

On shock symmetry in South America:
New evidence from intra-Brazilian
real exchange rates

Christian Rohe[†]

53/2016

[†] Department of Economics, University of Münster, Germany

On shock symmetry in South America: New evidence from intra-Brazilian real exchange rates

Christian Rohe *

August 25, 2016

Abstract

I analyze the symmetry of economic shocks in South America by comparing the volatility of unexpected changes in bilateral real exchange rates within an existing monetary union, the intra-Brazilian currency area, with the volatility found in real exchange rates between Brazilian regions and nine South American countries for the 1994-2013 time period. My results show that shocks across South America are substantially less symmetric than shocks within Brazil, indicating potentially high costs if a continent-wide monetary union should eliminate nominal exchange rate flexibility between countries.

JEL Classification: F31, F33, O54

Keywords: Optimum currency area; Real exchange rates; Monetary union

*Institute of International Economics, University of Muenster, Universitaetsstrasse 14-16, 48143 Muenster, Germany, Phone: +49 251 8328664, E-mail: christian.rohe@wiwi.uni-muenster.de

1 Introduction

Many studies have asked whether South America is an optimum currency area (OCA) in the sense of Mundell (1961). I rephrase this question and ask whether South America would form a *worse* currency area than the one already in force in South America's most important economy, Brazil. The methodology I employ is based on a study by von Hagen and Neumann (1994), who analyze the symmetry of economic shocks in the future Eurozone by comparing the conditional volatilities of real exchange rate (RER) shocks within Germany to shock volatilities between German states and other prospective Euro countries. Given Brazil's size and presumably central role in a currency area stretching across all or parts of South America, I reproduce this approach for the bilateral real exchange rates of eleven Brazilian regions against each other and against nine Spanish-speaking countries of South America, using a so far underutilized data set on Brazilian regional CPIs for the 1994-2013 time period.

For the purposes of this paper, RER shocks are defined as unexpected changes in bilateral real exchange rates. The rationale behind comparing their volatility is that nominal exchange rates and prices are the main shock absorption mechanism between two geographical units. According to Mundell, the cost of monetary union between these units is minimal if the pattern of economic shocks between them is symmetric, i.e. if the same shocks are absorbed in a similar way. An asymmetric pattern exists if a common shock leads to different reactions in the RER determinants *or* if the effects of a specific shock are restricted to only one region. As such a pattern would affect the size and frequency of real exchange rate changes, the degree of volatility in RER changes can thus be used to assess the degree of symmetry in the underlying economic shocks. This approach has already been employed by a number of studies for South America, which generally find less symmetry between the countries of the region than in studies for industrialized countries (Eichengreen, 1998; Licandro Ferrando, 2000; Larraín and Tavares, 2003).

An inherent problem in the aforementioned studies is that there is no objective criterion to determine the level of RER shock volatility at which monetary union becomes too costly. The

literature often relies on a benchmark from outside South America, such as the volatility of real exchange rate changes between US states. This ignores the fact that some of the observed volatility may be caused by region-specific shocks that the benchmark countries do not experience, thus yielding a biased threshold for acceptable levels of RER shock volatility. While von Hagen and Neumann (1994) emphasize this argument for a comparison between the EU and the US, it bears even greater importance for an analysis of South America, where idiosyncratic shocks are known to be important drivers of the business cycle (Canova, 2005; Aiolfi et al., 2011).

This paper provides a more natural benchmark for comparison: The volatility of RER changes within the intra-Brazilian currency area. In this approach, all bilateral real exchange rates include price data from South America only, and always include at least one Brazilian region. It should be noted that Brazil, like all real-world currency areas, must not necessarily exhibit perfect shock symmetry. Studies for the US, another country of continental dimensions, have already shown that some of its regions are subject to asymmetric shocks and might be better off with a currency of their own (Rockoff, 2000; Kouparitsas, 2001; Beckworth, 2010), and nothing suggests that this should not be the case for Brazil as well. The continued existence of these very large currency areas implies that a certain level of asymmetry can be tolerated within monetary unions.

The extraction of intra-Brazilian shock volatility from the relatively small set of time-series data for Brazilian regions is possible due to the parsimonious data requirements of the RER approach I use. It also allows to measure the volatility of economic shocks without having to make any identifying assumptions regarding their number and nature, a challenge often encountered in studies that analyze economic shocks by extracting them from larger structural vector autoregressive models (Hallwood et al., 2006; Eichler and Karmann, 2011). This offers a more straightforward way to measure and to assess shock symmetry in South America, given that price and nominal exchange rate reactions matter most for OCA considerations.

My results indicate that a monetary union in all of South America would be much more

costly than the existing currency area in Brazil. While there is some shock asymmetry within Brazil, especially in peripheral regions less integrated with the rest of the country, it increases considerably once an international border is included. This result holds for all country pairs and different subperiods, with the disparity between international and intra-Brazilian volatility actually increasing over time. Whereas international borders are detrimental to the stability of the real exchange rate, I find that geographical proximity, membership in the trade bloc Mercosur, and coordinated exchange rate policies decrease the level of shock asymmetry. The most symmetric international RERs are those of Argentina and Uruguay during the 1994-1999 subperiod, when these two countries and Brazil conducted similar exchange rate policies towards the US Dollar. A lack of nominal exchange rate coordination after 1999 appears to have amplified the effects of shocks between these countries and Brazil for later subperiods. While this suggests that Brazil's Southern neighborhood might be able to join the Brazilian currency area under the right set of circumstances, RER shock volatility with other countries is prohibitively high throughout the sample. I also study the persistence of RER shocks within Brazil and between Brazil and the rest of South America, finding that international RER shocks are relatively more persistent.

The rest of the paper is structured as follows. Section 2 reviews the idea of monetary union in South America and discusses the role of current exchange rate regimes on the continent. Section 3 describes the data set, focusing on the regional price data for Brazil. The empirical approach and the results are presented in section 4. Section 5 concludes.

2 Monetary Union in South America

I analyze the prospect of monetary union in South America both for the narrow case of a Mercosur currency area – focusing on the four traditional bloc members Brazil, Argentina, Uruguay, and Paraguay – and for the broader proposal of an All-South American currency area under the auspices of UNASUR, the Union of South American Nations. The latter was founded in 2004 to merge various regional integration processes in South America and

includes all sovereign states on the continent. For my analysis, I exclude the two non-Latin members of UNASUR, Guyana and Suriname, due to their negligible size, and focus on Brazil and the nine Spanish-speaking countries of South America.

Mercosur, the South American integration scheme most openly inspired by the European experience, has traditionally been viewed as a natural platform for establishing a joint currency area. In the early years of Mercosur, several commitments towards an eventual monetary union among its members were made, including a bilateral agreement between Argentina and Brazil regarding the necessity of a common currency (1987) and a Brazilian proposal to establish a multilateral system of exchange rate bands (1993), analogous to the European experience with EMS (Morales Sarriera et al., 2010). These initiatives received a setback during the emerging market crises from 1999 to 2002, when Brazil and Argentina disagreed over the choice of their respective exchange rate regimes. The floating of the Brazilian Real in 1999 led to a unilateral Brazilian depreciation that was regarded as “beggar-thy-neighbor” by Argentina, whereas the subsequent Argentinian crisis of 2001-02 was largely caused by the country’s continued adherence to a currency board vis-a-vis the US Dollar. The establishment of a Mercosur monetary union appeared infeasible under these circumstances, even more so when Argentina began considering the alternative proposal of unilateral dollarization (Genna and Hiroi, 2007).

The monetary union debate resurfaced after the collapse of the Argentinian currency board in 2002. Since then, it has been characterized by a curious combination of increasingly growing geographical ambitions and an absence of tangible policy measures. The vision of a currency area across the entire South American continent arose with the founding of UNASUR, which has financial integration as one of its long-term objectives, and has at times been endorsed by the governments of Peru, Ecuador, and Brazil (Garcia Rocabado, 2010). However, the lack of consequential steps to advance monetary integration within UNASUR shows that this vision is, for the moment, largely driven by rhetoric. In contrast, parallel to the founding of UNASUR, monetary integration was further advanced within

the more closely-knitted Mercosur. Notable steps in that direction include the setup of a macroeconomic monitoring group to improve policy coordination between Mercosur countries in 2004 and the introduction of a bilateral local currency payment system between Brazil and Argentina in 2007. With regard to the European experience of differentiated integration speeds, I therefore distinguish between Mercosur and Non-Mercosur countries for the rest of my analysis. I include Venezuela among the latter since my sample ends in 2013 and the country only joined Mercosur in 2012.

The theoretical argument to combine all or parts of South America in a joint currency area is based upon the elimination of the exchange rate risk, which lowers barriers for cross-border trade and investment and may serve to increase growth across the region (Rose and van Wincoop, 2001). Further welfare gains may arise from the elimination of harmful “beggar-thy-neighbor” policies and from an increase in macroeconomic stability due to the transfer of monetary authority to a supranational institution independent of local governments (Alesina and Barro, 2002). These benefits, however, must be weighted against the costs of monetary union, which stem from losing the ability to cushion asymmetric shocks via the nominal exchange rate and increase with a higher degree of shock asymmetry. Shock asymmetry has often been found to be particularly high in South America, based on studies of RER volatility (Eichengreen, 1998; Larraín and Tavares, 2003), goods and factor market flexibility (Levy Yeyati and Sturzenegger, 2000), or shocks identified via structural vector autoregressions (Hallwood et al., 2006; Eichler and Karmann, 2011).¹

The asymmetry of shocks may be amplified by a lack of coordinated exchange rate policies. This is especially relevant if countries do not agree on the most basic tenet of exchange rate policy, i.e. whether their nominal exchange rates should be fixed or flexible. Macroeconomic theory is generally in consensus that the choice of an exchange regime directly affects the degree of international business cycle transmission, although the exact implications of a

¹It should be noted that most of these studies are even more skeptical regarding the proposition of unilateral dollarization in South America, finding a large degree of shock asymmetry between the countries of the region and the US. See Hallwood et al. (2006) for details.

Table 1: Exchange Rate Regimes in South America, 1994-2013

| Exchange Rate Regime | 1994-1999 | 1999-2003 | 2004-2013 |
|---------------------------------------|--|--|---|
| Hard Peg | Argentina | Ecuador (2000/01) Venezuela (2003/02) | Ecuador Venezuela |
| Crawling Peg / Intermediate Regime | Bolivia Brazil Chile Colombia Ecuador Uruguay Venezuela | Bolivia | Argentina Bolivia |
| Managed Float / Float | Paraguay Peru | Argentina (2002/01) Brazil (1999/01) Chile (1999/09) Colombia (1999/09) Paraguay Peru Uruguay (2002/06) | Brazil Chile Colombia Paraguay Peru Uruguay |

Note: Own classification based on *de facto* exchange rate regimes as reported in the IMF's Annual Reports on Exchange Arrangements and Exchange Restrictions (AREAER). The date in brackets indicates the year and month when an intermediate regime was abandoned during the 1999-2003 crisis period.

specific exchange rate regime are sometimes subject to debate. If one follows the assumption that flexible exchange rates insulate a country more efficiently from foreign disturbances, a floating Dollar exchange rate would imply a more subdued reaction to shocks emanating from the US than a fixed exchange rate regime, thus affecting the degree of shock asymmetry between two countries with different regimes towards the Dollar. For a region with broadly comparable levels of exposure towards the US such as South America, asymmetry is likely to increase, as the opposite case – a balancing out of shock effects – could only occur between countries with very different shock exposure in the first place, e.g. between a country that trades extensively with the US and a country with very little US trade.

Table 1 summarizes the *de facto* exchange rate regimes in South America for the time period considered in this study. It is useful to distinguish three subperiods with very different characteristics. From 1994 to 1999, most South American countries pegged their domestic currencies towards the US Dollar, either in the form of a currency board or via fixed exchange rate bands. This policy was often motivated by the anchoring properties of the exchange rate for domestic inflation and entailed an implicit system of exchange rate pegs

across the region. This Dollar-oriented period ended with the floating of the Brazilian Real in January 1999, initiating a crisis period during which most countries felt the need to abandon their previous regimes. The unsystematic pattern of regime changes during this period indicates a very low degree of policy coordination, as every country adapted to the ongoing emerging market crises according to its own needs. Finally, a stable pattern of exchange rate regimes has emerged since 2004, resembling the “corners hypothesis” of the vanishing intermediate regime (Fischer, 2001). Bolivia, Ecuador and Venezuela, three countries dependent on Dollar-denominated hydrocarbon exports, have pegged – or, in the case of dollarized Ecuador, eliminated – their US Dollar exchange rates, whereas the rest of South America has now officially adopted flexible exchange rates. All but one of these regimes are also considered *de facto* floats by the IMF. The notable exception is Argentina, where official and black market exchange rates have differed strongly in recent years. Following the IMF classification, I categorize Argentina as an intermediate regime for the 2004-2013 time period, and consider its exchange rate policy to be more Dollar-oriented than the contemporaneous regime in Brazil.

3 The Data Set

I compute Intra-Brazilian real exchange rates as the simple price differential between two Brazilian regions. To obtain these price differentials, I reconstruct the unpublished regional price indices for eleven Brazilian regions by using published data on regional cumulative inflation from the Historical and Statistic Series database of the Brazilian Institute of Geography and Statistics (IBGE).² These indices and inflation rates are based on the same basket of consumer goods and services as the Broad National Consumer Price Index (IPCA), the price index used to determine the success rate of Brazil’s inflation targeting regime. The national IPCA is thus a weighted average of my reconstructed price indices, with regional

²Source: http://seriesestatisticas.ibge.gov.br/lista_tema.aspx?op=1&no=4. The price indices are available upon request.

weights given according to size and economic activity.

The dataset includes the eleven largest metropolitan areas of Brazil, denoted as regions for the rest of my analysis. It covers all five socio-economic macroregions of Brazil as defined by the IBGE, i.e. groupings of states with similar characteristics. The most important of these, the industrialized Brazilian Southeast, is represented by São Paulo, Rio de Janeiro, and Belo Horizonte, whose weights in the IPCA are 31.68 %, 12.46 %, and 11.23 %, respectively. The fact that these three regions explain more than 50 % of the overall IPCA indicates that they contain the core of Brazil's economic activity, and are most representative of the country as a whole.³ Furthermore, the dataset includes four cities from the South (Porto Alegre, 8.40 %, Curitiba, 7.79 %) and the Central West (Brasília, 3.46 %, Goiânia, 4.44 %) of Brazil, two relatively industrialized areas with a proximity to Brazil's international borders, and four cities from Northeastern (Salvador, 7.35 %, Fortaleza, 3.49 %, Recife, 5.05 %) and Northern Brazil (Belém, 4.65 %), which are less developed and geographically remote.

Figure 1 illustrates the five macroregions of Brazil and the geographical extent of the price data used in this study. With more than 3,200 km, the distance between Fortaleza and Porto Alegre is comparable to the distance between Helsinki and Lisbon, and the entire territory covered by the intra-Brazilian currency area is about three times the size of the Eurozone. Within this area, there are considerable differences in the degree of economic integration: Daumal and Zignano (2010) show that a strong interregional border effect exists for trade flows of regions in Western, Northeastern and Northern Brazil, which trade significantly less with the rest of the country than with themselves. This implies that the degree of shock asymmetry is likely to be higher for these more peripheral regions. On the other hand, interregional borders do not reduce trade flows from and to Southeastern and Southern Brazil, where the regions are more strongly integrated with the national economy.⁴

³All weights are taken from IBGE (2013).

⁴The IPCA sample, although covering most parts of the intra-Brazilian currency area, might yet exhibit some selection bias for being based upon urban agglomerations only. Since agricultural-specific shocks are more keenly felt in rural areas, this might somewhat underestimate the actual degree of shock asymmetry across Brazil, a country with vastly different climatic regions.

Figure 1: Geographical extent of the IPCA data set



Note: Outlined areas show the five macroregions of Brazil, Grey circles indicate the location of the 11 metropolitan areas covered in this study. The abbreviations used here and in the following are: SP: São Paulo, RJ: Rio de Janeiro, BH: Belo Horizonte, PA: Porto Alegre, CU: Curitiba, BR: Brasília, GO: Goiânia, SA: Salvador, FO: Fortaleza, RE: Recife, BE: Belém. Own figure based on a template from the GADM database of Global Administrative Areas, <http://www.gadm.org>.

For the rest of South America, I include national CPIs from central banks (for Paraguay and Venezuela) and statistical offices (for all other countries), obtained via Datastream. Since most of these CPIs are based on urban prices, a comparison between them and the Brazilian metropolitan price data is not problematic. The data quality of Argentina's CPI is sometimes considered unreliable due to political pressure on the statistical office of that country, but I assume that the fact that my sample ends in 2013 ignores the most blatant period of misreporting. For nominal exchange rate data, I use monthly averages taken from the IFS and also obtained via Datastream.

My sample begins in 1994:12 due to data limitations. This allows me to exclude the Brazilian hyperinflation period of 1989-1994, which distorted the normal process of price adjustment and only ended with a currency reform in July 1994. The sample ends in 2013:12

because of changes in the regional composition of the IPCA in January 2014 (IBGE, 2013). I also divide the sample into several subperiods to study the development of real exchange rate volatility over time. These subperiods are chosen according to the different stages of exchange rate management discussed in the previous section. Following table 1, I distinguish a Dollar-oriented period from 1994:12-1998:12, a crisis period from 1999:01-2003:12, and two “corners” periods from 2004:01-2008:12 and 2009:01-2013:12. I split the last stage of exchange rate management in two to obtain four subperiods of comparable length.

4 Empirical Analysis

4.1 The volatility of real exchange rate shocks

Real exchange rates are calculated on the basis of the logarithm of the $i = 1, \dots, 11$ Brazilian regional price indices, p_i , the logarithm of the $j = 1, \dots, 20$ full set of price indices, p_j , and the logarithm of the nominal exchange rate between i and j , s_{ij} . If both i and j are Brazilian regions, the nominal exchange rate between the two is set to 1, i.e. $s_{ij} = 0$. Since I do not calculate bilateral RERs between two countries other than Brazil and since no country has a real exchange rate with itself, this yields a sample of $\frac{11 \times 10}{2} + 11 \times 9 = 154$ series for the 1994:12-2013:12 time period. Formally, I have

$$q_{ij,t} = s_{ij,t} + p_{i,t} - p_{j,t}. \quad (1)$$

In addition to these monthly series, I also work with a second sample of quarterly real exchange rates Q that I obtain by forming three-month-aggregates over the monthly sample, i.e.

$$Q_{ij,t} = \sum_{m=0}^2 q_{ij,3t-m}. \quad (2)$$

The use of both monthly and quarterly series is motivated by the assumption in von Hagen

and Neumann (1994) that the relatively high frequency of monthly real exchange rate changes implies a strong influence of nominal and financial shocks, whereas real exchange rate changes are more strongly driven by real disturbances. Since economic theory often regards the latter as more persistent, they are arguably even more detrimental to the stability of a monetary union.

The monthly and quarterly real exchange rates are deseasonalized with X-13ARIMA-SEATS to eliminate seasonal patterns in the consumer price data. Their first differences over time, Δq and ΔQ , give me seasonally adjusted RER changes on a monthly and quarterly base. The information in this data needs to be further separated into its unexpected and its expected component, given that shocks in the sense of the OCA literature should result in fully unexpected RER variation. I therefore compute the conditional standard deviation of both RER samples by regressing Δq and ΔQ on their own lags, obtaining autocorrelation-free residual series u and U . The lag lengths needed to eliminate autocorrelation from the residuals is determined by the Ljung-Box test, which gives me $L_q = 7$ and $L_Q = 2$.

$$\Delta q_{ij,t} = \sum_{l=1}^{L_q} \alpha \Delta q_{ij,t-l} + u_{ij,t} \quad (3)$$

$$\Delta Q_{ij,t} = \sum_{l=1}^{L_Q} \alpha \Delta Q_{ij,t-l} + U_{ij,t} \quad (4)$$

The resulting series can then be interpreted as unexpected economic shocks to which the RER adjusts. Since my analysis focuses on the volatility rather than on the level of these shocks, equations (3) and (4) can be estimated without a constant term. The average shock volatility of each country or region j against the entire Brazilian currency area is now simply computed by averaging the conditional standard deviation of its N_j RER shocks with the rest of Brazil,

$$V_{u,j} = (1/N_j) \sum_{\substack{i=1 \\ i \neq j}}^{N_j} [\text{var}(u_{ij,t})]^{1/2} \quad (5)$$

$$V_{U,j} = (1/N_j) \sum_{\substack{i=1 \\ i \neq j}}^{N_j} [\text{var}(U_{ij,t})]^{1/2}, \quad (6)$$

where the number of shocks is $N_j = 11$ if j is a South American country and $N_j = 10$ if j is a Brazilian region.

The resulting conditional volatilities $V_{u,j}$ and $V_{U,j}$ are presented in table 2. Results are shown for the four different subperiods defined in the previous section. As a benchmark for comparing the intra-Brazilian results to the rest of South America, I also present the arithmetic mean over the 11 conditional volatilities of Brazilian regions as a Brazilian national average for each subperiod.

Looking at the standard deviations of monthly RER shocks, my results clearly show a lower shock volatility – and thus, following the discussion in section 1, less shock asymmetry – within the Brazilian currency area than between Brazil and the rest of South America. This result holds for all four subsamples; in fact, while the average intra-Brazilian shock volatility has declined from 1994-98 to 2009-13 (from 0.34 to 0.27), indicating a deepening of economic integration within the country, it has actually increased for the RERs of all other South American countries. This stands in sharp contrast to the results for the EU presented in von Hagen and Neumann (1994), who found a decline in RER volatility both within Germany and across the other EMS countries, and emphasizes the relative stagnation of the South American integration process over the past two decades, especially when compared to the high pace of European integration in the 1970s and 1980s.

While shock volatility is generally lower for Brazilian regions than for the rest of South America, intra-Brazilian results are still heterogeneous enough to question the OCA assumption for the country as a whole. This is especially true for the more peripheral regions identified by Daumal and Zignano (2010), i.e. the regions located in the Central West, Northeast, and North of Brazil. During the first three subperiods, RER shocks in these regions have a higher standard deviation than shocks in the Southeast or South of Brazil, with Belém in Northern Brazil standing out as the region hit by shocks that are the most

Table 2: Conditional Volatilities of Real Exchange Rate Shocks

| Monthly Real Exchange Rate Shocks | | | | | | | | | | | |
|-----------------------------------|-----------|------|------|-------|------|--------------|------|-----------|------|------|-------|
| <i>Period</i> | Southeast | | | South | | Central West | | Northeast | | RE | North |
| | SP | RJ | BH | PA | CU | BR | GO | SA | FO | | BE |
| 1994-98 | 0.35 | 0.31 | 0.30 | 0.32 | 0.33 | 0.33 | 0.34 | 0.34 | 0.33 | 0.38 | 0.46 |
| 1999-03 | 0.34 | 0.35 | 0.35 | 0.34 | 0.38 | 0.40 | 0.39 | 0.35 | 0.38 | 0.42 | 0.44 |
| 2004-08 | 0.31 | 0.30 | 0.32 | 0.32 | 0.36 | 0.37 | 0.38 | 0.35 | 0.29 | 0.33 | 0.38 |
| 2009-13 | 0.23 | 0.27 | 0.25 | 0.26 | 0.29 | 0.29 | 0.27 | 0.28 | 0.30 | 0.27 | 0.30 |

| <i>Period</i> | Mercosur | | | Non-Mercosur | | | | | | Brazil |
|---------------|----------|------|------|--------------|------|------|------|------|------|---------------|
| | ARG | URY | PRY | BOL | CHL | COL | ECU | PER | VEN | <i>(Avg)</i> |
| 1994-98 | 0.65 | 0.76 | 1.81 | 0.78 | 1.05 | 1.92 | 2.00 | 1.05 | 6.57 | <i>0.34</i> |
| 1999-03 | 6.27 | 5.67 | 5.07 | 5.12 | 4.48 | 4.89 | 7.17 | 4.86 | 7.20 | <i>0.38</i> |
| 2004-08 | 2.97 | 2.59 | 3.37 | 3.61 | 2.50 | 2.69 | 3.57 | 3.18 | 4.60 | <i>0.34</i> |
| 2009-13 | 2.80 | 2.33 | 3.31 | 2.68 | 2.35 | 2.69 | 2.95 | 2.66 | 8.09 | <i>0.27</i> |

| Quarterly Real Exchange Rate Shocks | | | | | | | | | | | |
|-------------------------------------|-----------|------|------|-------|------|--------------|------|-----------|------|------|-------|
| <i>Period</i> | Southeast | | | South | | Central West | | Northeast | | RE | North |
| | SP | RJ | BH | PA | CU | BR | GO | SA | FO | | BE |
| 1994-98 | 0.74 | 0.54 | 0.59 | 0.59 | 0.60 | 0.57 | 0.65 | 0.72 | 0.65 | 0.71 | 0.91 |
| 1999-03 | 0.58 | 0.66 | 0.61 | 0.60 | 0.68 | 0.81 | 0.61 | 0.61 | 0.65 | 0.80 | 0.92 |
| 2004-08 | 0.60 | 0.60 | 0.58 | 0.54 | 0.67 | 0.67 | 0.63 | 0.61 | 0.56 | 0.64 | 0.79 |
| 2009-13 | 0.41 | 0.49 | 0.41 | 0.46 | 0.46 | 0.51 | 0.44 | 0.47 | 0.52 | 0.44 | 0.59 |

| <i>Period</i> | Mercosur | | | Non-Mercosur | | | | | | Brazil |
|---------------|----------|-------|-------|--------------|-------|-------|-------|-------|-------|---------------|
| | ARG | URY | PRY | BOL | CHL | COL | ECU | PER | VEN | <i>(Avg)</i> |
| 1994-98 | 1.44 | 1.58 | 2.28 | 1.55 | 2.44 | 4.46 | 2.55 | 1.93 | 12.37 | <i>0.66</i> |
| 1999-03 | 21.33 | 13.02 | 12.13 | 13.00 | 11.63 | 12.99 | 12.04 | 11.58 | 14.54 | <i>0.69</i> |
| 2004-08 | 6.52 | 4.92 | 6.29 | 8.69 | 5.18 | 6.90 | 7.92 | 7.47 | 10.63 | <i>0.63</i> |
| 2009-13 | 5.87 | 4.18 | 6.34 | 6.38 | 3.81 | 5.40 | 6.12 | 5.72 | 15.95 | <i>0.47</i> |

Note: Estimates of the conditional standard deviations $V_{u,j}$ and $V_{U,j}$ of the unexpected RER shocks u and U , averaged over the respective country or region j . See equations (3) to (6) for details.

asymmetric to the rest of the country (0.46 in 1994-98). Intra-Brazilian heterogeneity is somewhat reduced for the 2009-13 subperiod, when many peripheral regions appear to become better integrated with the national economy, but their shock volatilities remain higher than the Brazilian average throughout the entire sample.

The differences within Brazil allow for a more nuanced comparison of volatilities to the rest of South America. For the 1994-98 subperiod, the conditional volatilities of the RERs of Argentina and Uruguay, two out of three of Brazil's Mercosur partners at the time, are

not much higher than the conditional standard deviation of Belém, a region already part of the Brazilian currency area. This indicates that the shocks the two Río de la Plata countries experienced during this period were not much more asymmetric to Brazil as a whole than those experienced by the most peripheral region of Brazil itself. Had this study been written in the late 1990s, both countries might thus have appeared as good candidates for an eventual monetary union with Brazil. This impression is obviously challenged by the results for later subperiods: In 1999-03, the shock volatility of Argentina and Uruguay towards Brazil was amongst the highest for all of South America, a result not surprising given the pattern of mutual depreciations between the three Mercosur countries during their respective crisis years. In 2004-08 and 2009-13, Argentina and Uruguay return to have lower volatility vis-a-vis Brazil, but the difference towards the volatility of shocks for Brazil's most peripheral region has risen from a factor smaller than 2 to a factor higher than 7 (Uruguay) and 9 (Argentina). It should also be noted that, since 2004, Argentina has observed a higher shock volatility towards Brazil than a number of non-Mercosur countries, most notably Chile. At 2.50 and 2.35, Chile's shock volatility has been at a similar level as Uruguay's during the last two subperiods, indicating a relatively low degree of shock asymmetry with Brazil even without being a member of the common trade bloc.

While Argentina, Uruguay, and potentially Chile appear as countries that may – under the right set of circumstances, such as those effective in 1994-1998 – eventually qualify to join an expanded Brazilian currency area in the future, the shock asymmetry of other countries towards Brazil appears to be prohibitively high for monetary union. This applies first and foremost to Venezuela, the country with the consistently highest level of shock volatility throughout the sample. With Venezuela's status as a major petroleum exporter, it is hardly surprising that global oil shocks should hit the country in an idiosyncratic way; this puts serious doubts, however, on Mercosur's ability to deepen future monetary integration, given Venezuela's entry to the bloc in 2012. RER volatility is also high for Ecuador, another oil-exporting country, and surprisingly high for Paraguay, a Mercosur member heavily dependent

on trade with Brazil. The latter finding suggests that even the four traditional Mercosur countries are far away from forming an OCA, and that Paraguay would likely turn out to be the weakest link of a currency area between them.

The pattern of quarterly volatilities presented in the bottom half of table 2 broadly confirms the findings for monthly data. Standard deviations of quarterly RER shocks are generally higher than those of monthly shocks for both intra- and international real exchange rates, but I find no evidence for a significant difference between intra-Brazilian and international shock asymmetry in the short and the medium run. In most cases, quarterly volatility exceeds monthly volatility by a factor of 2, with slightly smaller ratios in Uruguay and Paraguay. If one follows the assumption in von Hagen and Neumann (1994) regarding the nature of monthly and quarterly shocks, this may indicate that nominal shocks are relatively more important for shock asymmetries of these two countries with Brazil. In general, however, I find that countries which experience highly asymmetric monthly shocks are the same that experience highly asymmetric quarterly shocks, with the latter being of a generally higher magnitude.

4.2 Determinants of RER volatility

To further understand the determinants of higher and lower shock volatility for certain countries and subperiod in section 4.1, I regress all 154 conditional standard deviations derived in the previous section – $\text{var}(u_{ij,t})$ and $\text{var}(U_{ij,t})$ – on a number of variables likely to reduce or increase their degree of asymmetry. The most obvious of these is the distance between two geographical units, calculated as the logarithm of the geodesic distance between their respective capital cities (in the case of South American countries) and metropolitan areas (in the case of Brazilian regions).⁵ As known from the literature on the gravity model of trade, transportation costs are an increasing function of distance, which makes the variable

⁵Source: <http://www.distancefromto.net>. Distance is measured in kilometers. For Bolivia, I include distances from and to La Paz, the seat of the country's executive and legislative powers, rather than distances from and to the constitutional capital Sucre.

an important detriment to the trade-induced equalization of goods and factor prices between two geographical units.⁶

I further include three dummy variables. The first of these is a border dummy, which takes the value of 1 for every RER pair involving another South American country. This variable captures a variety of effects by which not-being-in-Brazil might reduce price equalization and increase RER volatility, including the effect of state borders on international trade and language barriers on international migration. Since Brazil is currently a single-country currency area, the variable also captures the effect of not being part of the same monetary union as Brazil, but it is impossible to distinguish this effect from the previous ones. I also include a dummy variable for Mercosur, intended to capture the facilitation of trade between member countries, which takes the value of 1 for every RER pair involving Argentina, Uruguay, Paraguay, or two Brazilian regions. As trade facilitation should help to weaken the effect of asymmetric shocks, the coefficient of this variable is expected to be negative. Finally, my third dummy variable takes the value of 1 for every RER pair where both sides have some sort of exchange rate policy coordination. This obviously includes all RERs from the intra-Brazilian currency area, but also extends to all South American countries classified as having the same exchange rate regime as Brazil for a given subperiod, following the classification of table 1. The inclusion of this variable is motivated by the destabilizing effect of diverging exchange rate policies as discussed in section 2, and captures by how much shock volatility is amplified due to a lack of policy coordination. In line with Brazil's exchange rate policy, I set the dummy to 1 for all countries with some sort of peg towards the Dollar for 1994-1998, and to 1 for all countries with a *de facto* floating currency after 1999.

Results for the OLS regressions described above are presented in columns (1), (2), (3) and (4) of table 3. With a single exception during the crisis period 1999-03, the estimated

⁶Geodesic distance can only be an imperfect proxy for transportation costs in South America, where the Andes and the Amazon constitute huge natural barriers to trade and all other forms of exchange. Since at least one of these barriers separates Brazil from all six non-Mercosur countries in this study, it is possible that some of their effect is also captured by the coefficient of my Mercosur dummy.

Table 3: Determinants of RER Shock Volatility

| | Monthly Real Exchange Rate Shocks | | | | | | | |
|-------------------------|-----------------------------------|---------|---------|---------|---------|---------|---------|---------|
| | 1994-98 | | 1999-03 | | 2004-08 | | 2009-13 | |
| | (1) | (1a) | (2) | (2a) | (3) | (3a) | (4) | (4a) |
| Log distance | 0.17** | 0.13** | 0.17** | 0.12** | 0.17** | 0.11** | 0.28** | 0.03** |
| Border | 0.70** | 0.56** | 5.17** | 5.19** | 2.35** | 2.46** | 1.98** | 2.48** |
| Mercosur | -1.05** | -0.26** | 1.00** | 0.97** | -0.13 | -0.01 | -0.35 | 0.18** |
| Coordination | 0.23 | -0.31** | -1.79** | -1.45** | -0.75** | -0.48** | -1.36** | -0.15** |
| Venezuela | - | 5.25** | - | 0.99** | - | 1.20** | - | 5.33** |
| Adjusted R ² | 0.28 | 0.94 | 0.96 | 0.97 | 0.93 | 0.97 | 0.62 | 0.99 |

| | Quarterly Real Exchange Rate Shocks | | | | | | | |
|-------------------------|-------------------------------------|---------|---------|---------|---------|---------|---------|---------|
| | 1994-98 | | 1999-03 | | 2004-08 | | 2009-13 | |
| | (1) | (1a) | (2) | (2a) | (3) | (3a) | (4) | (4a) |
| Log distance | 0.26** | 0.19** | -0.18** | -0.26** | 0.52** | 0.41** | 0.63** | 0.18** |
| Border | 1.27** | 1.02** | 14.73** | 14.77** | 4.49** | 4.73** | 3.68** | 4.62** |
| Mercosur | -2.20** | -0.73** | 3.22** | 3.17** | -1.17** | -0.91** | -0.81* | 0.19 |
| Coordination | 1.06* | 0.06 | -1.22** | -0.57 | -1.97** | -1.39** | -3.24** | -0.99** |
| Venezuela | - | 9.74** | - | 1.93** | - | 2.55** | - | 9.86** |
| Adjusted R ² | 0.31 | 0.95 | 0.90 | 0.91 | 0.94 | 0.97 | 0.66 | 0.98 |

Note: Estimates obtained from OLS regressions with $\text{var}(u_{ij,t})$ and $\text{var}(U_{ij,t})$ as dependent variables. Columns (1) to (4) contain results without a Venezuela dummy, columns (1a) to (4a) are the results with a Venezuela dummy included. ** and * indicate statistical significance at the 5 % and 10 % level, respectively.

coefficients for both distance and the border dummy are significant and of the expected sign for both monthly and quarterly data, indicating increased RER volatility between two regions whose bilateral trade is hampered by geographical constraints. The border coefficient is much smaller for the 1994-98 subperiod than for later periods, showing once again that the volatility of international real exchange rates has increased since the floating of the Brazilian currency in 1999.⁷

The Mercosur dummy coefficient is negative for all subperiods but the 1999-2003 crisis period, although often not significantly so. For the 2004-08 and 2009-13 subperiods, it is

⁷All regressions in table 3 are conducted without a constant term. Performing the same regressions with a constant included has negligible effects on the coefficients of every variable but distance, which ceases to be of significant influence on the results.

only significant for quarterly shocks, supporting the view that these are real disturbances more directly linked to the trade channel. The dummy for monetary cooperation indicates that a Dollar peg increased the volatility of an international RER with Brazil during the 1994-98 subperiod, but this result is again only significant for quarterly shocks. After 1999 and the floating of the Brazilian Real, both monthly and quarterly RER volatility is much lower for all countries that employ the same exchange rate regime as Brazil.

The low values for R^2 in the 1994-98 and 2009-13 regressions can largely be attributed to a specific Venezuela effect, caused by strong nominal devaluations of the Venezuelan Bolívar in 1995 and 2011. These imply a much higher volatility of Venezuela's nominal exchange rate with Brazil during these periods. To correct for this effect, I repeat all estimations with an additional Venezuela dummy, results for which are presented in columns (1a), (2a), (3a) and (4a) of table 3. The inclusion of the Venezuela dummy markedly improves the fit of the model for the critical subsamples, but also affects the coefficients of other variables that were previously distorted. Most importantly, the coordination dummy now significantly decreases the volatility of monthly shocks during *all* subperiods. On the other hand, adding Venezuela weakens the coefficient of the Mercosur dummy, and being a bloc member hardly reduces RER volatility anymore for much of the post-1999 period. It should be noted that the absolute value of the cooperation coefficient is higher than that of the Mercosur coefficient for both the 2004-2008 and the 2009-13 subperiod: Since 2004, non-Mercosur countries with the same exchange rate regime as Brazil had a lower RER volatility towards Brazil than Mercosur countries with a differing regime, a result exemplified by the comparison between floating Chile and pegged Argentina in the previous section.

Two important conclusions can be drawn from this analysis. The first one is that the coordination of exchange rate policies between two countries is fundamental to prevent an amplification of asymmetric shocks, as demonstrated by the Mercosur crisis in 1999-2003. On the other hand, my results show that exchange rate coordination in South America does not necessarily have to be based on a system of multilateral pegs, as suggested by proponents

of a South American EMS, but also decreases RER volatility towards Brazil if the rest of South America *floats* their currencies. That is not to say that a continent-wide system of floating exchange rates would have the same effects as a continent-wide system of multilateral pegs; we have seen from the analysis that absolute RER volatility was lowest for the 1994-98 period, which can likely be explained by the implicit system of multilateral Dollar pegs described in section 2. However, the analysis has shown that shocks are still amplified more by non-coordinated exchange rate policies, i.e. by a mix of pegged and flexible exchange rates, than by fully flexible exchange rates between two countries.

4.3 The persistence of real exchange rate shocks

While asymmetric shocks present a serious challenge to a monetary union in the short run, their destabilizing effect is reduced if they turn out not to be very persistent. This should be the case in a currency area where the regions have different economic structures but are still strongly integrated, such that an asymmetric shock leads to quick arbitrage adjustments on goods and factor markets. In such a scenario, real exchange rates can be both volatile and strongly mean-reverting. In contrast, the RER between two weakly integrated regions that experience an asymmetric shock is likely to adjust much more slowly, leading to persistent misalignments.

Unit root tests on the real exchange rate levels q_{ij} suggest that the shocks analyzed so far are indeed rather persistent. The augmented Dickey-Fuller test cannot reject the unit root hypothesis at the 5 percent level for more than 75 percent of my time series, indicating that the effect of shocks are accumulated over time. To further test for the presence of mean reversion in the data, I estimate first order autocorrelation coefficients for the demeaned series of monthly real exchange rate changes, i.e. the coefficient β in the equation

$$\Delta q_{ij,t} = \beta q_{ij,t-1} + e_{ij,t}. \quad (7)$$

For a mean-reverting process, this coefficient should be close to -1 , indicating that any

deviation of q from its mean is canceled out by an opposite-sign rate of change in subsequent periods. The results of this regression are presented in table 4, where the estimated coefficients are averaged over each Brazilian region and South American country. Since not all estimated β coefficients are statistically significant, the number in brackets indicates the number of significant coefficients found for a certain country or region. The upper bound for this number is N_j , i.e. 10 for Brazilian regions and 11 for South American countries.

The results indicate a general tendency for mean reversion within the intra-Brazilian currency area during all subsamples, with the average β coefficients ranging from -0.07 to -0.10 . For some regions, coefficients with a much smaller absolute value are found during isolated subsamples (e.g. 1999-2003 in São Paulo, 2004-2008 in Belém), but these can generally be associated with region-specific episodes of temporarily higher inflation. No particular pattern emerges regarding the different subsamples or Brazilian macroregions, although mean reversion is surprisingly weak for the Brazilian Southeast. The estimated coefficients are also often not significant: In more than half the cases, the number of coefficients clearly distinguishable from zero is less than half the possible number $N_j = 11$.

For South American RERs, I find even less significant negative autocorrelation coefficients. During the fixed exchange rate period of 1994-98, the only countries whose RERs with Brazil show a clear tendency for mean reversion are Paraguay and Peru, the only two countries with a floating exchange rate regime before 1999. Mean reversion is virtually absent for Argentina and Uruguay during this period, indicating that even relatively small RER shocks, as found for these countries in section 4.1, contain the risk of accumulating over time. This already hints at the later currency crises in Mercosur, which were partially caused by accumulated real exchange rate misalignments, and casts a more damning light on the OCA-friendly results of the previous section.

Evidence for mean reversion across South America is high for the 1999-2003 subperiod, which is unsurprising given the large nominal exchange rate swings during this period. The evidence becomes scant again after 2004, and the estimated coefficients are generally weaker

Table 4: Mean Reversion of Monthly Real Exchange Rate Changes, linear model

| | Southeast | | | South | | Central West | | Northeast | | | North |
|---------|---------------|--------------|---------------|---------------|---------------|---------------|--------------|---------------|---------------|---------------|--------------|
| | SP | RJ | BH | PA | CU | BR | GO | SA | FO | RE | BE |
| 1994-98 | -0.07 (7) | -0.04 (0) | -0.07 (5) | -0.13 (6) | -0.14 (7) | -0.14 (7) | -0.14 (8) | -0.10 (6) | -0.07 (8) | -0.13 (7) | -0.04 (3) |
| 1999-03 | -0.02 (2) | -0.12 (7) | -0.05 (2) | -0.11 (7) | -0.04 (3) | -0.08 (6) | -0.12 (5) | -0.05 (3) | -0.10 (4) | -0.11 (5) | -0.10 (4) |
| 2004-08 | -0.08 (4) | -0.09 (5) | -0.05 (6) | -0.09 (6) | -0.06 (2) | -0.09 (6) | -0.11 (6) | -0.07 (4) | -0.08 (7) | -0.05 (1) | -0.01 (1) |
| 2009-13 | -0.06 (3) | -0.09 (5) | -0.12 (4) | -0.09 (5) | -0.12 (6) | -0.15 (7) | -0.08 (6) | -0.11 (7) | -0.08 (3) | -0.08 (3) | -0.09 (5) |
| | Mercosur | | | Non-Mercosur | | | | | | Brazil | |
| | ARG | URY | PRY | BOL | CHL | COL | ECU | PER | VEN | (Avg) | |
| 1994-98 | -0.02 (0) | -0.05 (0) | -0.16 (10) | 0.00 (0) | -0.11 (4) | -0.07 (0) | -0.13 (8) | -0.23 (10) | -0.03 (0) | -0.10 | |
| 1999-03 | -0.02 (0) | -0.04 (0) | -0.18 (11) | -0.15 (11) | -0.16 (11) | -0.11 (11) | -0.02 (0) | -0.08 (11) | -0.17 (11) | -0.08 | |
| 2004-08 | -0.04 (0) | -0.05 (0) | -0.01 (0) | -0.03 (0) | -0.06 (10) | -0.05 (0) | -0.04 (0) | -0.04 (0) | -0.01 (0) | -0.07 | |
| 2009-13 | -0.15 (11) | 0.00 (0) | -0.04 (0) | -0.04 (0) | -0.05 (0) | -0.06 (0) | -0.06 (7) | -0.05 (0) | -0.10 (11) | -0.10 | |

Note: Estimates of the coefficient β in equation (7), averaged over the respective country or region. The value in brackets indicates how many of the estimated coefficients are statistically significant at the 5 % level.

than those within the Brazilian currency area. A notable exception is Argentina after 2009, for which a relatively strong mean reverting process is found. While this might be a result of the introduction of the Brazilian-Argentinian bilateral local currency payment system in 2007, the finding should not be overrated, given the aforementioned problems with Argentina's price and nominal exchange rate data during the last years of my sample.

Linear models are often regarded as inappropriate tests for mean-reverting behavior in emerging markets, given that high transportation costs and other barriers to trade might impede the adjustment of smaller RER deviations in these countries due to missing incentives for arbitrage (Bahmani-Oskooee et al., 2008). To account for this critique, I also fit my data to a nonlinear band-threshold autoregressive (band-TAR) model (Obstfeld and Taylor, 1997; Sarno et al., 2004). In this model, real exchange rate changes are allowed to follow a random walk process for as long as deviations of the RER from its mean stay below a threshold value

c , which represents the barrier at which arbitrage profits become high enough for prices to adjust even in the presence of transportation costs.

$$\Delta q_{ij,t} = \begin{cases} \beta(q_{ij,t-1} - c) + e_{ij,t}^{out} & \text{if } q_{ij,t-1} > c \\ e_{ij,t}^{in} & \text{if } -c \leq q_{ij,t-1} \leq c \\ \beta(q_{ij,t-1} + c) + e_{ij,t}^{out} & \text{if } q_{ij,t-1} < -c \end{cases} \quad (8)$$

To find the optimal c , I employ a grid search across the 15 percent trimmed absolute values of Δq for a given RER, choosing the value that minimizes the sum squared error from the residuals e^{out} and e^{in} . The estimated coefficient β can then be interpreted as the speed of mean reversion outside the threshold band, analogous to β from the previous analysis, whereas c describes the width of the threshold band, i.e. the range of small RER changes for which no mean reversion occurs.

Results for the band-TAR estimation are presented in table 5. Evidence for mean reversion within the Brazilian currency area becomes much more substantial in this model: The average estimated β coefficient is both higher and more stable across time, with values between -0.57 and -0.59 during all subperiods but the crisis years. On the other hand, the threshold coefficient c is clearly declining over time, which is particularly relevant for regions in Southeastern and Northern Brazil. While this reduction can be partially explained by the general reduction in RER volatility within Brazil, given that c is a function of Δq , it can also be understood as a gradual reduction of barriers to goods and factor movements within the country. Overall, the results suggest that mean reversion has always been present within the Brazilian currency area, but that a better integration of peripheral regions in recent years has decreased the threshold for interregional arbitrage.

For South American real exchange rates, the picture is once again more mixed. The only countries for which β coefficients are comparable to the intra-Brazilian level during all subperiods are Paraguay, Chile, and Colombia, of which only Chile showed relatively low RER volatility in section 4.1. Argentina and Uruguay are again amongst the countries

Table 5: Mean Reversion of Monthly Real Exchange Rate Changes, nonlinear model

| | Southeast | | | South | | Central West | | Northeast | | North | |
|--|-----------|-------|-------|--------------|-------|--------------|-------|-----------|-------|---------------|-------|
| | SP | RJ | BH | PA | CU | BR | GO | SA | FO | RE | BE |
| <i>β coefficients</i> | | | | | | | | | | | |
| 1994-98 | -0.43 | -0.77 | -0.44 | -0.57 | -0.60 | -0.66 | -0.72 | -0.58 | -0.32 | -0.87 | -0.37 |
| 1999-03 | -0.06 | -0.71 | -0.40 | -0.47 | -0.17 | -0.47 | -0.62 | -0.35 | -0.34 | -0.46 | -0.51 |
| 2004-08 | -0.64 | -0.71 | -0.39 | -0.63 | -0.57 | -0.99 | -0.78 | -0.61 | -0.38 | -0.50 | -0.30 |
| 2009-13 | -0.54 | -0.58 | -0.75 | -0.57 | -0.52 | -0.67 | -0.55 | -0.62 | -0.43 | -0.45 | -0.59 |
| <i>c coefficients</i> | | | | | | | | | | | |
| 1994-98 | 0.21 | 0.27 | 0.15 | 0.13 | 0.12 | 0.11 | 0.12 | 0.12 | 0.15 | 0.14 | 0.29 |
| 1999-03 | 0.23 | 0.09 | 0.16 | 0.10 | 0.10 | 0.14 | 0.12 | 0.13 | 0.08 | 0.09 | 0.11 |
| 2004-08 | 0.11 | 0.09 | 0.16 | 0.12 | 0.15 | 0.10 | 0.11 | 0.12 | 0.08 | 0.13 | 0.11 |
| 2009-13 | 0.08 | 0.08 | 0.05 | 0.06 | 0.07 | 0.04 | 0.10 | 0.03 | 0.08 | 0.06 | 0.07 |
| | Mercosur | | | Non-Mercosur | | | | | | Brazil | |
| | ARG | URY | PRY | BOL | CHL | COL | ECU | PER | VEN | (Avg) | |
| <i>β coefficients</i> | | | | | | | | | | | |
| 1994-98 | -0.15 | -0.19 | -0.84 | 0.00 | -0.80 | -0.54 | -1.02 | -1.59 | -0.22 | | -0.57 |
| 1999-03 | -0.14 | -0.16 | -0.99 | -0.34 | -0.32 | -0.64 | -0.30 | -0.35 | -0.35 | | -0.41 |
| 2004-08 | -0.32 | -1.23 | -0.31 | -0.13 | -0.58 | -0.51 | -0.31 | -0.19 | 0.13 | | -0.59 |
| 2009-13 | -0.25 | -0.18 | -0.54 | -0.33 | -0.95 | -0.86 | -0.38 | -0.49 | -0.16 | | -0.57 |
| <i>c coefficients</i> | | | | | | | | | | | |
| 1994-98 | 0.39 | 0.28 | 0.48 | 0.53 | 0.54 | 0.58 | 0.40 | 0.30 | 1.98 | | 0.16 |
| 1999-03 | 2.56 | 0.25 | 0.84 | 0.41 | 0.16 | 1.08 | 5.25 | 1.54 | 0.19 | | 0.12 |
| 2004-08 | 0.38 | 1.07 | 1.70 | 0.53 | 1.78 | 1.01 | 0.73 | 0.69 | 1.65 | | 0.12 |
| 2009-13 | 0.10 | 1.66 | 1.53 | 1.30 | 0.80 | 0.91 | 1.27 | 1.30 | 0.51 | | 0.07 |

Note: Estimates of the coefficients β and c in equation (8), averaged over the respective country or region.

with the weakest evidence of mean reversion, which reaffirms doubts about their level of integration with Brazil. The threshold coefficient c is many times the intra-Brazilian size for all South American countries, showing that barriers to goods and factor price adjustment are still very present across the continent. Only Argentina has relatively low values of c after 1999, suggesting that barriers to arbitrage are not the main cause of the country's lack of mean reversion with Brazil. Values of c are much higher for the other two Mercosur countries, Uruguay and Paraguay, where adjustment barriers are apparently too high – or the respective country size deemed as too small – to trigger the necessary adjustment in goods and factor prices with Brazil.

On balance, the results in this section have not served to disperse the critical assessment of OCA in South America derived from the previous sections. The countries with the potentially lowest level of shock asymmetry with Brazil – Argentina and Uruguay – are also those where RER shocks are very persistent, indicating the need for measures to reduce transportation costs and to increase goods and factor mobility between these three countries before monetary union becomes feasible. Those countries where shocks to the RER are balanced out at a faster pace – Paraguay, Chile, and Colombia – suffer from relatively high RER volatility in the first place, which makes them less suitable candidates for a joint currency area with Brazil. It should also be noted that, according to the band-TAR model, countries with faster mean reversion tend to be those with a fully flexible exchange rate. Instead of supporting the case for a South American currency area, this result suggests that, for a large number of South American countries, full nominal exchange rate flexibility is warranted by their current level of shock asymmetry with Brazil.

5 Conclusion

Which South American countries are in a position to consider monetary union with Brazil? The answer, currently, is none. Taking regional data from the intra-Brazilian currency area to construct a relative benchmark for shock symmetry, my study shows that the real exchange rates of all Spanish-speaking South American countries vis-a-vis Brazil are much more volatile than intra-Brazilian real exchange rates, suggesting a high degree of shock asymmetry between Brazil and its neighbors. I also find that shocks in international RERs have more persistent effects than shocks observed within Brazil, which shows that cross-border adjustment mechanisms are not very strong.

The lowest volatility of RER shocks, relatively speaking, was found for Argentina and Uruguay. These countries observed low shock volatility with Brazil during the late 1990s, although my analysis of shock persistence shows that RER misalignments were still being accumulated during that period. Still, this result suggests that the most likely candidates

for an eventual monetary union with Brazil can be found in Brazil's Southern neighborhood, where the level of shock volatility is generally lower than in the Northern half of the continent. This indicates that Mercosur, not UNASUR, remains the best platform to advance monetary union in South America, and casts doubt on the compatibility of Mercosur's recent enlargement process with the ideal of an ever closer union between its members. Just as the EU, a rapidly expanding Mercosur might eventually find itself in a situation where only a group of "core" countries is able to further deepen regional integration.

If the project of monetary union in South America should be taken up again, this study has identified several tasks that need to be solved. The first one is a coordination of exchange rate policies between the countries most likely to form a currency union in the future, first and foremost between Brazil and Argentina. The results for the determinants of shock volatility showed that RER shocks are amplified if countries pursue fundamentally different exchange rate regimes, which implies that a true float in Argentina would likely improve the conditions for monetary union in Mercosur. In addition, the high persistence of RER shocks across South America implies that a viable monetary union would require far more policy measures to increase the free exchange of goods and factors, including people, across national borders, thereby ensuring a quicker adjustment of regional economies to asymmetric shocks.

These tasks are necessary prerequisites for a more favorable assessment of monetary union in the future. However, all South American policymakers in favor of a continental monetary union should realize that, for most of their countries, the local pattern of economic shocks is highly divergent from that in Brazil, and that monetary union would likely position them at the periphery of a Brazil-centered currency area. Comparing themselves with the more peripheral regions of the intra-Brazilian currency area today might help them to assess the potential benefits and costs of joining that area.

References

- Aiolfi, M., Catão, L. A. V., and Timmermann, A. (2011). Common factors in Latin America's business cycles. *Journal of Development Economics*, 95(2):212–228.
- Alesina, A. and Barro, R. J. (2002). Currency unions. *The Quarterly Journal of Economics*, 117(2):409–436.
- Bahmani-Oskooee, M., Kutan, A. M., and Zhou, S. (2008). Do real exchange rates follow a nonlinear mean reverting process in developing countries? *Southern Economic Journal*, 74(4):1049–1062.
- Beckworth, D. (2010). One nation under the fed? The asymmetric effects of US monetary policy and its implications for the United States as an optimal currency area. *Journal of Macroeconomics*, 32(3):732–746.
- Canova, F. (2005). The transmission of US shocks to Latin America. *Journal of Applied Econometrics*, 20(2):229–251.
- Daumal, M. and Zignano, S. (2010). Measure and determinants of border effects of Brazilian states. *Papers in Regional Science*, 89(4):735–758.
- Eichengreen, B. (1998). Does Mercosur need a single currency? *NBER Working Paper 6821*.
- Eichler, S. and Karmann, A. (2011). Optimum currency areas in emerging market regions: Evidence based on the symmetry of economic shocks. *Open Economies Review*, 22(5):935–954.
- Fischer, S. (2001). Exchange Rate Regimes: Is the Bipolar View Correct? *Journal of Economic Perspectives*, 15(2):3–24.
- Garcia Rocabado, D. (2010). The road to monetary union in Latin America: An EMS-type fixed exchange rate system as an intermediate step. *Würzburg Economic Papers 85*.

- Genna, G. M. and Hiroi, T. (2007). Brazilian regional power in the development of Mercosul. *Latin American Perspectives*, 34(5):43–57.
- Hallwood, P., Marsh, I. W., and Scheibe, J. (2006). An assessment of the case for monetary union or official dollarization in five Latin American countries. *Emerging Markets Review*, 7(1):52–66.
- IBGE (2013). IPCA e INPC: Ampliação da abrangência geográfica. *Nota Técnica 03/2013*.
- Kouparitsas, M. A. (2001). Is the United States an optimum currency area? An empirical analysis of regional business cycles. *Federal Reserve Bank of Chicago Working Paper 2001-22*.
- Larraín, F. and Tavares, J. (2003). Regional currencies versus dollarization: Options for Asia and the Americas. *The Journal of Policy Reform*, 6(1):35–49.
- Levy Yeyati, E. and Sturzenegger, F. (2000). Is EMU a blueprint for Mercosur? *Cuadernos de Economía*, 110:63–99.
- Licandro Ferrando, G. (2000). Is Mercosur an optimal currency area? A shock correlation perspective. *BCU Documento de trabajo 004-2000*.
- Morales Sarriera, J., Cunha, A. M., and da Silva Bichara, J. (2010). Moeda única no Mercosul: Uma análise da simetria a choques para o período 1995-2007. *Economía*, 11(2):465–491.
- Mundell, R. A. (1961). A theory of optimum currency areas. *American Economic Review*, 51(4):657–665.
- Obstfeld, M. and Taylor, A. M. (1997). Nonlinear aspects of goods-market arbitrage and adjustment: Heckscher’s commodity points revisited. *Journal of the Japanese and International Economies*, 11(4):441–479.

- Rockoff, H. (2000). How long did it take the United States to become an optimal currency area? *NBER Historical Working Paper 124*.
- Rose, A. K. and van Wincoop, E. (2001). National money as a barrier to international trade: The real case for currency union. *American Economic Review*, 91(2):386–390.
- Sarno, L., Taylor, M. P., and Chowdhury, I. (2004). Nonlinear dynamics in deviations from the law of one price: A broad-based empirical study. *Journal of International Money and Finance*, 23(1):1–25.
- von Hagen, J. and Neumann, M. J. M. (1994). Real exchange rates within and between currency areas: How far away is EMU? *The Review of Economics and Statistics*, 76(2):236–244.