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DOES SPACE MATTER? INTERNATIONAL COMPARISONS OF THE PRICES OF TRADABLES AND NONTRADABLES

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One view of the consequence of trade among countries is that it tends to equalize prices of tradable goods in different countries. This paper reexamines this view when both geographic proximity and trade flows are taken into account. Two hypotheses are presented. The first is that distance is more strongly associated with countries' relative prices than the extent of trade between them. The second hypothesis is that, at given income levels, countries that are strong trading partners will have more similar prices. In both cases, this appears to be true for nontradables and even more so for low income countries. Additionally, much of the nontradable price difference can be captured by geographic variables. The implication is that a spatial component would enhance conventional approaches to the study of prices and incomes at the national level, particularly studies that include nontradable goods and services.

INTRODUCTION

One view of the consequence of trade among countries is that it tends to equalize prices of tradable goods in different countries. Whether prices do converge or whether deviations in national price levels can be explained by structural and nonstructural factors has been the subject of much research in recent years (Balassa 1964; Clague and Tanzi 1972; Kravis and Lipsey 1983; Heston, Nuxoll, and Summers 1994, among others). This paper draws on similar statistical studies of comparative price levels and real GDP from the International Comparison Programme (ICP) benchmark studies, introducing a geographic or spatial perspective to the discussion.

The first part of the paper defines tradable and nontradable price levels following Heston, Summers, Aten, and Nuxoll (1995) and reviews recent work on the relationship between the two. The second part of the paper explores the differential effects of geographic and trade-based weights on the prices of tradable and nontradable goods, as well as their relationship to income levels, and tests two main hypotheses. The first is that the relative location of two countries, measured by their geographical proximity, is more strongly associated with their relative prices than the extent of trade between them. The second hypothesis is that once incomes are taken into account, countries that are strong trading partners, as measured by the similarity of their trade flows, have more similar prices. Spatial autocorrelation coefficients are discussed, and estimates from a conventional

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regression model are compared to estimates from alternative spatial models. The third and final section summarizes the results and presents conclusions.

The ICP works from the expenditure side of national accounting systems. In the version used in this paper, GDP is broken down into 139 basic headings of final-goods spending on Consumption (108), Investment (29), and Government (2) covering everything from various kinds of food, clothing, and shelter to machinery and construction to items of government services. The price parities derived by the ICP for each country and heading are based upon prices of identical or very similar goods and services across countries, a task that is difficult and subject to considerable error. The average price of a subgroup of goods is referred to as a price parity to maintain consistency with the term purchasing power parity, or PPP, for the average price of all the goods of aggregate GDP. The work reported in this paper is based on the 1985 benchmark comparison. Three of the 139 headings of the benchmark study (change in stocks, net expenditures of residents abroad, and the net foreign balance) can be negative. They have been excluded, and the remaining 136 categories are divided between 94 tradable and 42 nontradable headings.

Determining which of the basic headings should be regarded as tradable and which nontradable is necessarily fairly arbitrary. In the absence of specific information on what goods might enter into international trade versus those that would be absorbed only domestically, the categories placed in the nontradable classification are all service and construction categories. Following Peter Hill (1977, 1987), a service is taken to be a nonstorable good, and all other categories are placed in the tradable classification. It should be emphasized that tradables in this definition are items that *could* be traded, but are not necessarily in fact traded.

Previous work on the average price parities of tradables and nontradables focused on the relationship between their levels and per capita income (Kravis and Lipsey 1983; Heston, Nuxoll, and Summers 1994). For example, the ratio of the price of tradables to nontradables was regressed against GDP per capita. As expected, the ratio varied inversely with income, because the price of tradables varies less with income than the price of nontradables. Low-income countries tend to have lower relative prices for nontradables, whereas if tradable goods follow the law of one price, the differential between tradables and nontradables will be more pronounced in poorer countries. More than that, the finding was replicated over the fifteen-year period between 1970 and 1985, and for a number of different country combinations. The work with average tradable and nontradable prices was extended to the relationship between price parities at the basic heading level. The regressions involving the disaggregated data confirmed what was found with the average price-parity data. Kravis and Lipsey (1983: 25) suggest the use of nonstructural variables, such as the growth rate of money, to explain short run variation in the national price levels in countries. They found that real income per capita, openness of the economy, and the share of nontradable goods were all positively correlated with the national price levels, but other factors such as the labor force composition or the level of education did not contribute to an explanation of changes in price levels. More recently, Weinhold (1995) observed spatial dependence among countries' growth rates, and Aten (1996) found preliminary evidence of spatial autocorrelation in international prices at the disaggregate level.

This paper extends the previous work in two directions. First, it focuses on the relationship of countries' geographic and trade proximity to their price parities. Second, it incorporates this relationship explicitly in regression models that seek to explain national price levels.

POSSIBLE SOURCES OF SPATIAL PATTERNS IN PRICE PARITIES

Prior to disentangling countries' spatial patterns in price parities following Anselin and Florax (1995), other possible sources of autocorrelation in the parities are examined. The strongest candidates are per capita income levels and the openness of the economy (Kravis and Lipsey 1983). The variables are defined below.

Price Parities

The price parity in country j is the weighted ratio of the sum of the nominal item prices to real prices, where the weights are the item quantities. There are 64 countries for which data in 1985 are available. Formally, price parity is defined as

$$PP_j = \frac{\sum_k p_{kj} q_{kj}}{\sum_k \pi_k q_{kj}}$$

where p_{kj} is the domestic price of item k in country j, q_{kj} is the associated quantity j, and π_k is the international price of item k.

The summation for the PP of tradables is over 94 items and for nontradables over 42 items. Derivation of international prices can be found in Kravis, Heston, and Summers (1982). The values used in this paper are from the 1985 ICP benchmark comparisons.

Incomes

Incomes are measured by the country's per capita national product level valued at purchasing power parities and converted to international dollars. The 1985 figures are from the updated Penn World Tables (PWT) 5.6a described in Summers and Heston (1991).

Openness

The share of exports and imports out of total GDP, or openness of country i (equation 1), is also from PWT 5.6a and valued in current international prices.

$$O_i = \frac{\sum_j X_{ij} + \sum_j M_{ji}}{GDP_i} \tag{1}$$

where X_{ij} are the exports of country i to country j, M_{ji} are the imports, and GDP_i is the gross domestic product of country i.

Price parities and income levels are significantly and positively correlated (0.642, p = 0.0001 for tradables and 0.857, p = 0.0001 for nontradables). As expected, both income levels and openness are more positively correlated with nontradables than with tradables, although the correlation with openness is weak for nontradables (0.178, p = 0.1605) and not significant at all for tradables. As Kravis and Lipsey (1983: 23) state:

> At the extreme, if there were pure tradable goods and if trade equalized their prices in different countries, no correlation at all would be expected between their prices and income levels, and the observed differences ... would have to be thought of as reflecting the non-tradable element in all tradable-goods prices.

Spatial Autocorrelation with Geographic and Trade-Based Weights

Weights matrices express the pairwise relationship between observations. Generally, spatial weights matrices are ones in which the weights describe relative location. Case, Rosen, and Hines (1993), in looking at states' expenditures, use the term "similarly situated states" to denote the concept of proximity with respect to both spatial and aspatial characteristics. For example, they use per capita income differences and the racial composition of states as weight matrices. In this paper, three measures of proximity are used: a contiguity measure, a distance measure, and a trade measure.

The contiguity measure is simply a nominal variable denoting whether countries share a boundary. The second measure of geographic proximity is a distance matrix, defined as the shortest great circle distance between each country's capital city. Clearly, both measures are limited descriptors of relative location, and a number of alternative measures have been examined. Anselin (1988) summarizes the general problems and properties associated with all spatial weights matrices, suggesting a choice of weights that is relevant to the alternative hypothesis of spatial dependence. The contiguity matrix for the 64 countries in this paper is a rough indicator of country groupings. European countries are represented, as are the United States and Canada. There are 22 African countries and 14 Asian countries that also are connected to some extent. The Caribbean countries are islands; thus, their pairwise contiguity to all other countries is zero. The elements of the spatial contiguity matrix $\boldsymbol{W}^C$ are given in (2):

$$w_{ij} = \frac{c_{ij}}{\sum_j c_{ij}} \tag{2}$$

where c_{ij} = 1 when country i and country j share a boundary and c_{ij} = 0 otherwise.

The distance matrix provides more information, enabling the weights to capture the proximity of the island groups, for example. The elements of the distance matrix $\boldsymbol{W}^D$ are defined in (3):

$$w_{ij} = \frac{1/d_{ij}}{1/\sum_j d_{ij}} \tag{3}$$

where d_{ij} = distance (kilometers) between country i and country j.

The third measure is trade proximity and reflects the trade flows between countries. It measures the relative volume of exports and imports between all pairs of countries. Each element, t_{ij}, is the proportion of trade to country j out of the total trade volume of country i:

$$t_{ij} = \frac{X_{ij} + M_{ji}}{\sum_j (X_{ij} + M_{ji})}.$$

X_{ij} are exports from i to j, and M_{ij} are the imports from j to i expressed in 1985 current U.S. dollars (International Monetary Fund 1992). The elements of the trade matrix $\boldsymbol{W}^T$ are given by

$$w_{ij} = \frac{t_{ij}}{\sum_j t_{ij}}.$$

Descriptive Measures of Autocorrelation

The autocorrelation statistic that is used here is Moran's I, a variation of the general cross-product statistic (Upton and Fingleton 1985). For a row-standardized spatial weights matrix $\boldsymbol{W}$, Moran's I is given by

$$I = \frac{\sum_i \sum_j w_{ij} x_i x_j}{\sum_i x_i^2}$$

where the x_i's are measured as deviations from the mean. The moments of I are derived in Cliff and Ord (1971) and given in Upton and Fingleton (1985), among others. The x_i's are, in turn, the price parities of tradables, the price parities of nontradables, the per capita income levels, and the openness level in country i. The w_{ij}'s refer to the elements of the three weight matrices: $\boldsymbol{W}^C$, $\boldsymbol{W}^D$, and $\boldsymbol{W}^T$. With no autocorrelation present, Moran's I approaches its expected value under spatial randomness, $-1/(N-1)$. For $N = 64$, the expected value of Moran's I under the null hypothesis is thus –0.0159. With maximum positive autocorrelation, Moran's I approaches 1. Positive spatial autocorrelation is interpreted as the clustering or juxtaposition of similar values; negative autocorrelation describes the tendency for dissimilar values to cluster. The lack of autocorrelation suggests that the actual arrangement of values is one that would be expected from a spatially random distribution. Table 1 shows Moran's I for each combination of xs and W's. Values in parentheses are the standardized z-values based on the normal distribution.

The first row of table 1 shows Moran's I values for tradables. The tradable prices and the first two geographic measures of proximity are not significant, but

TABLE 1. Spatial Autocorrelation

Moran's *I*	*W* (Contiguity)	*W* (Distance)	*W* (Trade)
Tradables	0.195	0.011	0.083**
	(1.32)	(0.90)	(2.42)
Nontradables	0.762**	0.200**	0.123**
	(4.85)	(7.20)	(3.40)
Incomes	1.067**	0.236**	0.137**
	(6.76)	(8.40)	(3.74)
Openness	0.282*	0.064**	–0.008
	(1.86)	(2.67)	(0.18)

*$p < .10$. **$p < .05$.

the greater the trade flows between countries, the more similar their tradable prices ($I = 0.083$). This relationship is even stronger for nontradables ($I = 0.123$).

Moran's I indicates the degree of spatial association between the price parities for each of the weight matrices. It is formally equivalent to the slope coefficient in a linear regression of $\boldsymbol{Wx}$ on $\boldsymbol{x}$ where $\boldsymbol{x}$ is the standardized value of the price parity or income variable (Anselin 1995, 1996). $\boldsymbol{Wx}$ (in matrix notation) is the spatially lagged value of the observation, and it is plotted against the actual observation $\boldsymbol{x}$ in a Moran scatterplot (Anselin 1996). The scatterplot provides additional information by distinguishing between types of positive and negative autocorrelation. Positive association between large values is shown in the upper right-hand side quadrant, while positive association between small values is in the lower left quadrant. Similarly, negative association between small values of $\boldsymbol{x}$ and high values at neighboring locations, measured by $\boldsymbol{Wx}$, is in the upper left quadrant, while negative association of high values and low neighboring values is shown in the lower right quadrant (O'Loughlin and Anselin 1996).

Figures 1a through 1c show the Moran scatterplots for tradables, nontradables, and income levels using contiguity as the weight matrix. Figures 2a through 2c and 3a through 3c are the equivalent plots using distance and trade-based spatial weights matrices.

The difference in the plots of the price parities of tradables and nontradables (figure 1a versus figure 1b) for contiguity-based weights can be seen in the different slopes. The latter is much steeper and positive, with observations clustered primarily in the upper right and lower left quadrant. Countries with higher price parities for nontradables (Europe, the U.S., and Canada) are likely to be neighbors with other high parity countries, and are thus located in the upper right-hand quadrant. Poland is an exception in Europe (figure 1b): its price parity for nontradables is low (–0.59 standard deviations from the mean), but its only neighbor in the sample is Germany, with a standardized parity of 1.48. Thus, it is in the upper left quadrant.

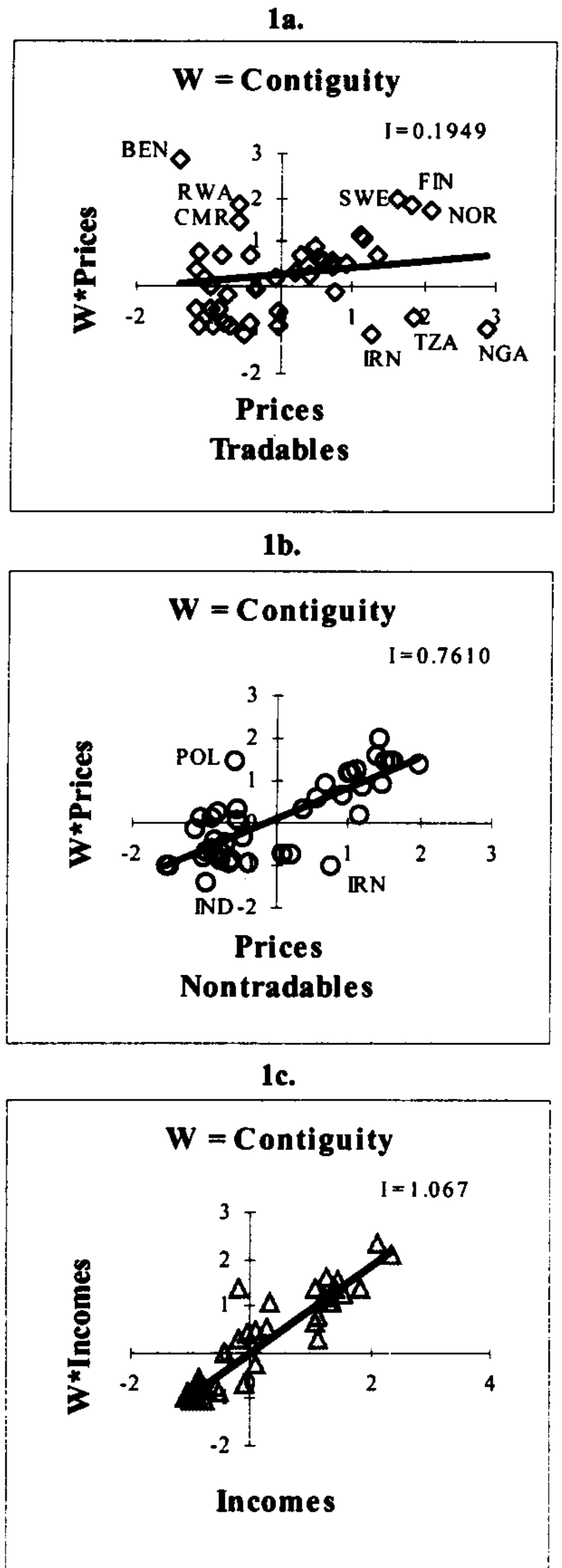

FIGURE 1. Moran Scatterplots Using Contiguity as Weights Matrix

Note: Table A.1 provides a complete list of the countries in the study.

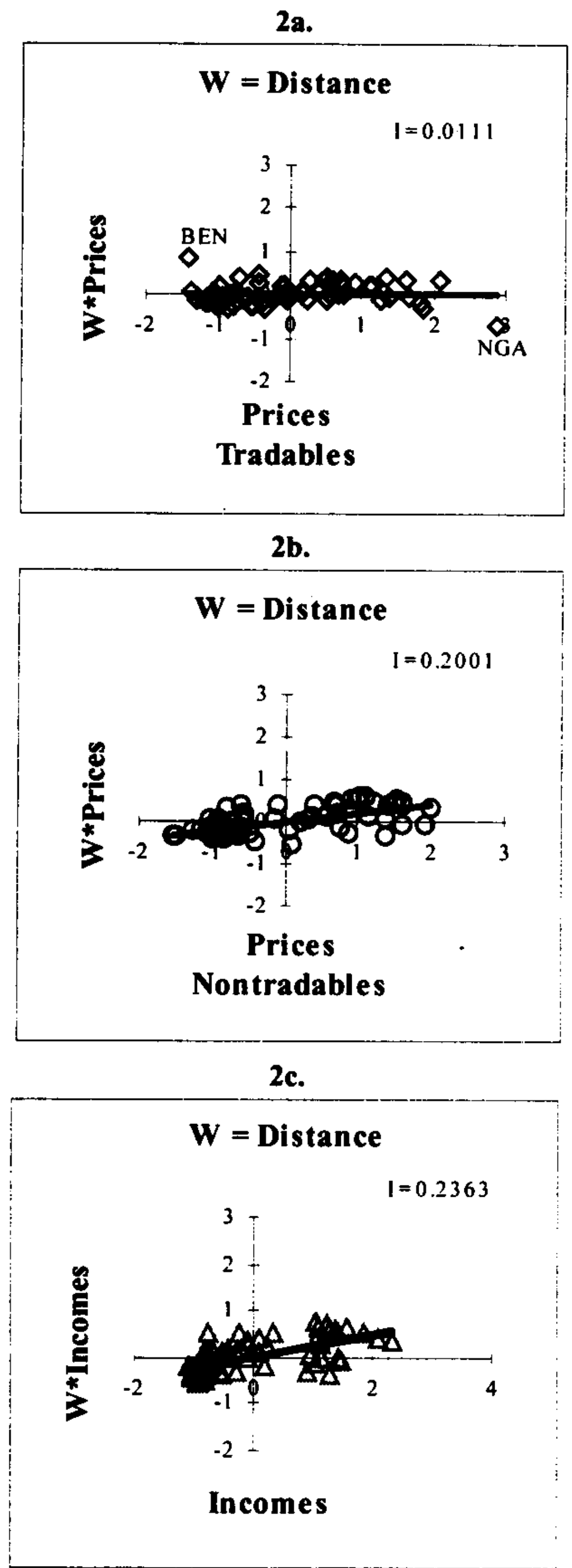

FIGURE 2. Moran Scatterplots Using Distance as Weights Matrix

Note: Table A.1 provides a complete list of the countries in the study.

For tradables, the association is still positive but much weaker (figure 1a). The price parities of tradables in western Europe and the U.S. and Canada are generally lower, while for some developing countries they are higher than their nontradable parities. Examples are Nigeria, Tanzania, and Iran. They are in the

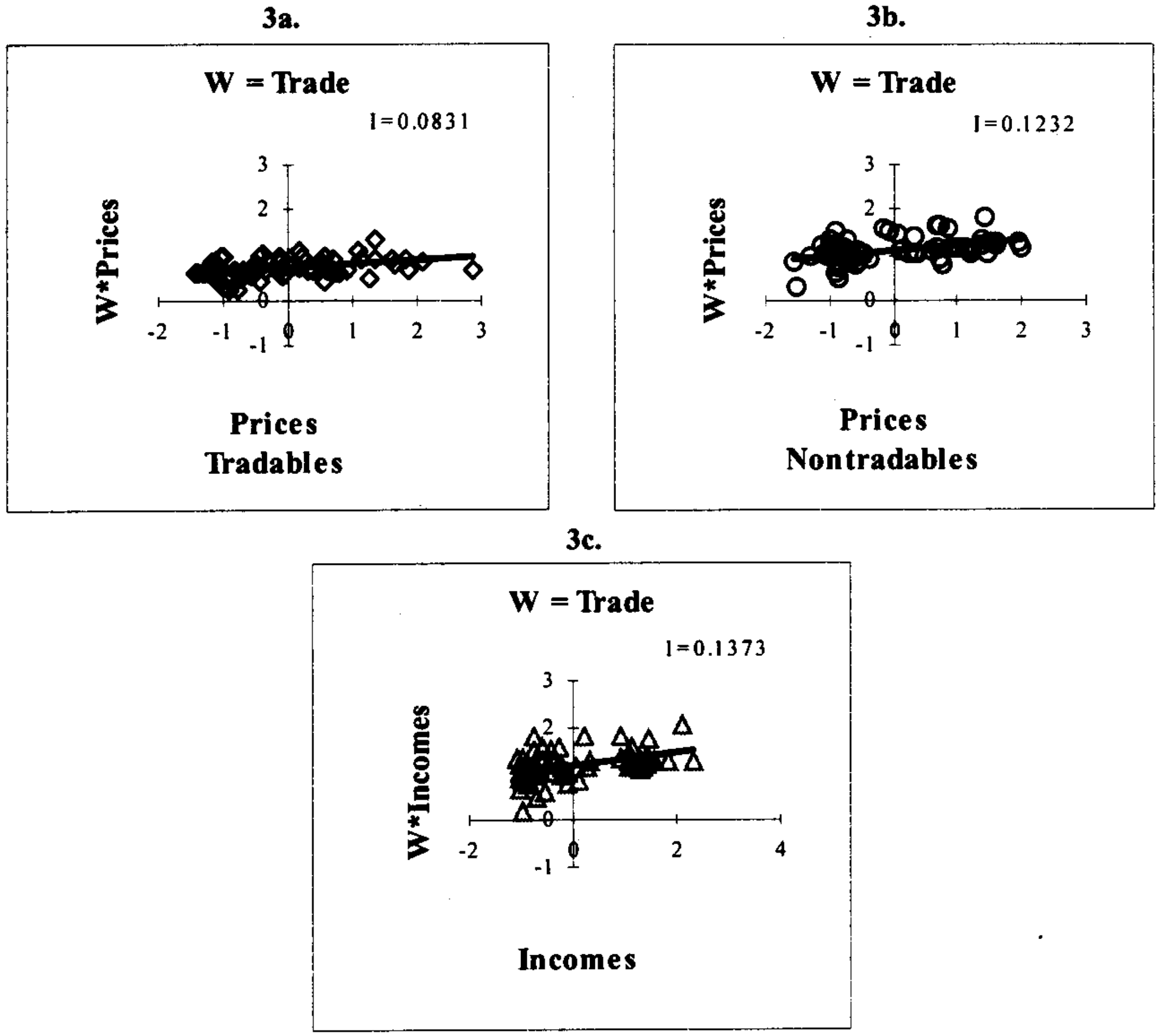

FIGURE 3. Moran Scatterplots Using Trade as Weights Matrix

lower right quadrant while their neighbors, with low tradable parities, such as Benin, Kenya, Malawi, Rwanda, and Pakistan, are in the upper left quadrant.

The stronger association for nontradables than for tradables remains when the weights are distance rather than contiguity. However, in both cases the slope of the regression line is smaller, reflecting a much weaker positive association. Only Nigeria and Benin continue to be outside the main cluster of observations for tradables (figure 2a). Other countries outside the main cluster for nontradables are Japan, Australia, and Finland. They have relatively high price parities for nontradables (1.93, 1.59, and 1.37 respectively), but their nearest neighbors (great circle distance-wise) do not.

Figures 3a and 3b show even flatter slopes, as well as regression intercepts greater than zero. That is, all the trade-based weights ($\boldsymbol{Wx}$) are positive. Previously, countries with negative $\boldsymbol{Wx}$'s were those with low parities (negative $\boldsymbol{x}$'s) located closer to other countries with low $\boldsymbol{x}$'s. In other words, geographical closeness resulted in more similar prices. For the trade-based weights, this association is less clear. Low parity countries trade proportionally more with high parity countries. For example, the relative trade between Bangladesh and India, both with low parities for tradables and nontradables, is proportionally much less than either country's trade with high parity countries. These countries are in the upper left quadrant with Wx's above zero and x's less than zero. The reverse is not true. Higher priced countries do not trade predominantly with lower priced countries. The proportion of their trade with low priced countries is only a small share of higher priced countries' total trade. These high parity countries are located predominantly on the upper right quadrant. Jointly, this results in flatter slopes than the slopes for the geographic weights.

The scatterplots for real per capita incomes are shown in figures 1c, 2c, and 3c. Moran's I is slightly higher than for price parities. In the upper right-hand quadrant are high income countries trading proportionally more with other high income countries. O'Loughlin and Anselin (1996) have shown that there is little evidence of "panregional" or large trade bloc formation in the context of import and export shares for Japan, Germany, or the U.S. Their findings suggest a more local clustering, for example, Japanese imports from East and Southeast Asia, and German exports to other European nations. The results in the scatterplots are consistent with this view, suggesting in addition, that low income countries have yet to create strong trade links with other low income countries. Their tendency is to trade with one or more wealthier partners.

Regression Analysis

Because both price parities and income levels are positively associated with contiguity, distance, and to a lesser extent, trade, how much of the variation in prices is not explained by incomes? And how does the variation differ between tradables and nontradables? Kravis and Lipsey (1983: 24) show that for 1975, the regression coefficient of income levels is higher for nontradable goods, and they suggest that this is because in the tradables regression, the effect of income is "only on the nontradable component of these goods' prices."

The analysis below begins by estimating ordinary least squares (OLS) coefficients and the distribution of residuals in a standard linear regression model of the form

$$y = X\beta + \varepsilon$$

where y is the vector of price parities, X is a matrix with observations on the explanatory variables of incomes and openness, and β and $\varepsilon \sim N(0, \sigma^2 I)$ are, respectively, the estimated coefficients and the normally distributed random error terms. In addition to the simple linear regression, other specifications were attempted. For some, such as the log-log specification, a parallel computation was done of all test diagnostics that follow. Based on both OLS and maximum likelihood estimates, the simple linear model appears to have the best "fit." Table 2 lists the coefficients and model results.

As expected, the income coefficient for nontradables (1.00) is higher than for tradables (0.54). The coefficients of openness are not significant, and F-values with the openness variable are lower than the F-values without openness. The openness variable is dropped in the subsequent analyses because *(a)* it fails to be

TABLE 2. Ordinary Least Squares Estimates

	Tradables		Nontradables	
Constant	0.57*	0.62*	0.32*	0.32*
	(0.04)	(0.06)	(0.04)	(0.06)
Income Levels[a]	0.54*	0.56*	1.00*	1.00*
	(0.08)	(0.08)	(0.08)	(0.08)
Openness[b]		−0.82		−0.01
		(0.68)		(0.65)
Adjusted R^2	0.403	0.407	0.730	0.725

Note: Standard errors in parentheses. $N = 64$.

[a] Coefficients multiplied by 10^4.

[b] Coefficients multiplied by 10^3.

*$p < 0.01$.

significant, and *(b)* the spatial association given in table 2 between trade proximity and incomes ($z = 3.74$) is stronger than that of openness and spatial proximity ($z = 1.86$ and $z = 2.67$). Thus, it seems more likely that any association between parities and trade will be captured by W^T rather than by the openness variable.

Regression Diagnostics

Residual plots for both equations suggest a lack of normality and that higher parities have lower residuals, but formal tests of heteroskedasticity (the Koenker-Bassett and the White test) are not conclusive. The question of heteroskedasticity is addressed in the next section, which discusses alternative models. There is some evidence of spatial dependence in the form of autocorrelated errors. Moran's I generated by the *SpaceStat* software (Anselin 1995), the Kelejian-Robinson statistic, and the robust Lagrange Multiplier tests yielded significant values for contiguity and distance weights in the case of tradables, and for trade-based weights for nontradables.

Alternative Specifications: Spatial Regression Models

It is clear from the regression results above that income levels not only account for much of the variation in price parities, but also have a greater effect on nontradables than on tradables. This was consistent with previous work on price levels. However, the presence of nonnormal errors and residual autocorrelation violates the assumptions of the OLS model and may lead to biased and inefficient coefficient estimates. Nonlinear transformations and their residual diagnostics also were estimated, but do not appear to differ significantly from the results of the simple linear model. Therefore, alternative models that explicitly incorporate the spatial element will be examined.

The first two spatial regression models include the weight matrices as part of the error term (spatial error model) and as a missing explanatory variable in the form of a lagged price parity (spatial lag model). They are discussed below. The spatial error model is given in (4):

$$y = X\beta + \varepsilon$$

$$\varepsilon = \lambda W\varepsilon + \mu \tag{4}$$

where λ is the autoregressive coefficient for the spatial error term $W\varepsilon$. The error term μ is assumed to be normally distributed as $N(0, \sigma^2 I)$. The second model is the spatial lag model given in (5):

$$y = \rho Wy + X\beta + \varepsilon \tag{5}$$

where ρ is the spatial autoregressive coefficient, and the error term ε is assumed to be normally distributed, $\varepsilon \sim N(0, \sigma^2 I)$.

The two autoregressive coefficients, one for the lagged error term, the other for the lagged dependent variable, are obtained through maximum likelihood estimation. They are shown in table 3 (tradables) and table 4 (nontradables).

In the contiguity-weighted models, islands and countries without neighbors in the sample have zero weights, and their effects are factored out of the coefficient estimates. For example, the estimated parities for Australia, Japan, and all the Caribbean countries will not be lagged, and in turn, their price parities will not affect the parities of other countries.

For tradables, a spatial lag in the form of distance-weighted parities (column 5, table 3) creates an income effect that is nearly 15% higher than the income effect in the OLS estimate (0.62 versus 0.54 for the OLS estimate). The significant distance-based lag coefficient, rho (ρ), also implies that at given income levels, the tradable price parities of countries that are geographically close affect the price levels of other countries.

For nontradables, the addition of the spatial error also creates a greater income effect than the OLS estimate, but by a smaller margin, 1.03 compared to 1.00 (column 3, table 4). The trade-based lag coefficient in the error model means that differences in nontradable prices are explained by the extent of trade between countries, as well as by relative income levels.

In both cases, the spatial component reveals how there may be patterns of interaction among countries that are not accounted for in conventional models. The spatial models also show how OLS estimates may be significantly biased when this interaction is not made explicit.

Recall that there was a hint of heteroskedasticity in the residual diagnostics for the simple model. In the spatial models, there is stronger evidence of residual heteroskedasticity, suggesting that a model that incorporates both spatial dependence and heteroskedasticity should be considered, particularly for tradables. If the residuals decline with higher parities, the effect of an outlier such as Nigeria, with a large positive residual for tradables (and not for nontradables) and a low income level, is to flatten the slope, or lower the estimated income coefficient.

TABLE 3. Maximum Likelihood Estimation of Spatial Models—Tradables

Tradables	Spatial Error Model			Spatial Lag Model		
	C	*D*	*T*	*C*	*D*	*T*
Constant	0.57**	0.58**	0.56**	0.56**	1.23**	0.26**
	(0.04)	(0.03)	(0.04)	(0.05)	(0.28)	(0.20)
Income[a]	0.53**	0.50**	0.54**	0.54**	0.62**	0.52**
	(0.07)	(0.06)	(0.08)	(0.09)	(0.08)	(0.08)
Lagged error (λ)	–0.09	–0.72	–0.03			
	(0.15)	(0.50)	(0.28)			
Lagged dependent variable (ρ)				0.004	–0.88*	0.32
				(0.07)	(0.37)	(0.20)
Heteroskedasticity (B-P test)	yes*	yes*	yes**	yes**	yes*	yes**
Error/Lag dependence (LM test)	W^D	no	W^D	W^D	no	W^D
	yes*		yes**	yes*		yes**
Maximum log likelihood	5.03	6.38	4.72	4.72	7.69	5.07

Note: Standard errors in parentheses.
[a] Coefficients multiplied by 10^4.
$^*p < 0.10$. $^{**}p < 0.05$.

TABLE 4. Maximum Likelihood Estimation of Spatial Models—Nontradables

Nontradables	Spatial Error Model			Spatial Lag Model		
	C	*D*	*T*	*C*	*D*	*T*
Constant	0.32**	0.33**	0.33**	0.33**	0.16	0.03
	(0.04)	(0.05)	(0.04)	(0.04)	(0.14)	(0.19)
Income[a]	1.00**	0.99**	1.03**	1.04**	0.94**	0.97**
	(0.07)	(0.08)	(0.07)	(0.09)	(0.09)	(0.08)
Lagged error (λ)	–0.09	0.36	–0.73**			
	(0.15)	(0.32)	(0.28)			
Lagged dependent variable (ρ)				–0.05	0.26	0.26
				(0.06)	(0.20)	(0.18)
Heteroskedasticity (B-P test)	no	no	no	no	no	no
Error/Lag dependence test (LM test)	no	no	no	no	no	no
Maximum log likelihood	8.85	9.24	9.55	9.07	9.31	9.29

Note: Standard errors in parentheses.
[a] Coefficients multiplied by 10^4.
$^*p < 0.10$. $^{**}p < 0.05$.

TABLE 5. Heteroskedastic Error Model

	Tradables	Nontradables
Constant	0.56**	0.32**
	(0.05)	(0.04)
Income Levels[a]	0.55**	1.00**
	(0.07)	(0.07)
Heteroskedastic coefficient	0.039**	0.025*
	(0.015)	(0.014)
Adjusted R^2	0.499	0.773
Maximum log likelihood	7.57	10.08
Error dependence	no	no
Lag dependence	W^D yes**	W^T yes**
	W^T yes*	

Note: Standard errors in parentheses.
[a] Coefficients multiplied by 10^4.
$^*p < 0.10$. $^{**}p < 0.05$.

Below is a test for whether a heteroskedastic coefficient is significant and then a discussion of a mixed spatial-heteroskedastic model.

The first model is a generic heteroskedastic regression, shown in (6):

$$y = X\beta + \varepsilon \tag{6}$$

where $Var(\varepsilon) = Z\gamma$, and Z contains a constant term and a dummy variable for low income countries with γ as the corresponding vector of coefficients. Low income observations are countries with less than \$6,000 per capita GDP. This threshold level was found by visually inspecting the regression lines and the residual plots. Table 5 shows the model results for tradables and nontradables.

The estimated coefficients on income for tradables are slightly higher than the OLS estimate (0.55 versus 0.54), as expected, and the heteroskedastic coefficient is also greater for tradables. The positive sign of both heteroskedastic coefficients confirms that the error variance for low income countries is higher than the variance for high income countries.

Do low income countries exhibit different spatial patterns than high income countries? Because there is still evidence of spatial dependence in the residual diagnostics of the heteroskedastic regression, the answer is probably yes. Estimating a separate model for low income countries can test whether the income parameter and the spatial effect are fixed across all countries or whether they should be allowed to vary across the two regimes. A test for changing parameters in the simple OLS model yielded no significant differences, but some of the spatial effects are worth mentioning.

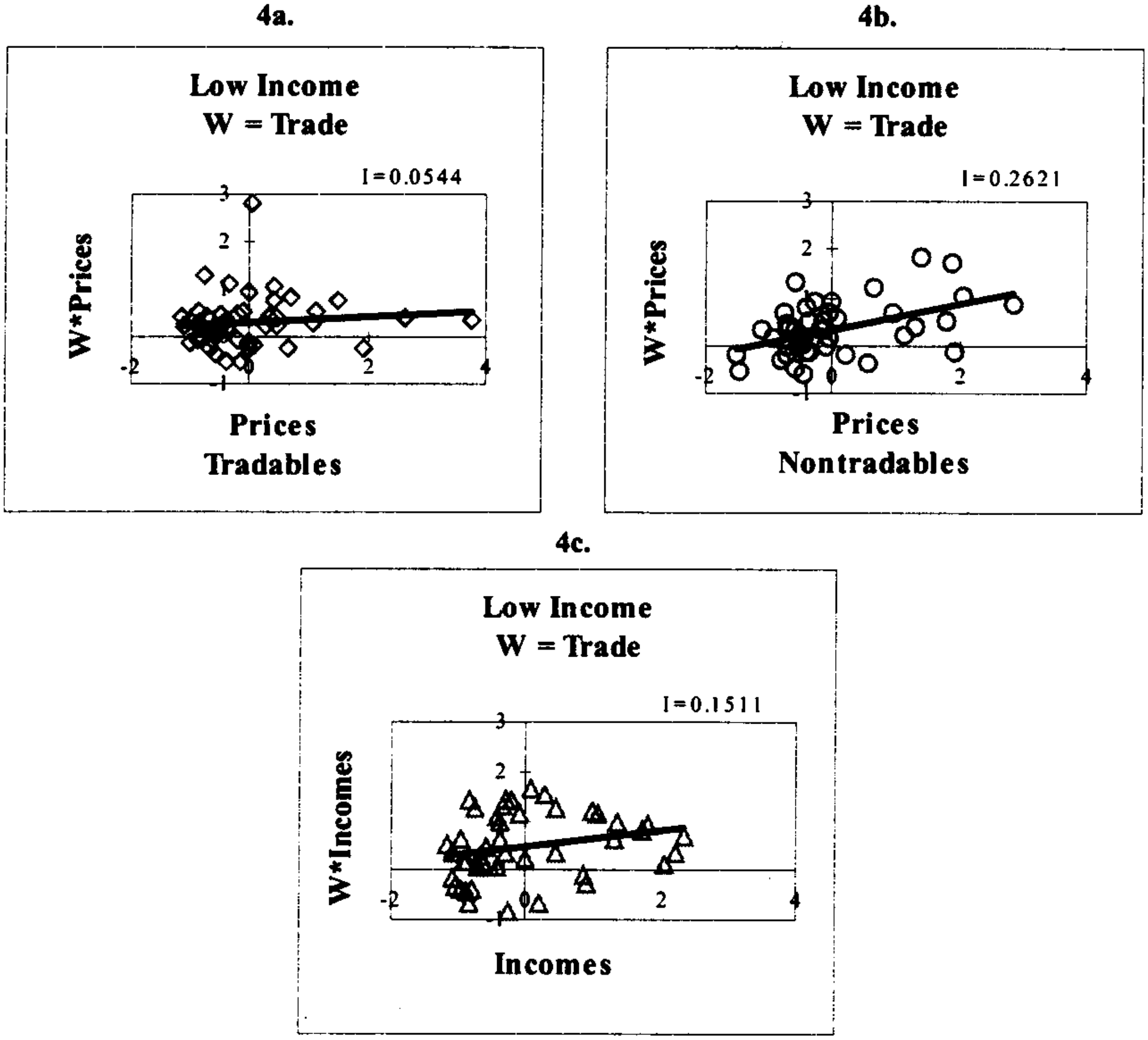

FIGURE 4. Moran Scatterplots Using Trade as Weights Matrix in the Low Income Group

First, the autocorrelation coefficient (Moran's I) for tradable parities is negative and significant for both contiguity and distance (it was positive and not significant for all countries), while for nontradables and income levels, the geographic-based autocorrelation is still positive but less strong than for the larger sample. One interpretation of these results is that the differential in tradable prices among low income countries has more to do with their location relative to high income countries than their location relative to other low income countries. If this is the case, then trade rather than geography should be more positively correlated with the parities. The trade-based correlations are discussed below.

Moran's I and the corresponding scatterplots for the trade-based weights in the low income group are shown in figures 4a through 4c. Although the regression line intercepts are still above zero, in contrast to figures 3a through 3c there are countries with $\boldsymbol{Wx}$'s below zero. That is, some of the low income countries are closer, or trade proportionally more, with other low income countries. For nontradables, Moran's I is twice as large using the trade-based weights than it was for all countries. This is again consistent with the view that the effect of trade can be seen more clearly in nontradables, if indeed, trade has equalized the prices of tradables, which it appears to have done.

TABLE 6. Spatial Effects for Nontradables: Low Income vs. All Countries

	Income[a]		Lagged Error (λ)		Lagged Parity (ρ)	
Nontradables	All	Low Income	All	Low Income	All	Low Income
Distance	0.99*	1.27*	0.36	0.80*		
	0.94*	1.00*			0.26	0.64*
Trade-based weights	1.03*	0.92*	–0.73*	0.64*		
	0.97*	0.96*			0.26	0.58*

[a] Coefficients multiplied by 10^4.
$*p < 0.05$.

The spatial error model for low income countries results in insignificant income and lagged error estimates for tradables. It seems likely that the correlation between income and geography and trade for poor countries overshadows the spatial or trade effect on their tradable parities. For nontradables, the difference is in the opposite direction, with strongly significant coefficients for both income and error estimates. The distance-based error coefficient, for example, increases to 0.80, and becomes significant compared to a nonsignificant value of 0.36 in the regression with all countries. The income coefficient rises to 1.27 from 0.99. The same is true for the trade-based weights. The nontradables error coefficient is now positive and significant (0.64 versus –0.73), while the income coefficient drops from 1.03 to 0.92, but remains highly significant. This implies that low income countries that trade with one another are more likely to see higher prices for their nontradable goods than low income countries that do not trade with each other. It also implies that this trade effect is greater relative to the income effect, for poorer countries. In addition, distance is also important in determining nontradable price parities for low income countries, more so than for all countries taken together.

Interestingly, the spatial lag model results in insignificant spatial effects for tradables, where before in the larger sample, the distance lag was negative and significant. It also results in insignificant income coefficients, in much the same way as the spatial error model. Thus, for tradables, one can safely reject the hypothesis of two regimes based on a poor/rich classification of countries. For nontradables, on the other hand, the income coefficients remain strongly significant, and previously insignificant spatial and trade-based lag effects become significantly positive (0.64 for distance and 0.58 for trade-based weights). A summary of the major changes between the low income regime and all countries for nontradable parities is shown in table 6.

The larger, positive coefficients on the spatial error model vis-à-vis the spatial lag model for both distance and trade suggest that a lagged price parity is significant but may not capture all the effect on nontradables. The remaining effect, significant only in the low income countries, may be due to greater measurement errors. This would explain why it would not be so for the entire sample, as one might expect more homogeneity in price collection practices for the wealthier countries.

CONCLUSION

The spatial component, geographic or trade-based, provides some useful insights for understanding the differences between price relatives of tradables and nontradables. Prices tend to be more similar for countries that are geographically close. This is also true with respect to trade, but in this case, the correlation is lower as low parity countries trade proportionately more with high parity countries, while high parity countries trade predominantly with other high parity countries.

One possible source of autocorrelation in parities is income levels, as previous research has shown that they appear to capture much of the variation in national price levels. However, these models did not explicitly test for spatial effects. Diagnostic tests on the simple model that regresses parities on incomes revealed sources of misspecification, primarily in the form of an omission of a relevant independent variable and the existence of nonspherical disturbances. The consequences of these two violations of the OLS assumptions may lead to biased and inefficient coefficient estimates. Income may not be capturing as much of the variation as one might expect, while both geographic and trade effects may play a greater role than previously thought.

Two spatial regressive models were estimated: a spatial error model where the disturbances are assumed to be autocorrelated, and a spatial lag model where it is assumed that the price parities have an effect on the parities of countries that are geographically close or that have strong trading ties with one another. The spatial lag model using distance-based weights for tradables increased the OLS income coefficient by 15%, strongly suggesting that there is such an effect. For nontradables, the error-lagged coefficient using the trade matrix was strongly significant. Countries that trade more with each other have more similar price parities for their nontradables, but not necessarily for their tradables. In other words, the price effect that Case, Rosen, and Hines (1993) term "spillover" is higher on nontradables than on tradables, where spillover refers to the effect of prices on countries with proportionally similar trade flows.

For both tradables and nontradables, there was evidence that a model was needed to account for the simultaneous presence of heteroskedasticity and spatial dependence. This was tested by separating the countries into two regimes, based on their per capita GDPs (below or above $6,000). It became clear that the spatial effect, both distance-based and trade-based, is much more significant in the low income countries, and that this effect is nearly entirely confined to the prices in the nontradable sector.

Two hypotheses were introduced in the beginning of the paper. The first states that geographical proximity is more strongly associated with price parities than trade proximity. This is true for nontradables but not conclusive for tradables. The second hypothesis is that at given incomes, trade flows will be positively autocorrelated with price parities. That is, countries that are strong trading partners will have more similar prices. Again, this appears to be true more for nontradables than for tradables. The results for the spatial regression models also made it clear that in the case of nontradables, it may be useful to separate low income from high income countries, as the spatial effect varies greatly between the two regimes. Space does matter! The presence and the varying effect of distance and trade-based weights on prices at the national level suggest that conventional models often may be misspecified, or may mask changes that are due to spatial rather than to purely economic factors.

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TABLE A.1. Country List

1. DEU	Germany, West	33. ETH	Ethiopia
2. FRA	France	34. KEN	Kenya
3. ITA	Italy	35. MWI	Malawi
4. NLD	Netherlands	36. MUS	Mauritius
5. BEL	Belgium	37. NGA	Nigeria
6. LUX	Luxembourg	38. SLE	Sierra Leone
7. GBR	United Kingdom	39. SWZ	Swaziland
8. IRL	Ireland	40. TZA	Tanzania
9. DNK	Denmark	41. ZMB	Zambia
10. GRC	Greece	42. ZWE	Zimbabwe
11. ESP	Spain	43. BEN	Benin
12. PRT	Portugal	44. CMR	Cameroon
13. AUT	Austria	45. COG	Congo
14. FIN	Finland	46. CIV	Ivory Coast
15. NOR	Norway	47. MDG	Madagascar
16. SWE	Sweden	48. MLI	Mali
17. AUS	Australia	49. MAR	Morocco
18. NZL	New Zealand	50. RWA	Rwanda
19. JPN	Japan	51. SEN	Senegal
20. CAN	Canada	52. TUN	Tunisia
21. USA	United States	53. POL	Poland
22. TUR	Turkey	54. HUN	Hungary
23. HKG	Hong Kong	55. YUG	Yugoslavia
24. KOR	Korea, South (R)	56. BHS	Bahamas
25. THA	Thailand	57. BRB	Barbados
26. IND	India	58. GRD	Grenada
27. IRN	Iran	59. JAM	Jamaica
28. LKA	Sri Lanka	60. LCA	St. Lucia
29. PAK	Pakistan	61. SUR	Suriname
30. PHL	Philippines	62. TTO	Trinidad & Tobago
31. BWA	Botswana	63. BGD	Bangladesh
32. EGY	Egypt	64. NPL	Nepal