The effects of alternative exchange rate regimes on real exchange rate volatility. Evidence based on a new data set †

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ABSTRACT

Do alternative exchange rate regimes affect short-term real exchange rate volatility differently? The existing empirical evidence is quite mixed with slightly more papers supporting that they do. We show that such lack of consensus is mainly due to current literature limitations regarding the measurement of real exchange rates (RERs), the identification of exchange rate regimes (ERRs), and the control for the incidence of real and nominal shocks.

To address these limitations, we construct a novel monthly dataset for 63 countries over the period 1946-2007, which includes market-determined multilateral RER and a proxy for terms of trade.

We find that ERRs indeed affect short-term real exchange rate volatility differently. While the evidence is generally consistent with Mussa's sticky prices argument, we find that for non-advanced countries in post Bretton Woods there exists a "U-shape nominal flexibility puzzle of RER." We also find evidence of a "short-run RER volatility puzzle." Having controlled for the incidence of real and nominal shocks, non-advanced countries' RER volatility remains between 25% and 150% greater than that of the advanced economies. Moreover, the key literature finding that short-term RER volatility is higher in BW than in PBW for industrialized countries vanishes when using market-determined multilateral RER instead of official bilateral RER.

JEL Classification: F31, F33, F41.

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For pairs of countries with similar and moderate inflation rates, it is shown that there are substantial and systematic differences in the behavior of real exchange rates under these two different exchange rate regimes. Under a floating exchange rate regime, real exchange rates typically show much greater short term variability than under a fixed exchange rate regime. (…). [These] substantial and systematic differences (...) are consistent with models that assume sluggishness of adjustment of national price levels.
Mussa (1986, pages 117-120)

1. Introduction

Do alternative exchange rate regimes affect short-term real exchange rate volatility differently? The empirical literature's evidence is quite mixed with slightly more papers supporting that they do. Using the terminology early coined in this literature, exchange rate regimes are *non-neutral* to short-term real exchange rate volatility. While many papers support Mussa's contention that higher real exchange rate (**RER**) volatility under flexible exchange rate regimes (**ERRs**) is due to the relative sluggishness in price adjustment (Baxter and Stockman, 1989; Gosh et al., 1997; Liang, 1998; Kent and Naja, 1998; Carrera and Vuletin, 2003), others argue that this heightened volatility derives from a greater incidence of real and nominal shocks under flexible regimes (Stockman, 1983; Grilli and Kaminsky, 1991; Clarida and Gali, 1994; Rogers, 1999).

Establishing the relative importance of these arguments is crucial as RER volatility has important implications for consumption, investment, economic growth, and trade flows (Frankel and Rose, 2002; Razin and Rubinstein, 2004; Clark et al., 2004; Broda and Romalis, 2003). This question is also important when evaluating the pros and cons of alternative ERRs.

We show that the mixed, and at times contradictory, evidence regarding the impact of ERRs on short-term RER volatility is a consequence of three sets of important limitations present in the literature to date:

1. RER measurement: The most appropriate intra-annual (monthly or quarterly) measurement of RER should be multilateral as opposed to bilateral. As originally suggested by Black (1986, page 217) in his comments on Mussa (1986), “while it is true that bilateral [purchasing power parity] PPP with all trading partners implies multilateral PPP, bilateral deviations from PPP do not necessarily imply multilateral deviations from PPP.” Moreover, RER should be constructed using the market-determined exchange rate as opposed to the official one (Bahamani-Oskooe, 1993; Luintel, 2000; Koveos and Seifert, 1985; Reinhart and Rogoff, 2004; Cashin and McDermott, 2006).

   Unfortunately, most early papers use the bilateral RER (Mussa, 1986; Grilli and Kaminsky, 1991; Gosh et al., 1997; Hasan and Wallace, 1996; Liang, 1998). While more recent studies utilize multilateral RER, they do so for the period after 1970 (Kent and Naja, 1998; Carrera and Vuletin, 2003). With the exception of few country studies (Bahmani-Oskooe, 1993; Luintel, 2000), most of the literature relies on official exchange rates.

2. Identification of ERRs: This is one of the most notorious weaknesses of papers in this literature. A majority of papers rely on comparisons of different international monetary arrangements (**IMAs**) to delineate fixed and flexible nominal ERRs. For example, Mussa (1986) and Liang (1998) use Bretton Woods and post Bretton Woods as a benchmark for fixed and flexible regimes; Grilli and Kaminsky (1991) and Hasan and Wallace (1996) expand their analysis backward to include the Gold Standard. This identification problem is key since around 40% of the time, countries did not have fixed ERRs in Bretton Woods and more than 50% had fixed or limited flexibility ERRs in post Bretton Woods.

While more recent papers use national ERRs, they do so only for the post Bretton Woods era and, in many cases, they rely on de jure announcements to identify ERRs as opposed to de facto behavior. The latter limitation is extremely relevant in light of the well established phenomenon of fear of floating (Calvo and Reinhart, 2002; Hausmann et al, 2001).

3. Incidence of real and nominal shocks: While the degree of nominal exchange rate flexibility could certainly be a candidate in explaining short-run RER volatility; it may be that there is a higher incidence of real and nominal shocks under more flexible arrangements, which could give the misleading perception that flexible regimes induce higher volatility (Stockman, 1983; Grilli and Kaminsky, 1991; Clarida and Gali, 1994; Rogers, 1999).

Grilli and Kaminsky (1991) argue that the difference in short-term volatility of RER found by Mussa (1986) and others using Bretton Woods and post Bretton Woods to identify fixed and flexible ERRs is not attributable to the impact of ERRs, but rather to the higher influence of real and nominal shocks under post Bretton Woods. Using the monthly bilateral RER between the U.S. dollar and the British pound for the period 1885-1986, they find that RER volatility varies across IMAs after, but not before, World War II. Hence, they argue that RER behavior is likely to be dependent on the particular historical period rather than the ERR per se.

Other papers like Hasan and Wallace (1996) and Lothian (1990) include inter-war dummies ultimately finding that they are insignificant. Hasan and Wallace calculate the long-term volatility of the unpredictable annual component of RERs by using the error component of an equation of RER on lags of RER. This seems a reasonable way to get around the problem of being unable to identify the underlying "primitive" nominal and real shocks as long as their impacts have persistent effects on the RER.

This paper revisits whether ERRs are neutral to RER volatility taking into account the aforementioned limitations. We tackle the RER measurement concern by constructing a novel dataset of monthly RERs for 63 countries (21 advanced and 42 developing countries) for the period 1946-2007. Our RER dataset includes a monthly price index, official and market-determined exchange rates, and yearly trade partners data which enables us to calculate official and market-determined rates for both bilateral and multilateral RERs. Our highly

balanced RER data covers around 95% of maximum potential observations for bilateral RER measurements and around 90% of multilateral ones. By itself, this new data is an important contribution.

We identify national ERRs using Ilzetzki, Reinhart and Rogoff (2008) de facto ERR classification and IMAs using four periods: 1946-1950 for early Bretton Woods (**EBW**), 1951-1972 for Bretton Woods (**BW**), 1973-2000 post Bretton Woods (**PBW**), and 2001-2007 Bretton Woods II (**BW2**). We also use the timing in which countries joined Bretton Woods during the period 1946-1972 and countries' ERRs announcements to the IMF during the period 1973-2007 to identify ERR announcements.

We control for the incidence of real and nominal shocks by calculating the RER volatility of the error component of an equation of monthly RER changes[1] on its monthly lags -in a similar vein to Hasan and Wallace (1996)- and a set of variables intended to capture monthly real and nominal shocks. For our analysis we create a monthly dataset, which includes a proxy for terms of trade, inflation and currency crises for the period 1946-2007.

We can summarize our main findings as follows:

1. There are strong differences between alternative RER measures. In particular, the correlation between monthly changes in official bilateral and official multilateral RERs averages 0.4 while the correlation between the official bilateral and market-determined bilateral RERs is 0.35 on average. Such differences emphasize the importance of using appropriate RER measures.
2. We find evidence of a "short-run RER volatility puzzle." Despite finding that real and nominal shocks explain between 22% and 50% of monthly RER movements, the unexplained RER volatility of developing countries still remains between 25% and 150% greater than that for advanced economies.
3. The key literature finding that short-term RER volatility is higher in BW than in PBW for industrialized countries (Mussa, 1986; Liang, 1998; Grilli and Kaminsky, 1991; Hasan and Wallace, 1996) vanishes when using market-determined multilateral RER instead of official bilateral RER, supporting our observations regarding the importance of RER measurement.
4. We find strong support for Mussa's argument for advanced and developing countries only in the BW era. We do, however, find evidence of a "U-shape RER nominal flexibility puzzle" for developing countries in PBW; fixed and flexible regimes have similar RER volatility, while limited flexibility regimes are associated with the lowest RER volatility.
5. We find that EBW was a period of particularly high exchange rate turbulence -especially for advanced countries (Grilli and Kaminsky, 1991; Mussa, 1986)- in the same way that BW2 was a period of notoriously low exchange rate international turbulence across the board; even after controlling for the incidence of nominal and real shocks.

[1] Using changes in exchange rates to control for trending behavior in RER is a standard procedure to control for the Balassa-Samuelson effect.

The rest of the paper is structured as follows: Section 2 describes the data; in Section 3, we present the econometric strategy; Section 4 discusses the results; and we make some final remarks in Section 5.

2. Data

We construct a novel dataset of monthly RER for 63 countries (21 advanced and 42 developing countries) for the period 1946-2007.[2] We include countries that have at least 10 years of monthly RER data in both BW and PBW and monthly exchange rate and price index information for at least 10 months per year.

2.1. Real exchange rate measures

We construct a monthly dataset of official and market-determined rates for both bilateral and multilateral RERs (i.e., official bilateral, official multilateral, market-determined bilateral and market-determined multilateral).[3] We employ official and black/parallel exchange rate data as well as a monthly price index collected from Global Financial Data.[4,5] We obtain yearly trade data for main trade partners from several sources: Mitchell (2008a, 2008b and 2008c) from 1946-1961; Feenstra et al. (2004) from 1962-1979; and, from the IMF, Direction of Trade Statistics for the period 1980-2007.[6] Our RER data is highly balanced covering 95% of the maximum potential observations for bilateral RER measures and 90% of the maximum for multilateral RER measures.

There is an important empirical difference between monthly bilateral and multilateral RER movements. Figure 1 shows that the correlation between official bilateral and official multilateral RERs range from 0.005 for Italy to 0.96 for Bolivia while the cross-country average correlation is just 0.4. This difference emphasizes the importance of using multilateral RERs as opposed to bilateral ones.

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[2] The countries in our sample are:
Advanced countries (21): Austria, Belgium, Canada, Hong Kong, Cyprus, Finland, France, Germany, Greece, Iceland, Italy, Japan, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States.
Developing countries (42): Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Egypt, El Salvador, Gabon, Ghana, Guatemala, Guyana, Haiti, Honduras, India, Indonesia, Israel, Jamaica, Korea, Madagascar, Malaysia, Mauritius, Mexico, Morocco, Nigeria, Pakistan, Paraguay, Peru, Philippines, Senegal, Singapore, South Africa, Sri Lanka, Syrian Arab Republic, Tanzania, Thailand, Tunisia, Turkey, Uruguay, Venezuela.

[3] We use the bilateral RER between the local currency and the US dollar for all countries except the United States. For the United States, we use US dollars per Deutschmark until December 1998 and US dollars per Euro since January 1999.

[4] Wholesale price index was used when available, otherwise consumer price index.

[5] To construct market-determined exchange rates, we use the black/parallel exchange rates when available (73% of the observations). For the missing information, we use official exchange rates if the immediately posterior or anterior exchange rate premium is lower than 2% and there are no de jure capital or exchange rate controls as measured by both the IMF's Annual Report on Exchange Arrangements and Exchange Rate Restrictions and Ilzetzki, Reinhart and Rogoff (2008) chronologies (26% of the observations).

[6] See Appendix for a matrix of trade partners.

Most studies use bilateral RER measures and those which calculate multilateral RER for longer periods rely on time-invariant trade weights for main trade partners (Aghion et al., 2006; Bahmani-Oskooe et al., 2008; Benetrix and Lane, 2009). Given the important short-term and long-term changes in trade patterns (e.g., Argentina's trade with the United Kingdom and Brazil represented around 20 and 5 percent of total trade in 1950s respectively, while around 2 and 25 percent in the 2000s) we sustain that annual trade partner information must be used to accurately calculate multilateral RERs.

Indeed, Figure 2 shows the correlations between monthly movements of official multilateral RERs using yearly trade weights and 2000's trade weights. Correlations range from -0.68 for Chile to 0.91 for Switzerland, while the cross-country average is just 0.18. This notable difference highlights the importance of collecting annual main trade partners data, particularly when conducting historical analysis.

There is an important empirical difference between the monthly bilateral movements in the official and market-determined RERs. Figure 3 shows the correlations of official bilateral and market-determined bilateral RERs range from -0.38 for Bolivia to 1 for Gabon and Senegal, while the cross-country average correlation is only 0.35. This large difference emphasizes the importance of using market-determined, rather than official, real exchange rate data.

Figure 4 presents preliminary evidence confirming previous studies' (Carrera and Vuletin (2003); Hausmann et al., 2006) findings that volatility of RERs is higher in developing economies than advanced ones. Table 1 mean tests confirm that depending on the RER measure used, short-term RER volatility is between 27.5% and 142.9% greater for developing countries than advanced ones.

2.2. Exchange rate regime classifications and international monetary arrangements

We use Ilzetzki, Reinhart and Rogoff (2008) de facto classification to identify the behavior of nominal exchange rates and distinguish between de facto fixed (**IRR Fixed**), limited flexibility (**IRR Lim Flex**) and flexible (**IRR Flex**).[7] Table 2 shows that most non-advanced economies had fixed regimes in EBW (78.9%) while most advanced economies had flexible regimes (55.2%); in BW, a majority of countries have fixed ERRs, though a non-trivial minority (34.7%) did not; in PBW, countries are split more evenly across fixed, limited flexibility and flexible regimes; in BW2, most advanced countries have either fixed or flexible regimes, while non-advanced countries gravitate toward limited flexibility or flexible arrangements.

We distinguish four IMAs to capture different institutional structures, international financial architectures and international coordination arrangements that frame the rules of balance of payments imbalances and exchange rate adjustments. In identifying IMAs, we conform to the

[7] ERRs are associated with coarse categories 1 (no separate legal tender, currency board, peg or horizontal band that is narrower than or equal to +/-2%), 2 (crawling peg or crawling band that is narrower than or equal to +/-2%), and 3 and 4 (crawling band that is wider than or equal to +/-2%, managed floating or freely floating) respectively.

generally accepted methodology of the literature (Grilli and Kaminsky, 1991; Dooley et al., 2003) and identify i) Early Bretton Woods from 1946-1950[8], ii) Bretton Woods from 1951-1972, iii) post Bretton Woods from 1973-2000 and iv) Bretton Woods II from 2001-2007.[9]

We also use the date in which a country joined the IMF over the period 1946-1972 as a proxy for timing in joining BW (**join_bw**) and the announcement that countries make to the IMF for the period 1973-2007 to identify ERRs announcements (**IMF Fixed**, **IMF Lim Flex** and **IMF Flex**).[10] Table 3 shows that around half of the time, both advanced and non-advanced countries announce to pursue flexible ERRs; the other half is equally split between fixed and limited flexibility for advanced countries while mostly fixed for developing countries.

Table 4 shows the percentage distribution of ERR announcements and Ilzetzki, Reinhart and Rogoff (2008) ERRs across groups of countries for periods 1946-1972 and 1973-2007. For the period 1946-1972, both advanced and non-advanced countries joined BW. Yet, about 40% of those that joined did not actually have fixed ERRs. Though most countries with nominal fixed ERRs joined the IMF, many others, particularly non-advanced countries, did not. Over the period 1973-2007, announcements match actual behavior around 45% of the time for both advanced and non-advanced economies. Roughly 20% of the time countries announce nominal flexibility lower than actual behavior and 30% of the time they announce a more flexible ERR than their behavior reflects.

2.3. Nominal and real shocks

We create a novel monthly dataset, which includes a terms of trade shock proxy, as well as inflation and currency crises for the period 1946-2007. We calculate a proxy for terms of trade shocks by using the monthly growth rate of the ratio of a country's main commodity export prices over main commodity import prices.[11] Using this strategy we identify exported commodities for 42 non-advanced economies including cattle, coconut oil, coffee, copper, gold, jute, oil, orange, peanut, rice, rubber, soybean, steel, sugar and wheat.[12] Oil serves as the

[8] Even though most advanced nations ratified Bretton Woods in 1945, it was not until the end of the decade when it became fully operational.

[9] From 2003, Dooley, Garber, and Folkerts-Landau began writing papers describing the emergence, since 2001, of a new international system involving an interdependency between states with generally high savings in Asia lending and exporting to western states with generally high spending. Similar to the original Bretton Woods, this included Asian currencies being pegged to the dollar, though this time by the unilateral intervention of Asian governments in the currency market to stop their currencies appreciating. The literature coined this IMA as "Bretton Woods II" or "New Bretton Woods."

[10] For the period 1973-1996 this announcements coincide with the de jure IMF ERR classification. However, since 1997 the IMF ERR classification has intended to be more de facto oriented. While each country desk still receives central banks' ERR announcements, the regime reported in the IMF classification is adjusted when considered necessary. Our IMF data includes those ERRs reported by countries as opposed to the ones finally assigned by the IMF.

[11] When we are not able to identify a main export commodity for a country, we replace such missing information with number one.

[12] Main export commodity per country: cattle (Argentina, Uruguay), coconut oil (Philippines), coffee (Brazil, Colombia, Guatemala, Honduras, Haiti, Madagascar, El Salvador), copper (Chile, Peru), gold (Ghana, Tanzania, South Africa), jute (Nepal), oil (Bolivia, Ecuador, Egypt, Gabon, Indonesia, Mexico, Nigeria, Singapore, Syrian Arab Republic, Tunisia, Venezuela), orange (Israel, Jamaica), peanut (Senegal), rice (India, Sri Lanka, Pakistan,

main import commodity for 31 non-advanced countries and 22 advanced ones. This approach captures the impact of oil price shocks for both net exporters and net importers, as well as the relevance of certain export commodities for non-advanced economies.[13] We employ monthly commodity price data from Global Financial Data.

We calculate four measures of currency crashes using official bilateral, official multilateral, market-determined bilateral and market-determined multilateral nominal exchange rates. Currency crashes are dummy variables which equal one if the monthly nominal devaluation is greater than 25%.

3. Econometric strategy and the incidence of real and nominal shocks

Our econometric strategy consists of three stages. We first estimate country regressions of monthly RER growth rate on its monthly lags and a set of variables intended to capture monthly real and nominal shocks. [14] Next, we use the residuals of those regressions to calculate intra-year residual RER volatility. Finally, we use such intra-year residual RER volatility to estimate panel data country-fixed effects annual regressions. The rest of this section details the first two stages.

In the first stage we estimate various subsets of the following regressions:

$$grRER_{i,t} = \alpha_i + \sum_{j=0}^{11} \beta_{i,j}^{rer} grRER_{i,t-j} + \sum_{j=0}^{11} \beta_{i,j}^{tot} grTOT_{i,t-j} + \sum_{j=0}^{11} \beta_{i,j}^{\inf} grINF_{i,t-j} + \sum_{j=0}^{11} \beta_{i,j}^{crisis} crisis_{i,t-j} + \varepsilon_{i,t} \qquad (1)$$

where *i* refers to country, *t* refers to year-month time[15], **grRER** is the monthly RER growth rate, **grTOT** and **grINF** are the monthly terms of trade and inflation growth rates and **crisis** is a monthly dummy variable for currency crash. It is important to notice that we estimate (1) for each country separately. In doing so we allow the elasticity of those shocks to be country-specific thus capturing the possibility that those countries respond differently depending on several unobserved institutional and economic characteristics.[16]

Table 5 summarizes the results obtained for 63 country regressions. Columns 1-4 present official bilateral RER, column 5 uses official multilateral RER, and columns 6 and 7 present market-determined bilateral and multilateral RERs. In Column 1 we control for terms of trade shocks (grTOT) to account for real shocks. We find mixed evidence regarding the impact on official bilateral RER. Most importantly, the average R^2 is quite low (R^2=0.023) suggesting that terms of trade shocks can explain only a very small fraction of the variance in RER.

In column 2 we add a control for inflation shocks (grINF) to account for nominal shocks. We find that on average only 10.8% of regressions have coefficients that are statistically different

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Thailand), rubber (Malaysia), soybean (Paraguay), steel (Turkey), sugar (Dominican Republic, Guyana, Mauritius), wheat (Morocco).

[13] It is worth noting that the Spearman's rank correlation coefficient between annual terms of trade shock from World Development Indicators and our terms of trade shock proxy is 0.27. Such test rejects the null hypothesis that these variables are independent at 1% significance.

[14] Using growth rates to control for trending behavior in RER is a standard procedure to control for the Balassa-Samuelson effect.

[15] For example, t=1 for year 1946, month 1; t=2 for year 1946, month 2; and lastly t=744 for year 2007, month 12.

[16] Results are not significantly affected if more lags are included.

from zero. However, inflation shocks decrease RER on impact and tend to be reversed later. The latter result is consistent with PPP holding in the long-run but not in the short-run. When including inflation shocks the mean R^2 increases only to 0.052.

In column 3 we add RER monthly lags (grRER) -in a similar vein to Hasan and Wallace (1996)- and find that past increases in RER increase RER in the short-run but that (similar to nominal shocks) their effects tend to be reverted later. When including RER lags, the average R^2 increases to 0.101.

In Column 4 we include currency crashes (crisis); this variable proxies for both nominal and real shows (Aghion et al., 2001; Kaminsky et al., 2009). Much like inflation shocks and RER lags, currency crises definitively increase RER in the short-run (as this variable is partially based on the dependent variable) but reduce it in the long-run. When including crisis the mean R^2 jumps to 0.497 indicating that drastic movements in the nominal bilateral exchange rate can explain, on average, 40% of movement in official bilateral RER.

Columns 5, 6 and 7 report similar country based regressions for official multilateral, market-determined bilateral and market-determined multilateral RER, respectively. We obtain similar results to those of column 4, though the average R^2 obtained for the full regressions are lower - around 0.21-0.29. These findings are consistent with Hausmann et al. (2006) who find that terms of trade, inflation and currency crises contribute, respectively, 3%, 4% and 20% to long-run variance in multilateral RER.

After estimating regression (1) for each country, we recover the error term $\varepsilon_{i,t}$ and compute the intra-year residual RER volatility as

$$\sigma^{\varepsilon}_{i,y} = \sqrt{\frac{1}{12}\sum_{m=1}^{12}(\varepsilon_{i,y,m} - \overline{\varepsilon_{i,y,m}})^2} \qquad (2)$$

where *i* refers to country, *y* refers to year, *m* refers to month, and $\overline{\varepsilon_{i,y,m}} = \left(\sum_{m=1}^{12}\varepsilon_{i,y,m}\right)/12$. Table 6 mean tests confirm that depending on the RER measure used, short-term conditional RER volatility is between 24.9% and 151.3% greater for developing economies than advanced ones. That is to say, despite finding that real and nominal shocks explain between one fifth and one half of monthly RER movement, the unexplained RER volatility of non-advanced countries still remains greater than that for advanced economies. This result is the short-run counterpart version of Hausmann et al. (2006) "long-run volatility puzzle of real exchange rate." In absence of a better name, we call this new puzzle the "short-run RER volatility puzzle."

4. Empirical results

In this section we use the intra-year residual RER volatility described before and estimate annual panel data country-fixed effects regressions against de facto ERRs, IMAs, and ERR announcements.

Considering the "short-run RER volatility puzzle" and the fact that ERR behavior and announcements vary significantly across advanced and non-advanced countries, we report

three sets of regressions including all, advanced and non-advanced countries. As discussed in the introduction we consider the market-determined multilateral RER to be the most comprehensive and appropriate measure of RER. We also show the results for official bilateral, official multilateral and market-determined bilateral RERs allowing for easier comparison of our results to that of the existing literature. Regression tables also include a battery of tests regarding the equality of coefficients (when analyzing them we use the conventional 5% of confidence level).

4.1. International monetary arrangements

Table 7 shows the relationship between IMAs and short-term conditional RER volatility. Our results match the key finding from the existing literature that PBW has higher bilateral RER volatility than BW in industrialized economies (col. 5). This important feature vanishes, however, when the market-determined multilateral RER is used instead (col. 8), supporting our concern regarding the importance of RER measurement. Similar to Grilli and Kaminsky (1991), EBW exhibits higher RER volatility than BW for advanced countries (col. 8). Non-advanced countries have similar RER volatility across IMAs, with the exception of BW2 (col.12). RER volatility is the lowest in BW2, both for advanced and non-advanced economies (col. 8 and 12).

4.2. De facto exchange rate regimes

Table 8 shows the relationship between nominal exchange rate flexibility and short-term conditional RER volatility. The influence of ERRs significantly varies between advanced and non-advanced countries. The results for advanced countries support Mussa's argument that RER volatility increases with nominal flexibility (col.8). However, developing countries show a U-shaped pattern where fixed and flexible regimes have similar RER volatility and limited flexibility regimes are associated with the lowest RER volatility (col. 12). The latter result is a new puzzle which favors the selection of limited flexibility ERRs against both fixed and flexible ERRs. We call this puzzle the “U-shape nominal flexibility puzzle of RER.”

4.3. Exchange rate regime announcements

Table 9 shows the relationship between ERR announcements and short-term conditional RER volatility for periods 1946-1972 and 1973-2007. The influence of announcements varies significantly between advanced and non-advanced countries. While RER volatility does not vary across ERR announcements for advanced countries (col. 8), announcements do matter for non-advanced economies. Fixed ERR announcements are associated with lower RER volatility for the period 1946-1972 and higher volatility for the period 1973-2007 (col. 12).

4.4. De facto exchange rate regimes vs. international monetary arrangements

Table 10 shows the relationship between nominal exchange rate flexibility and IMAs on short-term conditional RER volatility. This rich econometric specification allows us to disentangle the effect of IMAs from de facto ERRs. Considering the results from columns 8 and 12 we find:

Within EBW, alternative de facto ERRs provide similar RER volatility for both advanced and non-advanced countries.[17] Alternative ERRs have higher RER volatility in EBW than in BW for advanced countries but they are similar for non-advanced ones.[18] These results confirm that EBW was, as posited by Grilli and Kaminsky (1991), a period of especially high exchange rate turbulence, particularly for advanced countries.

For advanced economies, RER volatility increases with nominal flexibility within BW and PBW. RER volatility, though, is similar for alternative ERRs across BW and PBW.[19] This result is consistent with Mussa's argument.

For non-advanced economies, RER volatility increases with nominal flexibility within BW. It is important to note that the "U-shape nominal flexibility puzzle of RER" described in section 4.2, is found to be a PBW phenomenon.[20] Much like our findings for advanced countries, RER volatility is similar for fixed and limited flexibility regimes across BW and PBW. Flexible regimes, however, are found to have almost ten times greater RER volatility in BW than in PBW.[21] The latter result is consistent with the idea that it is relatively more costly in terms of RER volatility to have flexible regimes when global economic institutions and the state of international macroeconomic coordination support the selection of fixed regimes.

Within BW2, alternative de facto ERRs provide similar RER volatility for non-advanced countries.[22] RER volatility is also similar for the main ERRs categories for advanced economies (fixed and flexible ERRs comprise more than 99% of observations).[23] Meanwhile, fixed and flexible regimes have lower RER volatility in BW2 than in PBW for both advanced and non-advanced countries. This is especially the case for flexible regimes.[24] These results

[17] We cannot reject that IRR Fixed*ebw=IRR Lim Flex*ebw, IRR Fixed*ebw=IRR Flex*ebw and IRR Lim Flex*ebw=IRR Flex*ebw for advanced countries (col. 8) and that IRR Fixed*ebw = IRR Flex*ebw for non-advanced economies (col. 12) at 5% of significance.

[18] We cannot reject that IRR Fixed*ebw>IRR Fixed*bw and IRR Flex*ebw>IRR Flex*bw for advanced countries (col. 8) and that IRR Fixed*ebw=IRR Fixed*bw and IRR Flex*ebw= IRR Flex*bw for non-advanced economies (col. 12) at 5% of significance.

[19] We cannot reject that IRR Flex*bw>IRR Fixed*bw and IRR Flex*pbw>IRR Fixed*pbw for advanced countries (col. 8) and that IRR Fixed*bw=IRR Fixed*pbw, IRR Lim Flex*bw=IRR Lim Flex*pbw and IRR Flex*bw=IRR Flex*pbw for non-advanced economies (col. 12) at 5% of significance.

[20] We cannot reject that IRR Flex*bw>IRR Fixed*bw, IRR Flex*bw>IRR Lim Flex*bw and IRR Fixed*bw=IRR Lim Flex*bw for non-advanced economies (col. 12) at 5% of significance.

[21] We cannot reject that IRR Fixed*bw=IRR Fixed*pbw, IRR Lim Flex*bw= IRR Lim Flex*pbw and IRR Flex*bw>IRR Flex*pbw for non-advanced economies (col. 12) at 5% of significance.

[22] We cannot reject that IRR Fixed*bw2=IRR Lim Flex*bw2, IRR Fixed*bw2=IRR Flex*bw2 and IRR Lim Flex*bw2=IRR Flex*bw2 for non-advanced economies (col. 12) at 5% of significance.

[23] We cannot reject that IRR Fixed*bw2=IRR Flex*bw2 for advanced countries (col. 8) at 5% of significance.

[24] We cannot reject that IRR Fixed*pbw>IRR Fixed*bw2 for advanced (col. 8) and non-advanced economies (col. 12) at 10% of significance. We cannot reject that IRR Flex*pbw>IRR Flex*bw2 for advanced (col. 8) and non-advanced countries (col. 12) at 5% of significance.

support the idea of BW2 was a period of particularly low exchange rate turbulence for both advanced and non-advanced countries.

5. Final remarks

Since early papers by Dornbush (1980), Stockman (1983) and Mussa (1986), there have been several empirical studies analyzing whether ERRs are neutral on RER volatility. However, there seems not to be consensus yet about such neutrality.

Previous studies have been limited by their use of official bilateral RER where market-determined multilateral RER is the most appropriate RER measurement. Additionally, many papers use IMAs to distinguish fixed from flexible nominal ERRs and do not control for the incidence of real and nominal shocks.

This paper shows that these limitations have consequential results. Indeed, when taking into account these factors, we find evidence to refute much of the literature arguing that short-term RER volatility is greater in BW than in PBW for industrialized countries.

Our findings confirm Mussa's argument for advanced and non-advanced economies in the BW era. We find evidence of a "U-Shape RER Nominal Flexibility Puzzle" for non-advanced countries in PBW. It seems that fixed and flexible regimes have similar RER volatility while limited flexibility regimes are associated with the lowest RER volatility.

We also find that in EBW advanced economies experienced particularly high exchange rate turbulence, while BW2 is associated with notoriously low exchange rate turbulence for both advanced and non-advanced economies.

Resembling Hausmann et al. (2006) "long-run volatility puzzle of real exchange rate," we find that, despite finding that real and nominal shocks explain between one fifth and one half of monthly RER movement, the unexplained RER volatility of non-advanced countries still remains greater than for advanced economies. In absence of a better name, we call this new puzzle the "short-run RER volatility puzzle."

Acknowledgements

Appendix

Trade partners per country

	Trade Partners																												
	ARG	AUT	BEL	BRA	CAN	CHE	DEU	ESP	FRA	GBR	GTM	HKG	HND	IDN	IND	ITA	JPN	KOR	MEX	MYS	NLD	NOR	PAK	SGP	SLV	SWE	TUR	USA
ARG				x			x			x																		x
AUT						x	x			x						x												x
BEL	x						x		x	x					x						x							x
BOL	x						x			x							x											x
BRA	x						x			x							x											x
CAN							x			x							x											x
CHE		x					x		x	x						x												x
CHL	x						x			x							x											x
COL							x			x							x											x
CRI							x			x							x											x
CYP							x		x	x						x												x
DEU		x	x						x	x						x					x					x		x
DOM							x	x								x	x											x
ECU							x			x							x											x
EGY							x		x	x					x	x												x
ESP	x						x		x	x																		x
FIN							x			x																x		x
FRA			x				x	x		x						x												x
GAB			x						x	x											x							x
GBR	x				x		x		x						x						x							x
GHA							x			x																		x
GRC							x		x	x						x											x	x
GTM							x			x							x								x			x
GUY					x					x																		x
HKG							x			x							x	x						x				x
HND							x			x	x						x								x			x
HTI			x				x		x							x	x											x
IDN							x			x							x			x	x			x				x
IND					x		x			x		x					x						x					x
ISL							x			x						x					x	x				x		x
ISR							x			x																		x
ITA		x				x	x		x	x																		x
JAM										x																		x
JPN							x		x	x				x	x			x										x
KOR							x					x					x			x								x
LKA										x					x		x											x
MAR							x	x	x	x						x												x
MDG							x		x	x						x					x							x
MEX							x		x	x							x											x
MLT							x		x	x						x	x							x				x
MUS					x		x		x	x							x											x
MYS										x				x	x		x											x
NGA							x			x											x							x
NLD			x				x			x				x														x
NOR					x		x		x	x											x					x		x
PAK							x			x							x											x
PER							x			x							x											x
PHL										x							x											x
PRT							x	x	x	x																		x
PRY	x			x																								x
SEN							x		x							x												x
SGP							x			x										x								x
SLV							x			x	x		x				x											x
SWE							x		x	x											x	x						x
SYR							x		x	x						x												x
THA										x							x			x								x
TUN			x				x		x	x						x					x							x
TUR							x			x						x												x
TZA							x			x						x												x
URY	x			x			x			x																		x
USA					x		x		x	x							x		x									
VEN					x		x		x	x							x											x
ZAF							x			x							x											x

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Figure 1. Correlation between monthly changes of official bilateral and official multilateral RERs. All countries, 1946-2007.

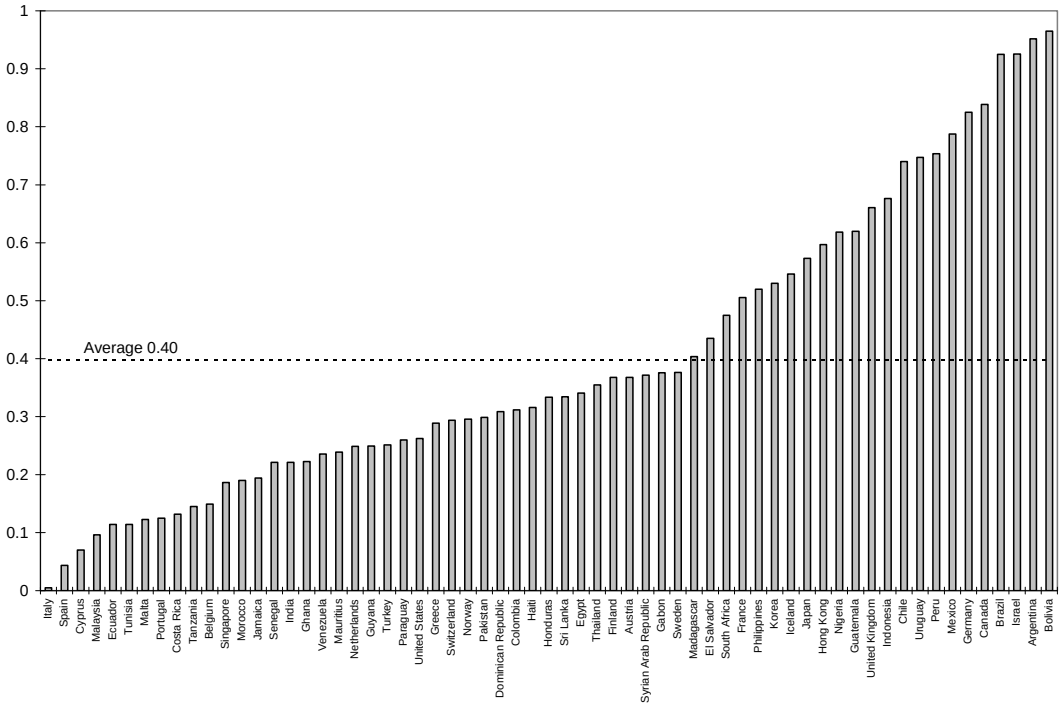

Figure 2. Correlation between official multilateral RERs using yearly trade weights and 2000's trade weights. All countries, 1946-2007.

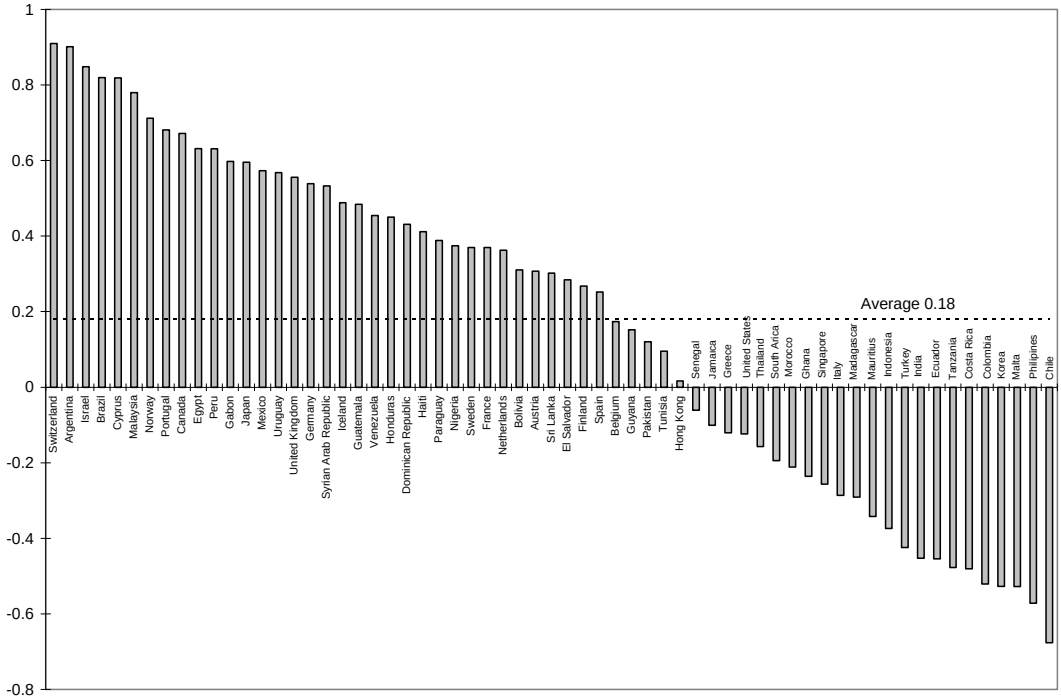

Figure 3. Correlation between monthly changes of official bilateral and market-determined bilateral RERs. All countries, 1946-2007.

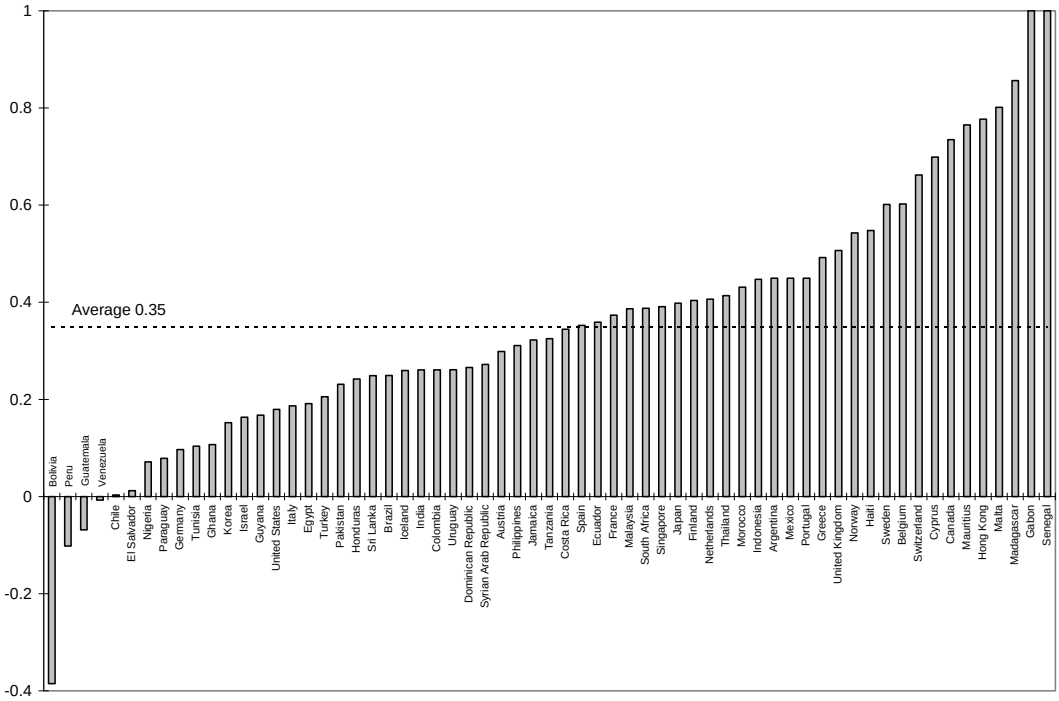

Figure 4. Intra-year volatility of market-determined multilateral RER. All countries, 1946-2007.

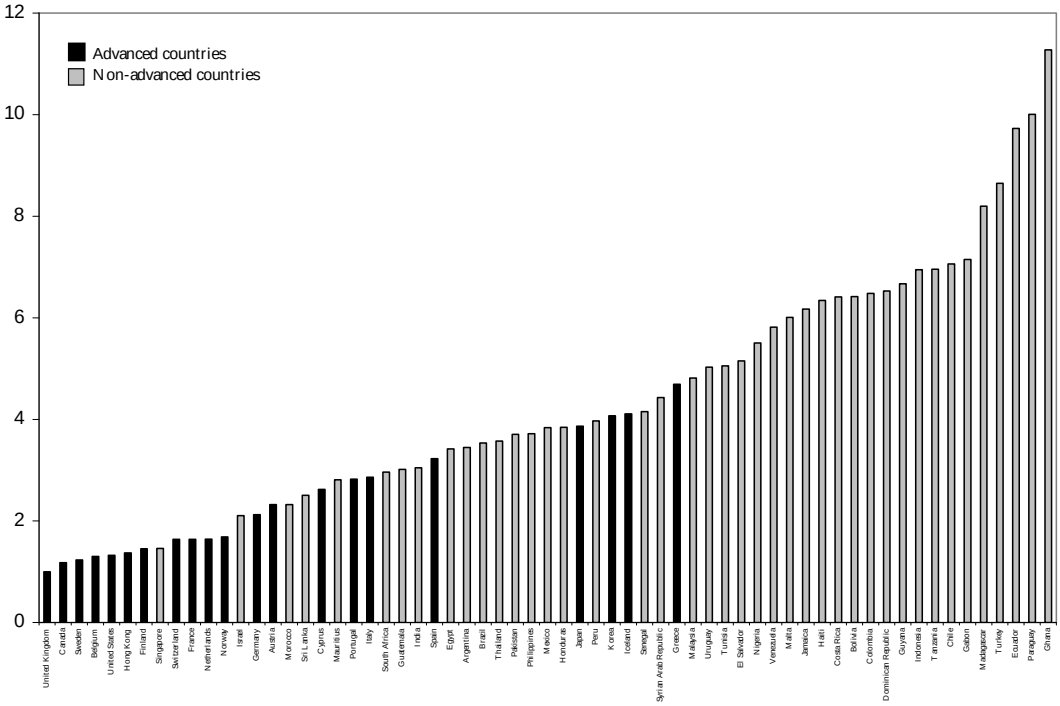

Table 1. Intra-year RER volatility in Advanced and Non-advanced countries. Includes IRR free falling category.

	Official Bilateral	*Official Multilateral*	*Market-determined Bilateral*	*Market-determined Multilateral*
Non-Adv	2.881	4.751	4.132	5.218
Adv	2.260	1.956	2.881	2.249
Absolute difference	0.621	2.795	1.251	2.969
Percentual difference	27.5%	142.9%	43.4%	132.0%
t-stat	3.998	14.165	8.231	15.173
p-value (Adv>Non-Adv)	1	1	1	1

Table 2. Percentage distribution of IRR ERRs across international monetary arrangements and groups of countries (1946-2007). Excludes IRR free falling category.

	Early Bretton Woods (1946-1950)			**Bretton Woods (1951-1972)**			**Post Bretton Woods (1973-2000)**			**Bretton Woods II (2001-2007)**		
	All	*Adv.*	*Non-Adv*	*All*	*Adv.*	*Non-Adv*	*All*	*Adv.*	*Non-Adv*	*All*	*Adv.*	*Non-Adv*
RR Fixed	66.1	37.9	78.9	65.3	62.4	66.9	25.6	26.5	25.1	30.6	57.1	16.9
RR Lim. Flex.	2.9	6.9	1.1	13.1	19.0	9.8	39.3	44.0	36.4	29.7	0.7	44.7
RR Flex.	31.0	55.2	20.0	21.6	18.6	23.3	35.1	29.5	38.6	39.7	42.2	38.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 3. Percentage distribution of ERRs announcements to IMF across groups of countries (1973-2007). Excludes IRR free falling category.

	All	*Adv.*	*Non-Adv*
IMF Fixed	37.4	28.2	42.8
IMF Lim. Flex.	10.8	23.1	3.6
IMF Flex.	51.8	48.7	53.6
Total	100	100	100

Table 4. Percentage distribution of ERRs announcements and IRR ERRs across groups of countries for periods 1946-1972 and 1973-2007. Excludes IRR free falling category.

Period 1946-1972:

All

	RR Fixed	RR Lim. Flex.	RR Flex.
join_bw	45%	10%	20%
not join_bw	20%	1%	4%

Adv

	RR Fixed	RR Lim. Flex.	RR Flex.
join_bw	48%	14%	21%
not join_bw	10%	2%	5%

Non-Adv

	RR Fixed	RR Lim. Flex.	RR Flex.
join_bw	44%	7%	20%
not join_bw	25%	1%	3%

Period 1973-2007:

All

	RR Fixed	RR Lim. Flex.	RR Flex.
IMF Fixed	18%		22%
IMF Lim. Flex.		3%	
IMF Flex.	34%		23%

Adv

	RR Fixed	RR Lim. Flex.	RR Flex.
IMF Fixed	15%		18%
IMF Lim. Flex.		6%	
IMF Flex.	36%		25%

Non-Adv

	RR Fixed	RR Lim. Flex.	RR Flex.
IMF Fixed	20%		23%
IMF Lim. Flex.		2%	
IMF Flex.	33%		22%

Table 5. Incidence of real and nominal monthly shocks on monthly RER movements (1946-2007). Includes IRR free falling category.

	Official Bilateral													*Official Multilateral*				*Market-determined Bilateral*				*Market-determined Multilateral*			
	(1)			(2)			(3)			(4)				(5)				(6)				(7)			
	(+)	(0)	(-)	(+)	(0)	(-)	(+)	(0)	(-)	(+)	(0)	(-)	NA	(+)	(0)	(-)	NA	(+)	(0)	(-)	NA	(+)	(0)	(-)	NA
grTOT		61	2	1	60	2	1	59	3	1	59	3		2	59	2		1	60	2		3	59	1	
grTOT_1		62	1		61	2		62	1	1	58	4			61	2			61	2		1	60	2	
grTOT_2	1	61	1	1	61	1		61	2	2	60	1		2	61			1	62			3	58	2	
grTOT_3		62	1	1	61	1	2	60	1	1	60	2		4	57	2			61	2		1	61	1	
grTOT_4	11	52		12	51		11	52		12	51			4	59			8	54	1		2	60	1	
grTOT_5	1	61	1		62	1	2	60	1		62	1		4	58	1			61	2		2	59	2	
grTOT_6	1	57	5	1	62		1	57	5	1	58	4		3	60				50	13		3	57	3	
grTOT_7	1	58	4	1	58	4	1	59	3	1	56	6			62	1		2	60	1		6	56	1	
grTOT_8	2	60	1	1	60	2	1	61	1	3	57	3			61	2		3	57	3		2	60	1	
grTOT_9		63			62	1		63		1	61	1		1	61	1		2	59	2			62	1	
grTOT_10	2	60	1	1	61	1		62	1	1	60	2		1	62				61	2			62	1	
grTOT_11	1	62		1	62		3	60		3	60				62	1		2	60	1		1	60	2	
Average share	2.6	95.1	2.2	2.6	95.4	2.0	2.8	94.8	2.4	3.5	92.9	3.6		2.8	95.7	1.5		2.4	93.4	4.2		3.2	94.4	2.4	
grINF				4	48	11	3	48	12	3	45	15		4	49	10		2	42	19		2	53	8	
grINF_1				3	56	4	3	57	3	4	55	4		1	60	2		2	57	4			59	4	
grINF_2				4	56	3	4	57	2	7	55	1		2	57	4		5	54	4		4	58	1	
grINF_3				2	55	6	2	57	4	2	55	6			62	1		2	59	2		2	59	2	
grINF_4				3	59	1	1	59	3	3	57	3		1	62			4	54	5			63		
grINF_5				4	58	1	2	60	1	3	58	2		2	59	2		5	54	4		4	56	3	
grINF_6					58	5		59	4	3	55	5		1	59	3		1	57	5		1	57	5	
grINF_7				1	57	5	2	56	5	4	53	6		2	57	4		4	55	4		2	55	6	
grINF_8				3	59	1	2	59	2	2	59	2			62	1		5	57	1		2	60	1	
grINF_9				7	55	1	7	55	1	5	57	1		2	60	1		5	55	3			59	4	
grINF_10				1	58	4	1	55	7	2	54	7		1	60	2		3	54	6		4	56	3	
grINF_11				4	56	3	4	58	1	4	57	2		2	60	1		8	52	3		1	60	2	
Average share				4.8	89.1	6.0	4.2	89.8	6.0	5.6	87.1	7.3		2.3	93.8	3.9		6.2	85.8	8.1		2.8	92.1	5.1	
grRER_1							20	43		36	27			5	57	1		4	54	5		1	58	4	
grRER_2							1	55	7	3	53	7			61	2		2	55	6		1	60	2	
grRER_3							1	61	1	5	57	1		1	59	3		3	56	4			60	3	
grRER_4								59	4		60	3		2	60	1		1	59	3		1	60	2	
grRER_5							1	60	2	4	57	2			61	2		2	60	1		1	61	1	
grRER_6							3	58	2	2	58	3		1	60	2		1	54	8			63		
grRER_7							2	58	3	3	56	4			61	2		4	55	4			61	2	
grRER_8							3	58	2	6	57				61	2		3	58	2		1	56	6	
grRER_9							2	59	2	4	55	4		1	58	4		5	55	3		1	57	5	
grRER_10							4	57	2	4	59			2	60	1		4	57	2			60	3	
grRER_11							1	60	2	3	59	1		2	60	1		4	58	1		2	57	4	
Average share							5.4	90.8	3.8	10.1	86.2	3.7		1.9	95.0	3.1		4.8	89.4	5.7		1.2	94.1	4.7	
crisis										53	1		9	35	11	3	14	45	1		17	32	10	4	17
crisis_1										3	24	27	9	3	44	2	14		33	13	17	4	38	4	17
crisis_2										7	39	8	9	4	43	2	14	3	33	10	17	3	42	1	17
crisis_3											43	11	9	4	43	2	14	2	41	3	17	5	39	2	17
crisis_4										3	50	1	9	3	43	3	14	5	37	4	17	4	38	4	17
crisis_5										1	48	5	9	3	42	4	14	2	37	7	17	4	39	3	17
crisis_6										4	48	2	9	4	40	5	14	6	36	4	17	2	41	3	17
crisis_7										2	48	4	9	4	43	2	14	1	36	9	17	5	40	1	17
crisis_8										3	45	6	9	3	43	3	14	3	38	5	17	4	40	2	17
crisis_9										2	49	3	9	7	39	3	14	2	40	4	17	6	38	2	17
crisis_10										3	44	7	9	4	43	2	14	7	33	6	17	5	40	1	17
crisis_11										3	49	2	9	4	42	3	14	3	36	7	17	3	42	1	17
Average share										11.1	64.6	10.1	14.3	10.3	63.0	4.5	22.2	10.4	53.0	9.5	27.0	10.2	59.1	3.7	27.0
Observations	44456			44119			44102			44102				41884				43614				41456			
N. of countries	63			63			63			63				63				63				63			
Average R^2	0.023			0.052			0.101			0.497				0.234				0.290				0.216			

Note: OLS robust regressions, monthly frequency. Intercept estimates not reported. For each indpendent variable (e.g., grTOT_2) we summarize how many country regressions have coeficients that are statistically positive (+), negative (-); or not statistically different from zero (0). For currency crises we report NA when a country never had a currency crisis. We use official bilateral, official multilateral, market-determined bilateral and market-determined multilateral currency crises in columns 4, 5, 6 and 7 respectively.

Table 6. Intra-year residual RER volatility in Advanced and Non-advanced countries. Includes IRR free falling category.

	Official Bilateral	*Official Multilateral*	*Market-determined Bilateral*	*Market-determined Multilateral*
Non-Adv	2.366	4.324	3.671	4.734
Adv	1.894	1.721	2.591	2.047
Absolute difference	0.472	2.603	1.080	2.687
Percentual difference	24.9%	151.3%	41.7%	131.3%
t-stat	5.081	17.116	10.097	17.628
p-value (Adv>Non-Adv)	1	1	1	1

Note: Intra-year residual RER volatility is calculated according to equations (1) and (2) from pages 13 and 14.

Table 7. Intra-year residual RER volatility across International Monetary Arrangements (1946-2007). Excludes IRR free falling category.

	All				**Adv**				**Non-Adv**			
	Official Bilateral (1)	*Official Multilateral* (2)	*Market-determined Bilateral* (3)	*Market-determined Multilateral* (4)	*Official Bilateral* (5)	*Official Multilateral* (6)	*Market-determined Bilateral* (7)	*Market-determined Multilateral* (8)	*Official Bilateral* (9)	*Official Multilateral* (10)	*Market-determined Bilateral* (11)	*Market-determined Multilateral* (12)
ebw	1.024***	1.021**	2.244***	1.643***	1.640**	1.294**	3.706***	2.352***	0.627*	0.834	1.240***	1.145
	[2.74]	[2.17]	[4.64]	[3.16]	[2.20]	[2.47]	[4.03]	[3.07]	[1.84]	[1.16]	[3.35]	[1.65]
pbw	0.575***	-0.394**	0.845***	-0.3	1.191***	-0.277*	1.560***	-0.121	0.179	-0.467	0.393	-0.409
	[4.41]	[-2.13]	[4.12]	[-1.54]	[8.47]	[-2.04]	[9.94]	[-0.90]	[1.14]	[-1.60]	[1.32]	[-1.33]
bw2	0.404***	-0.780***	-0.383*	-1.164***	0.938***	-0.435***	0.474**	-0.617***	0.085	-0.972***	-0.883***	-1.469***
	[2.75]	[-3.54]	[-1.73]	[-5.27]	[7.36]	[-3.16]	[2.59]	[-4.28]	[0.43]	[-2.92]	[-2.97]	[-4.52]
Observations	3109	3109	3109	3109	1174	1174	1174	1174	1935	1935	1935	1935
N. of countries	63	63	63	63	21	21	21	21	42	42	42	42
R^2	0.032	0.01	0.078	0.019	0.16	0.036	0.256	0.064	0.005	0.008	0.041	0.015
tests (p-value):												
ebw=bw	0.008	0.034	0	0.002	0.040	0.023	0.001	0.006	0.073	0.253	0.002	0.107
pbw=bw	0	0.038	0	0.128	0	0.055	0	0.381	0.262	0.117	0.195	0.189
bw2=bw	0.008	0.001	0.088	0	0	0.005	0.018	0	0.670	0.006	0.005	0
ebw=pbw	0.224	0.003	0.004	0	0.546	0.011	0.029	0.005	0.209	0.061	0.053	0.031
ebw=bw2	0.088	0	0	0	0.299	0.007	0.001	0.001	0.160	0.017	0	0.001
pbw=bw2	0.104	0.003	0	0	0.051	0.005	0	0	0.515	0.011	0	0

Note: Panel data fixed effects regressions. Intercept estimates not reported. Ominted category Bretton Woods, bw (1951-1972). Ebw, pbw and bw2 stand for early Bretton Woods (1946-1950), post Bretton Woods (1973-2000) and Bretton Woods II (2001-2007). The value 0 is reported when the first three decimal digits are equal to zero. Intra-year residual RER volatility is calculated according to equations (1) and (2) from pages 12 and 13. Robust t stat in brackets. *, ** and *** denote significance at 10%, 5% and 1% levels, respectively.

Table 8. Intra-year residual RER volatility across IRR de facto ERRs (1946-2007). Excludes IRR free falling category.

	All				**Adv**				**Non_Adv**			
	Official Bilateral (1)	*Official Multilateral* (2)	*Market-determined Bilateral* (3)	*Market-determined Multilateral* (4)	*Official Bilateral* (5)	*Official Multilateral* (6)	*Market-determined Bilateral* (7)	*Market-determined Multilateral* (8)	*Official Bilateral* (9)	*Official Multilateral* (10)	*Market-determined Bilateral* (11)	*Market-determined Multilateral* (12)
RR Lim Flex (rr_2)	0.232**	-0.555**	0.397**	-0.582**	0.622***	0.06	1.119***	0.279	-0.033	-0.971***	-0.093	-1.165***
	[2.05]	[-2.53]	[2.18]	[-2.45]	[4.05]	[0.30]	[5.98]	[1.42]	[-0.25]	[-3.12]	[-0.42]	[-3.71]
RR Flex (rr_3)	0.863***	0.026	1.729***	0.439*	0.773***	0.442**	1.509***	0.891***	0.897***	-0.236	1.821***	0.147
	[6.40]	[0.12]	[6.86]	[1.98]	[4.09]	[2.63]	[5.40]	[4.69]	[4.81]	[-0.74]	[5.10]	[0.45]
Observations	3109	3109	3109	3109	1174	1174	1174	1174	1935	1935	1935	1935
N. of countries	63	63	63	63	21	21	21	21	42	42	42	42
R^2	0.035	0.004	0.081	0.008	0.044	0.008	0.1	0.022	0.042	0.007	0.096	0.012
tests (p-value):												
rr_2=rr_1	0.045	0.014	0.033	0.017	0.001	0.764	0	0.171	0.807	0.003	0.676	0.001
rr_3=rr_1	0	0.905	0	0.052	0.001	0.016	0	0	0	0.465	0	0.655
rr_2=rr_3	0	0.042	0	0.001	0.424	0.126	0.117	0.018	0	0.088	0	0.003

Note: Panel data fixed effects regressions. Intercept estimates not reported. Ominted category RR Fixed, rr_1. RR Fixed, RR Lim. Flex. and RR Flex. stand for Reinhart-Rogoff fixed, limited flexibility and flexible regimes respectively. The value 0 is reported when the first three decimal digits are equal to zero. Intra-year residual RER volatility is calculated according to equations (1) and (2) from pages 12 and 13. Robust t stat in brackets. *, ** and *** denote significance at 10%, 5% and 1% levels, respectively.

Table 9. Intra-year residual RER volatility across ERRs announcements (1946-2007). Excludes IRR free falling category.

	All				Adv				Non_Adv			
	Official Bilateral	*Official Multilateral*	*Market-determined Bilateral*	*Market-determined Multilateral*	*Official Bilateral*	*Official Multilateral*	*Market-determined Bilateral*	*Market-determined Multilateral*	*Official Bilateral*	*Official Multilateral*	*Market-determined Bilateral*	*Market-determined Multilateral*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
join_bw	-0.343**	-0.079	-0.677***	-0.207	-0.655***	0.358	-0.634**	0.406*	-0.148	-0.284	-0.636**	-0.488
	[-2.55]	[-0.31]	[-3.10]	[-0.76]	[-3.25]	[1.69]	[-2.65]	[2.06]	[-0.95]	[-0.79]	[-2.21]	[-1.27]
not_join_bw	-0.184	1.630***	-0.338	1.899***	-0.123	1.823	1.044	2.810*	-0.243	1.563**	-0.952	1.528*
	[-0.55]	[2.71]	[-0.47]	[2.67]	[-0.30]	[1.62]	[1.16]	[1.78]	[-0.56]	[2.21]	[-1.04]	[1.87]
IMF Lim Flex (imf_2)	0.471***	-0.183	0.015	-0.424	0.567***	-0.065	0.693**	0.027	-0.302*	0.523	-1.824***	-0.4
	[2.84]	[-0.57]	[0.042]	[-1.64]	[3.34]	[-0.37]	[2.44]	[0.19]	[-1.94]	[0.41]	[-3.45]	[-0.42]
IMF Flex (imf_3)	0.058	-0.778***	-0.574**	-1.011***	0.353	0.144	0.502	0.298	-0.077	-1.187***	-1.075***	-1.605***
	[0.38]	[-3.33]	[-2.08]	[-3.71]	[1.22]	[0.73]	[1.31]	[1.36]	[-0.48]	[-3.83]	[-3.41]	[-4.61]
Observations	3109	3109	3109	3109	1174	1174	1174	1174	1935	1935	1935	1935
N. of countries	63	63	63	63	21	21	21	21	42	42	42	42
R^2	0.018	0.019	0.015	0.025	0.106	0.033	0.089	0.048	0.002	0.022	0.03	0.029
tests (p-value):												
join_bw=not_join_bw	0.610	0.006	0.592	0.004	0.201	0.233	0.087	0.163	0.807	0.009	0.684	0.012
imf_2=imf_1	0.006	0.571	0.967	0.106	0.003	0.712	0.024	0.849	0.060	0.683	0.001	0.677
imf_3=imf_1	0.704	0.001	0.042	0.000	0.237	0.472	0.206	0.190	0.634	0	0.001	0.000
imf_2=imf_3	0.018	0.141	0.074	0.081	0.303	0.307	0.539	0.240	0.128	0.220	0.106	0.259

Note: Panel data fixed effects regressions. Intercept estimates not reported. Ominted category is IMF Fixed (imf_1). IMF Fixed, IMF Lim Flex and IMF Flex stand for IMF fixed, limited flexible regimes respectively. Join_bw and not_join_bw stand for countries joining or not Bretton Woods. The value 0 is reported when the first three decimal digits are equal to zero. Intra-year residual RER volatility is calculated according to equations (1) and (2) from pages 12 and 13.

Robust t stat in brackets. *, ** and *** denote significance at 10%, 5% and 1% levels, respectively.

Table 10. Intra-year residual RER volatility across International Monetary regimes and. IRR ERRs (1946-2007). Excludes IRR free falling category.

	All				Adv				Non_Adv			
	Official Bilateral	*Official Multilateral*	*Market-determined Bilateral*	*Market-determined Multilateral*	*Official Bilateral*	*Official Multilateral*	*Market-determined Bilateral*	*Market-determined Multilateral*	*Official Bilateral*	*Official Multilateral*	*Market-determined Bilateral*	*Market-determined Multilateral*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
RR Fixed * ebw (1)	1.631***	0.776	2.606***	1.281**	3.467*	1.308*	4.749*	1.928***	0.942***	0.573	1.809***	1.017
	[2.70]	[1.51]	[3.21]	[2.07]	[1.83]	[2.02]	[1.87]	[3.49]	[3.37]	[0.84]	[4.09]	[1.24]
RR Lim Flex * ebw (2)	-0.022	0.033	2.099***	0.763***	0.258	0.227	2.339***	0.986***				
	[-0.11]	[0.10]	[4.38]	[3.49]	[1.22]	[0.74]	[5.07]	[4.88]				
RR Flex * ebw (3)	1.240***	1.817**	3.584***	2.983***	1.247***	1.782*	4.097***	3.366**	1.446*	1.902	3.165***	2.570*
	[2.85]	[2.06]	[7.53]	[3.22]	[3.06]	[2.03]	[6.34]	[2.56]	[1.72]	[1.15]	[4.68]	[1.94]
RR Lim Flex * bw (5)	0.382*	-0.063	0.735***	0.046	0.607*	0.313	0.828***	0.487	0.237	-0.373	0.731*	-0.294
	[1.83]	[-0.14]	[2.79]	[0.10]	[1.88]	[0.51]	[3.11]	[0.82]	[0.79]	[-0.63]	[1.80]	[-0.44]
RR Flex * bw (6)	1.098***	0.695**	2.468***	1.322***	0.413*	0.506	1.362***	1.052**	1.362***	0.745*	2.883***	1.371***
	[3.69]	[2.20]	[6.68]	[4.27]	[1.90]	[1.00]	[4.98]	[2.26]	[3.46]	[1.89]	[6.09]	[3.46]
RR Fixed * pbw (7)	0.725***	0.13	1.019***	0.25	1.211***	-0.410*	1.583***	-0.248	0.406**	0.475	0.667**	0.579
	[4.70]	[0.35]	[5.18]	[0.66]	[5.11]	[-1.92]	[7.44]	[-0.97]	[2.52]	[0.82]	[2.46]	[0.98]
RR Lim Flex * pbw (8)	0.671***	-0.560**	1.093***	-0.469*	1.331***	-0.183	1.919***	0.069	0.203	-0.859*	0.501*	-0.886**
	[4.94]	[-2.06]	[5.33]	[-1.69]	[7.46]	[-1.12]	[9.69]	[0.46]	[1.54]	[-2.01]	[1.97]	[-2.09]
RR Flex * pbw (9)	1.167***	-0.188	2.228***	0.321	1.532***	0.155	2.249***	0.575***	0.917***	-0.371	2.135***	0.168
	[8.04]	[-0.65]	[7.22]	[1.09]	[11.5]	[1.21]	[10.8]	[3.22]	[4.51]	[-0.85]	[4.59]	[0.38]
RR Fixed * bw2 (10)	0.460***	-0.586*	0.122	-0.715*	0.862***	-0.445***	0.612***	-0.520***	0.089	-0.779	-0.332	-0.92
	[3.67]	[-1.75]	[0.59]	[-1.98]	[6.44]	[-3.06]	[4.18]	[-3.63]	[0.36]	[-0.95]	[-0.75]	[-1.02]
RR Lim Flex * bw2 (11)	0.206	-0.800**	-0.499*	-1.268***	1.410***	0.276**	1.517***	0.277**	-0.014	-0.900*	-0.744**	-1.416***
	[1.32]	[-2.03]	[-1.95]	[-3.68]	[7.00]	[2.83]	[6.37]	[2.83]	[-0.088]	[-1.95]	[-2.49]	[-3.52]
RR Flex * bw2 (12)	1.281***	-0.549**	0.977***	-0.675**	1.425***	-0.109	1.155***	-0.139	1.227***	-0.778*	0.876*	-0.977**
	[5.42]	[-2.15]	[3.07]	[-2.63]	[7.40]	[-0.71]	[4.80]	[-0.88]	[3.33]	[-1.93]	[1.77]	[-2.45]
Observations	3109	3109	3109	3109	1174	1174	1174	1174	1935	1935	1935	1935
N. of countries	63	63	63	63	21	21	21	21	42	42	42	42
R^2	0.067	0.015	0.161	0.03	0.199	0.048	0.293	0.089	0.055	0.016	0.152	0.028

Table 10 continuation.

	All				Adv				Non_Adv			
	Official Bilateral	*Official Multilateral*	*Market-determined Bilateral*	*Market-determined Multilateral*	*Official Bilateral*	*Official Multilateral*	*Market-determined Bilateral*	*Market-determined Multilateral*	*Official Bilateral*	*Official Multilateral*	*Market-determined Bilateral*	*Market-determined Multilateral*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
tests (p-value):												
1=2	0.008	0.190	0.573	0.397	0.098	0.165	0.346	0.099	.	.	.	.
1=3	0.595	0.312	0.287	0.127	0.257	0.675	0.804	0.322	0.571	0.458	0.086	0.319
1=4	0.009	0.135	0.002	0.042	0.083	0.057	0.076	0.002	0.002	0.404	0	0.222
1=5	0.043	0.187	0.024	0.096	0.142	0.287	0.134	0.085	0.107	0.249	0.053	0.193
1=6	0.365	0.882	0.871	0.948	0.112	0.349	0.195	0.236	0.237	0.795	0.065	0.663
1=7	0.126	0.286	0.052	0.149	0.239	0.026	0.218	0.002	0.078	0.905	0.024	0.651
1=8	0.101	0.010	0.057	0.008	0.256	0.051	0.267	0.005	0.023	0.036	0.005	0.034
1=9	0.447	0.050	0.662	0.120	0.327	0.111	0.352	0.029	0.936	0.130	0.531	0.295
1=10	0.048	0.022	0.003	0.005	0.174	0.020	0.111	0	0.018	0.183	0.001	0.098
1=11	0.017	0.011	0	0.001	0.246	0.124	0.180	0.006	0.002	0.046	0	0.009
1=12	0.556	0.010	0.041	0.002	0.257	0.065	0.152	0.004	0.551	0.045	0.113	0.018
2=3	0.008	0.061	0.023	0.017	0.027	0.127	0.029	0.081	.	.	.	.
2=4	0.909	0.919	0	0.001	0.237	0.468	0	0	.	.	.	.
2=5	0.093	0.864	0.012	0.084	0.270	0.911	0.007	0.350	.	.	.	.
2=6	0.002	0.096	0.525	0.067	0.555	0.650	0.082	0.900	.	.	.	.
2=7	0.001	0.812	0.036	0.193	0.003	0.054	0.160	0.002	.	.	.	.
2=8	0.001	0.105	0.049	0	0	0.238	0.402	0	.	.	.	.
2=9	0	0.509	0.801	0.108	0	0.803	0.861	0.123	.	.	.	.
2=10	0.021	0.113	0	0	0.011	0.040	0.002	0	.	.	.	.
2=11	0.304	0.070	0	0	0	0.883	0.102	0.001	.	.	.	.
2=12	0	0.068	0.033	0	0	0.287	0.023	0	.	.	.	.
3=4	0.006	0.044	0	0.002	0.006	0.056	0	0.019	0.094	0.255	0	0.059
3=5	0.076	0.083	0	0.009	0.264	0.297	0	0.085	0.172	0.196	0.002	0.060
3=6	0.793	0.226	0.038	0.070	0.075	0.049	0	0.048	0.928	0.507	0.669	0.381
3=7	0.254	0.067	0	0.004	0.932	0.028	0.001	0.011	0.221	0.391	0.001	0.145
3=8	0.218	0.011	0	0	0.846	0.041	0.003	0.019	0.144	0.110	0.000	0.015
3=9	0.866	0.032	0.007	0.007	0.431	0.104	0.010	0.061	0.531	0.171	0.137	0.076
3=10	0.075	0.010	0	0	0.329	0.022	0.000	0.007	0.125	0.134	0	0.025
3=11	0.023	0.007	0	0	0.713	0.116	0.001	0.029	0.082	0.099	0	0.005
3=12	0.933	0.013	0	0	0.685	0.066	0	0.016	0.809	0.119	0.002	0.011
5=4	0.073	0.886	0.007	0.920	0.074	0.615	0.005	0.421	0.433	0.530	0.079	0.661
6=4	0	0.032	0	0	0.072	0.329	0	0.035	0.001	0.066	0	0.001
7=4	0	0.725	0	0.512	0	0.069	0	0.343	0.016	0.415	0.018	0.333
8=4	0	0.043	0	0.097	0	0.274	0	0.648	0.130	0.051	0.056	0.043
9=4	0	0.517	0	0.281	0	0.241	0	0.004	0	0.402	0	0.709
10=4	0.001	0.086	0.557	0.053	0	0.006	0	0.002	0.720	0.347	0.455	0.311
11=4	0.191	0.047	0.055	0	0	0.010	0	0.010	0.931	0.058	0.017	0.001
12=4	0	0.035	0.003	0.011	0	0.488	0	0.391	0.002	0.060	0.084	0.019
5=6	0.040	0.152	0	0.015	0.456	0.843	0.116	0.532	0.036	0.058	0	0.011
5=7	0.135	0.725	0.270	0.712	0.079	0.304	0.011	0.296	0.590	0.274	0.859	0.277
5=8	0.138	0.219	0.210	0.205	0.028	0.405	0.002	0.457	0.897	0.387	0.592	0.335
5=9	0	0.791	0	0.597	0.013	0.778	0.000	0.874	0.016	0.997	0.005	0.554
5=10	0.703	0.270	0.014	0.123	0.385	0.249	0.347	0.116	0.666	0.640	0.011	0.515
5=11	0.395	0.192	0	0.016	0.016	0.947	0.037	0.696	0.375	0.451	0.001	0.119
5=12	0.001	0.280	0.481	0.129	0.008	0.424	0.347	0.246	0.022	0.532	0.784	0.337
6=7	0.245	0.168	0	0.011	0.005	0.095	0.486	0.021	0.020	0.624	0.000	0.164
6=8	0.189	0.000	0.001	0	0	0.181	0.079	0.048	0.006	0.001	0.000	0
6=9	0.821	0.004	0.529	0.002	0	0.548	0.012	0.416	0.262	0.000	0.112	0.001
6=10	0.047	0.001	0	0	0.017	0.067	0.013	0.003	0.013	0.044	0	0.007
6=11	0.007	0.001	0	0	0	0.663	0.649	0.123	0.002	0.001	0	0
6=12	0.595	0.000	0.001	0	0	0.306	0.632	0.041	0.780	0	0.001	0
7=8	0.703	0.047	0.738	0.052	0.533	0.281	0.119	0.213	0.188	0.016	0.588	0.012
7=9	0.012	0.446	0	0.876	0.169	0.029	0.041	0.032	0.013	0.168	0.002	0.531
7=10	0.054	0.059	0	0.020	0.039	0.750	0	0.092	0.238	0.143	0.008	0.089
7=11	0.003	0.014	0	0	0.392	0.005	0.790	0.053	0.023	0.006	0.000	0
7=12	0.030	0.045	0.905	0.010	0.366	0.247	0.184	0.723	0.030	0.012	0.693	0.003
8=9	0	0.291	0	0.037	0.249	0.063	0.246	0.078	0	0.370	0	0.065
8=10	0.075	0.929	0	0.429	0.001	0.076	0	0	0.657	0.915	0.094	0.968
8=11	0.001	0.432	0	0.010	0.551	0	0.033	0.019	0.096	0.901	0.000	0.125
8=12	0.005	0.967	0.683	0.457	0.576	0.613	0.005	0.183	0.002	0.859	0.365	0.842
9=10	0	0.253	0	0.008	0	0.002	0	0	0.002	0.594	0	0.199
9=11	0	0.172	0	0	0.603	0.333	0.050	0.172	0	0.327	0	0.005
9=12	0.572	0.069	0	0	0.645	0.005	0.003	0.002	0.304	0.180	0.012	0.001
10=11	0.094	0.601	0.022	0.174	0.002	0	0	0	0.697	0.879	0.384	0.563
10=12	0.001	0.908	0.014	0.907	0.001	0.090	0.042	0.081	0.008	0.999	0.053	0.945
11=12	0	0.507	0	0.093	0.876	0.004	0.077	0.005	0.001	0.785	0.001	0.303

Note: Panel data fixed effects regressions. Intercept estimates not reported. Ominted category RR Fixed * bw (4). Ebw, bw, pbw and bw2 stand for early Bretton Woods (1946-1950), Bretton Woods (1951-1972), Post Bretton Woods (1973-2000) and Bretton Woods II (2001-2007). RR Fixed, RR Lim. Flex. and RR Flex. stand for Reinhart-Rogoff fixed, limited flexibility and flexible regimes respectively. The value 0 is reported when the first three decimal digits are equal to zero. Intra-year residual RER volatility is calculated according to equations (1) and (2) from pages 12 and 13. Robust t stat in brackets. *, ** and *** denote significance at 10%, 5% and 1% levels, respectively.