluations, which we define as both nominal and real effective exchange rate appreciations of 10% (and more) within a 2 year window (or less). Studying the institutional context of each individual episode in detail, we identified 14 cases of appreciation shocks that occurred not as a result of discretionary policy action, but were passively linked to the appreciation of the anchor currency in the context of an exchange rate peg. We argue that these cases represent instances of exogenous appreciation shocks that we can use to estimate the macroeconomic impact of large appreciations and assess the robustness of estimates based on a wider definition of appreciation and revaluation events. Using a dummy-augmented autoregressive panel model we could indeed show that such large appreciations episodes have strong macroeconomic effects. Most importantly, we established four key stylized facts that can prove useful in the ongoing debate about the role of exchange rate adjustment for global rebalancing.

First, the current account balance typically falls strongly in response to large exchange rate revaluations. Three years after the revaluation, the current account

[17] We are grateful to an anymous referee for suggesting formal testing of the difference.

Table 4 Mean level effects in developing and advanced economies

Years after appreciation	1	2	3	4	5
Advanced economies					
Output	0.007	0.014	0.003	−0.004	−0.003
Current account/GDP	−1.165	−0.939	−2.309*	−0.827	−0.595
Investment/GDP	−0.094	0.787	−0.258	−1.712*	−1.886**
Savings/GDP	−1.171	−1.255	−1.176	−1.228	−1.246
Real exports	−0.038***	−0.108***	−0.088	−0.042	0.016
Real imports	−0.052**	−0.049	−0.031	−0.031	0.009
Developing economies					
Output	0.013*	0.012	0.002	−0.006	−0.014
Current account/GDP	−2.402**	−3.398***	−4.045***	−4.56***	−4.422***
Investment/GDP	0.965*	1.603**	1.272	0.769	−0.205
Savings/GDP	−0.999	−1.138	−3.161**	−2.893*	−3.668**
Real exports	−0.049	−0.137*	−0.231*	−0.247	−0.306
Real imports	−0.001	−0.020	−0.047	−0.113	−0.153

Cumulative log-level change for output, exports and imports. Percentage point change over GDP for current account, investment and savings. *denotes significance at 90 % level; **at 95 % level; ***at 99 % level

balance deteriorates by about 3 percentage points relative to GDP. This is due to a reduction in aggregate savings without a concomitant fall in investment. The effect on the current account balance is statistically significant and robust to variation in the country sample and the definition of appreciation events.

Second, the effects on output seem limited. Our point estimates suggest a negative effect of output growth, albeit of relatively small magnitude: on average, the aggregate level effect on output amounts to about 1% after 6 years. The confidence intervals are considerably wider than for the current account and the output effects are statistically not significant.

Third, while aggregate output is not strongly affected, export growth falls significantly after appreciation shocks. Import growth remains by and large unchanged resulting in the observed deterioration in external balances. As aggregate economic growth is much less affected, our results point to a positive domestic demand response following appreciation episodes.

Fourth, these effects seem to be more pronounced in developing countries. The sensitivity of the current account balance to revaluation shocks is higher. The effect reaches almost 4 percentage points of GDP after 3 years and is statistically significant. But also the potentially negative effects on output are larger. Our point estimates point to a loss in output of 2% over 10 years. But confidence intervals remain wide, so that these results miss statistically significant levels. Why these effects are stronger in developing countries will be an important question that we aim to address in future research.

In sum, the historical record of large exchange rate revaluations that we have studied in this paper lends some support to the idea that large exchange rate

appreciations and revaluations have an impact on the current account as they lead to marked changes of savings and investment within countries. Appreciation shocks impact external balances, but this effect potentially comes at the cost of a reduction of dynamism in exports. While the domestic economy seems to pick up some of the external slack, leaving overall growth relatively unaffected, the prospect of sharp decelerations in export growth will remain a concern for policy-makers and bears watching especially in the context of developing countries.

Appendix: Data Sources

1. Real GDP per capita in constant prices
   Angus Maddison, *The World Economy: Historical Statistics*, OECD, Paris 2003. The data can be found online at http://www.ggdc.net/maddison/
2. Current account balance (% of GDP)
   Data are from the World Bank, World Development Indicators 2006, Washington DC.
   Taiwanese data were obtained from the *Key Indicators of Developing Asian and Pacific Countries*, published by the Asian Development Bank.
3. Gross national savings (% of GDP)
   Calculated as current price gross national savings as a proportion of current price GDP.
   Data are from International Monetary Fund (2009), World Economic Outlook Database, Washington DC. For Taiwan, see above
4. Investment (% of GDP)
   Calculated as current price investment as a proportion of current price GDP.
   Data are from the International Monetary Fund, World Economic Outlook Database (2009), Washington DC. Data are based on individual countries' national accounts statistics. For Taiwan, see above
5. Nominal Effective Exchange Rate (NEER)
   Data are from the International Monetary Fund, International Financial Statistics (2009), Washington DC. We also used Bank for International Settlements estimates to extend the sample from 1963, when data are available.
6. Real Effective Exchange Rate (REER)
   Real effective exchange rate are based on relative consumer prices.
   Data are from the International Monetary Fund, International Financial Statistics (2009), Washington DC. We also used Bank for International Settlements estimates to extend the sample from 1963, when data are available.
7. Exchange rate regime
   We used the Reinhart-Rogoff (RR) classification of exchange rate regimes, updated by Ilzetzki, Reinhart and Rogoff (2008). We used the fine RR classification, ranging de facto exchange rate regimes from 1 to 15. For an index from 1 to 8, we classified the exchange rate regime as pegged, and from 9 to 15, we classified it as floating. For each case, we then described in greater details the appreciations, to identify episodes corresponding to our definition. We also included a small number of episodes in the broad sample when countries'

managed their exchange rates tightly in a narrow band corresponding to classification 9–11 on the RR scale.

The classification codes are the following:

1	No separate legal tender
2	Pre announced peg or currency board arrangement
3	Pre announced horizontal band that is narrower than or equal to +/−2 %
4	De facto peg
5	Pre announced crawling peg
6	Pre announced crawling band that is narrower than or equal to +/−2 %
7	De factor crawling peg
8	De facto crawling band that is narrower than or equal to +/−2 %
9	Pre announced crawling band that is wider than or equal to +/−2 %
10	De facto crawling band that is narrower than or equal to +/−5 %
11	Moving band that is narrower than or equal to +/−2 %
12	Managed floating
13	Freely floating
14	Freely falling
15	Dual market in which parallel market data is missing.

Source: Ilzetzki, Ethan O., Reinhart, Carmen, and Kenneth S. Rogoff (2008) "Exchange Rate Arrangements Entering the 21st Century: Which Anchor Will Hold?" available at: http://terpconnect.umd.edu/~creinhar/Papers.html

8. Real exports and imports

Data are from the World Bank, World Development Indicators 2006, Washington DC.

Taiwanese data were obtained from the *Key Indicators of Developing Asian and Pacific Countries*, published by the Asian Development Bank.

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