Sam Houston State University
Department of Economics and International Business
Working Paper Series

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SHSU Economics & Intl. Business Working Paper No. SHSU_ECO_WP08-03
October 2008

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JEL Classifications: E3, R1

Keywords: City Relative Price; Relative Price Variability; Convergence; Region Dummy

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1. Introduction

The behavior of relative prices across the U.S. cities has been the focus of a relatively recent literature. In a pioneering work in this area, Engel and Rogers (1996) use consumer price index (CPI) data for 14 categories of consumer items in 14 U. S. cities between 1978 and 1994 to show that there is substantial variation in the prices of similar goods in different cities.[1] Using quarterly data on prices of 51 final goods and services across 48 U.S. cities over the period from 1975 through 1992, Parsley and Wei (1996) find that prices converge to the purchasing power parity (PPP) at a rate much faster than typically found in cross-country data. More recently, Cecchetti et al. (2002) and Chen and Devereux (2003) use aggregate price data for different cities across the U.S. over a long period of time starting in 1918 to find evidence of convergence among city relative prices. Both studies find that the speed of convergence is slow. This literature has been primarily motivated by the law of one price or the PPP hypothesis.

In this paper, we examine the importance of regions of the United States: Northeast, Midwest, South, and West, in the behavior of city level relative prices.[2,3] Specifically, we are asking three questions. First, do relative prices between two cities located in the same region behave differently than cities located in different regions? Second, does any of the four regions have any significant specific implications for the relative price behavior? Finally, are there any significant differences in the effect of distance – which has been shown to have some important implications for city relative prices in the literature – on the relative price behavior by regions? Intuitively, the market conditions could be quite different across these regions due to differences

[1] They also considered prices in 9 Canadian cities to examine the effect of national borders on relative prices.
[2] By relative price, we mean the general price level (CPI) in a city relative to the general price level in another city. For a precise definition, see Section 2.
[3] We follow the regional divisions defined by the U.S. Census Bureau and used by the Bureau of Labor Statistics (BLS) for their regional price indices.

in demographics, geography, history etc. – yet very similar within each region – with significant implications for the behavior of relative prices.

Our results indicate that regions have some important implications for the behavior of relative prices. For example, average relative price variability is significantly lower if the city pairs associated with a relative price series belong to the same region. However, after controlling for the effect of distance, relative price variability – measured by standard deviation of relative prices - increases significantly if both cities are in the West and relative price variability – measured by standard deviation of relative price changes - decreases if they both are in the Northeast. Further, relative price variability increases significantly if at least one city is located either in the South or in the West. We find that the likelihood of relative price convergence increases if both cities belong to the South irrespective of whether we control for distance or not. It, however, decreases if at least one city belongs to the West. Finally, distance appears to increase relative price variability and to lower the likelihood of relative price convergence if at least one city is located in the South.

The rest of the paper is organized as follows. Section 2 describes the data and the empirical methods used in this study. In Section 3, we present the empirical results. Section 4 summarizes and concludes.

2. Data and Empirical Methods

We obtain annual Consumer Price Index (CPI) data for 17 major cities in the U.S. for the period between 1918 and 2007 from the Bureau of Labor Statistics (BLS). [4] The availability of data dictates the choice of the cities and the sample period. For all possible pairs of cities, we

[4] The cities are: Atlanta, Boston, Chicago, Cincinnati, Cleveland, Detroit, Houston, Kansas City, Los Angeles, Minneapolis, New York, Philadelphia, Pittsburgh, Portland, San Francisco, Seattle, St. Louis.

construct 136 independent relative price series. The relative price in city i relative to city j is calculated as follows:

$$r_t^{ij} = p_t^i - p_t^j \tag{1}$$

where r_t^{ij} is the logarithm of the relative price in city i vis-à-vis city j, p_t^i is the logarithm of CPI in city i and p_t^j is the logarithm of CPI in city j. t indexes time with t = 1, 2, 3, …, T, and i, j index cities with i, j = 1, 2, …, N.

We examine the time series behavior of relative prices in two ways. First, we measure year-to-year relative price variability by calculating standard deviation of log-levels and of log first differences of each relative price series. Note that relative prices are in logarithms by definition. Second, we conduct Augmented Dickey-Fuller (ADF) test on each relative price series to determine its stochastic trending properties. Note that in the PPP literature, rejection of the unit root null is considered evidence in support of the PPP hypothesis or the convergence in relative prices. Thus, for each relative price series we estimate the following test equation that includes an intercept:

$$\Delta r_t^{ij} = \alpha_o^{ij} + \gamma^{ij} r_{t-1}^{ij} + \sum_{k=1}^{p} \beta_k^{ij} \Delta r_{t-k}^{ij} + \varepsilon_t^{ij} \tag{2}$$

where α_0^{ij} represents the intercept term, Δr_{t-k}^{ij}'s are the augmented terms, p is the appropriate lag length of the augmented terms, and ε_t^{ij} is the white noise error term. To be consistent with the PPP theory and existing literature, we do not include a deterministic trend in the test equation. The ADF test is essentially the test of significance of the coefficient, γ^{ij}, in the above equation.[5]

[5] In order to select the lag length p, we start with a maximum lag of 5 and pare it down to the appropriate lag by looking at the Schwartz Information Criterion (SIC). There is no general rule as to how one chooses the maximum lag length to start with. Enders (2004) suggests 'to start with a relatively long lag length…' (pp.192). Some

To capture the effects of regions on the behavior of relative prices we introduce several dummy variables. As mentioned earlier, we divide the U.S. into four regions: Northeast, Midwest, South, and West. According to this classification, Boston, Philadelphia, Pittsburgh, and New York belong to the Northeast region; Chicago, Cincinnati, Cleveland, Detroit, Kansas City, Minneapolis, and St. Louis belong to the Midwest region; Atlanta and Houston belong to the South, and Los Angeles, Portland, San Francisco, and Seattle belong to the West region. The region dummies are defined as follows:

REG = 1 if both cities in a relative price pair belong to the same region; 0 otherwise

REGNE = 1 if both cities belong to the Northeast region; 0 otherwise

REGMW = 1 if both cities belong to the Midwest region; 0 otherwise

REGSO = 1 if both cities belong to the South region; 0 otherwise

REGWE = 1 if both cities belong to the West region; 0 otherwise

NE = 1 if at least one of the cities in a relative price pair belongs to the Northeast region; 0 otherwise

MW = 1 if at least one city belongs to the Midwest region; 0 otherwise

SO = 1 if at least one city belongs to the South region; 0 otherwise

WE = 1 if at least one city belongs to the West region; 0 otherwise

To examine if there are 'region effects' in the relative price behavior, we estimate various specifications of the following cross-section regression model:

$$y_i = \beta_o + \beta_1 RD_i + \beta_2 X_i + \varepsilon_i \tag{3}$$

where y_i is the dependent variable that could be one of the following: standard deviation of relative prices, standard deviation of relative price changes, one *minus* the *p*-value of the ADF

researchers use the following rule of thumb: start with a maximum lag length equal to the cube root of the number of observations which is 4.46 (= $\sqrt[3]{89}$) in our case.

tests, and the autoregressive coefficient (AR) of relative prices.[6] β_0 is the intercept term; RD_i is a vector (scalar) of region dummy variables that belong to the set: {*REG*, *REGNE*, *REGMW*, *REGSO*, *REGWE*, *NE*, *MW*, *SO*, *WE*} and β_1 is the corresponding vector (scalar) of coefficients; X_i is a vector (or scalar) of other independent variables and β_2 is the corresponding vector (scalar) of coefficients; and ε_i is the white-noise error term. i indexes relative price series and i = 1, 2, …, 136. We will broadly refer to the dependent variables as relative price behavior measures. The first two variables reflect average year-to-year relative price variability and, therefore, may be referred to as short-run relative price behavior measures. In contrast, the latter two variables reflect the stochastic trending properties and may be called long-run relative price behavior measures.[7]

3. Empirical Results

Table 1 presents selected summary statistics of relative price behavior measures. For 34 out of a total of 136 relative price series, the city pairs belong to the same region. As we can see from column 2 and 3, mean standard deviation of both relative prices and changes in them is smaller if the corresponding city pairs belong to the same region than if they belong to different regions. Also, the range of standard deviation as reflected by the minimum and the maximum is also smaller for the first group. We find evidence of relative price convergence (that is, the unit root null is rejected) for 60 relative price series, of which 17 involve city pairs belonging to the same

[6] Ideally, we would like to use an estimate of half-life, a measure of the speed of convergence in relative price as the dependent variable. The approximate half-life of relative price, r^{ij}, is computed as: $h^{ij} = -\frac{\ln 2}{\ln \rho^{ij}}$ where ρ^{ij} is the AR(1) coefficient of the relative price, which can be calculated from equation (2): $\rho^{ij} = \gamma^{ij} + 1$. However, for a unit root relative price series, the half-life estimate is undefined and, therefore, we have decided to use the AR(1) coefficient, instead.

[7] Although not directly comparable, 1- p-value and autoregressive coefficient would convey some of the same information about long-run stochastic trending properties of relative prices.

region. In percentage term, we reject the null of unit root 50 percent of the times when city pairs belong to the same region and 42 percent of the times when they belong to different regions. The *p*-values of the ADF test statistics are smaller on an average for relative prices involving same region city pairs. The average AR coefficient of relative prices is slightly smaller for same region city pairs than for different region pairs.[8]

[Insert Table 1 here]

3.1 Regressions with region dummies only

In Table 2, we present the results from regressions of relative price behavior measures on various region dummies. The coefficients reported in column 1 and 4 indicate that the average relative price variability is significantly smaller if the city pairs belong to the same region than if they had belonged to different regions: standard deviation of relative prices is lower, on an average, by 0.70 and standard deviation of relative price changes by 0.14. However, there are important differences by the regions that they belong to. For example, if both cities are in the Northeast region, the standard deviation of relative prices is lower, on an average, by 1.41 whereas if they are in the West, it is up by 0.21 (although this is not statistically significant). Similarly, standard deviation of relative price changes is lower by 0.33 if both cities belong to the Northeast, but only by 0.07 if they both belong to the South. Furthermore, if at least one of the cities associated with a relative price series is located in the West region, standard deviation of relative prices goes up by 1.45 and that of relative price changes, by 0.26. They go up only by 0.22 (not statistically significant) and 0.07 respectively if at least one city is located in the Northeast region.

[8] Note that because of nonlinearity of the half-life measure, even a small difference in the autoregressive coefficient can make a substantially large difference in half-life measures.

[Insert Table 2 here]

That, on an average, 1- *p*-value of the ADF test - which measures the strength of the evidence of convergence or PPP - is higher and the AR coefficient is lower suggest that the likelihood of rejecting the null of unit root in relative price is higher and the speed of convergence is faster if both cities are located in the same region. However, the estimated coefficients are not statistically significant. With more specific region dummies we find that if both cities belong to the South, 1- *p*-value goes up significantly (by 0.23, on an average) and the value of AR coefficient decreases significantly (by 0.01). Furthermore, the autoregressive coefficient increases significantly if both cities are located in the West. There is a significant decline in 1 – *p*-value if at least one city belongs to the West. Also, the AR coefficient increases significantly by 0.03 if at least one city is from the West. These results suggest that the likelihood of convergence in relative price increases if both cities belong to the South and it decreases if at least one city belongs to the West.

3.2 Regressions with distance and region dummies

In the international PPP literature, transportation costs - which are often proxied by distance - are shown to be one of the explanatory variables for the breakdown of the PPP hypothesis. Even in the city relative price literature, distance is found to have some significant effect on the relative price behavior across cities. For example, Engel and Rogers (1996) report that the distance between cities explains a significant amount of variation in the prices of similar goods in different cities. Parsley and Wei (1996) too find that prices in cities located far apart converge slower than do prices in cities located closer. We now, therefore, include distance (in logarithm) in our regression model.[9] One might be inclined to think that cities belonging to the same region are closer in distance than are cities belonging to different regions, and therefore effects of regions on relative prices will disappear after controlling for distance. But there are several caveats. First, cities located in different regions may be closer in distance than cities located in the same region. For example, Pittsburgh is in the Northeast region while Cleveland is in the Midwest but they are only 131 miles apart. Los Angeles and Seattle both belong to the West but they are 1150 miles apart. Second, for the same distance, relative price may behave differently if one or both of the cities involved belong to a particular region. In other words, there may be important differences in the effect of distance on the relative price behavior by regions.

[Insert Table 3 here]

The results from these specifications are reported in Table 3. First six columns of Panel A of Table 3 report results from various specifications of the regression model of standard deviation of relative price on distance and region dummies. Distance has positive and mostly significant effect on the standard deviation of relative prices. This result accords well with the findings of some previous studies (for example, Engel and Rogers 1996). A significant positive coefficient of the region dummy in column (1) indicates that for same distance, city pairs located in the same region have higher standard deviation of relative prices, which seems counter-intuitive. However, when we introduce separate dummies for cities being in the same region for each of the four regions, the coefficient is significantly positive only for cities in the West. Furthermore, results from the specifications of the model with dummies for at least one city belonging to a particular region suggest that only when at least one city belongs to the West, the standard deviation goes up. For all others, it in fact goes down. However, the coefficient estimates are not statistically significant. When we include the dummy variable for cities being in the same region

[9] We obtain data on distances between cities from http://www.mapquest.com/ and http://www.infoplease.com

along with separate dummies for at least one city being in the Northeast, Midwest, and South, we find the coefficients to be negative and statistically significant for the Northeast and Midwest. Note that we use the West as the base region to avoid the dummy variable trap. Thus the results suggest, for example, that if at least one city belongs to the Northeast, standard deviation of relative prices is lower by 0.65, on an average, compared to if at least one city had belonged to the West, after controlling for distance and the fact that the cities are in the same region.

Last two columns include interaction terms. The results reported in column (5) indicate that when the two cities are located in two different regions, as mean distance (1359 miles for the city pairs we have considered) increases by 1%, mean standard deviation increases by 0.99. But if they are located in the same region the increase in standard deviation due to distance is smaller (0.99 – 0.33 = 0.66). Furthermore, the estimated coefficients for the dummy for at least one city being in the South and its interaction with distance turn out to be statistically significant (column 6). However, because the region dummies and their interactions with distance are highly correlated and therefore the coefficients are estimated less precisely, it is difficult to infer much from individual estimated coefficients. To take full stock of how distance affects the relative price variability in this case, we conduct tests of joint significance of the region dummies and the interaction terms. The results are reported in Table 4 and discussed below.

Columns (7) - (12) report results from regressions of standard deviation of relative price changes on distance and region dummies. Distance has positive significant effect under all specifications. Controlled for distance, there is no significant difference in standard deviation of relative price changes by whether the city pairs belong to the same region or not. However, if the city pairs are located in the Northeast region, variability in relative price changes goes down significantly after controlling for distance. Further, when we control for distance and the fact that cities are in the same region relative prices involving at least one city either from the Northeast or from the South have significantly lower standard deviation of relative price changes than do relative prices involving at least one city from the West. When the dummy for cities being in the same region is interacted with distance, neither *REG* nor *REG×LDIST* is statistically significant. When individual dummies are interacted with distance they all (as well as the interaction terms) are found to be statistically insignificant.

In panel B of Table 3, we report the regression results for two long-run relative price behavior measures: 1 – *p*-value of the ADF tests and the AR coefficient. Distance has negative and mostly significant effect on 1 – *p*-value when entered with the dummy variables for city pairs being in the same region. That is, as distance between cities increases, the strength of the evidence of convergence in relative prices weakens. The results further indicate that the likelihood of convergence in relative price increases significantly if the cities are in the South after controlling for distance (column (2)). Also, when we control for distance and cities being in the same region, at least one city being in South increases 1 – *p*-value of the ADF test significantly relative to that for a relative price series with at least one city in the West. When the same region dummy is interacted with distance, the estimated coefficient for the region dummy is negative and for the interaction term is positive and both are statistically significant. Thus, the results from the model specification in column (5) suggest that as distance increases 1- *p*-value decrease by 0.12 for cities located in different regions. However, for cities located in the same region, 1- *p*-value would in fact increase by 0.04 (= - 0.12 + 0.16). That is, the evidence of relative price convergence will strengthen if the city pairs are in the same region. Interactions with individual region dummies yield significant negative effects on 1 – *p*-value of the ADF test if at least one city belongs to either the Midwest or the South. That is, if at least one city is located either in the Midwest or in the South, as distance increases the strength of the evidence of convergence in relative prices significantly weakens.

Distance has positive and mostly significant effect on the AR coefficient when entered with dummy variables for both cities being in the same region. One implication is that as distance between cities increases the speed of convergence in relative prices significantly decreases. When we control for distance, the fact that cities are in the same region does not have any significant effect on the AR coefficient. However, the value of the AR coefficient increases significantly if both cities belong to the West. Further, when we control for distance and cities being in the same region, the AR coefficient is lower, on an average, by 0.03 – which is statistically significant – if at least one of the cities belong to the South as compared to if at least one city belongs to the West. When distance is interacted with the same region dummy, the estimated coefficients are not statistically significant. However, when it is interacted with individual region dummies, both the dummy for at least one city being in the South and its interaction with distance are statistically significant. However, a significant negative coefficient of the dummy variable and a significant positive coefficient of the interaction term indicate that the mean value of the AR coefficient is significantly lower but as distance increases the AR coefficient increases at a significantly faster rate if at least one city is in the South.

[Insert Table 4 here]

In Table 4, we report the *F*-test results for joint significance of the region dummies and their interactions with distance. This test is important to answer the question if there are significant differences in the effect of distance by regions. The test results indicate that distance has some significant effect on standard deviation of relative prices when at least one of the cities associated with a relative price series belongs to the South. It also has significant effect on the *p*-

value of the ADF test when the city pairs belong to the same region, and when at least one city belongs either to the Midwest or to the South. The South region also stands out when we examine the effect of distance on the AR coefficient. Thus, in general, the effect of distance on the relative price behavior measures appears to be significantly different when at least one city belongs to the South.

4. Conclusions

In this paper, we examine the 'region effects' on the behavior of relative prices across 17 U.S. cities. We summarize our findings by answering the questions we raised in the introduction. First, we find that relative prices between two cities located in the same region behave differently than cities located in different regions. For example, average relative price variability – measured by standard deviation of relative prices and of relative price changes - is significantly lower if the city pairs belong to the same region. However, after controlling for the effect of distance, relative price variability – measured by standard deviation of relative prices - increases if both cities are in the West, and relative price variability – measured by standard deviation of relative price changes - decreases if they both are in the Northeast. Furthermore, the strength of the evidence of relative price convergence increases if both cities belong to the South and this result is robust irrespective of whether we control for distance or not. Second, if at least one city is located either in the South or in the West, relative price variability increases significantly. The likelihood of convergence in relative prices decreases if at least one city belongs to the West**.** Finally, distance appears to increase relative price variability and to weaken the strength of the evidence of relative price convergence if at least one city is located in the South.

This paper does not address why the behavior of city relative prices is significantly different if a city belongs to the West or to the South. Nor does it explore why, even after controlling for distance, there are important differences in relative price behavior by regions. Future research will investigate some of these issues.

Table 1: Selected summary statistics

	No. of relative price series	Mean standard deviation of relative prices	Mean standard deviation of relative price changes	No. of relative price series for which unit root null is rejected	Mean *p*-value	Mean AR coefficient
	(1)	(2)	(3)	(4)	(5)	(6)
Full sample of city pairs	136	3.75 (1.50, 7.95)	1.28 (0.82, 1.81)	60 (44.12%)	0.26 (0.00, 0.82)	0.90 (0.68, 1.01)
City pairs in the same region	34	3.23 (1.64, 6.16)	1.17 (0.86, 1.57)	17 (50.00%)	0.21 (0.00, 0.97)	0.89 (0.76, 0.97)
City pairs in different regions	102	3.93 (1.50, 7.95)	1.31 (0.82, 1.81)	43 (42.16%)	0.28 (0.00, 0.97)	0.90 (0.68, 1.01)

Note: Minimum and maximum values or percentages are in brackets.

Table 2: Regression results with region dummies

Dependent variable →	Standard deviation of relative prices			Standard deviation of relative price changes			1-*p*-value of ADF test			AR coefficient		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
REG	-0.70***			-0.14***			0.07			-0.01		
	(0.21)			(0.03)			(0.05)			(0.01)		
REGNE		-1.41***			-0.33***			0.00			0.00	
		(0.32)			(0.05)			(0.12)			(0.02)	
REGMW		-0.76***			-0.10**			0.07			-0.02	
		(0.22)			(0.04)			(0.06)			(0.02)	
REGSO		-0.57***			-0.07***			0.23***			-0.01**	
		(0.14)			(0.02)			(0.03)			(0.01)	
REGWE		0.21			-0.09			0.09			0.03**	
		(0.51)			(0.08)			(0.08)			(0.01)	
NE			0.22			0.07*			-0.04			0.01
			(0.23)			(0.04)			(0.06)			(0.1)
MW			0.29			0.16***			-0.09			0.00
			(0.29)			(0.04)			(0.07)			(0.01)
SO			0.47*			0.08*			0.04			-0.01
			(0.25)			(0.04)			(0.06)			(0.02)
WE			1.45***			0.26***			-0.18**			0.03**
			(0.27)			(0.04)			(0.07)			(0.01)
Adjusted R-squared	0.05	0.06	0.21	0.10	0.14	0.27	0.00	-0.02	0.06	0.00	-0.01	0.05

Note: White heteroskedasticity-consistent standard errors are in brackets. ***significant at the 1% level,**significant at the 5% level, *significant at the 10 % level. An intercept term is included in the regressions.

Table 3. Panel A: Regression results with distance, region dummies, and interactions

	Standard deviation of relative prices						Standard deviation of relative price changes					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
LDIST	0.92***	0.88***	0.60***	0.60***	0.99***	0.50	0.14***	0.13***	0.13***	0.13***	0.14***	0.16*
	(0.14)	(0.15)	(0.19)	(0.19)	(0.17)	(0.55)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)	(0.09)
REG	0.39*			-0.37	2.47		0.03			-0.02	-0.05	
	(0.22)			(0.41)	(1.85)		(0.04)			(0.06)	(0.34)	
REGNE		0.03						-0.12**				
		(0.30)						(0.05)				
REGMW		0.28						0.06				
		(0.25)						(0.05)				
REGSO		-0.07						0.00				
		(0.12)						(0.02)				
REGWE		0.98*						0.03				
		(0.52)						(0.07)				
NE			-0.28	-0.65*		-0.93			-0.04	-0.06*		-0.05
			(0.23)	(0.35)		(2.40)			(0.05)	(0.04)		(0.40)
MW			-0.18	-0.55*		-0.21			0.06	0.04		0.38
			(0.29)	(0.33)		(2.17)			(0.05)	(0.04)		(0.38)
SO			-0.12	-0.48		-6.69**			-0.05	-0.07*		-0.40
			(0.28)	(0.32)		(3.16)			(0.04)	(0.04)		(0.44)
WE			0.37			2.31			0.02			0.23
			(0.41)			(3.26)			(0.06)			(0.44)
REG×LDIST					-0.33						0.01	
					(0.29)						(0.05)	
NE×LDIST						0.12						0.00
						(0.37)						(0.06)
MW×LDIST						0.04						-0.04
						(0.34)						(0.06)
SO×LDIST						0.95**						0.05
						(0.48)						(0.07)
WE×LDIST						-0.25						-0.03
						(0.44)						(0.06)
Adjusted R-squared	0.24	0.24	0.24	0.24	0.24	0.25	0.31	0.33	0.36	0.36	0.31	0.35

Note: White heteroskedasticity-consistent standard errors are in brackets. ***significant at the 1% level,**significant at the 5% level, *significant at the 10 % level. An intercept term is included in the regressions.

Table 3. Panel B: Regression results with distance, region dummies, and interactions

	1- *p*-value of ADF test						AR coefficient					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
LDIST	-0.09***	-0.10***	-0.04	-0.04	-0.12***	0.15	0.02***	0.02***	0.01	0.01	0.03***	-0.01
	(0.03)	(0.03)	(0.05)	(0.05)	(0.04)	(0.12)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.03)
REG	-0.04			0.10	-1.04**		0.02			-0.01	0.16	
	(0.06)			(0.11)	(0.45)		(0.02)			(0.03)	(0.11)	
REGNE		-0.16						0.04				
		(0.12)						(0.02)				
REGMW		-0.05						0.01				
		(0.07)						(0.02)				
REGSO		0.18***						0.00				
		(0.03)						(0.01)				
REGWE		0.00						0.05***				
		(0.10)						(0.02)				
NE			-0.00	0.10		0.48			0.00	-0.01		-0.06
			(0.06)	(0.09)		(0.48)			(0.02)	(0.02)		(0.13)
MW			-0.06	0.04		1.15**			-0.01	-0.02		-0.15
			(0.08)	(0.08)		(0.57)			(0.02)	(0.02)		(0.13)
SO			0.08	0.19**		2.55***			-0.03	-0.03**		-0.51**
			(0.07)	(0.08)		(0.71)			(0.02)	(0.02)		(0.20)
WE			-0.10			0.19			0.01			0.12
			(0.10)			(0.61)			(0.03)			(0.12)
REG×LDIST					0.16**						-0.02	
					(0.07)						(0.02)	
NE×LDIST						-0.08						0.01
						(0.08)						(0.02)
MW×LDIST						-0.19**						0.02
						(0.09)						(0.02)
SO×LDIST						-0.36***						0.07**
						(0.11)						(0.03)
WE×LDIST						-0.05						-0.02
						(0.09)						(0.02)
Adjusted R-squared	0.03	0.02	0.06	0.06	0.04	0.10	0.04	0.04	0.06	0.06	0.05	0.09

Note: White heteroskedasticity-consistent standard errors are in brackets. ***significant at the 1% level,**significant at the 5% level, *significant at the 10 % level. An intercept term is included in the regressions.

Table 4. *F*-test results for joint significance

Variables of which joint significance is tested	Dependent variable			
	Standard deviation of relative prices	Standard deviation of relative price changes	1-*p*-value of ADF test	AR coefficient
	(1)	(2)	(3)	(4)
REG, REG×LDIST	1.94 (0.15)	0.26 (0.77)	2.68 (0.07)	1.50 (0.23)
NE, NE×LDIST	0.35 (0.71)	0.29 (0.75)	0.61 (0.55)	0.16 (0.85)
MW, MW×LDIST	0.02 (0.98)	1.97 (0.14)	2.75 (0.07)	0.66 (0.52)
SO, SO×LDIST	3.03 (0.05)	1.66 (0.19)	8.85 (0.00)	3.96 (0.02)
WE, WE×LDIST	0.60 (0.55)	0.31 (0.74)	0.75 (0.47)	0.72 (0.49)

Note: *p*-values are in brackets.

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