What's Keeping the Apples Away? Addressing the Market Integration Issue

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Abstract

Apples have been grown in India for a century. At present apple production exceeds 1.4 million tonnes a year. Still, there are wide variations in the apple prices across the country. We test the price data for market integration using cointegration and error correction methodology. Delhi, the major wholesale market for apples, does not seem to influence other markets. Mumbai market does influence Bangalore market, although with about a two week lag. Absence of integration can be attributed to traders from southern region bypassing the Delhi wholesale market, cascading effect of trader margins at various distribution points, absence of competition to agricultural produce marketing committee markets, and, inadequacy of road and cool chain infrastructure.

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1 Background

The beginning of the apple production in India was quite quixotic. At the beginning of the twentieth century, Samuel Evans Stokes landed in India from Philadelphia, USA, to join the Leprosy Mission of India. He settled in the areas of Kotgarh and Thanedar in the present day state of Himachal Pradesh, and was re-christened as Satyanand. He was convinced that apple cultivation could end the ills of the farmers in Himachal Pradesh. In 1916, he brought in the saplings of the Stark Brothers' Delicious variety of apples from USA. It is from these first few saplings of the Delicious apples that the Indian states like Himachal Pradesh have become famous in India for apple cultivation (Mehta, 2003).

2 Motivation

Today, India ranks second in the world in terms of area under apple cultivation. With 2.5 million hectares under cultivation, India produces more than 1.4 million tonnes of apples every year (FAO). Among the fruits grown in India, apple has the third largest area under cultivation, after banana and mango. Apple is different from other fruits produced in India. It is a temperate zone fruits and has a long shelf life. Its perishability is reduced for it can be kept in cold storages for many months. Being somewhat hard fruit, transporting apples long distances is relatively easy compared to other fruits such as banana, chikoo, and mangoes. Moreover, for about five years now, imported apples are giving competition to the domestic ones. One would expect, therefore, that price arbitrage can ensure that apples are available at reasonable prices throughout India with no much price fluctuations during the year.

Quite to the contrary, however, apple is the most expensive fruit in India and suffers from significant price variability. While wholesale banana prices hardly exceed Rs. 6 per kilogram throughout the year, wholesale apple prices are at minimum five times higher than that of banana. Apple price differences between different regions are high. While prices in Delhi are the lowest, they are quite high in other cities. Yearly average price for Chennai was seventy-three percent higher than that in Delhi in 2003. Physical distance is not the culprit, for transportation charges are negligible. Moreover, price variability within a region is also very high. All the coefficients of variation for apple prices are in double digits, with the coefficient being highest for Chennai (Table 1).

Table 1: Wholesale Prices at Indian Cities, 2003

City	Average Price (Rs/kg)	Std. Deviation	Coefficient of Variation
Bangalore	33.78	4.73	14.00
Kolkata	28.79	5.22	18.10
Chennai	45.93	17.65	38.40
Delhi	26.59	3.72	14.00
Mumbai	34.97	4.60	13.20

Source: NHB.

India is a country of continental proportions and several regional markets operate for agricultural produce. Supplies of agricultural commodities too come from various regions. In case of apples, however, supply mostly comes from two northernmost states of India, Himachal

Pradesh and Jammu and Kashmir. As a result, a significant quantity of apples first reaches Delhi wholesale market, and, later, it is marketed through various wholesale markets in different parts of India. If markets operate efficiently with good supply chain infrastructure and institutional mechanisms, then one would expect apple shipments and prices to be linked to each other in general, and to Delhi market in particular.

Something is keeping the apples away. Are the regional markets for apple integrated? The yearly descriptive data can conceal the dynamics of the regular movements of prices over the year. Therefore, we study the weekly prices across all the major cities. We carry out the cointegration exercise to find out whether or not some or all of the major cities' wholesale markets are integrated. Moreover, we undertake the error correction approach to understand the lag with which prices might be adjusting between different cities. The results have implications for the working of the parastatal agencies operating in the apple market, transport and infrastructural set up, and, for imports acting as a disciplining mechanism for domestic prices.

2. Methodology

Stationarity

First we test for stationarity of time-series data on apple prices. It can happen that two time series show good econometric relation between them in levels, simply because of the presence of trend components. One has to guard against such spurious relationships (Davidson and Mackinnon, 1993). This involves testing for stationarity of the variables using tests such as the Phillips-Perron test or the Augmented Dickey-Fuller test. A stationary series is one whose parameters are independent of time, exhibiting constant mean and variance and having autocorrelations that are invariant through time. If the series is found to be non-stationary, the first differences of the series are tested for stationarity. The number of times (d) a series is differenced to make it stationary is referred to as the order of integration, I(d).

The tests mentioned above consider the null hypothesis that a given series has a unit root, i.e., it is non stationary. The test is applied by running the regression of the following form:

$$\Delta Y_t = \beta_1 + \delta Y_{t-1} + \alpha_i \Sigma \Delta Y_{t-1} + e_t$$

If the coefficient δ is not statistically different from zero, it implies that the series has a unit root, and, therefore, the series in non-stationary.

Cointegration

It is possible that individual time series of apple prices may be non-stationary in levels, but a linear combination of them may be stationary indicating a long-run equilibrium relationship between them (Engle and Granger, 1987). If a linear combination of two non-stationary series is stationary, then the two series are considered to be cointegrated. To find this out, essentially, one tests whether or not the residual term of the regression between the two time series in question is stationary. Cointegration tests start with the premise that for a long-run equilibrium relationship to exist between two variables it is necessary that they should have the same inter-temporal characteristics. We first establish that the order of integration is the same for each time series of prices, and then test for cointegration. Only variables of the same order of integration qualify for the pair wise con-integrating relationships. The specific linear combinations tested are the residuals from a static cointegrating regression such as: $Y_t = \beta_1 + \beta_2 X_t + Z_t$, where Y_t and X_t are two price series in levels and Z_t is the residual term. Testing for cointegration implies testing stationarity of the residual term Z_t.

Error Correction Methodology (ECM)

If price series are I(1), then one could run regressions in their first differences. However, by taking first differences, we lose the long-run relationship that is stored in the data. This implies that one needs to use variables in levels as well. Advantage of the error correction methodology (ECM) is that it incorporates variables both in their levels and first differences. By doing this, ECM captures the short-run disequilibrium situations as well as the long-run equilibrium adjustments between prices. Even if one demonstrates market integration through cointegration, there could be disequilibrium in the short-run. I.e. price adjustment across markets may not happen instantaneously. It may take some time for the spatial price adjustments. ECM can incorporate such short-run and long-run changes in the price movements. A generalised ECM formulation to understand both the short-run and long-run behaviour of prices can be considered by first taking the autoregressive distributed lag (ADL) equation as follows:

$$Y_t = a_{01}X_t + a_{11}X_{t-1} + a_{12}Y_{t-1} + \varepsilon_t.$$

By adding and deleting Y_{t-1}, $a_{01}X_{t-1}$, rearranging the terms, and using the difference operator, the above equation can be written in the ECM format as follows:

$$\Delta Y_t = a_{01}\Delta X_t + (1-a_{12})\left[\frac{(a_{01}+a_{11})}{(1-a_{12})}X_{t-1} - Y_{t-1}\right] + \varepsilon_t.$$

The generalised form of this equation for k lags and an intercept term is as follows:

$$\Delta Y_t = a_{00} + \sum_{i=0}^{k-1} a_{i1}\Delta X_{t-i} + \sum_{i=1}^{k-1} a_{i2}\Delta Y_{t-i} + m_0\left[m_1 X_{t-k} - Y_{t-k}\right] + \varepsilon_t,$$

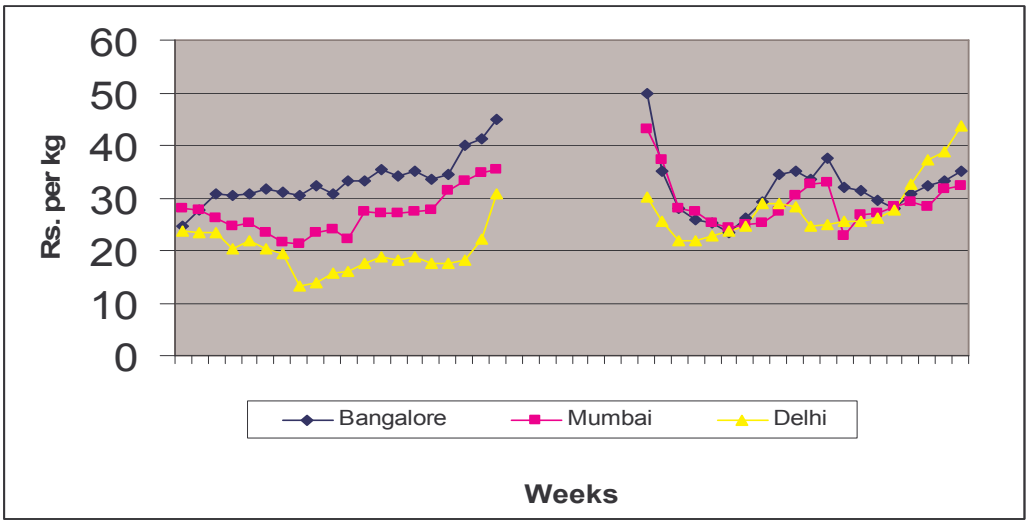
where $m_0 = (1-\sum_{i=1}^{k} a_{i2})$, and $m_1 = \dfrac{\sum_{i=0}^{k} a_{i1}}{m_0}$.

If all the variables are I(1), i.e., they are integrated of order 1, they are stationary in first differences. Therefore, all the summations in the above equation are also stationary. Moreover, if the variables are cointegrated, the ECM term, i.e., the linear combination of variables represented in parentheses is also stationary. The a_{ij} coefficients capture the short-run effects and m_j coefficients represent the stationary long-run impacts of the right hand side variables. The parameter m_0 measures the rate of adjustment of the short-run deviations towards the long run equilibrium. Theoretically, this parameter lies between 0 and 1. The value 0 denotes no adjustment and 1 indicates an instantaneous adjustment. A value between 0 and 1 indicates that any deviations will have gradual adjustment to the long-run equilibrium values.

3 Estimation

We tested for stationarity of weekly wholesale apple prices for the years 2000 and 2001 for which data was available from NHB. Weekly prices for the year 2000 are shown in Figure 1 below. Price differences appear to be quite high in the first half of the year, and, Delhi prices seem to be less in tandem with other prices in the later half. We had to exclude Chennai from the study as significant data points were missing for that market. We used Phillips-Perron test (PP) to test stationarity. The PP tests gave clearly insignificant estimates for price series in levels. Therefore, null hypothesis of non-stationarity could not be rejected. The test was then applied on the first differences of the price series. Now, PP test statistics were all significant. Table 1 gives the details of the PP test.

Figure 1: Weekly Prices at Wholesale Markets (Jan-Dec, 2000)



With all price series being I(1), they qualified for pair-wise test of cointegration. For testing whether or not the prices were cointegrated, we again used the Phillips-Perron test. The pair wise combinations of Bangalore-Mumbai, Kolkata-Mumbai, Mumbai-Kolkata, Bangalore-Kolkata and Kolkata-Bangalore gave significant estimates at 1 percent significance level, showing that the prices of apples in these markets were co-integrated (Table 2). Delhi prices seemed to be cointegrated only with Mumbai, and, we could accept this barely at 5 percent significance level.

Table 1: Stationarity Test for Wholesale Apple Prices

Prices		Phillips-Perron Test*
Bangalore Market		
	I (0)	-3.4098
	I (1)	-11.343
Mumbai Market		
	I (0)	-2.1249
	I (1)	-8.8227
Kolkata Market		
	I (0)	-1.7410
	I (1)	-10.204
Delhi Market		
	I (0)	-3.3919
	I (1)	-8.5721

* All I(0) statistics were insignificant and all I(1) price series were significant at 1%. We also used Augmented Dickey Fuller test. Results were similar if not identical.

Table 2: Pairwise Cointegration Test of Apple Prices.

Dependent variable	Independent variable	Phillips-Perron Test
Bangalore	Mumbai	-5.0577*
	Kolkata	-6.0628*
	Delhi	-3.6218
Mumbai	Bangalore	-3.7663
	Kolkata	-5.7100*
	Delhi	-2.5926
Kolkata	Banaglore	-4.5672*
	Mumbai	-5.5744*
	Delhi	-2.2124
Delhi	Bangalore	-3.5841
	Mumbai	-3.7807**
	Kolkata	-3.7162

* Significant at 1 percent, ** barely significant at 5 percent.

These cointegrating pairs of prices qualify to estimate error correction model which will depict both the short-run and long-run time periods required for price transmission across markets. However, although these pairs of prices may be cointegrated, if the price transmission takes a fairly long period of time, then the data is not likely to produce statistically significant error correction equation. We ran error correction equation on all the combinations. Only two equations showed statistically significant relation in terms of R^2, t-statistics, and the theoretical range of the adjustment coefficient m_0. The results of these error correction equations are provided in Tables 3 and 4 below.

Both the equations show that Apple prices in Mumbai have an effect on the prices in Bangalore and Kolkata. In both cases, the adjustment parameter, m_o, is between 0 and 1. In fact, for both the equations, the parameter is little more than 0.4. This indicates that the adjustment of prices in Bangalore and Kolkata due to changes in prices in Mumbai is only partial each week. It takes more than 2 weeks for prices to get adjusted due to a particular change in price in Mumbai. In both places, the instantaneous adjustment in the same week is only about 50 percent.

Table 3: Error Correction Model for Bangalore–Mumbai Wholesale Prices

Variable	Estimated coefficient	T-Ratio
Δ Mumbai	0.512553	4.942379
Lag Δ Mumbai	0.491419	4.082613
2Lag Δ Mumbai	0.014614	0.10793
Lag Δ Bangalore	-0.53769	-4.52354
2Lag Δ Bangalore	-0.28854	-2.13489
3Lag Mumbai (m_1)	0.485094	4.184314
3Lag Bangalore (m_0)	0.416772	3.261569
Constant	565.1429	3.205162
R-square = 00.45268	Adjusted R-square = 0.3972	

Table 4: Error Correction Model for Kolkata-Mumbai Wholesale Prices

Variable	Estimated coefficient	T-Ratio
Δ Mumbai	0.526279	6.397178
Lag Δ Mumbai	0.348977	3.149225
2Lag Δ Mumbai	0.347016	2.716818
Lag Δ Kolkata	-0.51106	-4.08421
2Lag Δ Kolkata	-0.35146	-2.34657
3Lag Mumbai (m_1)	0.715076	8.487148
3Lag Kolkata (m_0)	0.443729	2.829072
Constant	193.0658	2.412387
R-square = 0.44052	Adjusted R-square = 0.3802	

4 Inferences and Conclusions

Results show that except for Mumbai prices affecting prices in Bangalore and Kolkata, none of the other markets exhibit any strong long-run relationship. Even between Mumbai and Bangalore/Kolkata, data reveal that only about half of the change in price gets transmitted within a week. In fact, results indicate that it takes more than 2 weeks to get full transmission of price changes. Importantly, results also show that Delhi prices do not significantly affect prices elsewhere. With widespread use of various communication channels, lack of information flow across the markets cannot be thre reason for this situation. A likely reason is that traders is distant places in the south and east strike deals and procure apples directly from growers, circumventing price movements in Delhi market. Traders did corroborate this fact when we visited them in Chennai wholesale market. And, although Delhi market may be circumvented, number of intermediaries has not reduced much.

In fact, there could be substantive cascading effect of heavy margins at various stages of supply chain. Study by Deodhar (2005) indicates that even for a short distance between growing areas in Himachal Pradesh and the Delhi market, trader margins account for 46 percent of the consumer rupee spent on apple. For imported apples moving from Mumbai port to Delhi, this margin is as high as 51 percent of the consumer rupee. In contrast, per unit transportation cost is extremely low. Even for a refrigerated container shipment from Mumbai port to Delhi market, the cost of transport is merely Rs.70 per 20 kilogram box. The cost is considerably lower for non-refrigerated transport.

The solution may lie in opening-up the Agricultural Produce Marketing Committee (APMC) markets. At this time, it is mandatory for produce to go through APMC markets. APMCs have a restricted number of traders with licences to trade. Prices at these markets are determined by auctions. However, at many places negotiation practices are not transparent. These practices include negotiating prices by holding hands, covering fists with a towel, and signalling bid-ask quotes through finger movements. As an alternative, if produce is allowed to move without going through APMC markets, and suppliers are allowed to operate through private wholesale markets, it would generate competition to APMC markets, increasing competition among traders.

That the price movements in Mumbai market do affect prices in Bangalore and Kolkata is indicative, perhaps, of the changing trade pattern in apples. India started importing apples since the year 2000, and the imports reached a level of about 22,000 tonnes in 2003. Most of these imported apples arrive in the Mumbai port. Traders in Bangalore and Kolkata do procure apples

from Mumbai where imports arrive throughout the year. Currently, imports account for about 1.5 percent of domestic production, and they are rising. Study by Deodhar, indicates imports may at most rise to 70,000 tonnes a year in a decade. This rise in imports is not going to be injurious to domestic suppliers; however, it will be significant enough to discipline the domestic prices, especially in the south.

Finally, we would like to make an oft repeated but nevertheless important point. Transport infrastructure and the cold storage facilities still have not improved considerably. It takes about ten days for apples to reach Chennai, that too when the apples are exposed to heat and chances of rain. Moreover, there are no sufficient cold storage facilities available. Risks and delays associated with such environment in this business prevent integration of markets across cities. Changes such as the implementation of golden quadrilateral highways, and, allowing foreign direct investments in wholesale/retail cool supply chain would change this situation.

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