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Domestic Market Integration and the Law of One Price in Brazil

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Abstract

This paper presents the first assessment domestic market integration in Brazil using the law of one price. The law of one price is tested using two panel unit root methodologies and a unique data set comprising price indices for 51 products across 11 metro-areas. We find that the law of one price holds for most tradable products and, not surprisingly, non-tradable products are found to be less likely to satisfy the law of one price. While these findings are consistent with evidence found for other countries, price convergence occurs very slowly in Brazil, suggesting relatively limited domestic market integration.

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1. INTRODUCTION

Brazil is the fifth largest country in the world by population and landmass and has the seventh largest economy. Yet little is known about the extent of domestic market integration in Brazil. Recent research has shown that Brazil has relatively poor infrastructure (cf. Garcia-Escribano, Góes, and Karpowicz, 2015) suggesting that there are significant barriers to intra-regional trade and limited domestic market integration.

In this paper, we examine domestic market integration in Brazil using the law of one price for the first time. Since the seminal work by Parsley and Wei (1996), the use of a panel unit root methodology to investigate the prevalence of the law of one (LOOP) on intra-country trade has increased (see, for instance, Li and Huang, 2006, and Fan and Wei, 2006). An overwhelming majority of the literature finds that the LOOP holds within countries. We extend the literature by assessing price convergence within Brazil for 51 products (33 tradables and 19 non-tradables) across 11 metro-areas over 14 years.

Two recent panel unit root testing methodologies (Levin, Lin, and Chu, 2002, and Im, Pesaran, and Shin, 2002) suggest that LOOP holds for most tradable products in Brazil and, not surprisingly, non-tradable products are found to be less likely to satisfy LOOP. While these findings are similar to other studies, we find that price convergence occurs relatively slowly, suggesting limited domestic market integration.

2. METHODOLOGY

If goods markets are fully integrated, then the difference between the (log) price levels for a tradable product in different cities should be stationary. This implies that there should be co-integration for all pairs of cities i and j: algebraically, $\left.p_{it}-p_{jt}\right)\sim I(0)\;\forall\, i,j$ or, equivalently, $(p_{i,t}-\bar{p}_t)\sim I(0)\;\forall\, i$, with $\bar{p}_t=N^{-1}\sum_{i=1}^{N}p_{i,t}$. If $p_{i,t}^{*}=(p_{it}-\bar{p}_t)\sim I(0)\;\forall\, i$, then $p_{i,t}^{*}$ is stationary, $p_{i,t}$ is cointegrated, and the LOOP holds.

Two panel unit root tests that build on the Augmented Dickey-Fuller (ADF) framework are used, Levin and others (2002) and Im and others (2002), henceforth, LLC and IPS, respectively. The most important difference between these two methodologies is that LLC impose the parameter of interest ρ (defined below) to be same for all individuals, while IPS relax this assumption.

Both methods start by estimating individual ADF equations using time-effect-treated price indices $p_{i,m,t}^{*}\equiv p_{i,m,t}-\bar{p}_{m,t}$ for every city i=[1,2,…,11] and product m=[1,2…,51]. For each product m, the basic model is:[1]

$$\Delta p_{i,m,t}^{*}=\tilde{c}_{i,m}+\sum_{k=1}^{K_{i,m}}\phi_{i,m,k}\Delta p_{i,m,t-k}^{*}+(\rho_{i,m}-1)p_{i,m,t-1}^{*}+\eta_{i,m,t} \qquad (1)$$

[1] In this paper, the lag length k is determined using the Akaike information criterion separately for each equation.

The LLC framework uses two auxiliary regressions to dissipate individual-specific dynamics:

$$p^*_{i,m,t} = \hat{\alpha}_{1,i,m} + \sum_{k=1}^{K_{i,m}} \phi_{i,m,k} \Delta p^*_{i,m,t-k} + \hat{e}_{i,m,t} \quad (2)$$
$$\Delta p^*_{i,m,t-1} = \hat{\alpha}_{2,i} + \sum_{k=1}^{K_{i,m}} \phi_{i,m,k} \Delta p^*_{i,m,t-k} + \hat{v}_{i,m,t-1} \quad (3)$$

and takes the averaged residuals of (1) to standardize $\hat{e}_{i,m,t}$ and $\hat{v}_{i,m,t}$, resulting in $\tilde{e}_{i,m,t}$ and $\tilde{v}_{i,m,t}$. The panel model is then estimated to calculate an asymptotically-normal Z-statistic, that is:

$$\tilde{v}_{i,m,t} = (\rho_{i,m} - 1)\tilde{e}_{i,m,t-1} + \xi_{i,m,t}, \qquad \rho_{i,m} = \rho_m \ \forall \ i \quad (4)$$
$$t_{\rho_{NT}} = \left[\left(N^{-1} \sum_{i=1}^{N} \xi^2_{i,m,t} \right) \sum_{i=1}^{N} \sum_{t=2+K_{i,m}}^{T} \tilde{e}^2_{i,m,t-1}\right]^{-\frac{1}{2}} \sum_{i=1}^{N} \sum_{t=2+K_{i,m}}^{T} \tilde{e}_{i,m,t-1} \xi_{i,m,t} \quad (5)$$
$$Z^{LLC} = v^{-\frac{1}{2}}(t_{\rho_{NT}} - \mu\sqrt{N}) \quad (6)$$

where with μ and v can be found in LLC.

Similarly, following IPS, (1) is estimated and individual t-statistics for i cross sections are calculated and used to compute an asymptotically-normally-distributed panel Z_{t-bar} statistic. Autoregressive parameters $\rho_{i,m}$ are allowed to vary individually. The Z_{t-bar} statistic is:

$$Z_{t-bar} = \frac{\sqrt{N}\left(N^{-1} \sum_{i=1}^{N} t_{i,m} - N^{-1} \sum_{i=1}^{N} E[t_{i,m} | \rho_{i,m} = 1]\right)}{\sqrt{N^{-1} \sum_{i=1}^{N} Var[t_{i,m} | \rho_{i,m} = 1]}}, \quad \rho_{i,m}(\bar{\rho}, \sigma^2_{\rho_{i,m}}) \quad (7)$$

where $E[t_{i,m} | \rho_{i,m} = 1]$ and $Var[t_{i,m} | \rho_{i,m} = 1]$ can be found in Im and others (2002).

For those processes that are not explosive, half lives $h_{i,m}$ are computed from the individual ADF regressions (1) and the pooled (4):

$$h_{i,m} = \frac{\ln(0.5)}{\ln(|\rho_{i,m}|)}, \ |\rho_{i,m}| < 1 \ \forall \ i \quad (8)$$

3. DATA

We constructed a new dataset of price indices for 51 products categories across 11 metro-areas using extended CPI (IPCA) microdata; the original data were seasonally adjusted monthly percent changes, which we transformed into price indexes. We then used CPI weights to construct indices for the 51 product categories we analyze. Our original sample starts in August 1999, when the inflation targeting regime begins. After transforming the data, however, we dropped first 18 months to avoid potential bias from the fact that all price indices arbitrarily have the same value by the beginning of the sample. After such adjustments, the final sample ranges from January 2002 to July 2014.

4. RESULTS

The empirical evidence in support for domestic market integration in Brazil is mixed at best. While LOOP seems to hold for most tradable products, the speed of convergence towards the national long-run trend is very slow.

Figure 1 below summarizes the aggregate results, after categorizing the 51 products as being either tradable or non-tradable. At the 10 percent significance level, using IPS, we reject the null hypothesis of a unit root for almost 70 percent of tradable products, while LLC rejects the null hypothesis for just under half of all tradable products. Despite (expected) divergences in rejection rates due to methodological differences, the results are broadly consistent: both LLC and IPS suggest that non-tradable product prices tend to have unit roots more frequently than tradable product prices. Table 1 details the product-specific p-values for both tests.

Figure 1: Panel Unit Root Tests Results
(percent rejection of null hypothesis of a panel unit root under different levels of significance, per methodology)

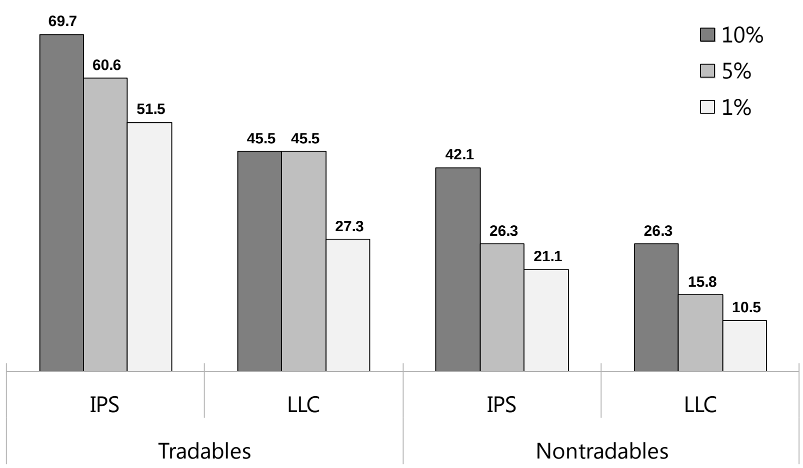


Table 1. Panel Unit Root Tests

	Description	**IPS p-value**	**LLC p-value**
Tradables	Cereals, seeds and oilseeds	0.000***	0.000***
	Flours and pasta	0.001***	0.019**
Correlation	Tubers, roots and legumes	0.000***	0.000***
of IPS & LLC	Sugars and derivatives	0.000***	0.009***
p-values:	Vegetables	0.000***	0.000***
	Fruits	0.000***	0.000***
0.65	Meats	0.000***	0.001***
	Fishes	0.058*	0.644
	Processed meat and fish	0.043**	0.491
	Poultry and eggs	0.000***	0.000***
	Milk and dairy products	0.000***	0.170
	Bakery products	0.003***	0.031**
	Oils and fats	0.000***	0.020**
	Beverages and infusions	0.000***	0.047**
	Canned and preserved foods	0.484	0.210
	Salt and spices	0.137	0.443
	Pre-cooked meals	0.001***	0.017**
	Cleaning chemicals	0.623	0.622
	Fuels (domestic)	0.000***	0.011**
	Residential electricity	0.003***	0.153
	Furniture	0.626	0.641
	Utensils and ornaments	0.568	0.288
	Bed, bath and table	0.075*	0.632
	Domestic appliances	0.080*	0.346
	TV, stereos and computers	0.137	0.315
	Menswear	0.037**	0.157
	Women's clothes	0.323	0.607
	Children clothes	0.034**	0.207
	Shoes and accessories	0.175	0.725
	Jewelry	0.896	0.709
	Fabrics and haberdashery	0.382	0.340
	Fuels (vehicles)	0.000***	0.000***
	Tobacco	0.000***	0.000***
Nontradables	Food away from home	0.330	0.436
	Rent and fees	0.087*	0.001***
Correlation	Domestic repairs	0.007***	0.129
of IPS & LLC	Repairs and maintenance	0.001***	0.141
p-values:	Public transportation	0.000***	0.093*
	Personal transportation	0.562	0.740
0.82	Pharmaceuticals	0.201	0.647
	Optical products	0.641	0.467
	Medical and dental services	0.462	0.663
	Laboratory and hospital services	1.000	0.991
	Health Plan	0.857	0.502
	Personal hygiene	0.610	0.506
	Personal services	0.043**	0.009***
	Recreation	0.989	0.911
	Photography and filming	0.050*	0.090*
	Courses	0.645	0.910
	Reading material	0.007***	0.020**
	Stationery	0.167	0.606
	Communication	0.069*	0.387

Null hypotheses: all cities have a unit root

Significant at the *** 1% level; ** 5% level; * 10% level.

Table 2 compares the simple average of the half-lives calculated from the individual ADF regressions (1) with the half-lives of the pooled LLC coefficients for each product. As expected, prices of tradable products converge faster than prices of non-tradable products. However, price convergence is very slow. Average half lives are about 14−16 months for tradable prices and about 20−27 months for non-tradable prices.

Table 2. Product Half-Lives

	Description	**Simple average of individual half-lives**	**LLC pooled half-lives**
Tradables	Cereals, seeds and oilseeds	7.34	7.16
	Flours and pasta	20.81	21.88
Correlation:	Tubers, roots and legumes	3.95	3.90
0.83	Sugars and derivatives	7.46	7.28
	Vegetables	3.87	3.76
Average	Fruits	15.72	17.86
of individual	Meats	6.12	5.86
half-lives:	Fishes	18.14	17.75
14.02	Processed meat and fish	19.34	15.90
	Poultry and eggs	10.63	10.39
Average	Milk and dairy products	7.58	9.89
of pooled			
LLC	Bakery products	14.87	13.28
half-lives:	Oils and fats	12.12	13.64
16.13	Beverages and infusions	9.33	8.91
	Canned and preserved foods	27.68	28.24
	Salt and spices	18.15	22.28
	Pre-cooked meals	6.27	3.03
	Cleaning chemicals	20.13	27.13
	Fuels (domestic)	13.93	10.41
	Residential electricity	12.65	12.70
	Furniture	25.23	34.24
	Utensils and ornaments	23.49	31.94
	Bed, bath and table	11.87	18.49
	Domestic appliances	14.51	13.73
	TV, stereos and computers	13.67	28.04
	Menswear	20.31	20.35
	Women's clothes	14.27	33.66
	Children clothes	13.86	14.31
	Shoes and accessories	15.27	21.41
	Jewelry	28.20	NA
	Fabrics and haberdashery	14.68	28.70
	Fuels (vehicles)	5.11	5.10
	Tobacco	6.11	5.00
Nontradables	Food away from home	20.45	23.14
	Rent and fees	26.40	27.89
Correlation:	Domestic repairs	12.03	34.43
0.57	Repairs and maintenance	12.72	12.46
	Public transportation	11.61	11.60
Average	Personal transportation	19.33	22.66
of individual	Pharmaceuticals	17.93	23.54
half-lives:	Optical products	19.85	37.28
19.93	Medical and dental services	22.48	35.98
	Laboratory and hospital services	26.46	NA
Average	Health Plan	20.90	NA
of pooled			
LLC	Personal hygiene	23.89	25.27
half-lives:	Personal services	21.44	20.99
27.14	Recreation	29.46	53.05
	Photography and filming	15.14	16.01
	Courses	21.90	34.89
	Reading material	25.59	24.17
	Stationery	8.06	24.05
	Communication	22.96	34.05

Figure 2 shows the distribution function of $\rho_{i,m}$ across tradable and non-tradable products. Tables 1 and 2 provide further evidence that the expected difference between the two groups holds. That is, larger share of non-tradable prices have explosive processes, and amongst those processes that are not explosive, non-tradable prices tend to have higher autoregressive parameters.

Figure 2: Distribution of ADF coefficients

(distribution function of product-city pairs ADF coefficients, in percent)

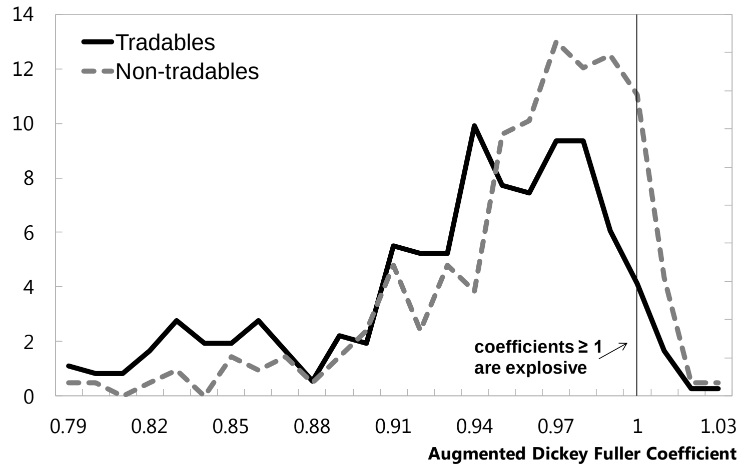
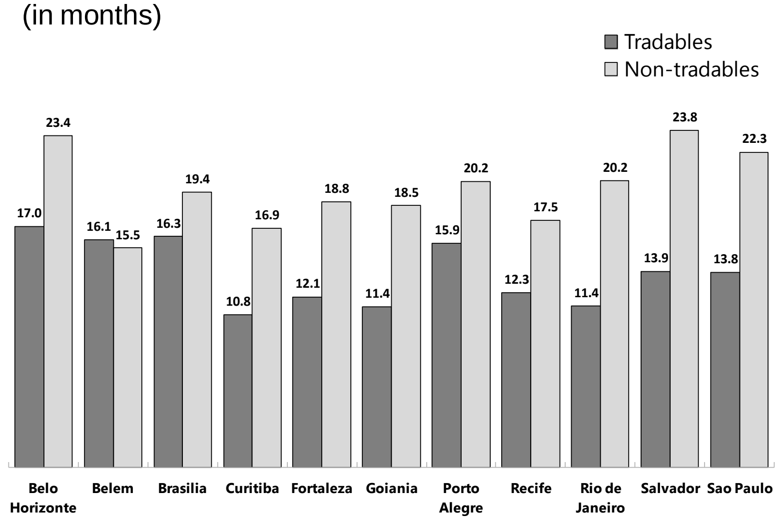


Figure 3 shows how the persistence of price level deviations varies across cities. Tradable price divergences range from a maximum of 17 months in Belo Horizonte to a minimum of 10.8 months in Curitiba. By contrast, non-tradable price divergences vary from 23.8 months in Salvador to 15.5 months in Belem. The standard deviation of half lives averages between cities is 2.3 and 2.7 months for tradables and non-tradables, respectively. There seems to be no overarching pattern in the distribution of half lives, suggesting a potential avenue for further research.

Figure 3: Metro-Area Half-Lives

(in months)

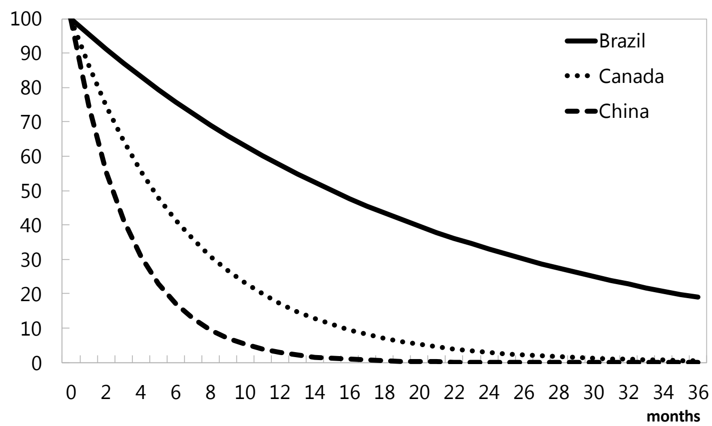


5. International comparisons

While the literature generally supports LOOP within countries, estimated half lives of domestic price deviations vary significantly due to methodological differences. Our work is perhaps most comparable to that of Li and Huang (2006) and Fan and Wei (2006), who found evidence that LOOP holds domestically in Canada and China with monthly data. Average half-lives estimated for Canada and China are 4.72 and 2.35 months, respectively—much lower than we found for tradable products in Brazil (14−16 months).

Brazil's relatively slow price convergence is further illustrated in Figure 4, where we display derive the implied autoregressive terms for Canada, China, and Brazil using $|\rho| = \exp(ln(0.5)/h)$. For both in Canada and China more than 90% of price deviations are corrected within 18 months, but in Brazil the pace of convergence is much slower.

Figure 4: Reaction Functions of Price Dispersion
(shock = 100, x axis in months)



Note: Canada and China calculated from half-lives estimated by Li & Huang (2006) and Fan & Wei (2006).

6. Conclusions

We found mixed evidence for domestic market integration in Brazil. LOOP is found to hold for most tradable products and, non-surprisingly, non-tradable products are found to be less likely to satisfy the law of one price. While consistent with evidence found for other countries, our evidence suggests price convergence occurs very slowly in Brazil. This suggests limited domestic market integration and highlights the need for improvements in infrastructure to improve the efficiency and productivity. We also found divergence in the speed of convergence across metro-areas, which may be a useful avenue for future research.

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