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STRUCTURAL DETERMINANTS OF MARKET INTEGRATION: THE CASE OF RICE MARKETS IN BANGLADESH

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I. INTRODUCTION

SPATIAL market integration refers to co-movements of prices, and, more generally, to the smooth transmission of price signals and information across spatially separated markets. In this paper, the topic of spatial market integration, as opposed to inter-temporal price integration and vertical price integration, will be generically referred to as market integration. There are several reasons for studying market integration. Such study makes it possible to identify groups of integrated markets, so as to avoid duplication of intervention. If locations A, B, and C are well integrated, then the government may think of withdrawing from, or at least reduce, its effort to influence the price process in those locations. A scarcity in A will be quickly transmitted to B and C, making it redundant to duplicate the same program (for example, an open market sale operation or a procurement activity) in all three locations. Moreover, by giving a more detailed picture of the process of transmission of incentives across the marketing chain, knowledge of market integration is relevant to the success of policies such as market liberalization or price stabilization. Market integration ensures that a regional balance occurs among food-deficit and food-surplus regions, and regions producing nonfood cash crops (see Delgado [8]). If price transmission does not occur, the localized scarcities and abundances may result in excessive strain on the population (see Ravallion [21]). Finally, the identification of the structural factors responsible for the integration of markets may improve policy oriented toward market development.

The study of market integration has usually tried to characterize the degree of co-movement of prices across spatially separated markets. Since prices are the most readily available and often the most reliable information on developing country marketing systems, market integration studies have almost exclusively referred to events resulting in price changes. Most specifically, market integration is restricted to the interdependence of price changes across spatially separated locations in a market (Wyeth [23]).

Past research has identified various measures of market integration including

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This paper is based on an earlier work conducted at the International Food Policy Research Institute (see [13]). The current version is the result of substantial revisions following referees' comments.

correlation coefficients (see Farruk [12], Lele [17], Jones [16], Blyn [5]), short- and long-term tests of integration (see Ravallion [21]), long-term multipliers and times to adjust (see Boyd and Brorsen [6], Mendoza and Rosegrant [19]), cointegration coefficients (see Ardeni [3], Goodwin and Schroeder [14], Wyeth [23], Palaskas and Harriss [20]), causality and centrality tests (see Mendoza and Farris [18]). However, a comparison of various measures as well as an analysis of the structural factors affecting these measures of market integration has been largely neglected, with the exception of the papers by Goodwin and Schroeder [14], and Faminow and Benson [11].

Markets are complex institutions, encompassing hierarchies and interlinked transactions that may involve the simultaneous consideration of various commodities (see Palaskas and Harriss [20]). To expect that a simple measure based only on price sources can describe the process of transmission of information conveyed by price signals is quite ambitious. A more systematic effort to relate the available measures of market integration to structural factors should be undertaken.

The objective of this paper is to understand how different measures of market integration may be used to derive conclusions about the structural determinants of market integration. The underlying hypotheses are that marketing infrastructure, volatility of government intervention, and the degree of self-sufficiency in production are the major determinants of market integration.

The organization of the paper is as follows. Section II presents the main issues and methodology used in the remaining sections. Section III reports different approaches to measure market integration, highlighting some of their uses. Section IV links the previous measures of market integration to structural factors. Section V sets forth our conclusions.

II. THE MAIN ISSUES AND METHODOLOGY

This paper addresses two main sets of issues. The first set is about the concept and measurement of market integration. What is meant exactly when saying that markets are integrated? How is market integration measured and translated into an operational concept? How do different measures of market integration relate to each other, and what different insights do they give?

The second set of issues is about the relation between market integration and structural factors. Assuming that we know how to measure market integration, what are the main factors responsible for it? To what extent are marketing infrastructure, policy, and the degree of self-sufficiency in production the main determinants of market integration?

We address these issues through a two-stage approach. At the first stage, time series analysis of price data is conducted in order to arrive at a reasonable set of measures of market integration. Four measures are considered. The first is given by the correlation coefficient of prices. The second measure consists of the statistics associated with cointegration coefficients that capture the existence of a stable long-term linear relation between price series. The third measure is given by long-term multipliers that express the cumulative response of one market to price shocks

originating in another market, incorporating the dynamics of price transmission. The last measure is the speed of the price adjustment process to the long-term multipliers.

At the second stage, the measures of integration computed at the first stage are linked to structural factors. The structural factors considered in this paper are those related to marketing infrastructure, volatility of government intervention, and degree of self-sufficiency in production.

Marketing infrastructure is the set of transportation, communication, credit, and storage facilities that allow a smooth functioning of markets.

Government policies affect market integration in a variety of ways. Price stabilization policy, trade restrictions, credit and transport regulations are just a small sample of the numerous public interventions affecting the marketing system. The volatility of government intervention is often perceived as one major obstacle to the integration of markets. It is possible, however, that some degree of volatility of government intervention may actually contribute to improving the process of price transmission. For example, public stocks may respond to new information flexibly. Government interventions may thus have both a positive or a negative effect on marketing integration.

Finally, the level of production of the area surrounding each market will determine its self-sufficiency status relative to the rest of the country. Markets divide into those that have generally a surplus in the commodity under consideration, those that have generally a deficit, and those that are generally marginally self-sufficient. The more diverse their respective self-sufficiency position, the more likely that two markets are integrated.

The analysis uses weekly prices of coarse rice over a period of three years, from 1989/90 to 1991/92, and structural variables for sixty-four districts (*zilas*). A description of the main variables is given in the Appendix.

III. MEASURES OF INTEGRATION

The intuitive idea behind the measurement of market integration is to understand the interaction among prices in spatially separated markets. In the extreme case of two markets A and B completely separated from each other, the prices of the same commodity should not be related. If the areas where market A is located experiences a bad harvest, prices will suddenly increase. In market B, there is no reason to assume that a bad harvest has also occurred. In the absence of communication flows between the two markets, prices in B would not show any movement. On the other hand, if A and B were integrated, the price in B would also increase. This is because some food would flow from B to A decreasing the available supply in B. At the same time the price in A would be lower than in the absence of market integration.

Therefore, the co-movement of prices gives an indication of the degree of market integration. However, it is conceivable that two pairs of markets (A, B) and (A′, B′) exhibit the same price co-movement and yet show a different process of price adjustment. That suggests that the dynamics of price adjustment may also give

important information about the integration of the two markets. If, for example, price shocks from A to B take longer to be transmitted than from A′ to B′, even though the index of price co-movement between A and B is the same as between A′ and B′, then we may think of the second pair more integrated than the first one.

This section considers various measures of integration derived from the transformation of time series of prices. The first two measures, correlation coefficients and cointegration coefficients are explicitly trying to capture the co-movement aspect of price integration. The last two measures, long-term multipliers and speed of adjustment, try to capture the dynamic aspect of price integration.

A. *Correlation Coefficients*

One simple way to study market integration is to consider the correlation of price series for different markets. This is intuitively related to the idea that integrated markets exhibit prices that move together. Price correlations are the easiest way to measure these co-movements. However, the traditional tests of market integration focused on correlation coefficients of spatial prices (see Lele [17] for India, Farruk [12] for Bangladesh, Jones [16] for Nigeria) mask the presence of other synchronous factors, such as general price inflation, seasonality, population growth, procurement policy, etc. Early criticism of this approach has been advanced by Blyn [5], Harriss [15], and Timmer [22].

One way to take care of some of this criticism is to consider the correlation of price differences, which has the attractive property of interpreting market integration as interdependence of price changes in different markets. Moreover, price change would largely eliminate common trends that introduce spurious correlation.

Besides the problem of spurious correlation, there are other serious problems related to the often nonstationary nature of the price series involved. These problems are taken up by the cointegration analysis undertaken in the following paragraphs.

B. *Cointegration Coefficients and Market Segmentation*

Cointegration analysis is concerned with the existence of a stable relation among prices in different localities. Prices move from time to time, and their margins are subject to various shocks. When a long-run linear relation exists among different series, these series are said to be cointegrated (see Engle and Granger [10]).

The presence of cointegration between two series is indicative of interdependence; its absence indicates market segmentation. In particular, a segmented link is one where cointegration is rejected in both directions along which the link can be traced, whereas an integrated link is one where cointegration is accepted in both directions. In the data set used in this analysis, 216 out of 2,016 links are segmented. However, in order to have practical relevance, the definition of market segmentation should be restricted even further.

Only those pairs of markets that are “close enough” should be considered. If market A and B are very far away from each other, the lack of cointegration may be due to transportation costs. It is more interesting to focus on those markets that, in

spite of being "close enough," do not exhibit cointegration. The problem is to define what constitutes a "close enough" distance. One reasonable way to solve this problem in the case of rice markets in Bangladesh, is to consider only those markets where a truck could make a delivery within one day. A crude approximation is to consider markets separated by a distance of less than 250 kilometers, assuming that this is the maximum distance that could be covered in a one-day trip by a truck loaded with bags of rice.

Under these assumptions, segmented markets are those markets that are not cointegrated with each other and that are separated by a distance of less than 250 kilometers. Given that there are sixty-four markets, each for every district (or *zila*), the possible market links are (64*63)/2, that is 2,016. The interesting result is that, out of 2,016 links, there are 667 links separated by a distance of less than 250 kilometers, and, among the latter, only about 44 (6.6 per cent) are segmented in the sense specified above (see Table I).

C. *Dynamic Adjustments*

Often it is not enough to say that markets are integrated. One would like to know the extent of integration. Segmentation occurs when there is no cointegration. Perfect integration would occur if the price in one market is just a translation of the price in the other market, implying that price changes are the same. The translation factor can be interpreted as a transfer cost between the two markets. However, it is only in extreme cases that perfect integration or segmentation occurs. Most of the time, intermediate degrees of integration occur. The effort of the analyst then is to work out precisely how to measure these different degrees. The main issue becomes that of measuring the magnitude of price transmission. The immediate impact of price shocks should be distinguished from the impact that builds over time. The process of price transmission usually takes time as the result of complex dynamic adjustments. Following Ravallion [21], a short run and a long run can then be distinguished, and dynamic multipliers computed from the estimation of equations such as

$$p_{i,t} = \sum_{k=1}^{k=m_i} \alpha_{i,k}\, p_{i,t-k} + \sum_{h=0}^{h=n_j} \beta_{i,h}\, p_{j,t-h} + X_{i,t}\, \gamma_i + \varepsilon_{i,t}, \tag{1}$$

where $p_{i,t}$ is the price of rice in market i at time t, $p_{j,t}$ is the price of rice in market j at time t; $X_{i,t}$ are exogenous variables such as seasonal dummies and time trend, and $\varepsilon_{i,t}$ is an error term. $\alpha_{i,k}$,$\beta_{i,h}$, and γ_i are coefficients to be estimated, and m_i, and n_j are the number of lags of prices in market i and j, respectively.

In the estimation, problems of simultaneity may be encountered, related to the contemporaneous use of price in market i and in market j. Since both prices may respond to the same type of shocks, it is expected the error term $\varepsilon_{i,t}$ to be correlated with the price $p_{j,t}$. To overcome this problem, an instrumental variables estimation of $p_{j,t}$ has been used, taking lagged values of the prices of all markets included in the study. The three lags, one for prices in market i, one for prices in market j, and one for the instrumental variables, are determined simultaneously by application of the Akaike information criterion (see Akaike [2]).

TABLE I

SEGMENTED LINKS: MARKETS NOT COINTEGRATED AND LESS THAN 250 KM APART

Link	District *i*	District *j*	Cointegration Statistics (s_{ij})	Cointegration Statistics (s_{ji})	Distance (km)	Correlation
1	Panchagar	Lalmonir	–2.15	–0.70	176	0.27
2	Rangpur	Lalmonir	–2.41	–1.13	39	0.37
3	Lalmonir	Noagaon	–2.18	–1.36	194	0.11
4	Nilphamari	Noagaon	–2.40	–0.98	212	–0.02
5	Kurigram	Noagaon	–2.80	–0.98	205	0.19
6	Bogra	Joypurhat	–2.00	–2.86	57	0.25
7	Bogra	Gopalgonj	–2.50	–2.78	228	0.23
8	Bogra	Dhaka	–2.34	–2.37	220	–0.04
9	Rajshahi	Noagaon	–2.17	–1.82	88	0.16
10	Rajshahi	Nawabgonj	–1.24	–2.39	48	0.09
11	Rajshahi	Kushtia	–1.71	–2.43	142	0.02
12	Pabna	Manikgonj	–2.81	–2.37	103	0.08
13	Magura	Comilla	–2.28	–2.06	231	0.08
14	Jhalokat	Gopalgonj	–2.51	–2.18	121	0.22
15	Jhalokat	Dhaka	–2.06	–2.80	153	0.05
16	Jhalokat	Manikgonj	–1.52	–1.28	193	0.10
17	Bhola	Munshigonj	–2.78	–2.59	202	0.42
18	Netrokona	Manikgonj	–2.88	–2.74	202	0.30
19	Sherpur	Manikgonj	–2.47	–1.80	170	0.29
20	Faridpur	Manikgonj	–2.47	–2.85	56	0.06
21	Rajbari	Manikgonj	–2.69	–0.95	44	0.41
22	Madaripur	Gopalgonj	–2.07	–2.85	69	0.35
23	Madaripur	Manikgonj	–2.08	–1.75	123	0.14
24	Gopalgonj	Munshigonj	–2.55	–2.22	154	–0.11
25	Gopalgonj	Manikgonj	–2.54	–2.04	121	0.26
26	Gopalgonj	Comilla	–2.57	–1.59	211	–0.02
27	Gopalgonj	B. Baria	–2.15	–2.61	237	0.12
28	Dhaka	Lakshmipur	–1.72	–1.70	194	0.10
29	Gazipur	Lakshmipur	–2.82	–2.55	234	–0.03
30	Munshigonj	Lakshmipur	–2.07	–1.59	206	0.01
31	Munshigonj	Chittagong	–2.89	–2.83	245	0.11
32	Moulvi Bazar	Hobigonj	–1.60	–2.77	46	0.16
33	Moulvi Bazar	Sunamgonj	–2.59	–2.38	128	0.23
34	Comilla	Lakshmipur	–2.19	–1.66	113	–0.08
35	B. Baria	Lakshmipur	–2.06	–1.78	204	–0.06
36	Noakhali	Khagrachari	–2.21	–1.94	215	–0.10
37	Noakhali	Bandarban	–1.70	–1.80	205	0.21
38	Lakshmipur	Feni	–0.48	–2.89	48	0.24
39	Lakshmipur	Chittagong	–1.66	–2.56	137	–0.02
40	Lakshmipur	Khagrachari	–0.24	–0.32	219	0.16
41	Lakshmipur	Bandarban	–1.92	–2.34	209	–0.20
42	Feni	Khagrachari	–2.54	–1.63	171	–0.03
43	Chittagong	Bandarban	–2.76	–1.90	72	0.09
44	Cox's Bazar	Khagrachari	–2.41	–1.80	230	–0.01

Source: Computed by the authors based on prices from the Department of Agricultural Marketing (Bangladesh) and on market infrastructure data collected by IFPRI.
Note: A segmented link between *i* and *j* is one where the statistics s_{ij} and s_{ji} are both below the critical value of 2.89 (see Dickey and Fuller [9]).

The magnitude of price adjustment is estimated with dynamic multipliers. Dynamic multipliers are interpreted as the effect of a price change due to a random shock or a shift in an exogenous variable. In the context of the model introduced above, the cumulative effect of a shock to the price in market j on the price in market i, after k periods is denoted by $\lambda_k^{i,j}$:

$$\lambda_k^{i,j} = \sum_{h=0}^{k} \frac{\partial E_t p_{i,t+h}}{\partial p_{j,t}} \ , \tag{2}$$

where E_t denotes the expectation operator based on information available at time t.

The full adjustment of the dynamic process described by the model is given by the long-run dynamic multiplier, which corresponds to

$$\lambda_\infty^{i,j} = \lim_{k\to\infty} \lambda_k^{i,j}. \tag{3}$$

D. *Speed of Adjustment*

The analysis of dynamic adjustments permits the study of the speed of price transmission, i.e., how many days, weeks, or months are needed for prices to be transmitted from one location to another. This is an issue of concern to policymakers for reasons related to the planning of food distribution and price stabilization. Sometimes the speed in the response of prices is related to the efficiency of the market system. However, this assumption is not always valid. Rapid adjustments are just an indication of the flexibility of the mechanism. They do not necessarily imply well-functioning systems. Within the context of this discussion, it is important to consider the speed of adjustment as just one dimension of integration. Given two markets A and B with the same value in the magnitude of price adjustment with respect to a third market C, the shorter the time to complete this adjustment, the better integrated the market. The definition of the long-term multiplier $\lambda_\infty^{i,j}$ permits to define the speed of adjustment $\tau_\infty^{i,j}$ as the first time after which the percentage deviations of the interim multiplier $\lambda_k^{i,j}$ from the long-term multiplier $\lambda_\infty^{i,j}$ are "small enough." In other words, for a given tolerance limit ε, for every $k > \tau_\infty^{i,j}$ we have

$$\left| \frac{\lambda_k^{i,j} - \lambda_\infty^{i,j}}{\lambda_\infty^{i,j}} \right| < \varepsilon. \tag{4}$$

In our computations, the tolerance limit has been taken as equal to 1 per cent.

E. *Comparison of the Main Indicators of Market Integration*

As shown in Table II, over 50 per cent of the markets are integrated according to the correlation and cointegration measures, while only 35 per cent of the market links are integrated according to the dynamic adjustment measures (long-term multiplier and speed of adjustment). One possible explanation for this lower percentage in the case of measures that explicitly involve dynamics of price transmission is that the requirement for the long-term multipliers to be significantly differ-

TABLE II

COMPARISON OF VARIOUS MEASURES OF INTEGRATION

Measure of Integration	Percentage of Significant Market Links	Average of the Measure of Integration over the Significant Market Links	Standard Deviation of the Measure of Integration over the Significant Market Links
Correlation coefficient (ρ)	53	0.23	0.08
Statistics associated to the cointegration coefficient (b)	56	3.71	1.25
Long-term multiplier (λ)	35	0.61	0.25
Speed of adjustment (τ)	35	2.60	1.15

Source: The same as in Table I.

Note: Significant market links are those for which the relative measure of integration is significantly different from zero in both directions of each link. The value 3.71 in the table is the absolute value of the statistics associated to the cointegration coefficient. The actual value is –3.71.

ent from zeros is more stringent than the requirement that prices simply move together.

Table II also provides the descriptive statistics for these measures of integration showing that the average correlation coefficient of price changes is 0.23, the average absolute value of cointegration statistics is 3.71, and the long-term adjustment is 61 per cent and takes an average of 2.6 weeks. Given the details of the market network considered in this paper, the results show a moderate amount of market integration, lending support to the appropriateness of aggregate price policies that are not region specific. This is not surprising given the size of the country; however, it is remarkable given the very low level of infrastructure available.

IV. STRUCTURAL DETERMINANTS OF MARKET INTEGRATION

Market integration, however measured, is the result of the action of traders, as well as the operating environment determined by the infrastructure available for trading and policies affecting price transmission. All the measures of integration considered so far have in common the feature of being computed using only price information available in a specified period of time (156 weeks, covering three years). Each market link is summarized by just one number. But markets are complex institutions, and their performance as well as their integration is the result of numerous factors.

Among these factors, marketing infrastructure related to transportation and communication is an obvious candidate as an explanatory variable. The effect of food grain policy, with particular reference to its volatility, needs also to be taken into account. In the extreme case, perfect market integration occurs when prices are stabilized at the same level all over the country. This is rarely the case, but it is

indicative of the fact that integration as measured by price co-movements and price transmission is heavily affected by government intervention. A third structural factor is the degree of dissimilarity in rice production of various markets. The more dissimilar the markets, the more incentive they have to trade with each other. A final factor that might explain integration is the presence of monopolistic practices, as suggested by Faminow and Benson [11]. However, recent surveys conducted of rice markets in Bangladesh seem to lend little reliability to collusive or basis point pricing as a good description of the market structure (see Chowdhury [7]).

The various groups of factors can be succinctly expressed as follows.

$$\text{Market integration} = f\,(\text{marketing infrastructure, volatility of policy, production}). \tag{5}$$

The hypotheses are that marketing infrastructure is a positive contribution to integration; the degree of dissimilarity of production per capita also affects market integration positively, since the more dissimilar the markets the more the incentive to trade with each other; and, finally, the volatility of government intervention affects market integration negatively, since the private sector will have more difficulty in interpreting new information. In order to test these hypotheses, one needs to specify the variables mentioned in formulation (5), and to estimate the related equations.

For each pair of markets i and j, let M_{ij} denote a measure of market integration. The four measures introduced in the previous section will be used, namely, the correlation of price differences (ρ_{ij}), the statistics associated to the cointegration coefficient (b_{ij}), the long-term multiplier (λ_{ij}), and the speed of adjustment (τ_{ij}).

Marketing infrastructure includes transportation, communication, and credit. Transportation infrastructure and costs are captured by the road distance between markets i and j, d_{ij}; the road density measured by the density of paved roads per squared kilometer in the areas surrounding the two markets i and j, $road_{ij}$; the railway density measured by the density of railways per squared kilometers in the areas surrounding the two markets i and j, $rail_{ij}$; and the number of strikes in the areas surrounding the two markets i and j, $strike_{ij}$.

Communication is measured by the density of telephones per capita in the areas surrounding markets i and j, $tele_{ij}$; credit availability is measured by the density of bank branches per squared kilometer in the areas surrounding markets i and j, $bank_{ij}$.

Volatility of government intervention can influence market integration in both a positive or a negative way. On the one hand, price intervention smoothes seasonal and inter-year fluctuations thus enhancing the co-movement of prices across markets. On the other hand, this very stabilizing process may become unpredictable and therefore hinder the transmission of price signals across markets. In order to test this hypothesis, it is necessary to get an index of the volatility of government intervention. One simple way to do this is to consider the coefficient of variation in the monthly end-of-period public stocks in each district, as explained in the Appendix. This variable is denoted by $policy_{ij}$.

Production affects market integration through the degree of dissimilarity in rice

TABLE

DETERMINANTS OF

Variable	Correlation of Price Differences (ρ)			Cointegration Coefficient Statistics (b)		
	(1)	(2)	(3)	(1)	(2)	(3)
Constant	0.0049	0.1475		5.5718	14.2144	
Distance	–0.0001	–5.0164	–0.2660	–0.0026	–9.1176	–0.4335
Paved road density	0.5835	4.0178	0.3150	–9.6854	–5.6076	–0.3536
Telephone density	3.5282	0.9929	0.0747	66.0499	1.5629	–0.0753
Bank branch density	–0.0008	–2.5837	0.1544	–0.0109	–2.9102	–0.1016
Railway density	–0.0000	–0.2337	0.0704	0.0047	2.0964	–0.1375
Number of strikes	–0.0000	–0.2338	–0.0179	–0.0009	–1.0219	–0.1516
Number of shocks to production	0.0003	2.9578	0.1222	0.0020	1.5163	–0.0368
Degree of dissimilarity in production	0.0150	1.8521	0.0715	0.0454	0.4716	–0.0639
Volatility of stock policy	0.1490	5.0407	0.4194	1.1828	3.3648	0.0952
Mean of dependent variable	0.1526			3.8800		
No. of observations	2,016			2,016		
R^2	0.29			0.37		

Source: The same as in Table I.
Note: (1) = coefficient, (2) = *t*-statistics, and (3) = correlation with dependent variable.

self-sufficiency of various markets. If market *i* is a surplus market and market *j* is a deficit market, then the likelihood that *i* and *j* are linked by trade in rice is higher than if both markets were surplus or deficit, ceteris paribus. The degree of dissimilarity is measured by the absolute value of the percentage difference in production per capita, and is denoted by $prodct_{ij}$. Another variable related to production is the number of production shocks affecting various districts. These shocks as collected from newspapers include days of flooding, drought, cyclones, salinated water, and pest attacks. They are denoted by $shock_{ij}$. Their effect on market integration is not clearly a priori. When the production shocks are of a tremendous magnitude, as for example during the floods of 1987/88 and 1988/89, one would expect that market integration is disrupted. In the case of normal production shocks, they may even positively affect market integration, in so far as they add incentives to trade between affected areas and other areas.

The equations that are estimated are then of the following type:

$$M_{ij} = f(d_{ij}, road_{ij}, rail_{ij}, strike_{ij}, tele_{ij}, bank_{ij}, policy_{ij}, prodct_{ij}, shock_{ij}). \quad (6)$$

The results of the estimations are reported in detailed form in Table III. Multicollinearity among explanatory variables was tested following Belsley, Kuh, and Welsh [4] and did not prove to be a major problem. The signs of the effects of

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MARKET INTEGRATION

Long-term Multiplier (λ)			Speed of Adjustment (τ)			Mean of Independent Variable
(1)	(2)	(3)	(1)	(2)	(3)	
0.1801	1.6933		2.2531	5.0880		
–0.0000	–0.6132	–0.1042	–0.0004	–1.2815	–0.0602	310.8215
–0.4722	–1.0078	0.0041	–10.3571	–5.3080	–0.1971	0.1401
–27.7953	–2.4244	0.0271	101.7659	2.1316	0.0448	0.0026
0.0012	1.2022	0.0680	–0.0148	–3.5036	–0.0308	85.6841
–0.0005	–0.8692	–0.0213	0.0151	5.9876	0.1377	43.1670
–0.0001	–0.3554	–0.0253	0.0033	3.5070	0.1639	237.3684
0.0006	1.7828	0.0449	–0.0004	–0.2592	0.1316	104.4211
0.1173	4.4966	0.1906	0.2606	2.3984	0.1196	0.3735
0.1597	1.6751	0.1148	1.8368	4.6253	–0.0502	0.8794
0.3424			2.7821			
2,016			2,016			
0.09			0.21			

TABLE IV

SUMMARY OF EFFECTS OF STRUCTURAL FACTORS ON MEASURES OF INTEGRATION

	Correlation of Price Differences	Cointegration Coefficients Statistics	Long-term Multiplier	Speed of Ajustment
Distance	–	–	0	0
Paved road density	+	–	0	+
Telephone density	0	+	–	–
Bank branch density	–	–	0	+
Railway density	0	+	0	–
Number of strikes	0	0	0	–
Production shocks	+	+	+	0
Degree of dissimilarity in production	+	0	+	–
Volatility of stock policy	+	+	+	–
R^2	0.29	0.37	0.09	0.21

Source: The same as in Table I.

Notes: The signs + and – denote a positive and negative significant effect on market integration respectively. The significance level is 90 per cent. The sign 0 implies that the coefficient is not statistically significant.

various structural factors are quite diverse, depending on the measure of integration considered. That suggests the need of using available measures of market integration with caution because they may actually refer to different aspects of the process of price transmission.

Table IV summarizes the results. First, there is no independent variable for which the effects on the various measures of market integration are significant and of the same sign. In a few cases there is a congruence of results in the sense that the various effects do not contradict each other and only weakly agree mutually as in the case of the number of strikes, the number of shocks to production, and the road distance. Strikes have a significant negative effect on market integration, since they disrupt normal trade. Shocks to production also show a positive effect on market integration. This has probably to do with the period considered in the estimation, namely, the three years 1989/90 to 1991/92 characterized by only mild (relative to Bangladesh history) production shocks. The negative effect of road distance on market integration is not surprising. The greater the distance between two markets, the more costly it is to undertake trade, and opportunities with closer markets are explored.

Second, there are other cases in which the majority of the signs agree among themselves, as in the case of the degree of dissimilarity in production, volatility of stock policy, paved road density, telephone density, and bank branches density. Dissimilarity in production affects market integration positively since it creates an opportunity for trade. The volatility of stock policy in Bangladesh could be interpreted as a measure of the degree of price stabilization. If stocks are responding flexibly to price signals, they may actually contribute to market integration, as highlighted by the positive effect on the first three measures of integration. However, stock policy has also a disruptive effect on private trade making it slower to respond. This may be related to the great flexibility of the private sector to access transportation facilities. For example, a shipment made by a public agency needs much more "paper" work to be authorized and completed than the same shipment made by the private sector. The ensuing price response may have the same magnitude, but be slower because of this bureaucratic sluggishness. The positive effects of paved road density is not very strong across different measures. Similarly, the negative effects of telephone and bank branch density run counter to intuition. The case of railway density is completely unpredictable, as no sign seems to predominate across different specifications.

V. CONCLUSIONS

This paper has explored several issues related to market integration, according to a two-stage approach. The first stage used time series methods to construct four measures of market integration; the second stage introduced structural variables to explain market integration. The analysis was applied to rice markets in Bangladesh, and used a set of new and very comprehensive data that included weekly prices of rice over a period of three years for sixty-four districts, and structural variables at the district level.

The major conclusion of the first stage is that the degree of market integration in Bangladesh is rather moderate. Segmented markets make up less than 10 per cent of all conceivable links in the network of the sixty-four markets of the data set, a network of 2,016 links. Moreover, if only those links among markets that are separated by a distance of less than 250 kilometers from each other are considered, the number of segmented market links is just 44.

The major conclusion of the second stage is that different measures of market integration respond differently to the same structural factors. The various measures of integration proposed in this study may be capturing various dimensions of market integration and therefore argue for further study to deepen our understanding of the process of price transmission over spatial distance. The weak congruence of the effect of various structural factors suggests that market integration is affected negatively by the distance between markets and by the number of strikes, whereas it is positively affected by the number of production shocks.

Given the preliminary nature of this investigation, we need to be cautious about the implications of this kind of analysis for policy. It is necessary to pursue the research further in terms of better price and structural data, covering a longer time period, so that more robust results could be derived. With this disclaimer in mind, we can point to several implications for policy emerging from the foregoing analysis. First, a negotiating role in solving labor relation conflicts will help in reducing the frequency and the incidence of strikes, thereby enhancing the strength of market integration. Second, the improvement of the existing roads may actually improve the extent of market integration in so far as a better road could be considered equivalent to a shorter distance or simply to lower transportation cost. The emphasis on infrastructure development should therefore not simply be on the construction of new roads, but on the improvement of existing ones. Finally, the positive effect of production shocks on market integration suggests that under moderate supply disturbances to production, the private sector can operate efficiently and a reduced need for government intervention may be acceptable.

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APPENDIX

DATA USED IN THE PAPER

Marketing infrastructure

Data on population, areas, production, communications and transportation infrastructure was assembled on a district basis for 1990/91 (see Table 11 of Goletti [13]). In terms of geographic distribution, structural variables exhibit quite a variety of behavior. Whereas road, bank branches, and post offices have relatively little variation over regions, railway density, density of electric connections, and tele-

APPENDIX TABLE I

VARIOUS TYPES OF DISTURBANCES AND STRIKE AND SUPPLY CATEGORIES

		1989/90	1990/91	1991/92	1989/92
1.	Full-day strikes	347	267	276	890
2.	Half-day strikes	7	2	8	17
3.	Curfews	0	2	0	2
4.	Transportation strikes	296	91	1,055	1,442
5.	Demurrage	7	20	6	33
6.	Government godown closures	1	0	0	1
7.	Government godown pest attacks	1	0	0	1
8.	Tidal surges and cyclones	108	46	33	187
9.	Flood damage	27	35	34	96
10.	Indian water	52	64	48	164
11.	River/dam damage	50	91	30	171
12.	Salinated water	0	18	0	18
13.	Droughts	38	29	64	131
14.	Pest attacks	69	90	90	249
Strike disturbances (1–4)		650	362	1,339	2,351
Supply disturbances (8–14)		344	373	299	1,016

Source: Computed by the authors based on data collected by IFPRI.

phones per capita have quite a large variation as measured by a coefficient of variation of over 100 per cent.

Disturbances

Disturbances are categorized into fourteen groups (see Appendix Table I) and include events such as strikes, floods, droughts, pest attacks, etc. They were obtained from newspapers reports relative to all districts. All disturbances were classified into the two categories of strike and supply disturbances. The first category included full-day strikes, half-day strikes, transportation strikes, and curfews; it directly affects the movement of goods. The second category included tidal surges and cyclones, floods, Indian water (water flow problems caused by the Indian barrage on the Ganges), river/dam damage, droughts, salinated water, and pest attacks; these affect production of rice directly by creating localized scarcities.

Prices

Data on prices were collected from the Department of Agricultural Marketing. These were weekly wholesale rice prices between 1989/90 and 1991/92 for the sixty-four district headquarters (*zila*). Missing data were encountered in the data set. A three-step fitting procedure was used to arrive at a data set of wholesale coarse rice price. In the first step, four rice prices series compiled by the Department of Agricultural Marketing were considered: Aman HYV, Aman local coarse, Aus HYV, and Boro HYV. For each series a linear interpolation of missing data was used whenever no more than four consecutive weeks were missing. In the second step, the four weekly series were put together to create a series of weekly

APPENDIX TABLE II

PRICE STATISTICS BY DISTRICTS

	1989/90			1990/91			1991/92			1989/92		
	Mean	CV	Missing	Mean	CV	Missing	Mean	CV	Missing	Mean	CV	Missing
Dinajpur	911	4.4	0	944	6.9	0	1,067	5.0	0	974	8.8	0
Thakurgaon	917	5.8	0	965	6.4	16	1,067	4.9	0	985	8.7	16
Panchagar	912	4.0	0	943	5.6	5	1,071	6.6	0	976	9.1	5
Rangpur	900	6.0	0	970	5.5	0	1,067	6.8	0	979	9.3	0
Lalmonir	882	6.2	0	992	7.2	17	1,090	7.0	1	987	11.4	18
Nilphamari	882	5.8	0	997	7.6	17	1,033	6.2	0	968	9.5	17
Kurigram	927	5.8	0	1,015	6.6	15	1,045	4.9	15	988	7.8	30
Gaibanda	890	7.1	0	983	6.7	0	1,051	7.6	0	975	9.8	0
Bogra	892	5.3	0	985	8.3	12	1,050	5.5	0	975	9.4	12
Joypurhat	900	5.9	0	966	6.2	9	1,029	6.3	0	965	8.3	9
Rajshahi	911	5.5	0	944	5.3	0	1,076	4.1	0	977	8.8	0
Noagaon	923	5.3	0	1,013	8.4	5	1,081	5.0	0	1,006	9.1	5
Natore	913	4.3	0	1,039	7.0	0	1,064	6.0	0	1,005	8.9	0
Nawabgonj	921	8.0	0	1,017	7.8	8	1,086	5.4	0	1,008	9.8	8
Pabna	938	6.2	0	1,023	6.0	0	1,084	5.6	0	1,015	8.4	0
Serajgonj	874	7.8	0	957	5.8	0	1,039	6.1	0	957	9.6	0
Kushtia	885	5.9	0	1,003	6.6	6	1,015	5.3	0	967	8.5	6
Chuadanga	930	5.8	0	991	10.2	0	1,042	4.9	0	987	8.7	0
Meherpur	925	7.9	0	999	6.9	0	1,059	6.8	0	994	9.0	0
Jessore	934	6.0	0	994	6.1	19	1,110	7.3	0	1,015	10.1	19
Jhenaida	893	6.8	0	1,019	9.4	0	1,031	6.8	0	981	10.1	0
Magura	916	7.7	0	1,021	7.3	0	1,048	6.0	0	995	9.0	0
Narail	944	8.8	0	1,064	8.5	0	1,032	5.9	0	1,014	9.3	0
Khulna	897	6.6	0	1,053	8.2	0	1,025	5.6	0	992	9.7	0
Satkhira	887	7.1	0	1,017	9.0	5	1,031	4.0	5	975	9.7	10
Bagerhat	926	7.4	0	1,033	11.0	0	1,024	4.5	4	994	9.6	4
Barisal	938	6.1	0	1,000	6.9	5	1,073	6.5	0	1,004	8.6	5
Jhalokat	945	7.2	0	998	6.7	6	1,105	6.0	0	1,017	9.4	6
Pirojpur	915	8.1	0	1,031	8.2	8	1,075	5.7	0	1,006	10.0	8
Bhola	909	7.6	0	1,001	5.7	14	1,080	7.2	0	996	10.1	14
Patuakhali	954	10.6	0	1,019	5.3	16	1,133	7.0	0	1,037	10.9	16
Barguna	899	7.8	0	1,012	4.7	9	1,083	4.6	0	997	9.7	9

APPENDIX TABLE II (Continued)

	1989/90			1990/91			1991/92			1989/92		
	Mean	CV	Missing	Mean	CV	Missing	Mean	CV	Missing	Mean	CV	Missing
Mymensingh	930	8.5	0	1,021	5.9	0	1,098	7.7	0	1,017	10.0	0
Netrokona	947	7.9	0	1,007	6.3	0	1,096	7.9	0	1,017	9.5	0
Kishore	916	7.3	0	1,028	5.4	0	1,074	7.2	0	1,006	9.4	0
Jamalpur	914	8.4	0	1,045	5.2	0	1,065	8.5	0	1,008	9.9	0
Sherpur	931	7.1	0	1,081	7.9	6	1,096	8.4	0	1,034	10.7	6
Tangail	924	6.4	0	1,024	7.8	0	1,087	6.9	0	1,012	9.7	0
Faridpur	924	5.2	0	995	5.5	0	1,073	4.8	0	997	8.0	0
Rajbari	966	8.1	0	1,008	6.1	8	1,068	6.4	0	1,014	8.1	8
Madaripur	974	4.9	0	1,007	6.7	0	1,121	5.2	0	1,034	8.3	0
Gopalgonj	936	5.9	0	1,012	7.0	12	1,068	4.2	0	1,005	7.9	12
Shariat	984	6.3	0	1,034	8.5	0	1,157	5.2	0	1,058	9.6	0
Dhaka	923	8.1	0	1,034	7.4	8	1,115	5.3	0	1,024	10.4	8
Gazipur	951	6.1	0	1,039	6.1	0	1,096	4.8	21	1,018	8.1	21
Norshinj	941	7.6	0	1,058	7.8	0	1,085	7.2	0	1,029	9.7	0
Narayan	925	7.4	0	1,023	7.1	4	1,090	4.5	0	1,012	9.2	4
Munshigonj	899	7.6	0	1,057	5.3	6	1,034	6.3	0	995	9.5	6
Manikgonj	967	6.1	0	1,116	9.6	7	1,131	6.2	0	1,070	10.2	7
Sylhet	904	10.6	0	1,074	6.6	0	1,037	5.8	0	1,005	10.5	0
Moulvi Bazar	964	8.1	0	1,075	4.3	8	1,141	6.6	0	1,059	9.6	8
Hobigonj	929	12.8	0	1,088	5.2	16	1,092	9.7	0	1,031	12.3	16
Sunamgonj	965	8.8	0	1,082	4.8	0	1,107	8.2	5	1,050	9.4	5
Comilla	950	8.5	0	1,071	4.0	26	1,126	6.5	0	1,045	10.2	26
B. Baria	929	10.1	0	1,088	8.6	10	1,094	7.7	0	1,034	11.5	10
Chandpur	939	7.4	0	1,042	6.2	18	1,083	5.6	0	1,019	8.9	18
Noakhali	967	8.8	0	1,027	8.7	23	1,134	6.1	0	1,045	10.4	23
Lakshmipur	1,008	10.8	27	986	5.3	0	1,166	4.5	27	1,035	9.9	54
Feni	972	7.7	0	1,016	5.6	6	1,143	4.9	0	1,045	9.3	6
Chittagong	1,001	7.9	0	1,037	7.3	9	1,124	6.0	2	1,054	8.6	11
Cox's Bazar	985	7.8	0	990	6.1	20	1,125	6.4	0	1,039	9.4	20
Rangamati	992	7.7	8	1,021	7.1	13	1,174	7.1	0	1,070	10.6	21
Khagrachari	925	4.1	45	1,027	12.2	4	1,101	4.2	8	1,053	10.0	57
Bandarban	993	5.8	13	1,007	8.0	13	1,075	3.4	18	1,023	6.9	44
All	931	7.1	1	1,019	6.9	6	1,082	6.0	2	1,010	9.4	10

Source: Computed by the authors based on data collected by IFPRI.
Note: CV = coefficients of variation of prices.

coarse prices. For each week of the year, the minimum price available among the four series was chosen. In the third step, a new interpolation of missing data, as in the first step, was undertaken on the series constructed in the second step.

Unlike the claim of the Ahmed and Bernard study [1], the monsoon months are not the cause of missing data (supposedly because transactions are not recorded). The staff at DAM is doing an excellent job with the available technology of desk calculators. In the absence of a computerized system, however, the failure to catch inconsistencies in the data generation process is quite likely to happen. Given that the percentage of missing data in our sample is less than 9 per cent of overall data, the problem is not considered to be too serious.

Looking at mean and coefficients of variation of prices (see Appendix Table II), the volatility of prices seems to decline between 1989/90 and 1990/91, and price variability is quite limited, being less than 10 per cent in all years for most of the markets considered.

Policy

Numerous policy interventions may be identified that have a bearing on market integration. However, the only set of policies that is considered in this paper is that related to food grain price stabilization. In its attempt to stabilize seasonal and inter-year price fluctuations, the government affects the behavior of markets. The main instrument used in the context of Bangladesh is stock policy that involves operations with food grain stocks, namely, rice and wheat. The main operations are those related to public distribution, procurement, and open market operations. Public distribution involves either subsidization of consumption of food grains to target groups, or transfers in kind according to specific programs, such as food for work programs. Procurement involves the purchase of domestically produced rice at prespecified prices with the purpose of supporting prices. Open market sales involve the sales of rice and wheat at prespecified prices with the purpose of avoiding price hikes.

The government maintains public stocks of food grains and releases those stocks or increases them in order to stabilize prices. Changes in public stocks reflect various interventions in the food grain sector originating from domestic procurement, imports, and distribution. A simple, crude measure of the degree of volatility of stock policy is given by the coefficient of variation of monthly stocks at each district.