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Vegetable Market Integration In Bangladesh

by

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I. INTRODUCTION

Starting in the early 1990s the topic of crop diversification began to receive renewed attention from economists and policymakers in Bangladesh. Several reasons can be cited. First, with food grain production at or near self-sufficiency levels (GOB 2001), attention naturally began to shift away from a narrow focus on rice and wheat production. Second, confronted with a steady decline in real prices of food grains (Dorosh 2000), concerns regarding sustained income generation in Bangladesh's agriculture sector began to surface, which also led to interest in non-grain crops as the latter tend to provide better opportunities for income generation than grains. For example, according to a study by Mahmud, Rahman and Zohir (1994), vegetables rank among the top high valued crops in Bangladesh. Third, vegetables are important from the perspective of the quality of food intake. Many nutritionists have emphasised the importance of micro-nutrients in human diets and vegetables are good source of essential micronutrients.

All of these factors have sparked interest in vegetable production and marketing in Bangladesh and have led to a substantial increase in applied research directed at vegetable crops. Analysis of the structure of the vegetable market is important for understanding price determination and price transmittal, and—ultimately—crop choices in Bangladesh. These understandings are in turn necessary for developing and targeting priority areas for research. This study is aimed at examining the existing market structure for vegetables in Bangladesh, and measuring statistically the degree to which key vegetable markets in Bangladesh are integrated. The objective is to provide insights regarding spatial and temporal connections between markets. The analysis relies on a series of descriptive and

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econometric procedures and data collected at weekly intervals over the period March 2000 to February 2001.

II. MARKETING IN THEORY AND PRACTICE

Dhaka plays an important role in vegetable marketing in Bangladesh. The main reason for this stems from consumer demand. Due to higher urban incomes, Dhaka enjoys relatively strong effective demand for vegetables compared with other cities. Strong demand in Dhaka also reflects export potential. The city acts as a hub for vegetable exports as it is the only city which enjoys essential infrastructure and facilities for vegetable handling and export.

From the perspective of vegetable supply, Gazipur (combined with the greater Dhaka area), Comilla, and Jessore are all important vegetable growing areas in Bangladesh. For example in 1997-98, 23 per cent, 25 per cent and 44 per cent of total production of Rabi brinjal, cabbage and tomato took place in these regions (BBS 1997). We briefly review the characteristics of these key vegetable markets below.

Gazipur is located approximately 35 km north of Dhaka. The Bangladesh Agricultural Development Corporation (BADC) runs a pilot project in Gazipur focusing on dissemination of vegetable growing technologies among farmers in the surrounding areas. Although Gazipur is not the most intensive vegetable growing area in Bangladesh, it is particularly important due to its excellent transport communication and linkages with Dhaka markets. At the start of each day at numerous assembly markets in Gazipur, bulk vegetables are collected and moved to Dhaka city markets.

Comilla is an intensive vegetable growing area located approximately 150 km east of Dhaka. Comilla enjoys good transport communication and links with both Dhaka and Chittagong, the second largest urban centre in Bangladesh. Two bridges span rivers on the road between Comilla and Dhaka, and rail linkages are also very good. Vegetables are carried to Dhaka city markets from Comilla by both road and rail. A major portion of vegetables originating in Comilla cater to Chittagong markets.

Jessore is a key vegetable growing area, although far from Dhaka, and suffers from relatively poor transport linkages. Jessore is located 250 km south-west of Dhaka. Produce from Jessore is transported to Dhaka by trucks, which must cross rivers by ferries. This mode of transportation is not particularly reliable, and often results in delays and, in some cases, loss of perishable products. Regardless of origin, most vegetables reach Dhaka's Kawranbazar in the early morning. Vegetables are then de-bulked, graded, and dispersed to urban retail markets.

Primary Marketing Chains

Among the many stakeholders involved in the vegetable marketing system in Bangladesh are farmers, beparies (traders), aratdars (commission agents), stallholders, retailers and exporters. The combination of interactions between these economic agents results in multiple, complex marketing chains that bring vegetables from producers to consumers. Chart 1 illustrates the complexity of the vegetable marketing system in Bangladesh. One prevalent set of linkages exists between farmers, beparies (who transport crops to city markets), commission agents and retailers. The most common marketing chains are: (1) Farmer–Bepari–Stallholder/Retailer–Consumer;(2)Farmer–Aratdar–Stallholder/Retailer-Consumer; (3) Farmer–Stallholder/Retailer–Consumer; (4) Farmer–Bepari–Exporter–Foreign Consumer. The empirical analysis conducted below focuses on the first of these chains.

Market Integration in Theory

A common method used in studying market integration is to measure the static price correlation of prices between two markets, typically using bivariate correlation or regression coefficients estimated using spot prices of the same good in different markets. A weakness with this method is that a third factor, common to both markets, can influence prices of different markets even though the markets may not be connected spatially. For example, inflation or seasonality in supply may cause systematic changes in price levels for a pair of markets, whether connected or not. If one does not control for price variation, spurious correlations among prices can result.[1]

The main early contributions to the study of market integration are those of Delgado (1986), Ravallion (1986), Timmer (1987), and Heytens (1986). Methods used in this paper are based upon the approaches of Ravallion and Timmer.

Ravallion posits the existence of local (rural) markets and a single central (urban) market that are spatially linked. Price in the central market P_1 is taken to be a function of prices in the local markets $P_{i,}$ and also a vector of other factors X_1 particularly to the central market. Similarly, prices in the local markets are determined by the price in the central market and other market specific factors X_i.

$$P_1 = f_1(P_2, P_3, ...P_n, X_1) \quad (1)$$

$$P_i = f_i(P_1, X_i) \quad (2)$$

[1] For discussion, see Blyn (1973), Timmer (1974a, 1974b), Hariss (1979).

Assuming linear functional relationships, the model is given a dynamic structure as follows:

$$P_{1t} = \sum_{j=1}^{n} a_{1j} P_{1t-j} + \sum_{k=2}^{N} \sum_{j=0}^{n} b_{1j}^{k} P_{kt-j} + X_{1t} c_1 + e_{1t} \quad (3)$$

$$P_{it} = \sum_{j=1}^{n} a_{ij} P_{it-j} + \sum_{j=0}^{n} b_{ij} P_{1t-j} + X_{it} c_i + e_{it} \;\; (i = 2,.........N) \quad (4)$$

where P_{1t} and P_{it} denote prices in the central and i^{th} local markets at time t respectively, P_{1t-j} denote lagged prices in the central market, P_{kt-j} stands for prices at the k-th local market at time period t-j and X_{1t} stands for the vector of other factors influencing central market prices. Ravallion focuses on the later equation and illustrates how several tests can be conducted to check for market integration. For example, if $b_{ij} = 0$ for all j, then local markets can be said to be segmented from the central market. $B_{i0} = 1$ mean that price transmission is instantaneous. Moreover, if local markets are well connected to the central market then we are likely to find $\sum_{j=1}^{n} a_{ij} + \sum_{j=0}^{n} b_{ij} = 1$. Ravallion's model suggests two possible market integration tests appropriate to vegetable markets in Bangladesh.

Test of integration within districts: To find out if prices are well integrated at different stakeholder levels one can regress farm gate prices on wholesale prices and then wholesale prices on retailer prices within districts. Additional explanatory variables can be included to control for seasonality and price variation occurring due to quality differences of crops. Using current prices as explanatory variables, the test of integration is a test of the hypothesis that different nodes in the marketing chains within the districts are well integrated.

Test of integration of district markets with the central market at Dhaka:

Regressions can also be conducted in which wholesale prices at district markets are regressed on retailer's prices at the central market. For these regressions both current and lagged prices at the central market serve as explanatory variables. Variables can again be included to account for seasonality and other factors.

III. DATA AND STUDY SITES

Data for the current study comes from weekly price surveys conducted in Dhaka, Gazipur, Comilla and Jessore between March 2000 and February 2001. Dhaka is included as it serves as a central market in the flow of vegetable trade in Bangladesh. The other three districts, namely, Gazipur, Comilla and Jessore, are major vegetable growing regions of Bangladesh. Within each district, two markets were selected for data collection: Kanshanagar and Nimshar from Comilla; Konabari and Tongi from Gazipur; and Barinagar and Rupdia from Jessore. In each market, depending upon availability, data were collected from farmers and five intermediaries: traders (bepari), commission agents (aratdar), wholesalers, stallholders and retailers. From Dhaka city, one urban retail market for stallholders and one terminal market for exporters were selected. These were Kolmilata and Kawranbazar respectively. A total of 2,890 interviews were conducted during the survey, representing an average of two interviews per week per marketing node, per market. The highest number of interviews took place with retailers (n = 588) and beparies (n = 588), followed by farmers (n = 586). Most interviews were conducted in Jessore (n = 938), followed by Gazipur (n = 806) and Comilla (n = 784). Relatively fewer interviews were conducted in Dhaka (n = 362).

IV. RESULTS OF ANALYSIS OF PRICES AND PRICE VARIABILITY

Prices of vegetables vary for many reasons in Bangladesh. Agro-ecological conditions are not the same across the country. Different parts of the country differ in terms of soil types, rain fall, land elevation and availability of water. All of these factors affect the levels of production and the quality of crops and therefore crop prices. Prices are also affected by local conditions of supply and demand. This section reports price levels and price variability for major vegetable crops grown in Bangladesh. The discussion emphasises spatial and seasonal price differences for five principal vegetables: brinjal, cucumber, okra, potato and tomato. The discussion focuses on three representative stakeholders: farmer, bepari (trader), and retailer. Each vegetable, in turn, has been sub-grouped into the categories blemished (damaged) and blemish free (undamaged). Normally, traders purchase ungraded vegetables from farmers. Before selling they separate and grade vegetables to obtain different prices. Other grading practices are also observed on the part of traders. Consumers who choose from stock are charged higher prices. Remaining stock is then sold at lower prices.

Table I lists the average annual prices of 16 vegetables. The table includes prices at all points across the marketing chain. Annual average purchasing and selling prices are shown for blemished, blemish free, and mixed vegetables. The data in Table I show that among the 16 vegetables, farmers receive the highest price for tomato (Tk 18.34/kg) and on average receive the lowest price for Indian spinach (Tk 3.91/kg). All stakeholders in the marketing system buy mixed vegetables, except for exporters. Exporters buy only fresh and blemish free crops as quality is the key concern for export. Stakeholders who buy mixed vegetables typically receive 2 Tk/kg over the purchasing price. Table I also indicates that the highest mark up between purchasing and selling prices takes place at the exporter level for all crops. The average mark up at exporter's level is always more than 50 Tk/kg on average, reflecting the very high cost of transport incurred by exporters.

Seasonal Price Levels

Figure 1 depicts weekly wholesale (bepari) price levels for the five main vegetables included in the study. As the survey started in March 2000 and continued through February 2001, months on the horizontal axis have been depicted in the sequence of the survey. For okra, most weeks in January and February did not have any observations. June prices for tomato were also missing. These exceptions are reflected in missing data in the price graphs for the two crops.

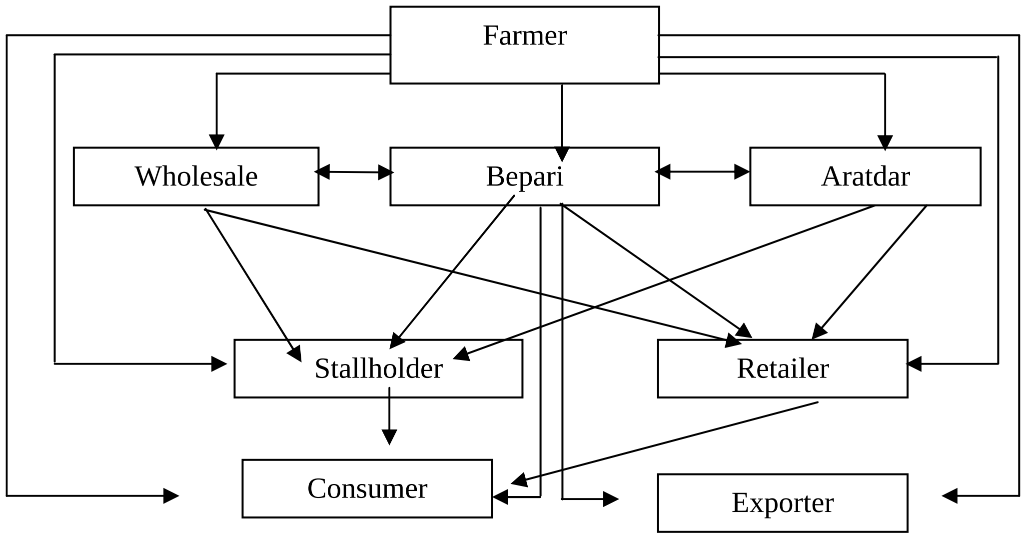
One feature common to these crops is seasonality, especially between the end of the 2nd Kharif season and the beginning of Rabi. The 2nd Kharif season stretches from July through November and Rabi starts from around December and ends in March. Seasonality of prices during this period reflects harvests. The bulk of the harvest usually takes place late in the Rabi season. Once the bulk of the Rabi harvest begins to arrive in markets, prices begin to drop. Another reason for the systematic price rise during November is that July through September is the lean season for vegetable production. This, together with the limited supply of fresh vegetables during October and November, tends to result in a price spike during this time. Tomato is an exception in this regard. It can be seen from the Figure 1 that, for tomato, not only do prices peak during the late Kharif two season, but also during the end of Kharif one. It is not clear why prices of Tomato should exhibit this double peak. One plausible reason is that the supply of fresh harvest starts to decline from the end of Rabi season but for fresh tomato remains strong, causing the prices to peak around this time. The fact that tomato enjoys a relatively stronger demand among vegetables is reflected in its higher price for most of the year, except during peak harvest time. At least there is a potential gap between demand and supply which causes the price to remain at higher level compared with other vegetables. The pattern shown here is consistent with the findings of Mahmud, Rahman and Zohir (1994), who argue that among brinjal, cucumber, potato and tomato it is the latter which is the most profitable.[2]

Figure 1 shows that all five vegetables have their lowest price level at around 5 Tk/kg; but a clear difference exists with respect to the highest weekly price. Tomato has the highest price among the five at 50 Tk/kg, followed by okra

[2] The study did not include okra. The study also shows that for brinjal net economic return for traditional variety exceeds returns from other crops; however, net private return of traditional brinjal is far below than that of tomato.

(25 Tk/kg), brinjal (18 Tk/kg), cucumber (16 Tk/kg) and potato (13 Tk/kg). From Figure 1 it can be seen that price fluctuations are greatest for tomato, while prices for potato are the least .

Chart 1: **The Vegetable Marketing Chain in Bangladesh**



Seasonal and Spatial Price Variation

As noted above, potato prices are the least variable among the five vegetables studied here (with a range of 9 Tk/kg) and tomato prices are the most variable (with a range of 45 Tk/kg). Coefficients of variation (CVs) for the five crops are presented in Table II, which depicts CVs for the five vegetables across markets and seasons. The table reports CVs for three stakeholders: farmer, bepari and retailer. All CVs are reported in percentage terms. The first three columns in the table present price variations separated by markets. The subsequent three columns report measures of variation by season. The last column shows the CVs for each crop, where the measures include prices from all markets, and seasons.

Figure 1: **Weekly Wholesale (Bepari) Vegetable Prices (Tk/kg), March 2000–February 2001**

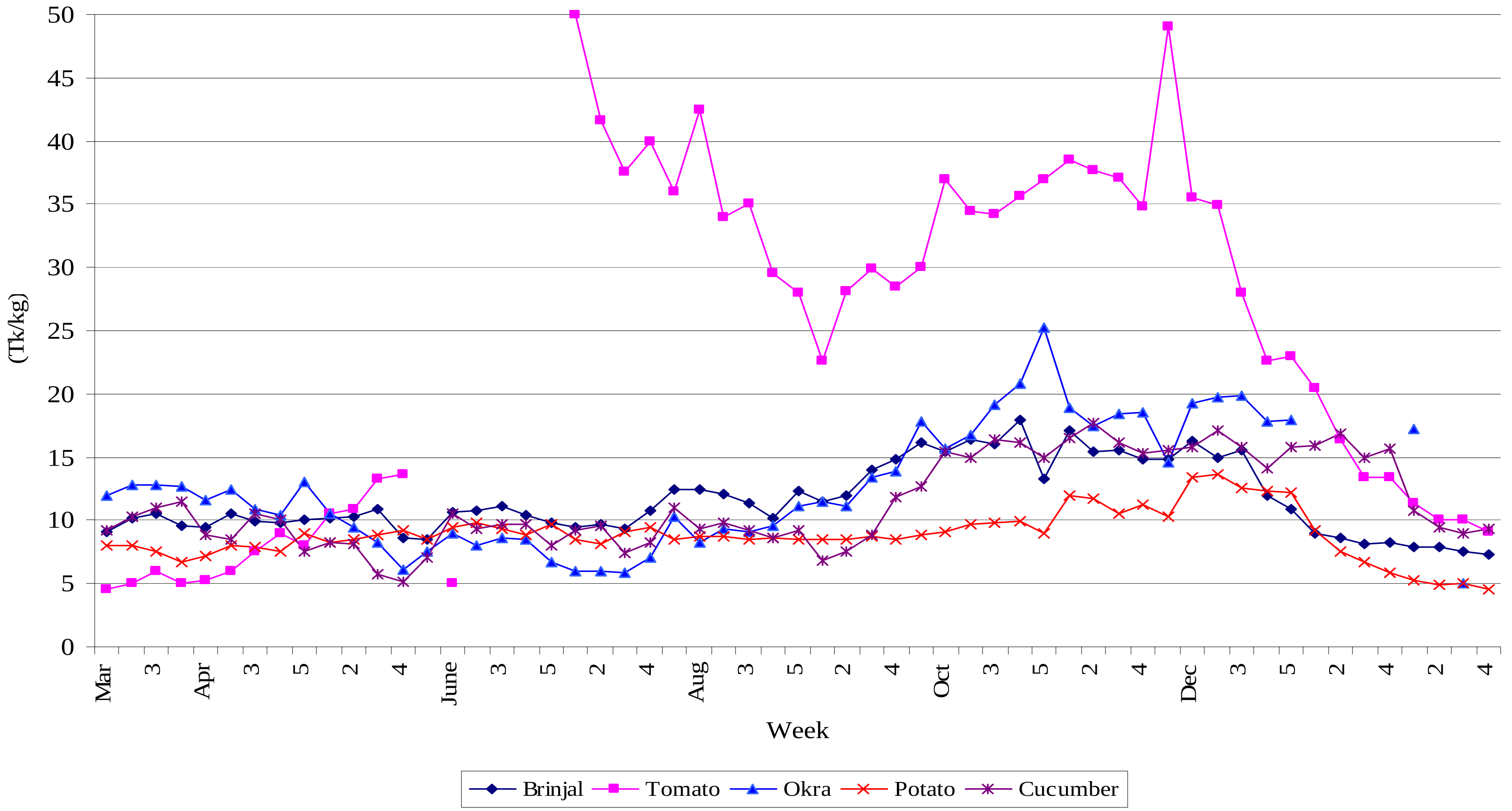


TABLE I
VEGETABLE PRICES (TK/KG)

Vegetables	Farmer	Bepari			Aratdar	Stallholder			Retailer			Exporter	
	S	P	S		S	P	S		P	S		P	S
	M	M	U	M	M	M	U	D	M	U	D	U	D
Bittergourd	13.18	-	-	-	-	13.71	16.97	14.29	13.63	16.61	13.89	20.8	74.80
Bottlegourd	5.24	4.80	6.22	5.11	5.43	13.71	16.97	14.27	5.24	6.86	5.41	14.89	80.97
Brinjal	8.92	9.27	11.52	9.38	10.56	9.24	11.91	9.46	9.67	12.28	10.07	19.68	80.96
Cabbage	8.92	9.20	11.16	9.16	14.32	12.75	16.27	12.97	10.54	13.43	11.03	-	-
Cauliflower	12.52	15.37	17.38	14.71	13.61	16.16	20.03	16.87	12.95	15.90	13.24	-	-
Cucumber	9.61	8.68	10.78	9.04	9.91	9.75	12.71	10.13	9.57	12.34	9.96	15.27	72.77
Indian spinach	3.91	3.83	5.54	4.51	3.76	4.29	6.38	4.90	3.95	5.90	4.54	11.55	98.47
Okra	9.95	10.05	12.42	10.42	11.29	12.24	15.62	12.60	10.86	13.75	11.24	19.93	67.93
Pointedgourd	10.05	10.02	13.23	10.94	9.80	9.26	12.06	10.05	10.11	13.60	10.57	14.71	80.85
Potato	7.29	7.17	8.75	7.50	7.33	7.27	9.26	7.88	7.42	9.38	7.96	-	-
Radish	6.44	6.53	8.26	6.73	6.75	7.04	9.40	7.39	6.95	9.14	7.42	-	-
Snakegourd	9.33	8.58	10.54	8.80	8.28	9.35	12.08	9.69	9.40	11.15	9.04	16.85	81
Stem amaranth	4.76	4.59	6.39	5.04	4.37	4.77	7.05	5.35	4.81	6.84	5.30	11.32	88.04
Sweetgourd	6.05	5.96	9.88	8.52	6.01	6.47	8.75	7.04	6.19	8.29	6.65	7.55	68.85
Tomato	18.34	20.43	22.84	20.02	22.2	22.37	26.64	22.28	21.29	22.09	18.92	-	-
Yard longbean	10.37	10.27	12.69	10.83	10.91	10.99	14.14	11.71	10.57	13.43	11.21	20.76	82.33

Note: S = Selling price
P = Purchase price
D = Damaged
U = Undamaged
M = Mixed

It is evident from the last column in Table II that tomato prices have the highest variation at all stakeholder levels among the five vegetables, while potato has the least variation. For example, the price variation at farm gate level for tomato is 66 per cent, followed by 49 per cent for okra, 41 per cent for cucumber, 36 per cent for brinjal and 33per cent for potato. One plausible reason for tomato having the highest price variation is that this is a seasonal crop mostly harvested during Rabi season, while both cucumber and brinjal are harvested throughout the year. Among the five crops, potato enjoys the best infrastructural facilities in Bangladesh so far storage is concerned. This factor may contribute to keeping prices within a smaller range compared with the other vegetables. From column one it also can be seen that, among all three stakeholders, price variation tends to be greatest for farmers and least for retailers. Potato is an exception, in which case the bepari price is slightly less variable than the retailer price. For brinjal, the CV for farmer is 36 per cent, while for retailers it is 31 per cent. For cucumber, okra and potato the figures are 41 per cent and 35 per cent, 66 per cent and 53 per cent, 49 per cent and 43 per cent respectively.

According to the CV measures listed in Table II, no single market emerges singularly as the most volatile in terms of prices. Tomato price variability is highest in Gazipur (97 per cent, 60 per cent and 60 per cent for farm gate, bepari and retailer respectively) followed by Comilla (52 per cent, 50 per cent and 46 per cent) and Jessore (41 per cent, 39 per cent and 36 per cent); for brinjal, Jessore prices (38 per cent and 32 per cent for farm gate and retailer respectively) have the highest variability followed by Gazipur (36 per cent and 29 per cent) and Comilla (28 per cent and 24 per cent). However, the Jessore markets tend to have the highest price variation followed by Gazipur. Comilla market prices did not have the highest CV for any crop compared with other two markets.

Table II also shows price variation across seasons. It is evident from the data that Rabi season prices vary the most. The only exception is okra, for which prices vary most during Kharif two. For tomato, price variation is greatest during Rabi (65 per cent, 62 per cent and 54 per cent for farmer, bepari and retailer respectively), followed by Kharif one (54 per cent, 34 per cent and 35 per cent) and Kharif two (19 per cent, 19 per cent and 22 per cent). For potato and cucumber, the greatest price variation occurs in Rabi followed by Kharif two and Kharif one. For brinjal and okra, no clear pattern emerges across seasons or along marketing chains.

TABLE II
PRICE FLUCTUATION FOR 5 MAJOR VEGETABLE CROPS*

(CV in percentage)

	Comilla	Gazipur	Jessore	Kharif One	Kharif Two	Rabi	All Seasons and Markets
Brinjal							
Farmer	28.19	35.82	38.41	30.49	30.12	38.84	35.83
Bepari	24.33	37.10	29.44	24.30	25.71	35.89	31.24
Retailer	23.65	29.47	31.91	26.99	26.67	30.51	30.48
Tomato							
Farmer	52.45	90.39	41.07	53.91	18.76	65.29	65.63
Bepari	49.51	59.68	38.56	33.74	19.34	62.16	54.36
Retailer	46.16	59.68	36.33	35.08	22.47	54.34	53.24
Okra							
Farmer	43.01	45.07	50.28	35.21	48.76	35.42	49.19
Bepari	39.53	42.56	39.04	27.33	44.38	27.72	42.94
Retailer	38.26	37.19	42.36	29.14	44.32	26.13	42.76
Potato							
Farmer	23.71	28.30	43.25	18.87	22.87	48.70	32.62
Bepari	23.86	25.47	29.70	16.22	17.00	43.11	27.01
Retailer	25.61	22.81	32.71	15.41	17.46	40.71	27.38
Cucumber							
Farmer	35.42	32.79	44.75	30.05	37.44	39.40	40.89
Bepari	31.00	35.52	42.15	28.63	36.31	40.85	40.56
Retailer	29.48	29.98	37.72	25.40	30.96	34.21	34.61

*Measures are based on undamaged vegetables only.

Table III lists correlations among wholesale prices of the five vegetables. All correlations are positive, reflecting common periods of peaks and troughs (see Figure 1). Positive correlations may also reflect substitutability of these crops among consumers. In Bangladesh, substitutability among vegetables can be complex. Vegetables, being high-valued in a low-income country, are likely to be price elastic in general. However, it is possible that some vegetables are distinctly different from others in terms of their income elasticities (for example, tomato and cucumber are likely to have higher income elasticities in comparison with potato, okra and brinjal). As a result, an increase in the price of, say okra, is less likely to shift demand towards tomato, whereas a price rise for tomato may lend consumers to substitute okra. In addition to elasticities, other factors such as taste also play a key role. For example, tomato and cucumber tend to serve as complements rather than substitutes. Potato, on the other hand, is likely to be complement to brinjal and okra.

TABLE III
CORRELATION MATRIX OF WHOLESALE (BEPARI) PRICES FOR 5 MAJOR VEGETABLE CROPS

	Brinjal	Tomato	Okra	Potato	Cucumber
Brinjal	1.00	0.59	0.62	0.52	0.44
Tomato	0.59	1.00	0.24	0.53	0.30
Okra	0.62	0.24	1.00	0.33	0.64
Potato	0.52	0.53	0.33	1.00	0.40
Cucumber	0.44	0.30	0.64	0.40	1.00

Note: All correlations are significant at a 95 per cent confidence level.

From the data in Table III it can be seen that the highest correlation occurs between okra and cucumber (.64), followed by okra and brinjal (.62). Although the correlation is relatively weaker between brinjal and cucumber (.44), these positive correlations result from the fact that prices for brinjal, okra and cucumber follow almost a common trend and levels. The correlation between tomato and brinjal is also relatively strong (.59), but weak for okra (.24) and cucumber (.30). These results are probably explained by the fact that, among the latter three vegetables, brinjal is the only substitute for tomato, whereas cucumber is a complement; the relation between tomato and okra is not so obvious. Potato has a moderately high correlation with tomato, followed by brinjal, cucumber and okra.

V. RESULTS REGARDING PRICE TRANSMISSION

Tables IV through VII present results for regressions and tests used to measure price correlations among the principal vegetable markets. All regressions were conducted using ordinary least squares methods. Monthly dummy variables from February through December were used to control for seasonality in prices. The variable ‘‘Damaged’’ was included to account for price differences, if any, between damaged and undamaged vegetables. Prior expectations, based on the descriptive data, are that Jessore prices should be below those of Comilla. The dummy variable ‘‘Jessore’’ was included as an explanatory variable to account for any difference.

Table IV presents results for regressions in which farm gate prices have been regressed on the set of dummy variables and bepari prices. Regression results for Comilla and Jessore are shown in columns one and two, respectively. Results for pooled data are depicted in column three. The regressions explain a high degree of the observed price variation, as reflected in relatively high R^2 values.

Results in Table IV show that bepari prices are statistically useful in explaining variations in the farm gate price of brinjal for both Comilla and Jessore, as well as for the pooled data. In the pooled regression, a one Taka change in the bepari price is associated with a 0.854 Taka change in the farm gate price. For Comilla, monthly indicators are significantly different from zero except for May, implying that prices in Comilla exhibit a statistically significant monthly pattern. In contrast, the Jessore data exhibit less monthly variation. Pooling the data for Comilla and Jessore diminishes the explanatory importance of the monthly dummies further. Except for May and February no other monthly dummy variables are statistically significant in the pooled data regression. Another difference between Comilla and Jessore markets is the explanatory power of the ‘‘Damaged’’ dummy variable. For the Comilla data, prices for damaged vegetables were statistically lower than prices for undamaged vegetables. For Jessore, prices were not significantly different.

TABLE IV

FARM GATE-BEPARI REGRESSIONS, DEPENDENT VARIABLE IS FARM GATE PRICE

Variable	Comilla	Jessore	Pooled
Bepari price (Tk/kg)	0.630*(0.054.)	0.819* (.041)	0.864* (0.024)
March (0/1)	—	0.123 (0.313)	0.142 (0.293)
April (0/1)	—	-0.462 (0.318)	-0.400 (0.169)
May (0/1)	0.341 (0.377)	-1.172* (0.339)	-0.863* (0.232)
June (0/1)	1.113* (0.389)	-0.704* (0.326)	-0.314 (0.221)
July (0/1)	1.067* (0.38)	-0.864* (0.347)	-0.348 (0.226)
August (0/1)	1.608* (0.415)	-0.265 (0.331)	0.082 (0.229)
September (0/1)	1.394* (0.43)	0.359 (0.31)	0.156 (0.245)
October (0/1)	1.934* (0.487)	0.699 (0.389)	0.343 (0.277)
November (0/1)	2.014* (0.514)	0.823* (0.305)	0.441 (0.248)
December (0/1)	1.734* (0.460)	0.503 (0.304)	0.323 (0.245)
January[1] (0/1)	1.855* (0.490)	-0.628 (0.530)	-0.086 (0.302)
February (0/1)	-0.980* (0.293)	-0.371 (0.329)	-0.543* (0.234)
Damaged (0/1)	-0.784* (0.184)	-0.101 (0.127)	-0.124 (0.102)
Jessore (0/1)	—	—	-1.038* (0.102)
N	87	103	191
R^2	0.97	0.97	0.96

[1]Parameter values for January in 1st two columns (Comilla and Jessore) stand for undamaged brinjal prices in January; for pooled data, the parameter values stand for undamaged brinjal prices in January at Comilla.

* Indicates the estimated coefficient is significantly different from zero at a 95 per cent confidence level.

Figures in brackets are corresponding standard errors.

Table V reports results from regressions in which bepari prices have been regressed on retail prices. The total explained variation in prices at the bepari level is again quite high as is reflected in high R^2 values. The correlations between bepari prices and the retail prices are significantly different from zero at standard test levels for Comilla, Jessore, and pooled regression data. As in the farm gate regressions, these regressions exhibit significant monthly price patterns. In these bepari-retail regressions, monthly dummies from May through November show statistical significance for Comilla at a standard test level. For Jessore, seasonality is less pronounced: the only significant monthly dummy is July. When the data for Comilla and Jessore are pooled, the dummy variables for different months diminish in importance: none of the dummies is individually significant. Results for the pooled data also show that, controlling for other variables, Jessore bepari level prices are higher than those of Comilla, as reflected in the dummy variable "Jessore."

To further explore these patterns, current and lagged values of Dhaka stallholder prices are used as explanatory variables in bepari regressions to see if Dhaka retail prices help to explain variation in bepari level prices in Jessore and Comilla. These regression results are presented in Table VI. Models in Table VI differ in terms of the number of lagged values of retail prices used in each model. Adding more lags causes loss of data, and monthly dummies for March, May and April were dropped either due to absence or shortages of data for those months. The number of observations in the model is small (n = 51 for Jessore and n = 47 for Comilla). The total variation of prices at bepari level explained by Dhaka prices is lower for Jessore than for Comilla, .86 and .94 respectively. In addition to studying the individual significance of these estimated coefficients, joint tests of significance have been conducted for all the price variables, current and lagged. The respective p-values for F-tests are shown in the bottom row of Table VI.

TABLE V
BEPARI-RETAIL REGRESSIONS
(Dependent Variable is Bepari Price)

Variable	Comilla	Jessore	Pooled
Retail price (Tk/kg)	0.686*	0.963*	0.945*
	(0.088)	(0.060)	(0.035)
March (0/1)	—	-0.101	0.345
		(0.400)	(0.410)
April (0/1)	—	0.191	0.614
		(0.411)	(0.405)
May (0/1)	1.741*	0.264	0.465
	(0.575)	(0.452)	(0.326)
June (0/1)	1.965*	0.242	0.488
	(0.590)	(0.438)	(0.309)
July (0/1)	2.22*	-0.988*	0.175
	(0.550)	(0.432)	(0.317)
August (0/1)	2.627*	-0.207	0.65
	(0.590)	(0.426)	(0.319)
September (0/1)	2.015*	-0.523	0.049
	(0.658)	(0.414)	(0.342)
October (0/1)	2.614*	-0.036	0.475
	(0.748)	(0.531)	(0.394)
November (0/1)	2.398*	-0.769	-0.209
	(0.841)	(0.438)	(0.374)
December (0/1)	1.445	-0.399	-0.370
	(0.805)	(0.399)	(0.358)
January[1] (0/1)	1.359	0.989	-0.781
	(0.935)	(0.719)	(0.483)
February (0/1)	.174	-0.539	-0.046
	(0.471)	(0.417)	(0.330)
Damaged (0/1)	-.665*	0.190	0.112
	(0.310)	(0.170)	(0.148)
Jessore (0/1)	—	—	1.544*
			(0.166)
N	89	101	191
R^2	0.93	0.94	0.92

Notes: [1] Parameter values for January in 1st two columns (Comilla and Jessore) stand for undamaged brinjal prices in January; for pooled data, the parameter values stand for undamaged brinjal prices in January at Comilla.
* Indicates the estimated coefficient is significantly different from zero at a 95 per cent confidence level.
Figures in brackets are corresponding standard errors.

TABLE VI

BEPARI PRICE AS A FUNCTION OF DHAKA RETAIL PRICE (TK/KG)

Variables	Comilla				Jessore			
	1	2	3	4	1	2	3	4
Price	0.149	0.172	0.167	0.143	0.188	0.188	0.190	0.207*
(Tk/kg)	(0.114)	(0.113)	(0.115)	(0.103)	(.099)	(0.100)	(0.102)	(0.069)
Lag 1	0.045	0.033	0.038	0.974	.270	0.264	0.270	0.149
(Tk/kg)	(0.102)	(0.101)	(0.103)	(0.092)	(.159)	(0.162)	(0.166)	(0.113)
Lag 2		0.109	0.089	0.036		0.034	0.022	-0.007
(Tk/kg)		(0.074)	(0.090)	(0.082)		(0.115)	(0.129)	(0.087)
Lag 3			0.026	0.149*			0.021	-0.285*
(Tk/kg)			(0.064)	(0.069)			(0.099)	(0.080)
Lag 4				-0.186*				0.476*
(Tk/kg)				(0.059)				(0.070)
June	4.844*	4.689*	4.748*	4.192*	-4.964*	-4.977*	-4.961*	-2.856*
(0/1)	(0.636)	(0.634)	(0.658)	(0.612)	(.808)	(0.818)	(0.832)	(0.639)
July	4.536*	4.449*	4.455*	3.840*	-2.354*	-2.390*	-2.407*	0.423
(0/1)	(0.641)	(0.634)	(0.642)	(0.603)	(1.033)	(1.052)	(1.068)	(0.830)
Aug.	4.719*	4.406*	4.461*	3.851*	-5.161*	-5.227*	-5.238*	-2.943*
(0/1)	(0.758)	(0.776)	(0.797)	(0.735)	(.964)	(1.000)	(1.014)	(0.761)
Oct.	6.225*	4.892*	4.880*	3.519*	4.467*	4.134	4.015	10.214*
(0/1)	(1.365)	(1.621)	(1.641)	(1.522)	(1.735)	(2.009)	(2.189)	(1.730)
Nov.	5.791*	4.706*	4.721*	4.928*	-3.826*	-4.052*	-4.160	-2.214
(0/1)	(1.627)	(1.763)	(1.785)	(1.589)	(1.795)	(1.971)	(2.061)	(1.416)
Dec.	2.283*	1.018	1.034	1.510	-2.250	-2.514	-2.631	-0.951
(0/1)	(1.259)	(1.509)	(1.528)	(1.367)	(1.363)	(1.644)	(1.757)	(1.208)
Jan.[1]	6.105*	4.702*	4.580*	6.548*	7.008*	6.679*	6.456*	3.769*
(0/1)	(1.463)	(1.727)	(1.775)	(1.697)	(1.568)	(1.941)	(2.237)	(1.556)
Feb.	-0.673	-0.470	-0.419	-1.335*	-2.540*	-2.476*	-2.428*	-0.118
(0/1)	(0.400)	(0.417)	(0.441)	(0.488)	(0.632)	(0.676)	(0.722)	(0.592)
Damaged	-1.578*	-1.045	-1.015	-1.517*	1.024	1.140	1.213	1.479*
(0/1)	(0.648)	(0.734)	(0.747)	(0.683)	(0.706)	(0.815)	(0.897)	(0.605)
N	47	47	47	47	51	51	51	51
R^2	0.96	0.96	0.96	0.97	0.85	0.86	0.86	0.94
F-test	0.357	0.245	0.372	0.021	0.000	0.021	0.048	0.000

Notes: [1] Parameter values for January stand for undamaged brinjal prices in January. * Indicates the estimated coefficient is significantly different from zero at a 95 per cent confidence level.

Figures in brackets are corresponding standard errors.

F-test indicates the p-value for the test of joint significance of current and lagged price variables.

TABLE VII
GRANGER CAUSALITY TEST RESULTS (F TEST STATISTICS WITH NUMERATOR AND DENOMINATOR DEGREES OF FREEDOM)

	Dhaka explaining Jessore	Dhaka explaining Comilla	Jessore explaining Dhaka	Comilla explaining Dhaka
One Lag	10.611* (1,42)	0.090 (1,38)	4.171* (1,42)	1.799 (1,38)
Two Lag	7.344* (2,40)	1.116 (2,36)	4.469* (2,40)	1.718 (2,36)
Three Lag	4.790* (3,38)	1.109 (3,34)	25.830* (3,38)	2.905* (3,34)
Four Lag	18.658* (4,36)	3.063* (4,32)	21.248* (4,36)	2.389 (4,32)
N	45	41	45	41

*Indicates the model is significant at 95 per cent confidence level.
Numerator and denominator degrees of freedom are shown in parentheses in that order

Formula used to derive test statistics is: $\frac{ESS_{\mathrm{Re}duced} - ESS_{Full}}{P} \div \frac{ESS_{Full}}{(T-2P-1)}$, where P represents the number of lags in the model and T represents the number of observations

Test results reported in Table VI show that neither current nor lagged prices up to 3 periods at Dhaka are significantly correlated individually with bepari level prices in Jessore. But the addition of a 4th lag of the Dhaka retail price into the model increases the explanatory importance of Dhaka prices, as current price and 3rd and 4th period lagged retail prices at Dhaka become individually significant in explaining bepari level price variation in Jessore. F-tests indicate that, jointly, current and lagged Dhaka prices are significant in explaining the variation in bepari prices in Jessore. However, Dhaka retail prices are neither individually nor jointly significant in the Comilla regression. The two exceptions in this regard are the 3 and 4 period lagged Dhaka prices in the 4th model, where the estimated coefficients are significantly correlated with bepari prices in Comilla at a 95 per cent confidence level. Also, the p-value for model 4 for Comilla shows that the prices at Dhaka are correlated with Comilla prices.

As Dhaka retail prices were found to be jointly correlated with Jessore bepari prices and as Dhaka prices were also found to be jointly significant in explaining

Comilla prices (model 4 in Table VI), a subsequent attempt was made to find the direction of causality among prices. The aim was to see if Dhaka, being the central market in vegetable trading, *causes* price changes in Jessore and Comilla or if in reality, price changes in Jessore or Comilla cause price changes in Dhaka.

Table VII lists results obtained from Granger-causality tests (Hamilton 1994). Table VII reports test statistics computed for four different models. Columns one and two show test results for models in which Jessore and Comilla bepari prices were regressed on lagged retail prices at Dhaka. Columns three and four depict results from models in which Dhaka retail prices were regressed on lagged prices at Jessore and Comilla respectively. Significant test values in Table VII are those in which test statistics were found to be higher than the critical value at the respective degrees of freedom. As the null hypothesis in the tests is that all the coefficients of lagged prices variables are zero, having test statistics higher than critical values means lagged prices are jointly correlated with the dependent variable. These results show that one cannot neither reject the hypothesis that Dhaka prices "Granger-cause" Jessore prices nor that Jessore prices "Granger-cause" Dhaka retail prices. Such reverse causality is not uncommon, and indicates strong information flows between producing and consuming areas. In the case of Comilla, results are inconsistent. Neither Dhaka prices nor Comilla prices "Granger-cause" the other, with two minor exceptions.

VI. CONCLUSIONS AND POLICY RECOMMENDATIONS

It can be concluded from the present study that Jessore and Dhaka markets are well connected, though no decisive pattern emerges with respect to which market plays the determining role for vegetable prices between the two cities. Statistical results suggest causality runs both ways. Comilla markets are found to be not well integrated with Dhaka markets. Regression results show that variation in wholesale prices for Comilla cannot be explained by retail prices at Dhaka. A plausible reason can be that most of the production of vegetables in Comilla goes to Chittagong markets rather than Dhaka. The results show that Comilla wholesale prices are also not significant in explaining price variations in Dhaka. This pattern indicates that the vegetable supply from Comilla represents a relatively small share of total vegetable supplies in Dhaka. So far as marketing channels within Comilla and Jessore are concerned, it appears that prices are well linked along the marketing chains. For both districts, farm gate prices are explained by wholesale prices. The latter, in turn, are found to be explained by retail prices within the districts.

One limitation of the present study is that it is based on weekly price data covering only one year. In some cases, observations fewer than 52 were available.

When studying seasonality and variability in prices of agricultural crops, observations spanning several years would be preferred, so as to average out any unusual trends in prices within a given year.

Although our surveys show that consumers value undamaged produce favourably, some questions remain. Answering these questions will require further investigation, but will be informative for dissemination of new vegetable technologies. For example, what is the cost of supplying undamaged vegetables, especially in terms of the possible externalities associated with high rates of pesticide use? Could alternative technologies, such as integrated pest management (IPM), provide sufficient levels of crop protection at a lower cost to producers – and ultimately – consumers?

From the study it can be concluded that as Jessore and Dhaka prices are linked, given that Jessore contributes considerably in total vegetable production in Bangladesh, any improvement in communication between Dhaka and Jessore will reduce retail prices in Dhaka markets. It will also help create incentives for producers. Dhaka is the only place where export facilities for vegetables exist. Results from this study suggest that improvement in communication that reduces marketing costs will help to strengthen the link between exporter's purchasing prices and farm gate prices at Jessore.

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