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Intranational PPC for agricultural goods with structural breaks

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Summary
This paper analyzes the effect of structural breaks on the speed of convergence of six agricultural goods arranged in nine Brazilian cities. The choice for agricultural goods and for the intranational approach is due to the attempt to avoid the presence of some types of biases that reduce the speed of price convergence, such as: aggregation bias, sectorial bias and bias related to the volatility of the exchange rate and to trade barriers. From the results found, it was found that 90% of the combinations between cities and agricultural goods presented modification in the speed of convergence due to the presence of structural break. This result points out that economic instabilities can affect the dynamics of agricultural prices and that if disregarded, they can make the estimates of the half-life biased.
Keywords: Quebra estrutural. Convergência de preços. Paridade do poder de compra.

PPC Intranacional para bens agrícolas com quebras estruturais

Resumo
Os resumos (em fonte Arial, espaço simples, 11pt.), em parágrafo único, devem Este artigo analisa o efeito de quebras estruturais na velocidade de convergência de seis bens agrícolas em nove cidades brasileiras. A escolha dos bens agrícolas e da abordagem intranacional deve-se à tentativa de evitar o viés que afecta a velocidade da convergência como: viés de agregação, viés sectorial, volatilidade da taxa de câmbio e barreiras comerciais. Os resultados indicam que 90% da combinação boa-cidade altera a velocidade da sua convergência em presença de quebras estruturais. Este resultado indica que as instabilidades podem afectar a dinâmica dos preços agrícolas e, se negligenciadas, as estimativas tendenciosas dos rendimentos de meia-vida.
Palavras-chave: Quebra estrutural. Convergência de preços. Paridade do poder de compra.

1 Introducion

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The analysis of price convergence has been intensely debated in recent years. There are two reasons for this: on the one hand, the hypothesis of price convergence has been constantly assumed in models of international macroeconomics as in Backus, Kehoe and Kidland (1994), Mendoza and Yue (2012), Uribe and Schmitt-Grohé (2016) etc. On the other hand, although theoretically plausible, price convergence has not been verified in empirical studies.

Rogoff (1996) surveys the existing empirical literature and finds that the speed of price convergence across countries is quite high. This result became known as the Purchasing Power Parity (PPP) puzzle.

Many works have arisen since then, trying to verify why PPP took so long to occur. Several reasons were given, such as: sticky prices, comparisons of different baskets of goods between countries, the existence of tariff or non-tariff barriers, exchange rate volatility, structural breaks, among others.

Aiming to verify the validity of PPP, some authors have recently investigated price convergence across cities. This intranational approach significantly reduces some of the problems associated with PPP when compared internationally.

There are three advantages to using this approach. First, intranationally exchange rate volatility has no direct effect on PPP because cities are on the same currency. Second, there are no trade barriers that could impede the free movement of goods. Finally, problems associated with comparisons of different consumption baskets are reduced, given that the difference in consumption habits intranationally is much less heterogeneous.

Despite this initiative, there are still some possible biases that affect PPP. The time aggregation bias, identified by Taylor (2001), states that price indexes aggregated at different time frequencies, such as consumer price indexes, tend to increase the convergence time. Therefore, using prices not aggregated temporally could be a more interesting alternative than using price indexes.

Moreover, as Imbs et al. (2005) point out, calculating the speed of convergence disregarding the heterogeneity among productive sectors may cause a strong bias in the computation of PPP speed. This bias, called the sector bias, indicates that comparisons

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between price convergence are made across sectors. That is, the speed of convergence between the industrial and agricultural sectors, for example, may be different not because of noncompliance with the PPP, but because price formation is different.

This article investigates another source of bias regarding the speed of convergence of the PPP, which is the presence of structural breaks in the price series. Thus, we seek to verify whether structural breaks are relevant for measuring the speed of price convergence among Brazilian cities considering six agricultural goods: sugar, coffee, flour, meat, beans and rice.

The importance of structural breaks for price formation is quite relevant, especially in Brazil, which is configured as an unstable country (GOPINATH; AGUIAR, 2007). In fact, during the period under analysis there were several internal and external shocks that may have changed the way prices are formed, mainly by increasing asymmetric information. New Keynesian models such as Lucas (1976) and Phelps (1970) point out that changes in price expectations can alter price dynamics. This result has recently been confirmed by Drenik and Perez (2016).

The choice to analyze agricultural prices is due to two reasons. First, Brazil currently has one of the most important agricultural markets in the world, whether from a domestic or foreign market perspective. Therefore, understanding how prices are formed and how fast these prices converge can be useful to producers and consumers who seek to maximize their choices.

Second, unlike other approaches, analyzing price convergence between cities and with goods within the same sector allows one to avoid a number of biases that can hinder the inference about the speed of price convergence, especially the time aggregation bias and the sectoral bias. These biases are minimized when one chooses to use disaggregated and within-sector prices.

Thus, this paper will first estimate the existence of a possible date for the structural break in the relative price time series, considering São Paulo as the reference city. This identification will be made by an endogenous structural break test, developed by Andrews (1993). Subsequently, the convergence half-life, which is the most important measure to

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identify the speed of price convergence (IMBS et al, 2005), will be calculated for all goods and cities.

From the results, it appears that the existence of structural breaks in the relative price ratios significantly alters the speed of price convergence of agricultural goods. This result is valid for more than 90% of the combinations between goods and cities and indicates that disregarding the structural break on the PPP calculation may cause a bias.

This paper contributes to a growing literature that has recently been studying price convergence across cities such as Engel (1996), Engel and Rogers (1996), Cechetti, Mark and Sonora (2002), among others. A limitation of these works is due to the disregard of biases related to structural breaks, temporal and sectoral aggregation, which to some extent is avoided by the authors.

Moreover, this research corroborates recent findings of empirical work on the importance of structural breaks for the calculation of the speed of price convergence, even intranationally, as in Basher and Carrion-i-Silvestre (2009), Nath and Sakar (2011), Nath and Hegwood (2013), among others. However, unlike the previous findings, the result presented in this paper seeks to address other types of biases besides structural breaks and points to the importance of instabilities in agricultural price convergence.

This paper is organized in four more sections. In the next section, a discussion of the importance of measuring PPP and what it represents for economic agents is presented. Section 3 presents the econometric strategy and the database used. Section 4 discusses and presents the main results. Finally, section 5 discusses the conclusions of the paper.

2 Measuring Intranational PPP

According to Krugman and Obstfeld (2010, p. 291), "PPP theory explains exchange rate movements between two countries' currencies by changes in those countries' price levels. As such, purchasing power parity estimates can be derived from market exchange rates. That said, the domestic currency conversion rate should be such that it reflects the equality of purchasing power of the currencies in both countries (domestic and foreign),

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since PPP shows the amount of goods and services that can be purchased for each unit of local currency in different countries.

However, when different prices are observed for the same good between the different regions compared, there is an opening for arbitrage. Consequently, PPP will be validated in the short run, that is, the speed of price convergence tends to be high.

Several factors can increase the speed of price convergence, such as tariff barriers, transportation costs, currency and productive capacity volatility. Therefore, if the existence of these factors is not considered in competitive markets, prices are expected to converge to the same value more quickly (ENGEL; ROGERS, 1996).

There are several flaws and problems related to the PPP concept that prove the complexity in adjusting price levels. Authors such as Cecchetti et al. (2002), Krugman (2010), among others ratify this analysis of price levels. Tariff and non-tariff barriers combined with transportation costs are some of these problems that can cause permanent deviations from PPP. Thus, free trade between countries can be hindered or even prevented, because they raise the value of the product above equilibrium prices. For cases of non-tradable products, it is observed that these deviations have a longer duration (PALAIA; HOLLAND, 2010).

In this paper, we avoid some of the problems associated with the low speed of price convergence. This is due to the fact that, in unified economies, there are no problems related to tariff and non-tariff barriers - exchange rate volatility, because by having a unified currency, the nominal exchange rate is equal to one. Therefore, any change in the price level will correspond to a change in the real exchange rate between goods in different cities (SARAIVA, 2012).

However, even at the intranational level one can verify the low speed of convergence due to the existence of sticky prices. In their article, Vasconcelos and Lima (1999) explain why PPP is not valid in the short run. They report that, although there is variation in the exchange rate, producers may not adjust their prices proportionally for several reasons such as menu cost (MANKIW, 1985), informational problems (LUCAS, 1972), coordination failures, among others. When these factors are verified, what can be

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found are permanent PPP deviations, and for the cases of non-tradable products it is observed that these deviations have a longer duration (CHEUNG; FUJII, 2008).

Some researchers point to distance as one of the culprits of the deviations. Parsley and Wei (1996), Engel (1996), Engel and Rogers (2001), Ferrreira et al. (2008) revealed that the greater the distance between the cities compared, the lower was the rate of price convergence. Cecchetti, Mark and Sonora (2002) also point to distance and the price of non-tradable goods as responsible for this slow price convergence. Engel (1996) and Cecchetti, Mark and Sonora (2002) were the first to work with intra-national data.

Engel (1996) tried to investigate, based on the law of one price, the reasons why identical products suffer price variations when compared across different locations. His results showed distance as the cause of this volatility. According to Engel (1996), price divergence between two cities in different countries is greater than when compared between cities in the same country.

Cecchetti, Mark and Sonora (hereafter CMS) developed in 2002 a study on the validity of PPP with data for 19 cities in the United States for the period 1918 to 1995. CMS rejected the hypothesis of the presence of a unit root in the exchange rate data set and revealed that the deviations are temporary but surprisingly persistent with an average convergence speed of approximately 9 years. The explanation for the low convergence rate stems from problems related to distance between cities, asymmetric adjustments, and the presence of non-tradable goods.

Macroeconomic instability can affect the stochastic performance of the series over time, thus arising structural breaks in the series of national prices and nominal exchange rate (PALAIA; HOLLAND, 2009). Authors such as Basher and Carrion-i-Silvestre (2009), Gutierrez and Almeida (2013), among others, have found that the existence of structural breaks reduces the speed of convergence of the PPP.

Basher and Carrion-i-Silvestre (2009) in taking a fresh look at the work of CMS (2002) discussed the concepts and calculations of purchasing power parity in the face of structural breaks. They noted that when computing for the presence of structural breaks, the series results in stationarity and with an average convergence half-life of 1.5 to 2.65

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years. A much lower average half-life than the results of CMS (2002) and other authors. They make it clear in their research that not including the possible structural breaks occurring in the series can lead the researcher to incur distorted results.

Kannebley innovated in 2003 by testing PPP from unit root tests for the periods 1968 to 1994 considering the presence of structural breaks developed by Perron and Vogelsang (1992). According to Kannebley (2003), if the existence of structural breaks is not taken into account, the usual unit root tests could come out biased.

Hegwood and Nath (2013) investigated whether the presence of structural breaks were a relevant factor in achieving faster convergence of relative prices for 17 cities in the United States between 1918 and 2010. Their results were favorable to the existing literatures. Thus, they concluded that convergence becomes faster when structural breaks are observed in the series.

Nath and Sakar (2014) examined the Consumer Price Index - CPI series for seven Australian cities using quarterly data. Their results showed half-life estimates of 2.3 to 3.8 quarters. In their research, one can conclude that half-life estimates are lower when structural breaks and trend corrections are included.

Other works have also proven the importance of including structural breaks in the models. Papell and Prodan (2006) found evidence in favor of the PPP hypothesis for a sample of industrialized economies controlling for structural breaks. Gadea et al. (2004) is unable to reject the null hypothesis of unit root for a set of European real exchange rates when structural breaks were omitted. However, their analysis is reversed when structural breaks are incorporated.

In the Brazilian literature, there are no vast studies that address the effects of a structural break in a series for intranational prices. Among the works that report on the subject of structural breaks are: Kannebley (2003), Feijó and Morales (2008), Palaia and Holland (2009), among others that ratify biased results for the tests when the presence of structural breaks is not considered. Faced with the possibility of parameter instability, the very concept of PPC starts to be modified. Balassa (1964) and Samuelson (1964) state

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that it is not enough for the exchange rate to be simply stationary, it must be stationary in trend, thus defining this concept as "trend PPP" (TPPC).

In this conception of Balassa (1964) and Samuelson (1964), what actually generates the PPP is the productivity differential and not simply the price differential. Price is a reflection of productivity across countries, so more advanced countries will have much higher productivity. The TPPC is able to capture these productivity differential effects that generate deviations in PPP. Thus, for a better clarification of the PPP hypothesis, in this case, it is necessary to adapt these theories. Thus, the following generalizations emerge (BASHER; CARRIONI- SILVESTRE, 2009):

1- Quasi Purchasing Power Parity (QPPC): which tests whether real exchange rates are stationary - I (0) - in a fixed way around some level of change. This means that assuming there is presence of structural break in a given time series, the PPP will be valid between breaks (before and after the break it will be stationary), that is, around that change it will be stationary. What would not be possible to find such stationarity if the period as a whole is considered;

2- Qualified Trend Purchasing Power Parity (QPPP): that tests if the real exchange rates are stationary - I (0) - around a deterministic component given by a linear trend with level changes. This second concept is geared towards the conception of Balassa (1964) and Samuelson (1964) which, by introducing the deterministic component, checks whether the QPPC, nevertheless, is valid between breaks.

However, even when QPPC and TQPPC are valid, this does not necessarily mean that PPC will be true. Therefore, the validity of QPPS and QWCT in the presence of structural breaks is a necessary but not sufficient condition to ensure PPC (BASHER; CARRIONI-SILVESTRE, 2009).

Thus, when evidence is obtained in favor of TPPC and TQPPC, further investigations should be conducted. One should then apply the parity constraints on the coefficients of the first and last regime, so that they have the same sign and magnitude. Given this, it is noted that in the long run, the deterministic component does not change, becoming stationary. This implies that after the last breakdown has occurred, the

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deterministic component of the time series will be proportional to the period before the structural breakdown.

More recently, Barbosa et al. (2017) use panel structural break tests for 9 Brazilian cities correcting the price convergence speed calculation for the existence of two types of biases: temporal aggregation and Nickell bias. The results point to the presence of three structural breaks in the period between 1996 and 2016. Furthermore, correcting for the presence of structural break reduced the average convergence speed from 21 months to just over 5 months. These results were robust to the choice of reference city.

There is a high vulnerability of the agricultural sector with respect to supply and demand shocks. Especially when we observe natural factors controlling the quantity supplied - as an example, we have the excess or scarcity of rainfall - and the variation in the policy or economic conjuncture influencing the demand side, since the internal prices of agricultural products are strongly influenced by the external sector (MARGARIDO; BARROS, 2000). According to Margarido and Barros (2000), agricultural prices in Brazil (internal) became more sensitive to variations in external prices after the economic opening in 1990, the stabilization of domestic prices in 1994 and the implementation of the real plan.

Some works related to the convergence of agricultural products in the Brazilian market show not very satisfactory results such as Tabosa, Irffi and Penna (2014), Tabosa, Ferreira and Castelar (2014), Barbosa, Tabosa and Araújo (2016). The method used by them does not seem adequate, since they disregard biases arising from breaks present in the time series. And, as already exposed in several literatures, the half-life results change in the subsamples.

In view of the above and considering the concept of market integration, in which it is understood that the smaller the price disparity, the greater the degree of integration, Stigler and Sherwin (1985), it becomes relevant to examine whether the price indexes of disaggregated goods among the metropolitan regions of Brazil share the same trend. And, if proven, to measure what is the speed of reversal after a local shock. Thus, it will be possible to investigate whether the Brazilian intranational agricultural market is integrated and economically interdependent.

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3 Econometric approach and database

3.1 Data Basis

The data set extracted from IPEADATA - Institute for Applied Economic Research - corresponds to the period extending from January 1994 to July 2011. Monthly price information was compiled for sugar, rice, coffee, meat, flour and beans, all referring to the municipal food basket. These were examined in disaggregated form for 13 Brazilian cities representing their respective states, namely: Salvador - BA, Fortaleza - CE, Brasília - DF, Vitória - ES, Belo Horizonte - MG, Belém - PA, João Pessoa - PB, Recife - PE, Curitiba - PR, Rio de Janeiro - RJ, Natal - RN, Porto Alegre - RS and Florianópolis - SC.

Since Brazil's economic activity is strongly concentrated in the city of São Paulo, this, in turn, was the city considered as a comparison parameter. Only these cities were chosen due to insufficient data for the others.

3.2 Metodology

As an analysis of the validity of cross-city PPP is intended, it is important to note that monetarily unified regions have the nominal exchange rate equal to one. Therefore, price differences between these regions are a result of the impact generated on the real exchange rate, not the nominal exchange rate. Mathematically, the real exchange rate is described as:

(1)

Where: is the real exchange rate between city i and base city j at time t. E is the price of a certain good in an analyzed city i and is the price of the same good in the base city j. Therefore, (is the ratio that expresses the relative prices of the same good between different cities.

In this context, the real exchange rate will be equal to the ratio of prices between the base city (São Paulo) and the other cities. By applying logarithm to both sides of (1), we have the relative price in percentage terms of the prices of city i in relation to city j.

(2)

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It is of great importance to identify whether the series studied is stationary or not, because statistical inferences can be wrongly calculated if we are working with random walk models. In this study, the ADF test will be applied assuming no drift and no trend, as this is the functional form most often used in the empirical literature and also because it is theoretically more plausible.

Let be an autoregressive model (AR(1)) given by the equation below:

(3)

Where: is white noise. After estimating (3), the calculation of the half-life is easily obtained from:

(4)

In the face of structural breaks, the parameter r undergoes changes in its level. This, therefore, changes the convergence half-life. With this, one can infer that the half-life itself depends on the structural break. That is, assuming that the date of the break occurs on , with t = 1, ..., , ..., T. Then:

$$H_{1:\tau^*} = \frac{ln\ 0.5}{ln\ \hat{\rho}_1} \quad (5)$$

$$H_{\tau^*+1::T} = \frac{ln\ 0.5}{ln\ \hat{\rho}_2} \quad (6)$$

Therefore, identifying the structural breaks will allow us to obtain two half-lives before and after the break.

To identify the correct date of the break, the Andrews-Chow test will be used. This test, in brief, seeks to verify whether, in fact, a structural change has occurred in the series within a given period, observing whether the parameter values (intercept, angular coefficient or both) remain or not the same throughout the studied time.

To apply the Chow test, it is necessary to estimate a model assuming the structural break restriction in a given period . From each of the regressions, the restricted sum of

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squares of the residuals () is obtained. This value will be compared to the model without assuming the presence of breakage in , by means of the unrestricted sum of squares ().

The null hypothesis of Chow's test is that the restricted sum of squares, that is, before and after the break, is equal to the sum of squares of the residuals of the unrestricted model.

(7)

Where: correspond to the SQR of the restricted model before and after the structural break. If such a hypothesis is rejected, then there is significant evidence that it represents a structural break.

One problem associated with Chow's test is that the choice of the date of the break is performed exogenously, that is, one resorts to intuition or graphical resources to determine the possible date of the break. Andrews (1993) proposed a structural break test that allows the choice to be made endogenously. That is, it establishes a statistical criterion to determine the possible date of structural failure.

The procedure is quite simple. Suppose it is Chow's test statistic for the assumed structural break at t. Thus, one can calculate the test statistic for all t =1, ...,T. With this one has the following vector containing the test statistic for each period:{.

Andrews (1993) established as test statistic for the endogenous structural break the largest value of the sequence of Chow's test statistics, that is:

$$\hat{F}^{*}_{\tau} = \max \{\hat{F}_t\}_{t=1}^{T} \quad (8)$$

To implement this test it is necessary to reserve a period of the sample over which the structural break will not be checked, called trimming. This usually corresponds to the initial and final period of the time series (10% or 15%). The need for trimming derives from the impossibility of estimating the sum of squares of the residuals for very small samples. This work will adopt as trimming the first 15% and the last 15% of the sample, leaving 70% over which the presence of the structural break will be verified.

4 Results

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This section discusses the main results found after applying the Sup-Wald test for structural breaks, the analysis of the stationarity between the break periods when they occur, and the verification of whether the identification of such instabilities allows a reduction in the half-life of convergence of the price series.

Table 1 presents the results of the Andrews test applied to the relative prices between the Brazilian cities for each of the six goods (Sugar, Rice, Coffee, Flour, Beans and Meat). It can be seen that for all the goods, at least one city exhibited a structural break in the relative prices. This makes evident the influence that structural breaks can have on the series.

In fact, for sugar, only the cities of Salvador, Belo Horizonte and Florianopolis did not present instabilities in the parameters. As for rice, the cities that presented structural breaks were Salvador, Brasilia, Belo Horizonte, Rio de Janeiro and Florianopolis. In turn, coffee was the item that presented the least instability in the parameters, and this only occurred in the cities of Fortaleza, Brasília, Belém and Curitiba.

The cities of Salvador, Brasilia, Vitória, Belo Horizonte and Natal did not present any instability in the analyzed period for flour. Similarly, the cities of Salvador, Fortaleza, Belo Horizonte, João Pessoa, Natal and Porto Alegre did not show the presence of structural break for beans. Finally, Salvador, Brasilia, Curitiba and Porto Alegre also did not register instabilities in the parameters for the meat good.

In summary, the city that exhibited the most structural breaks in the period among all the goods was the city of Belem, not exhibiting instability only for the rice item. On the other hand, the city that showed the least instability was Salvador. It showed a change in the parameter only for rice.

Most of the structural breaks occurred in the years 2002 and 2008. In 2008, such instabilities in the parameters may be a result of the global financial crisis that started in mid-2007. In turn, 2002 is marked as the year that began the Lula government. This, due to market expectations, was a very unstable year (GIAMBIAGI et al., 2005).

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In 1999, the items that suffered the greatest impact on the value of the break were sugar and beans. The impact suffered by sugar in Natal reached 9.147 and beans reached 6.212 in Belém. Coffee and meat, on the other hand, had their highest break point in 2007. Coffee reached 4.449 in Belem and meat reached 8.172 in Belo Horizonte. The highest break point suffered by rice was in May 2006 in Brasilia with 7.458 and flour was in May 2008 with the highest impact of approximately 7.305 in Porto Alegre.

Tabela 1: Teste de Andrews para preço relativo de bens agrícolas

Sugar			Coffee			Beans		
Capital	Date of Breakage	Breakage Value	Capital	Date of Breakage	Breakage Value	Capital	Date of Breakage	Breakage Value
BA	-	-	BA	-	-	BA	-	-
CE	2002.09	4.783	CE	2008.02	3.738	CE	-	-
DF	1996.12	4.551	DF	2005.10	4.388	DF	2008.02	4.111
ES	2004.02	6.420	ES	-	-	ES	1998.01	4.449
MG	-	-	MG	-	-	MG	-	-
PA	2004.04	5.143	PA	2007.03	4.449	PA	1999.07	6.213
PB	2002.09	4.915	PB	-	-	PB	-	-
PE	2000.02	6.414	PE	-	-	PE	2008.10	5.484
PR	2004.10	7.029	PR	1998.09	3.786	PR	1997.12	3.772
RJ	2007.10	4.087	RJ	-	-	RJ	1997.12	4.688
RN	1999.04	9.148	RN	-	-	RN	-	-
RS	2000.07	4.384	RS	-	-	RS	-	-
SC	-	-	SC	-	-	SC	1997.12	4.151
Rice			**Flour**			Meat		
Capital	Date of Breakage	Breakage Value	Capital	Date of Breakage	Breakage Value	Capital	Date of Breakage	Breakage Value
CE	-	-	CE	1998.05	4.289	CE	2000.06	4.906
DF	2006.05	7.458	DF	-	-	DF	-	-
ES	-	-	ES	-	-	ES	2001.03	5.146
MG	2001.10	4.620	MG	-	-	MG	2007.06	8.172
PA	-	-	PA	1996.10	4.225	PA	1999.11	5.230
PB	-	-	PB	2002.11	4.162	PB	2003.06	7.017
PE	-	-	PE	2002.11	3.820	PE	1999.05	4.207
PR	-	-	PR	2008.07	4.726	PR	-	-
RJ	2000.04	4.596	RJ	2008.06	4.164	RJ	2006.06	5.796
RN	-	-	RN	-	-	RN	2002.03	4.454
RS	-	-	RS	2008.05	7.306	RS	-	-
SC	2008.11	4.367	SC	2008.05	1.010	SC	1997.01	3.847

Fonte: Elaboração dos autores.

Table 2 presents the ADF test results applied for full sample and between break periods when they occurred. An important limitation of this methodology and what significantly reduces the power of the ADF test and the half-life analysis is the sample size between breaks. For the ADF test to generate reliable results in both periods, before and after the structural break, it is necessary that the break occurred between 1998.12 and 2006.08. If the instability occurs before 1998.12 and after 2006.08 the sample size will be reduced to a size smaller than sixty observations, thereby impairing inference in this

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subsample. In Table 2, ADF 1 indicates the ADF test applied before the structural break and ADF 2 the break after the break date.

The advantage of using the ADF test between breaks is that the series is expected to be stationary before and after the break. Thus, if the ADF test indicates stationarity of the series before and after the break, this fact will represent evidence in favor of the validity of the PPP for the periods between breaks, as based on the QPPC theory cited by Basher and Carrion-i-Silvestre (2009).

From the analysis of Table 2, it can be seen that the indication of the date of the break did not significantly alter the results of the ADF test. In fact, for sugar, the stationarity before and after the break was verified whenever the test, without considering break, indicated stationarity, with the exception of Rio de Janeiro and João Pessoa. For rice, the cities of Salvador and Brasilia presented evidence of stationarity after the break, even though they did not indicate stationarity without the break. For this case, Belo Horizonte showed stationarity only in the post-break.

For coffee, post-breakup also showed stationary results for the cities of Fortaleza, Brasilia, Belem and Curitiba. However, for Fortaleza, Belem and Curitiba the date of the breakdown allowed a reduced post-breakdown subsample outside the reliable value. For flour, all indications of post-breakdown stationarity also occurred when considering the full sample, except Porto Alegre.

Finally, beans and meat exhibited little stationarity. Meat was stationary only in the sample before the structural break. Beans, on the other hand, indicated the presence of stationarity more frequently in the post-breakdown sample, following the pattern of most goods.

These results were, in a way, already expected. The fact of the existence of the structural break impairs the inference of the ADF test. Thus, when indicating stationarity for the full sample, the test disregarded the presence of the structural break. However, when controlling for the date of the break, stationarity was presented only for one of the periods, before or after the break.

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Finally, table 3 displays the results of the Half-Life (MV) estimation. This, as already commented, shows in how many periods price convergence will occur. In the case of this analysis, the frequency is being counted in months, so the half-life indicates in how many months relative prices will return to the long-run trend. Again in Table 3, the values reported as MV 1 and MV 2 represent the half-life of convergence before and after the estimated date of structural break, respectively.

From the results, it can be seen that the presence of the structural break reduces the half-life of relative prices in most cases, either before or after the break date. For the sugar good, there was an improvement in the speed of convergence before the break for the cities of Fortaleza, Distrito Federal, Vitória, Recife, Rio de Janeiro, and Porto Alegre. For after the crash, the cities of João Pessoa, Curitiba and Natal. The city of Belém was the one that presented the longest time for convergence to occur.

Table 2: Test ADF

Sugar				**Coffe**				**Bean**			
Capital	ADF Unbroken	ADF 1	ADF 2	Capital	ADF Unbroken	ADF 1	ADF 2	Capital	ADF Unbroken	ADF 1	ADF 2
BA	-3,326*	-	-	BA	-1.137	-	-	BA	-0.707	-	-
CE	-2,370*	- 2,087*	-1.445	CE	-0.759	0.280	-2,295*	CE	-0.798	-	-
DF	-0.205	0.851	-0.386	DF	-1.666	-0.169	-2,643*	DF	-3,602*	-2,114*	-2,932*
ES	-1,978*	-1.632	-1.335	ES	-0.808	-	-	ES	-2,483*	-0.467	-2,008*
MG	-1.644	-	-	MG	-1.915	-	-	MG	-1.249	-	-
PA	-0.950	-0.241	-1.038	PA	-1.274	0.192	-2,696*	PA	-2,569*	-2,139*	-1.768
PB	-1.770	-0.172	-3,000*	PB	-0.831	-	-	PB	-0.951	-	-
PE	-3,823*	-2,770*	-2,392*	PE	-1.301	-	-	PE	-1.38	-0.993	-1.728
PR	-2,849*	-1,998*	-1.932	PR	-1.025	0.229	-2.675	PR	-2,670*	-3,031*	-2,156*
RJ	-1.339	-2,028*	0.680	RJ	-1.299	-	-	RJ	-2,276*	-2,381*	-1.676
RN	-2,327*	-0.403	-3,430*	RN	-0.790	-	-	RN	-0.788	-	-
RS	-2,016*	-0.558	-2,158*	RS	-1.084	-	-	RS	-1,996*	-	-
SC	-0.719	-	-	SC	-0.991	-	-	SC	-3,367*	-2,560*	-2,726*
Rice				**Flour**				**Meat**			
Capital	ADF Unbroken	ADF 1	ADF 2	Capital	ADF Unbroken	ADF 1	ADF 2	Capital	ADF Unbroken	ADF 1	ADF 2
BA	-1.412	-0.397	-2,294*	BA	-2,675*	-	-	BA	-0.056	-	-
CE	-1.784	-	-	CE	-2,357*	-1.103	-2,495*	CE	-0.928	1.167	-1.706
DF	-1.091	0.722	-4,382*	DF	-1.921	-	-	DF	-1.145	-	-
ES	-1.189	-	-	ES	-2,191*	-	-	ES	-0,299*	0.030	-2.122
MG	-1,962*	-0.671	-3,486*	MG	-1.542	-	-	MG	-0.852	-0.516	-1.025
PA	-1.718	-	-	PA	-2,472*	-0.973	-2,262*	PA	-0.221	0.749	-1.387
PB	-0.878	-	-	PB	-2,823*	-0.410	-6,021*	PB	-1.249	-1,997*	-0.906
PE	-0.951	-	-	PE	-3,088*	-0.468	-4,233*	PE	-0.189	-0.380	-0.274
PR	-1.283	-	-	PR	-0.400	-0.831	0.726	PR	-1.82	-	-
RJ	-0.162	-0.113	-0.143	RJ	-2,189*	-1.585	-2,782*	RJ	0.189	-0.378	0.744
RN	-2,115*	-	-	RN	-2,993*	-	-	RN	-2,392*	-1.801	-1.436
RS	-1.206	-	-	RS	-0.634	-0.889	-2,993*	RS	-1.061	-	-
SC	-1.625	-1.536	-0.971	SC	-2,926*	-2,566*	-1.057	SC	-1.073	-2,868*	-1.129

Fonte: Elaboração dos autores.
*Indica que não houve rejeição da hipótese nula a 5% de significância.

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Tabela 3: Cálculo da meia-vida de convergência entre quebras estruturais

Sugar				Coffe				Bean			
Capital	MV Unbroken	MV 1	MV 2	Capital	MV Unbroken	MV 1	MV 2	Capital	MV Unbroken	MV 1	MV 2
BA	3.287	-	-	BA	27.554	-	-	BA	14.810	-	-
CE	7.770	7.051	7.950	CE	41.571	53.460	48.863	CE	9.063	-	-
DF	14.139	6.841	16.863	DF	11.185	12.695	51.550	DF	7.680	12.157	6.979
ES	3.893	2.447	10.589	ES	39.730	-	-	ES	8.768	4.326	13.532
MG	6.380	-	-	MG	19.435	-	-	MG	6.544	-	-
PA	22.713	34.060	28.118	PA	11.002	12.347	73.115	PA	4.210	6.319	3.845
PB	7.668	16.569	3.584	PB	47.746	-	-	PB	10.459	-	-
PE	2.435	2.251	2.651	PE	25.724	-	-	PE	6.795	4.256	1.335
PR	3.502	4.903	0.999	PR	19.327	18.991	5.834	PR	9.841	9.548	9.515
RJ	4.749	3.675	9.779	RJ	9.175	-	-	RJ	10.453	6.139	14.273
RN	3.634	4.557	2.801	RN	36.066	-	-	RN	11.613	-	-
RS	1.678	1.530	1.891	RS	24.175	-	-	RS	14.273	-	-
SC	4.588	-	-	SC	17.742	-	-	SC	6.821	5.587	8.319
Rice				Flour				Meat			
Capital	MV Unbroken	MV 1	MV 2	Capital	MV Unbroken	MV 1	MV 2	Capital	MV Unbroken	MV 1	MV 2
BA	18.701	28.463	16.049	BA	11.880	-	-	BA	28.861	-	-
CE	11.360	-	-	CE	10.933	14.564	9.530	CE	12.754	12.174	18.565
DF	6.128	10.812	1.027	DF	6.106	-	-	DF	3.605	-	-
ES	15.408	-	-	ES	6.670	-	-	ES	10.024	9.927	9.728
MG	2.069	4.860	0.735	MG	10.870	-	-	MG	10.077	10.497	36.490
PA	34.105	-	-	PA	20.529	13.672	22.434	PA	30.781	19.002	105.356
PB	25.296	-	-	PB	13.370	10.099	13.998	PB	5.877	3.073	12.823
PE	25.687	-	-	PE	11.266	15.987	3.049	PE	35.466	9.718	47.126
PR	4.934	-	-	PR	56.375	40.237	168.372	PR	1.737	-	-
RJ	32.595	2.790	40.388	RJ	5.548	6.041	3.007	RJ	25.847	17.875	51.430
RN	44.805	-	-	RN	9.586	-	-	RN	1.850	2.002	1.706
RS	4.540	-	-	RS	0.235	21.852	96.595	RS	8.973	-	-
SC	11.619	11.839	8.249	SC	2.088	2.034	3.069	SC	4.893	4.560	4.874

Fonte: Elaboração dos autores.

For rice, the half-life often improved after the break date. The cities that exhibited such a pattern were Salvador, Brasilia, Belo Horizonte and Florianopolis. The only city that exhibited improvement before the break date was Rio de Janeiro. For the coffee commodity, the half-life was reduced only for the city of Curitiba, which showed an improvement in convergence for both before and after the break date.

In relation to flour, there was a reduction in the speed of convergence before the break for the cities of Belém, João Pessoa, Curitiba and Florianopolis. In relation to the sub-sample after the crash, the cities of Fortaleza, Recife and Rio de Janeiro presented an improvement in the speed of convergence. The item beans presented a reduction in the half-life before the break in the cities of Rio de Janeiro, Curitiba, Florianopolis, Recife and Vitória. On the other hand, for the period after the crash, the cities Distrito Federal, Belém, Recife and Curitiba.

In January 1997, in the city of Florianópolis and in March 2001, in the city of Vitória, the meat presented an improvement in the half-life before and after the crash, thus, one

can verify the expected PPP with an improvement in convergence for both subsamples. Another item that also showed satisfactory results, with improvement in the half-life for before and after the break, was beans in the city of Curitiba in December 1997 and in the city of Recife in October 2008.

Finally, for meat, the cities that reduced the half-life before the break were Fortaleza, Vitória, Belém, João Pessoa, Recife, Rio de Janeiro and Florianópolis. For the sample after the crash, we have the following cities Vitória, Natal and Florianópolis.

The years 1997 and 2000 were the years that had the highest number of convergences before the crash. For the post-breakup period, the years that contributed the most to convergence were 2002 and 2008.

The results obtained here are satisfactory, with half-life estimates of up to 3 years for most of the cities and items investigated here. Which is quite small compared to estimates from other work with results for half-lives among North American cities. And an appropriate result, since the international standard for average half-life is around 3 to 5 years. This shows a rapid reversal of the price level parity in Brazil. Therefore, evidence that Brazilian cities are economically integrated and interdependent can be ratified.

The results seem to point to two conclusions. First, the presence of structural breaks in the relative price series among Brazilian cities interferes with the speed of convergence. This can be quickly evidenced because of the 43 cities/goods analyzed that presented parameter instability, 37 exhibited a reduction in the half-life of the series before or after the structural break. This result is quite relevant and indicates that the purchasing power parity, when exchange rate volatility, the presence of trade barriers and the existence of heterogeneous baskets are controlled, is still affected by instabilities in the parameters.

Such a finding contributes to a growing literature that has been identifying structural breaks as one of the relevant factors for the persistence of relative price series, such as Papell and Prodan (2006), Basher and Carrion i Silvestre (2011), Hedwood and Nath (2013), among others. According to the fact that there is no homogeneity in the improvement of the half-life before or after the structural break may be caused by some

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methodological limitations, such as: the reduction of degrees of freedom in subsamples, the presence of multiple structural breaks and the nature of the goods themselves. Regarding the nature of the good considered, we observe goods such as flour that evidenced similar amount of half-life improvements before and after the break. On the other hand, in goods such as rice, the highest frequency of convergence speed reductions was after the break. Sugar and meat, on the other hand, showed improvements after the crash.

5 Final considerations

This paper sought to investigate whether the presence of structural breaks interfered with the persistence of relative price deviations for Brazilian cities. Six goods from the consumer basket were chosen: sugar, rice, meat, coffee, flour and beans.

The choice to analyze intranationally such goods is due to the possibility of controlling for some of the problems usually attributed to failures in the persistence of price deviations such as: the heterogeneity of the consumer baskets, the volatility of the exchange rate, the presence of tariff or non-tariff trade barriers. To identify the presence of structural break, we used the endogenous test developed by Quandt (1958) and extended by Andrews (1993). Such a test allows the endogenous identification of the date of the break, unlike the Chow test, whose way of identifying the date of the break is done exogenously to the data.

After identifying the date of the break, an ADF test is run and the speed of convergence between structural breaks is estimated. The basic hypothesis is that instability in the parameters could increase the persistence of relative prices. The results proved satisfactory, with half-life estimates of up to 3 years for most of the cities and items investigated here.

From the implications, we conclude that structural breaks are a relevant factor in determining the persistence of price deviations for Brazilian cities. In fact, of the 43 structural breaks identified, 37 showed a reduction in the speed of price convergence.

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These results, focused on the Brazilian economy, are consistent with other studies of other economies. He innovates by showing his main conclusion, which is that structural breaks are strong factors for increasing the persistence of the price series. That is, structural breaks, when not controlled for, can result in biased estimates, causing no convergence and therefore invalidating purchasing power parity.

For a future study it is left to identify multiple structural breaks such as the Bai and Perron (1998) test and their implications for price convergence. An alternative could be the use of panel data as in Hedwooth and Nath (2013), Basher and Carrion i Silvestre (2011).

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