Spatial Price Integration in U.S. and Mexican Rice Markets

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Introduction

Despite a long history of agricultural protectionism on both sides of the border, the past 20 years have seen tremendous strides in liberalized U.S.-Mexico trade. Notable are the implementation of Mexican economic and sector reforms beginning in the 1980's, in which the protectionist *Sistema Alimentario Mexicano* was abolished and the agricultural budget was slashed (Merrill and Miro 2005), and the implementation of the North American Free Trade Agreement in 1994. Over the past decade, Mexico's agricultural sector has had progressively less government support each year, while agricultural exports in the 1990's to the U.S. grew at a striking annual rate of 11.5 percent (Chamber of Commerce 1999). On the import side, by 2002, Mexico had grown to be the third largest market for U.S. agricultural exports.

However, protectionism remains high in both U.S. and Mexican rice markets, the sector of interest here. Payments to U.S. rice growers totaled more than $1.2 billion in 2004. In Mexico, just prior to the scheduled removal of tariffs on U.S. milled rice imports in 2003, the protests of millers led to Mexico's imposing a 10 percent anti-dumping duty and amending its trade laws to facilitate future punitive actions (Office of the United States Trade Representative, 2005). The new duty outraged U.S. millers who saw a return to the protected markets of the past. Though both countries protect their rice sectors, these are two dramatically different industries. U.S. rice production is highly capitalized and efficient, with yields among the highest in the world (Economic Research Service, 2004). The U.S. distribution system is also highly efficient. Widespread on-farm drying of rice results in low levels of spoilage and high grain quality. The U.S. rice milling system enjoys scale economies and is highly competitive. Although U.S. producers only 2% of global rice production, about 40% of the U.S. rice crop is exported –

mostly long-grain milled rice – with the U.S. accounting for about 12% of global rice trade. Due to tariff escalation, most exports to Mexico and Central America are in rough (unmilled) form. These exports grew tremendously in the 1990-2004 period, with trade volume increasing more than six-fold to more than 731,000 metric tons (FAO, 2005).

By contrast, Mexican rice production faces significant constraints. Mexican rice mills are more numerous than American rice mills, but there are far fewer commercially viable operations. The vast majority are relatively inefficient community-run mills situated near *ejidos.* Large numbers of Mexican mills have closed within the past 15 years with thousands of job losses. The industry has become highly concentrated, with six mills estimated to process 90% of all rice milled in Mexico (Rindermann and Cruz, 1999; Fellin, Fuller and Salin, 2000).

Given the recent environment of significant changes in bilateral trade policy and industry competitiveness, this paper seeks to examine the extent to which trade policy and a resumption of protectionism has affected market integration and efficiency in North American rice markets. We examine whether the trade in milled rice has adhered to the principles of specialization according by comparative advantage. We analyze prices in 10 markets in the U.S. and Mexico, and examine market integration by testing price convergence and co-movement through a sequential process. We begin by examining descriptive statistics of prices, market price differentials, and effective tariffs. We then use bivariate cointegration to identify the existence of equilibrium relationships between market pairs over both the medium and long term. Multivariate cointegration is carried out so that the boundaries of continuous markets may be determined. Finally, markets with stable long-run relationships are subjected to impulse response analysis, yielding insights into the speed at which deviations from equilibrium are corrected. The conclusions and implications of the analysis are discussed in the last section.

Mexico and U.S. Market Data

Mexican rice market data are weekly prices of long grain milled rice reported at wholesale distribution centers (*centrales de abasto*) in southern and central Mexico, and collected by the National System of Integration and Integration of Markets (SNIIM). Only a small number of market locations report data with any regularity; seven market locations were selected on the basis of quality and consistency of price data. The Federal District market (serving Mexico City) is the largest of all wholesale markets, with the best transportation and access to millers. The Guadalajara market in Jalisco is the second largest, has good infrastructure, and is home to one of Mexico's six dominant millers. The other Mexican markets are smaller, in some cases more remote, and generally served by a greater share of domestic production versus imports. The original price data were reported in pesos per kg for 50 kg bags of rice. These prices were then converted to U.S. dollars using average weekly market dollar-peso spot rates.

For the U.S., we use weekly FOB prices at the milling site per hundredweight of long-grain milled rice in the three largest productive areas of the country, Arkansas, Louisiana and Texas. The data are from regular surveys conducted by the USDA's Agricultural Marketing Service. Arithmetic averages of reported high and low weekly prices were used. Arkansas is home to Riceland Foods, one of two companies found not to be dumping in Mexico's 2002 investigation and thus able to export its goods to Mexico duty-free (Office of the U.S. Trade Representative, 2004). Louisiana is important for its good ocean freight access. Texas (Houston) is the primary point from which U.S. exports leave to Mexico by truck, rail and ocean freight.

To examine medium-term changes in market integration, the time series are analyzed over the entire period, 1998:1 to 2002:52 (denoting year and week), and three subperiods. The first period, 1998:1 to 2000:17, represents a period of relatively high tariffs (10%, declining to

6%) and, as we will see, large U.S.-Mexico spatial price differentials. On average, the price differential between U.S. and Mexican markets was $10.43 per 50 kg of rice, with the tariff accounting for about $1.54. The second period, from 2000:18 to 2002:35, is characterized by lower tariffs (6%, declining to 2%) but higher price differentials. The average cross-border price differential was $12.83, to which tariffs contributed only 58 cents. The anti-dumping duty of 10.18 percent takes effect shortly before the beginning of the third subperiod, from 2002:36 to 2004:52, and persists throughout it. The average price differential in this subsample is $8.91, with the tariff contributing about $1.53. Nonetheless, in this period prices converge and trade volumes increase, suggesting that while the Mexican tariff structure affords substantial protection to millers, excess demand remains a major determinant of trade volumes (given that Mexico's milling capacity is fixed in the short run). During this period, subsidy support to Mexican rice producers increased which may account in part for the declining prices.

Empirical Modeling and Results

Given paper length limitations, the analysis is briefly summarized in seven stages. Due to the extent of the time-series results, we only cited the methods used, report selective results, and describe others qualitatively as space allows. Full details are available in *Anonymous*, 2005.

Descriptive Statistics. To begin, it is informative to examine descriptive statistics of the univariate time series to provide a starting point for comparative market analysis. Table 1 shows that the mean price of milled rice is consistently higher in Mexico than in the U.S.; the lowest Mexican prices are found in Mexico City, Jalisco, Oaxaca, and on the Yucatan Peninsula. The low prices in Jalisco and Mexico City may be a result of the fact that large mills in Central Mexico and Guadalajara process a large portion of the rough rice imported into Mexico from the U.S., and therefore enjoy lower input costs (Fellin, Fuller and Salin 2000). The prices in Oaxaca and Yucatan may be similarly affected by the U.S. prices due to their easy transportation access, particularly Yucatan's access to the Gulf of Mexico and U.S. ports. Prices in the smaller markets at Aguascalientes and Guanajuato are substantially higher than in other locations.

__Price Differentials.__ We examine market price differentials among the 10 Mexican and U.S. markets to test the law of one price. The quantitative results (not shown) show that U.S.-Mexico price differentials decreased consistently from 1998 to 2004. All of the U.S. markets showed persistently decreasing price differentials with respect to Mexico's Federal District and Jalisco markets, respectively. This seems to indicate increasingly efficient trade between the major U.S. and Mexican markets. For most other markets (12 of 20 pairs with data beginning in 1998), the middle period (2000:18 to 2002:35) brought with it substantial increases in price differentials.

A number of conclusions can be drawn. The cross-border price differential is typically so far in excess of the tariff that the tariff is not binding, and even given other transactions costs, it is unlikely that the tariff contributes substantially to demand decisions. Even as they decline, persistently large price differentials between the U.S. and smaller Mexican markets indicate that strong trade linkages may not exist between the center and peripheral markets, as arbitrage conditions are likely violated. With this in mind, it is unlikely that Aguascalientes (a peripheral market) will be cointegrated with U.S. and Central Mexican markets. For the two largest markets in Mexico (Federal District and Jalisco), narrower price differentials suggest trade linkages, and indicate that the tariff structure is likely to have a profound influence on market integration, as tariffs may be binding. Lastly, narrow price differentials between U.S. markets support the hypothesis that these markets are well-arbitraged and highly integrated.

__The Effective Tariff.__ The estimated effective tariff illustrates why Mexico's imposition of an anti-dumping duty on milled rice actually provides Mexican millers with a greater degree of protection than the nominal tariff alone would suggest. Mexican millers benefit from a low to nonexistent tariff on rough rice, and this duty-free import comprises a large proportion of the value of the finished (milled) product, thus the total protection afforded them extends beyond the nominal tariff. As shown in Table 2, the level of protection afforded to Mexican millers in 2003-2004 was greater than that which they enjoyed under seemingly less-liberal trade in 1998. The imposition of the 10.18 percent anti-dumping duty in mid-2002, combined with NAFTA's removal of all tariffs on rough rice has resulted in a system by which Mexican millers are able to capture nearly 20 percent more value than they would have been under free trade. Though this amount is still dramatically lower than the average price differential between U.S. and peripheral Mexican markets, it is likely to account for a substantial proportion of the narrow price differentials between U.S. markets and the central Mexican markets in the Federal District and Jalisco. This simply due to the fact that price differentials in smaller markets are so large that the tariffs are non-binding, indicating that other forces are causing higher prices in those markets.

<u>Unit Root Tests for Stationarity.</u> The Augmented Dickey Fuller (ADF) test (Mackinnon, 1991; Greene, 2003) was used to determine whether the time series possessed a unit root, and thus the suitability of using cointegration models. Both global and local unit root tests were calculated. The results (not shown) indicate that when the whole time series is considered, all markets possess a unit root, thus it is valid to carry out cointegration analysis on all markets when the full series is considered (Tanaka, 1999). The null hypothesis of a unit root was rejected for Irapuato in the first subsample, and for Irapuato and Leon in the second subsample. For all other market-subperiod combinations, the null hypothesis of the unit root is not rejected; stationarity of the first differenced series was found in all cases. The implication of this is that cointegration analysis may be carried out on the sub-samples of all markets but Leon and Irapuato.

Bivariate Cointegration. Based on the properties of the data and the subsamples, we can hypothesize that, given importation of low-cost foreign rice into Mexico, the Mexico City market should tend to be cointegrated with the U.S., especially in the first two periods given relatively low tariffs and high price differentials. The imposition of the anti-dumping duty may render integration less likely. Second, we expect Jalisco (Guadalajara), a large market in close proximity to one of Mexico's largest millers and host to nearly one hundred traders, to be highly linked to international markets. Finally, given the narrow price differentials and ease of transfer of information, it is probable that the U.S. markets will exhibit a high degree of integration over all time periods considered.

In the *first subsample* (1998:1 to 2000:17), virtually all market pairs show strong evidence of cointegration. In 4 of 15 cases, cointegration is indicated only in one direction. All of these cases involve Aguascalientes; it would seem sensible that a smaller and more isolated market such as Aguascalientes would act as a satellite market, its own price being a function of those in larger markets. The patterns of market integration in the *second period* are substantially different from those in the first. About half (13 of 28) of the market pairs do not exhibit cointegration. There is little evidence of any comovement between U.S. prices, surprisingly, since price differentials, while elevated, remained below fifty cents on average. All of the U.S. markets appear to be more closely tied to Jalisco than with one another; in fact, Jalisco appears to be cointegrated with every other market, underscoring its centrality in the context of the broader market. In the *third subsample* (2002:36 to 2004:52), patterns of integration appear to have changed once more. U.S. markets again all appear to be cointegrated with one another at a high level of significance. Integration in the international market appears to have changed. Texas is now cointegrated with the Yucatan market and with the Federal District. Both of these relationships are sensible given relatively high trade volumes, with Mexico City a major distribution hub in the food system, and Houston and Yucatan important Gulf ports.

In Table 3, we show the empirical results when the entire time series is considered. The results are in keeping with what one might predict: large markets are integrated with one another, both domestically and internationally. The satellite market at Aguascalientes does not exhibit a significant long run relationship with the others. All of the U.S. markets are integrated with one another, as are the Mexican markets (with the exception of Aguascalientes). Internationally, there is strong evidence for long-run equilibrium relationships between the Federal District and Jalisco and the U.S. markets. This is not surprising given that millers in these areas often employ imported rice, and therefore are subject to cost structures similar to American millers. Additionally, these markets are large in terms of number of wholesale traders and have good infrastructure, implying that arbitrage opportunities are better than in smaller markets.

Multivariate Cointegration. Multitvariate cointegration analysis allows for the delineation of continuous markets, so that it can be understood how each location fits into the entire market, giving us insights into *why* certain markets may be cointegrated. For instance, the finding of a continuous market between Gulf Coast locations might indicate that access to ocean freight is an important determinant of market integration. It is not possible to identify continuous markets unless all locations are integrated, so we discuss here the results including only fully integrated sets of locations, determined by an iterative procedure detailed in Anonymous, 2005. Analysis of the *first subsample* with six markets implies that all locations are integrated with one another in formation of a single market; this supports the findings from the bivariate analysis and clarifies the results for Aguascalientes. In the *second subsample* the results portray a far less cohesive marketplace, also in keeping with the bivariate analysis. Jalisco appears to occupy a central position on both sides of the border, serving both as a destination for U.S. rough rice and a point of origin for Mexican milled rice. Results for the *third subsample* imply that all markets are not integrated with one another. When Yucatan and Aguascalientes are excluded, the markets are fully integrated at the five percent level. This modestly contradicts the results of the bivariate analysis, which gives weak evidence of integration between Texas and Yucatan and strong evidence of integration between the Federal District and Yucatan. Considering these three markets simultaneously shows that the three series are integrated at the five percent level, highlighting that it is probable that the three locations comprise a single market. The multivariate analysis shows that the three American markets are cointegrated with Mexico City and Guadalajara. This renders the effect of the anti-dumping duty on market integration ambiguous, since it is difficult to posit one test of integration as superior to the other. The contradictory results may reflect the fact that on the one hand, a binding tariff separates the markets, but on the other they are linked by ongoing trade.

Table 4 shows Johansen cointegration test results when the series are considered in the long run (beginning in 1998 and 2000). The results are generally in keeping with those from the bivariate analysis. In both the seven and five year samples, the omission of Aguascalientes results in a fully integrated market. When Aguascalientes is included in the five year sample, it actually serves to reduce the rank of the cointegrating matrix.

Impulse Response Analysis. By mapping the responses of locations in a continuous market to a one-time shock in a single location, predictions can be made about how markets will respond to future innovations in price. The magnitude of response and speed of convergence indicate the depth of market integration. Generally, markets in the U.S. showed rapid positive responses to exogenous shocks, with convergence taking place between 11 and 16 weeks after the innovation.

Internationally, the Federal District tended to respond quickly and positively to innovations in U.S. markets, though its response was of a relatively small magnitude. Yucatan, and surprisingly, Jalisco demonstrated little sensitivity to innovations in U.S. markets. Shocks in the Federal District generated surprisingly weak responses from the other Mexican markets, with small positive responses being followed by gradual convergence. Overall, the results of the impulse response analysis confirm many of the findings of the cointegration models: that U.S. domestic markets respond fairly quickly to on another; that the Federal District is largely integrated with U.S. markets; and that information flows from Texas to Yucatan, unsurprising given both locations' access to the Gulf.

Conclusions and Implications.

Based on cointegration results, it seems that long-run equilibrating relationships bind most Mexican markets – the exceptions being Aguascalientes, Leon and Irapuato – to the U.S. markets, and that the U.S. markets are integrated with continuity. The small size and lack of proximity of the three smaller Mexican markets to transport hubs and milling centers tends to isolate them – like other such regional markets in Mexico – from the informational flows of the larger marketplace. There are some conflicting results. The disintegration of American markets in the second subsample shows that an isolated supply shock, such as a weather phenomenom, can have a substantial impact on whether markets are integrated. The results for the third subsample indicate that the imposition of a large tariff did in fact alter the relationships between the affected markets, though ongoing trade may have offset the divisive effects of the tariff.

Given the persistently large price differentials between U.S markets and peripheral Mexican markets, one must wonder why the markets are not better arbitraged—especially since relatively small land distances separate these markets from Texas. The thinness of these markets may empower those few sellers who participate in them, leading to distortions in the form of monopolistic pricing (especially see the Guanajuato results). It seems likely that retailers in these areas do not have access to the information necessary to transact business across the border. Informal barriers such as language and customs may also prevent brokers from pursuing relationships with low-priced, efficient U.S producers. In sum, the determinants of market integration include: access to information, trade routes, trade policy (for large markets), market power of sellers (for small markets), and exogenous shocks such as weather.

In large markets where tariffs tend to be binding, trade policy plays a key role in determining equilibrium market relationships. The tariff structure in rice largely determines whether rice consumed in Mexico will primarily be milled domestically or in the U.S. in the long run. American millers are correct that Mexico's anti-dumping duty is in fact detrimental to them, in spite of the fact that trade volumes in milled appear to vary independently of the tariff structure. The current policy is estimated to have generated a loss to U.S. producers of $10 million annually; the foregone gains to Mexican consumers may even be higher (Salin et al., 2000). Removal of the anti-dumping duty on milled rice would benefit U.S. millers by creating a (narrow) preference for U.S. milled rice, further boosting their competitive position.

Given the low volume of trade in milled rice relative to that in rough rice, one can easily assert that the full gains from freer trade have not been realized. While the narrow price differentials suggest that consumers in central markets stand only to gain marginally from price declines, consumers in rural markets would become substantially better off under free trade. While Mexico has large concentrations of urban poverty, almost all of its food insecurity is rural. Reducing the prices of staple foods would most greatly benefit those in remote areas. However, given the apparent insulation of rural locations from the rest of the market, it is difficult to imagine how integration might be achieved; given that tariffs are not binding, conventional trade policy options will not generate welfare gains in peripheral markets. Because integration is mainly limited to central areas, the gains from trade liberalization accruing to urban consumers in central Mexico are often not shared by the rural poor.

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Table 1. Descriptive Statistics of Variables in the Empirical Model*

Variable	Mean	Standard Deviation	Max.	Min.	*N*	Missing Values
USLA	14.80	3.47	20.94	9.65	365	12
USAR	14.50	3.70	20.94	8.27	365	12
USTX	14.91	3.59	20.94	8.27	365	12
CCAA	26.33	6.56	45.86	15.31	365	5
DFIZ	23.35	4.51	32.28	14.91	365	0
LEON	26.69	3.94	42.20	18.42	365	5
IRAP	29.77	3.88	40.28	20.27	365	6
JALI	21.21	3.96	30.56	13.19	365	9
OAXA	21.70	3.22	31.45	14.52	261	5
YUCA	22.21	3.04	26.93	14.98	261	5

*Abbreviations of Markets' Names for Use in the Empirical Models

USLA	U.S.: Louisiana
USAR	U.S.: Arkansas
USTX	U.S.: Texas
CCAA	Mexico: Aguascalientes
DFIZ	Mexico: Federal District
LEON	Mexico: Guanajuato – Leon
IRAP	Mexico: Guanajuato – Irapuato
JALI	Mexico: Jalisco
OAXA	Mexico: Oaxaca
YUCA	Mexico: Yucatan

Table 2. Nominal and Effective Tariffs on Milled Rice, 1998 – 2004

	Nominal Tariff, Milled	Nominal Tariff, Rough	Effective Tariff
1998	10.00%	5.00%	15.32%
1999	8.00%	4.00%	11.92%
2000	6.00%	3.00%	8.63%
2001	4.00%	2.00%	5.51%
2002*	4.00%	1.00%	6.18%
2003	10.18%	0.00%	17.65%
2004	10.18%	0.00%	18.90%

*Nominal tariff in 2002 calculated as time-weighted average of 2.0 percent NAFTA tariff, in addition to 10.18 percent anti-dumping duty.

Table 3. Cointegration Tests on $\mathbf{p_{it} = \alpha + \beta p_{it} + u_t}$
Full Series

p_i	p_i	b	't'	*CRDW*	*CRDF*
USLA	USAR	0.9307	147.73	0.420	-6.5017***
USAR	USLA	1.0567	146.76	0.421	-6.5080***
USLA	USTX	0.9590	143.13	0.391	-4.9646***
USTX	USLA	1.0249	144.35	0.390	-4.9356***
USLA	CCAA	0.2180	8.62	0.018	-1.9462
CCAA	USLA	0.7786	8.60	0.068	-2.4968
USLA	DFIZ	0.7264	55.03	0.128	-3.4721**
DFIZ	USLA	1.2300	55.16	0.132	-3.5861**
USLA	JALI	0.7711	35.05	0.239	-3.5141**
JALI	USLA	1.0022	35.04	0.299	-3.8588**
USLA	OAXA	0.6076	14.38	0.235	-1.7288
OAXA	USLA	0.7321	14.38	0.501	-2.7952
USLA	YUCA	0.7156	17.68	0.080	-1.9689
YUCA	USLA	0.7656	17.68	0.121	-2.7127
USAR	USTX	1.1020	139.49	0.391	-6.0519***
USTX	USAR	0.9598	129.70	0.389	-6.0150***
USAR	CCAA	0.2333	8.64	0.019	-1.9443
CCAA	USAR	0.7340	8.65	0.067	-2.4894
USAR	DFIZ	0.7760	56.64	0.139	-3.6232**
DFIZ	USAR	1.1573	56.45	0.142	-3.7232**
USAR	JALI	0.8263	35.93	0.254	-3.6638**
JALI	USAR	0.9459	35.97	0.312	-3.9909**
USAR	OAXA	0.6600	14.21	0.232	-2.1726
OAXA	USAR	0.6654	14.22	0.497	-6.1807***
USAR	YUCA	0.7697	17.07	0.080	-2.2704
YUCA	USAR	0.6890	17.07	0.120	-2.6928
USTX	CCAA	0.2400	9.30	0.019	-1.8721
CCAA	USTX	0.8021	9.29	0.069	-2.5282
USTX	DFIZ	0.7640	67.02	0.177	-4.0828***
DFIZ	USTX	1.2108	66.90	0.182	-4.2244***
USTX	JALI	0.8219	40.89	0.321	-4.1226***
JALI	USTX	0.9996	40.80	0.381	-4.4762***
USTX	OAXA	0.6678	15.68	0.267	-1.8833
OAXA	USTX	0.7307	15.67	0.534	-6.4244***
USTX	YUCA	0.7862	19.70	0.097	-2.5402
YUCA	USTX	0.7639	19.70	0.140	-3.0020
CCAA	DFIZ	0.7082	10.63	0.071	-2.6093
DFIZ	CCAA	0.3358	10.63	0.026	-2.2891
CCAA	JALI	0.8716	11.76	0.092	-2.9646
JALI	CCAA	0.3172	11.75	0.102	-2.4370
CCAA	OAXA	1.1981	9.75	0.160	-2.7189
OAXA	CCAA	0.2248	9.75	0.397	-3.3875**
CCAA	YUCA	1.5311	12.86	0.088	-2.4443
YUCA	CCAA	0.2551	12.86	0.100	-2.0932
DFIZ	JALI	1.0738	52.90	0.540	-5.4972***
JALI	DFIZ	0.8242	52.83	0.596	-5.7384***
DFIZ	OAXA	0.9598	21.95	0.543	-6.4085***
OAXA	DFIZ	0.6786	21.95	0.805	-8.1784***
DFIZ	YUCA	1.1141	30.18	0.229	-3.2681*
YUCA	DFIZ	0.6994	30.18	0.266	-3.4937**
JALI	OAXA	0.8437	20.78	0.628	-6.8889***
OAXA	JALI	0.7420	20.78	0.851	-8.4740***
JALI	YUCA	0.9497	24.79	0.328	-3.7326**
YUCA	JALI	0.7417	24.79	0.326	-3.7867**
OAXA	YUCA	0.8857	24.33	1.003	-9.4483***
YUCA	OAXA	0.7864	24.33	0.778	-7.9337***

Table 4a. Johansen Cointegration Test Results
First Subsample for Six Markets
1998: 1 2000:17

Null Hypothesis	Trace Statistic	5% Critical Value	Eigenvalue
r = 0	184.46	93.92	0.3688
r ≤ 1	128.79	68.68	0.3391
r ≤ 2	78.68	47.21	0.2943
r ≤ 3	36.51	29.38	0.1598
r ≤ 4	15.45	15.34	0.11
r ≤ 5	1.34	3.84	0.011

r = 5

Table 4b. Johansen Cointegration Test Results
Second Subsample for Eight Markets
2000:18 2002:35

Null Hypothesis	Trace Statistic	5% Critical Value	Eigenvalue
r = 0	211.45	155.75	0.3893
r ≤ 1	151.79	123.04	0.3307
r ≤ 2	103.21	93.92	0.2989
r ≤ 3	60.24	68.68	0.2261
r ≤ 4	29.23	47.21	0.1132
r ≤ 5	14.69	29.38	0.0704
r ≤ 6	5.87	15.34	0.0471
r ≤ 7	0.03	3.84	0.0002

r = 3

Table 4c. Johansen Cointegration Test Results
Third Subsample for Eight Markets
2002:36 2004:52

Null Hypothesis	Trace Statistic	5% Critical Value	Eigenvalue
r = 0	229.53	155.75	0.5065
r ≤ 1	144.77	123.04	0.2894
r ≤ 2	103.77	93.92	0.2566
r ≤ 3	68.2	68.68	0.1887
r ≤ 4	43.1	47.21	0.1496
r ≤ 5	23.64	29.38	0.0995
r ≤ 6	11.07	15.34	0.0675
r ≤ 7	2.68	3.84	0.0221

r = 3