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TESTING MARKET INTEGRATION†

In an efficiently integrated market system, there will be positive correlation over time among prices at different market locations. Since correlation coefficients directly measure how closely prices of a commodity move together in various marketplaces, they are often invoked to test the hypothesis that local markets in developing countries are not integrated, and therefore not efficient. In such countries, transport and communications are usually difficult and expensive—conditions not conducive to the efficient intermarket trading and arbitrage necessary to produce a tightly linked system of local markets. Examination of price relations that could be supplemented with observation of trading activity have proved to be useful tests of the hypothesis.

While it is true that prices in an efficient market system tend to move together, they may do so for other reasons. Common price trends (like general inflation), common seasonality (especially likely in agriculture), or any other synchronous common factor may produce sympathetic but unrelated price changes. Similarly, a perfect monopoly or price fixing by a central authority can just as easily produce a coefficient of one as a perfectly competitive market.

Correlation coefficients, then, are not unequivocal indicators of market conditions, and as applications became more indiscriminate, questions about their interpretation began to appear in the literature. (This is not to say that the various problems of correlation between time series were not known earlier—see Ravallion, 1983b, for examples). Barbara Harriss, who criticized the correlation approach most severely in a 1979 article in this journal, calls into question the equation of correlation coefficients with the action of regulating flows of commodities within integrated systems "because high correlation coefficients may characterize a situation of physical discontinuities..." (p. 200), but such a view of integration seems overly narrow. She noted, in particular, that high bivariate

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correlation for two markets that do not trade with each other are quite possible "if prices in each are highly correlated via the price and trading relationship of a joint destination market." (p. 200). There is nothing inappropriate, however, in designating two small market towns in surplus areas that never trade with each other but with a common large central market as integrated if their prices are otherwise formed competitively with that market.

Low correlation coefficients may also arise for other reasons than economic inefficiency. C. Peter Timmer (1974) provides an interesting example of a competitive and closely linked rice trade in Java that yields zero and even negative price correlation coefficients unless account is taken of the fact that there may be a seasonal change in the direction of commodity flow, and William O. Jones (1976) offers an example of low correlation in sorghum prices between two Nigerian towns that are otherwise closely linked commercially simply because of the high cost of transport.

High correlation coefficients, on the other hand, may result from price setting by public authority or private cartel; they nevertheless imply market integration, at least in the sense that local markets are linked together, however inefficient this linkage may be. But this raises questions of economic and technical efficiency that are beyond the scope of this paper. (It must be remembered that correlation analysis has also had great successes, notably in studies of highly sophisticated commodity futures markets.)

In an integrated and competitive market system, common temporal forces like general inflation and common seasonality should affect prices in various local markets in the same way. Viewed in this manner, the high correlation coefficients produced by common time trends are perfectly appropriate. Problems arise, however, because seasonal and secular trends tend to overwhelm the more subtle spatial relationships between prices in the simple correlation model. It does not seem logical to regard as integrated markets where general economic conditions are having a similar impact on the entire system, but that are failing to eliminate spatial differentials in excess of transfer costs. What is needed is a model that can pick up the more subtle spatial differentials and not be overwhelmed by common trends. An approach developed by Martin Ravallion (1985) and subsequently modified by C. Peter Timmer (1985) purports to do just this. It also provides a broader interpretive framework for examining questions pertaining to market integration.

What follows is a brief presentation of the Ravallion approach to modelling spatial market integration. A simple version of the model is then applied to data Elon H. Gilbert, William O. Jones, and Alan R. Thodey used in their studies of food crop marketing in Nigeria in 1965–67. A final section assesses the usefulness of the model for examining questions of market integration and efficiency.

THE MODEL

In the context of testing performance of grain markets in Bangladesh, just prior to and during the 1974 famine, Ravallion developed a general approach to modelling market integration that attempts to measure the extent to which local prices are influenced by prices elsewhere. As a starting point, he posits an autoregressive distributed lag relationship between each local price of a commodity and an appropriate reference price level (either some sort of national price or the price of a central market location or set of locations). Specifically,

$$\alpha_i(L)P_{it} = \beta_i(L)\bar{P}_t + \underline{\gamma}_i(L)\underline{X}_{it} + \mu_{it}, \quad (1)$$

$$(i = 1, 2, \ldots, k)$$

$$(t = 1, 2, \ldots, n)$$

where

P_{it} = price in market i at time t;
$\bar{P}_t$ = reference price at time t;
$\underline{X}$ = vector of seasonal and other relevant variables in market i at time t (with the same collection of variables used in all vectors $\underline{X}_{it}$, over all markets and all time periods);
u_{it} = an error term,

$\alpha_i(L), \beta_i(L)$ and $\gamma_i(L)$ denote polynomials in the lag operator ($L^i P_t = P_{t-i}$), defined as

$$\alpha_i(L) = 1 - \alpha_{i1}L - \ldots - \alpha_{in}L^n,$$

$$\beta_i(L) = \beta_{io} + \beta_{i1}L + \ldots + \beta_{im}L^m,$$

$$\gamma_i(L) = \gamma_{io} + \gamma_{i1}L + \ldots + \gamma_{in}L^n.$$

In this form, Equation (1) lacks a proper dependent variable for econometric estimation. To be of use empirically, the equation must be respecified. For reasons that will become clearer below, Equation (1) will be rewritten with the first difference of the local market price as the dependent variable. Before doing so, it is helpful to define Δ as the time-difference operator (e.g.,

$\Delta P_{it} = P_{it} - P_{it-1}$) and Δ^i as the spatial price differential (i.e., $\Delta^i = P_{it} - \bar{P}_t$). For the $n \leq m$ case, Equation (1) becomes

$$\begin{aligned}\Delta P_{it} = &((\sum_{j=1}^{n} \alpha_{ij} L^j) - L)\Delta^i P_t + \sum_{j=0}^{m-1}(\sum_{k=0}^{j} \alpha_{ik} + \sum_{k=0}^{j} \beta_{ik} - 1)L^j \Delta \bar{P}_t \\ &+ (\sum_{j=1}^{n} \alpha_{ij} + \sum_{j=0}^{m} \beta_{ij} - 1)\bar{P}_{t-1} + \underline{\gamma}_i(L)\underline{X} + \mu_{it},\end{aligned} \tag{2}$$

where $\alpha_{io} = 1$. Equation (1), then, can be manipulated to express the current period's price change as a distributed lag of past years' spatial[1] and temporal price differentials. The price variables can be defined in either absolute or logarithmic terms, making the Δ's either absolute or percentage price changes.

Unfortunately, Equation (2) is not very intuitive. Intuition and ease of calculation are aided by reducing it to one lag each for local and reference market price differences ($n = m = 1$):

$$\begin{aligned}\Delta P_{it} = &(\alpha_{i1} L - L)\Delta^i P_t + \beta_{io}\Delta \bar{P}_t \\ &+ (\alpha_{i1} + \beta_{io} + \beta_{i1} - 1)\bar{P}_{t-1} + \underline{\gamma_i X} + \mu_{it}.\end{aligned} \tag{3}$$

Removing the Δ's, Equation (3) reduces to

$$\begin{aligned}(P_{it} - P_{it-1}) = &(\alpha_i - 1)(P_{it} - \bar{P}_{t-1}) + \beta_{io}(\bar{P}_t - \bar{P}_{t-1}) \\ &+ (\alpha_i + \beta_{io} + \beta_{i1} - 1)\bar{P}_{t-1} + \underline{\gamma_i X} + \mu_{it}.\end{aligned} \tag{4}$$

The model summarized by Equation (4) specifies the change in local price as a function of the change in the reference price for the same period, last period's spatial price margin, last period's reference market price, and local market characteristics.[2] In Equation (4), β_{io} measures the extent to which local market participants (wholesalers, retailers, and farmers) know the conditions in the reference market quickly enough for local prices to be influenced in the same time period. The term, α_{i-1}, measures the extent to which last period's spatial price differential is reflected in this period's local market price change.[3] If, for example, the margin widened in the last time period (say the national price level or the central market price rose) and transactions costs remained the same, traders would have an incentive to move the commodity away from the local market to another part of the system, thus pushing up prices

[1] In the sense that it is the difference between the local market price and the reference market price.

[2] The discussion in the remainder of this section closely follows the interpretation of Timmer (1985).

[3] "Spatial" is used figuratively, rather than literally, when the reference price is a national price or some other general price level.

in the current time period. Other factors might also contribute to local price changes. Seasonal fluctuations in supplies (e.g., periodic shortages) or disruption of communication by local storms could dominate local price changes and sever the link with the reference market. Finally, the general level of prices in the reference market may provoke price changes in the local market. This is most likely to occur in strongly inflationary environments or when interest charges are a large component of marketing costs.

From Equation (4), the following hypotheses are directly testable:

1. *Market Segmentation.* The hypothesis of local market segmentation states that changes in the reference market price level will have no effect, immediate or lagged, on prices in local markets. Market i could be called segmented if (in terms of Equation (4)):

$$\beta_{io} = \beta_{i1} = 0, \tag{5}$$

which can be determined by testing Equation (4) against the following restricted model with an F-test:

$$(P_{it} - P_{it-1}) = (\alpha_{i-1})P_{it-1} + \underline{\gamma}_i \underline{X} + \mu_{it}. \tag{6}$$

Acceptance of Equation (6) indicates that the price in market i depends only on its own lagged values and local market characteristics.

2. *Short-run integration.* This hypothesis requires that reference price changes be immediately and fully reflected in the local price level, which means:

$$\beta_{io} = 1,\ \beta_i(L) = 1 \qquad (\Rightarrow \beta_{i1} = 0). \tag{7}$$

The hypothesis, in addition, requires that there be no lagged effects on prices in the future:

$$\alpha_i = 0. \tag{8}$$

If both (7) and (8) are accepted, market i is integrated with the reference market in one time period. Acceptance of the hypothesis makes $\beta_{io} = 1$ and $(\alpha_{i-1}) = -1$, indicating that this period's reference market price change and last period's spatial differential are fully reflected in the current local price level. When $n = 1$ (Equation (4)), short-run integration as indicated by (7) and (8) implies the absence of local price autocorrelation. Further, if $\underline{\gamma i} = \underline{0}$, local and reference market prices are equal.[4]

3. *Absence of local characteristics.* This hypothesis assumes $\underline{\gamma}_i = \underline{0}$, implying

$$\begin{aligned}(P_{it} - P_{it-1}) = \gamma_o + (\alpha_{i-1})(P_{it-1} - \bar{P}_{t-1}) + \beta_{io}(\bar{P}_t - \bar{P}_{t-1}) \\ + (\alpha_i + \beta_{io} + \beta_{i1} - 1)\bar{P}_{t-1} + \mu_{it}.\end{aligned} \tag{9}$$

[4] With $\beta_{io} = 1$, $\beta_{i1} = 0$, and $\alpha_i = 0$, Equation (4) reduces to $P_{it} = \bar{P}_t + \underline{\gamma}_i \underline{X} + \mu_{it}$. With $\underline{\gamma} = \underline{0}$, they are equal.

Testing this hypothesis is of interest when local prices are suspected to have different seasonality than the reference market. In that context, the $\underline{X}$ variable could be defined as a series of seasonal dummy variables and Equation (4) could be tested against (9) with an F-test. More generally, specifications of the $\underline{X}$ variable are limited to dummy variables defined over the same time frame as each price observation (e.g., monthly price data requires monthly dummy variables).

Equation (4) can also be manipulated to yield an indirect but more subtle and general indicator of market integration. To this end, it is helpful to rename the coefficients in Equation (4), making $\alpha_{i-1} = b_1$, $\beta_{io} = b_2$, $\alpha_i + \beta_{io} + \beta_{i1} - 1 = b_3$, and so on):

$$(P_{it} - P_{it-1}) = b_1(P_{it-1} - \bar{P}_{t-1}) + b_2(\bar{P}_t - \bar{P}_{t-1}) + b_3\bar{P}_{t-1} + \underline{b}_4\underline{X} + \mu_{it}, \tag{10}$$

and then to rearrange the variables:

$$P_{it} = (1 + b_1)P_{it-1} + b_2(\bar{P}_t - \bar{P}_{t-1}) + (b_3 - b_1)\bar{P}_{t-1} + \underline{b}_4\underline{X}. \tag{11}$$

Assuming that the reference market is in long-run equilibrium (i.e., $\bar{P}_t - \bar{P}_{t-1} = 0$) and also that $\underline{b}_4 = \underline{0}$, then $(1 + b_1)$ and $(b_3 - b_1)$ remain, and reflect, respectively, the relative contributions of local and reference market price history to the formation of the current local price level. Markets where previous reference prices are the primary determinants of local prices (rather than previous local prices) are well connected in the sense that supply and demand conditions in the reference market are communicated effectively to local markets and influence prices there irrespective of previous local conditions.

To capture the relative magnitude of the two sets of effects, Timmer constructed an index of market connection (IMC), defined as the ratio of the lagged local market coefficient to the lagged reference market coefficient:

$$IMC = \frac{1 + b_1}{b_3 - b_1}. \tag{12}$$

If what Ravallion calls short-run integration is accepted (hypothesis 2), $b_1 = -1$, (formerly α_{i-1}), and $IMC = 0$. When markets are segmented (hypothesis 1), b_1 and b_3 are equal and $IMC = \infty$. Given the model's specification, b_1 is between 0 and -1 under normal conditions, and the index is normally positive. In general, the closer the index is to 0 the greater the degree of market integration; Timmer considers a coefficient of less than 1 to reflect a high degree of short-run market integration.[5] Essentially, the Timmer Index indicates the degree to which local markets are connected to the reference market in the short-run (that is, in one time period).

[5] It is quite possible for b_2 to be 1 and the IMC to be very high.

A final indicator of market integration that can be drawn from the model derives from the plausible result that b_2 (formerly β_{io}) is close to 1, but Equation (8) does not hold. In that case, short-run integration cannot be accepted, yet economic forces causing reference market price changes are generally being reflected in the local price level. In this sense, the b_2 coefficient measures much the same thing as the simple bivariate correlation coefficient. A form of integration is taking place, even though the reference market and the local market are not being linked in the short run (i.e., changes in the spatial margin are not being passed on fully).

AN APPLICATION

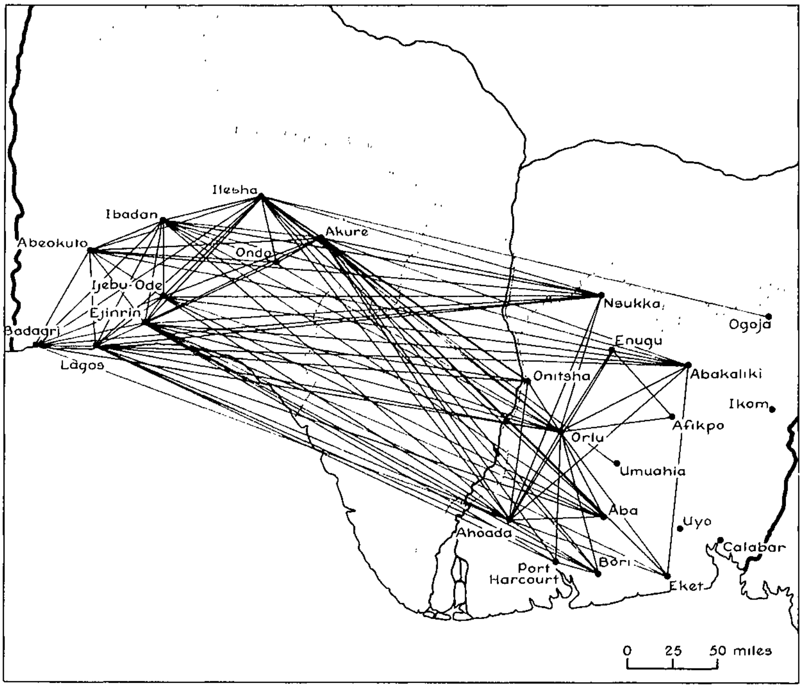
Both Timmer and Ravallion present convincing cases for the improved explanatory power of the model in testing the degree of market integration. Ultimately, the model's value will be proved in applications and in showing that the various hypotheses and tests are consistent with the observation of various marketing situations. The present paper applies the model to data from two situations where a great deal is already known about interpretation and then compares the model's performance with that of the correlations. To keep interpretation and estimation simple, the form of the model summarized by Equation (4) is used. The data from Jones's marketing studies in Nigeria provide particularly useful tests for the model. Gari (processed cassava) is interesting primarily because the bivariate correlations of gari prices between cities are very high (Map 1). Yet Thodey's earlier field evidence suggested a significant degree of market imperfection in the gari trade. Yam prices, on the other hand, were poorly correlated (Map 2), despite the high seasonal variation in their prices and will test the capability of the Ravallion model to pick up local market conditions.

Several general comments are in order before presenting the empirical results. First, data for both crops are average monthly retail prices from 1957 to 1966 for major cities and market towns in Nigeria. Second, during the period in question there was no government intervention in the trade of either commodity at any level. Third, gari and yams were each estimated by Thodey to contribute 30 to 40 percent of total daily calories consumed in urban areas, suggesting that they were important commodities consumed by most of the population. Finally, all cities for which data are examined were major consuming centers and relied on the surrounding area to satisfy the needs of their populations.

Gari price data from eight major cities in Western Nigeria are examined. Western Nigeria was a fairly self-contained gari market during the period, and only Lagos received significant supplies from outside the region. Supply areas were scattered throughout the region, with the largest located in the northern savanna. Most cities had their own exclusive areas of supply, competing with other cities only at the margins. A few (especially Ibadan and Ilesha) competed directly for the produce from the same areas.

To apply Equation (4) to the gari data, an appropriate regional price is

Map 1.—Correlation Map, Gari Prices in Nigeria*



Source: William O. Jones, 1972. *Marketing Staple Food Crops in Tropical Africa.* Cornell University Press, Ithaca, New York, p. 142.

*Lines indicate price correlation of .80 or greater.

needed. Prices in Ibadan are taken to represent the "reference" market price because of the city's importance as a consuming center and the high correlations of its prices with those in other western Nigerian markets:

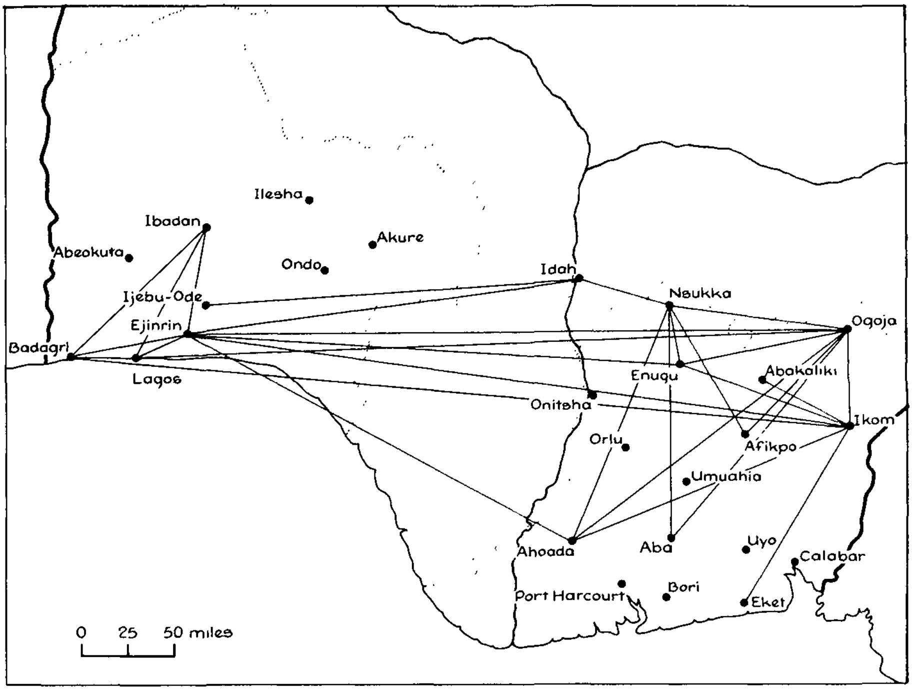
Market	Coefficient	Market	Coefficient
Abeokuta	.91	Ijebu-Ode	.93
Akure	.96	Ilesha	.93
Badagry	.88	Lagos	.93
Ejinrin	.94	Ondo	.86

Over the period, Ibadan consumed at least 25 percent of the annual gari production of Western Nigeria and accounted for 35 percent of total urban consumption. Moreover, it was the region's largest city.

The model can be applied to data in their actual form or as logarithmic (percentage) relations.[6] There is little a priori basis for deciding whether to use

[6] Deciding how to represent the data is important since it will affect the coefficients,

Map 2.—Correlation Map, Yam Prices in Nigeria*



Source: William O. Jones, 1972. *Marketing Staple Food Crops in Tropical Africa.* Cornell University Press, Ithaca, New York, p. 146.

*Lines indicate correlation of .65 or greater.

logged or actual prices. Marketing costs can be viewed either as fixed per unit of volume or ad valorem in nature. Actual costs typically comprise a number of factors (like transport, finance, and storage) and thus, their overall nature is difficult to determine. Both Ravallion and Timmer chose to estimate the model in percentage terms and that tradition is followed here.[7] Price series for all cities showed essentially the same seasonal pattern, so no dummy variables

most notably b_2. Recall that b_2 measures the extent to which general economic conditions affecting the reference market price level are being transmitted to the local market. If logged (nominal) prices are used and $b_2 = 1$, reference price changes are fully transmitted to local markets in percentage (absolute) terms. The key factor in this application is whether the spatial-differential equilibrium is fixed in percentage or absolute terms.

[7] Preliminary work with the data in both percentage and absolute terms suggested the percentage relations are the more accurate conceptualization; however, the same quantitative results were obtained either way.

for local seasonality are included.[8] An intercept term is included to capture overall differences in price levels between the major cities reflecting the varying distances that gari supplies had to be shipped.

While the hypothesis of local market segmentation is universally rejected, so is full short-run integration. The b_2 coefficient is within one standard error of one for only two cities (Table 1), indicating that changes in the Ibadan price were rarely, if ever, fully passed on in proportional terms to other cities. While not segmented from Ibadan, the other seven cities do not appear to form an overly integrated market system.

Table 1.—Regression Results and Intermarket Connection Index (IMC)

	1957–66[a]		1957–61			1962–66[a]	
Market	b_2	IMC	b_2	IMC	F[b]	b_2	IMC
Abeokuta	.53	1.63[c]	.21[e]	1.77[c]	4.43	.82[d]	.82[c]
Badagry	.50	1.78[c]	.28[e]	1.73	5.73	.75	.91[c]
Ejinrin	.61	1.50[c]	.45	1.55[c]	8.28	.81[d]	1.04[c]
Ijebu-Ode	.82[d]	1.33[c]	.70	2.03[c]	7.33	.87[d]	1.13[c]
Ilesha	.84[d]	1.00[c]	.54	1.17[c]	7.16	1.17[d]	.59[c]
Lagos	.44	6.75	.19[e]	5.00	2.68[f]	.69	6.67
Ondo	.52	3.55[c]	.20[e]	4.26[c]	1.48[f]	.88[d]	2.33[c]

[a]Both segmentation and strong short-run integration rejected for all at .01 level.
[b]F-statistic for segmentation (hypothesis 1).
[c]b_3 was not significant at .05 level and was not used in figuring IMC.
[d]Within one standard error of 1.
[e]Not significantly different from 0 at .05 level.
[f]Hypothesis of segmentation accepted at .05 level.

The results are in sharp contrast to those shown by the correlation coefficients. Given that gari prices over this period were subject to a small upward secular trend and fairly pronounced cyclical behavior, the criticisms of correlation coefficients discussed at the beginning of this paper seem to be valid for gari. The most graphic difference is for Lagos. Its correlation coefficient with Ibadan is highest (.93), yet it had the lowest b_2 coefficient and the highest IMC number. The poor integration implied by the model is still surprising, even though Lagos may have obtained much of its gari supply from outside the region.[9] The "high" b_2 coefficient and "low" IMC number for Ilesha are not sur-

[8] The model was initially run with seasonal dummies, but none of them were significant. The same overall results were obtained when the seasonals were included.

[9] The major road connecting Ibadan with Lagos was excellent at the time, and communications between the two cities were good. Perhaps some form of collusion was occurring in the gari market at Lagos.

prising since that city competed quite heavily with Ibadan for its gari supplies. The general result of poor integration does corroborate various observations made by Thodey of a general lack of communication of prices (traders for one city rarely knew what prevailing prices were in other cities) and other market information, problems for some traders in gaining timely access to credit, and poor transport facilities in some areas.

Despite poor integration overall, Thodey notes that as urban populations grew over the period, demand sharply increased, and many cities started to compete for the same supplies in the early 1960s. In addition, Jones found evidence of a great deal of trading activity by the mid-1960s. Retail prices in the various cities would be more tightly linked under these circumstances, resulting in a higher level of integration later in the period. To test this possibility the data were divided in half and separate integration tests were performed on the years 1957–61 and 1962–66. Bivariate correlations with Ibadan for the two periods were as follows:

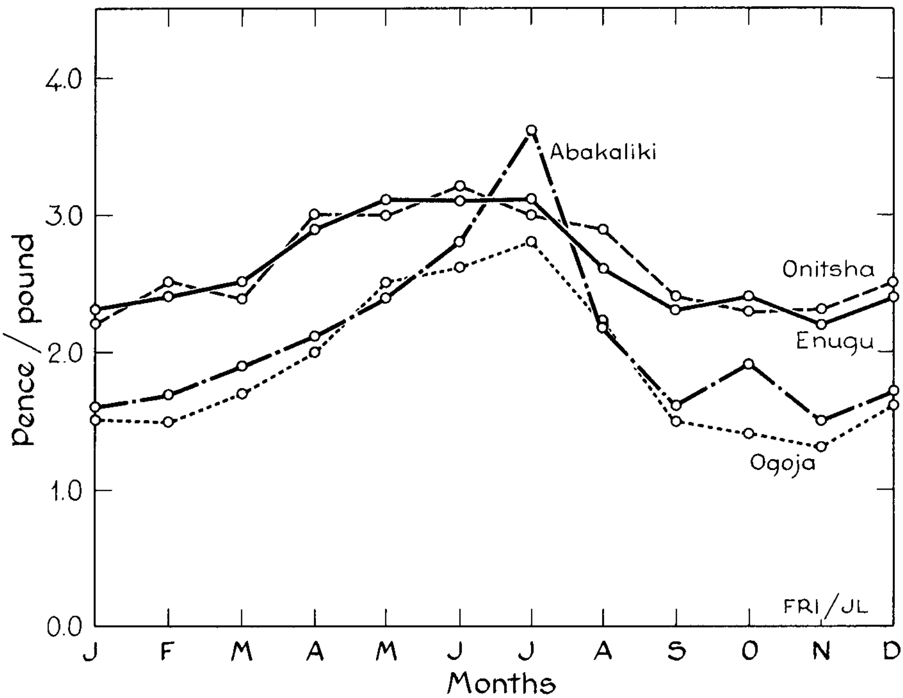
Market	Coefficient, 1957–61	Coefficient, 1962–66
Abeokuta	.76	.95
Badagry	.66	.93
Ejinrin	.86	.95
Ijebu-Ode	.88	.94
Ilesha	.79	.96
Lagos	.88	.94
Ondo	.73	.91

The gari system during the first five years can be characterized by a pronounced lack of integration (Table 1). Segmentation is accepted at the 5 percent level for two cities (including Lagos) and is almost accepted at the 1 percent level for a third. The b_2 coefficients are not only low, but four of them are not even statistically different from 0 at the 5 percent level. Further, all IMC's are greater than one.

The results improve dramatically in the next five years. Segmentation is rejected for all, six of seven cities have b_2 coefficients within one standard error of 1, three have IMC numbers less than 1, and full, short-run integration is almost accepted for Ilesha (just missing at the 1 percent level). The results indicate that the gari market comprised a fairly well integrated system later in the period despite the persistence of the problems mentioned by Thodey. The results, in addition, confirm Thodey's observation that integration improved later in the period.

The bivariate correlation coefficients for yam prices throughout the country were quite low. Yams are seasonally produced and are relatively expensive to store. Thus, a strong and regular seasonal price pattern is expected in local prices. Seasonal indices provided by Jones show June to be the month of highest average prices in the majority of markets. Variations in seasonality coefficients

Chart 1.—Average Monthly Prices for Yams
for Four Eastern Nigerian Markets, 1952–66



Source: William O. Jones, 1972. *Marketing Staple Food Crops in Tropical Africa.* Cornell University Press, New York, p. 128.

across regions appear to be the major cause of the low correlation coefficients (Chart 1).

Yam prices from a subset of Eastern Nigerian cities are examined (Map 2) with the Ravallion model. As before, prices are converted to logarithms. Eleven seasonal dummies are included as well as an intercept term. Onitsha is used as the reference market because of its importance as a transshipment point both inside and outside the region. Bivariate correlations of yam prices between Onitsha and major towns in its hinterland were:

Market	Coefficient	Market	Coefficient
Aba	.54	Ikom	.70
Abakaliki	.55	Nsukka	.46
Afikpo	.33	Ogoja	.67
Ahoada	.66	Orlu	.44
Enugu	.58		

Like the correlation coefficients, the model results show dismal integration (Table 2), though segmentation is universally rejected. Local seasonality is accepted at the 5 percent level for 7 of 9 cities, and 5 of 9 at 1 percent. For the cities where local seasonality is significant, there are interesting variations in the individual dummy coefficients. For some, the coefficients for June and July are significant. In addition, coefficients for April, May, September, and November are occasionally significant (Table 3). Whatever the pattern, the model shows significant local variations in seasonality.

The yam results go beyond the significance of local seasonality. Chart 1, for example, indicates that Abakaliki experienced very sharp price increases in both June and July over the period (much sharper than in Onitsha—suggesting yam supplies were much shorter in June and July in Abakaliki than in Onitsha). Its June and July coefficients are .30 and .53, respectively, and both are significant at the 1 percent level. Since the dependant variable is the percentage monthly price change for Abakaliki, the June and July coefficients indicate that the monthly price change is on average 30 and 53 percent greater in Abakaliki than in Onitsha for those two months. The coefficients certainly corroborate what is shown on Chart 1, with the Abakaliki price rising sharply over those two months and the Onitsha price actually falling slightly. Positive dummy coefficients are expected because the Abakaliki price is rising relative to the Onitsha price. For Abakaliki, the only other dummy coefficient that is significant is that for November (at the 5 percent level). Chart 1 shows the Abakaliki price to be falling when the Onitsha price is rising. As expected, the November coefficient is negative (−.23). Similar logical coefficients exist for the other two towns on Chart 1 as well.

There is a temptation to say that the model has identified the source of the poor integration results, namely local seasonality. For example, only a few of the monthly dummies are significant for Abakaliki, strongly suggesting that seasonal characteristics there were the major determinant of local price changes. Supplies from elsewhere in the region apparently failed to move in to alleviate the shortage in Abakaliki. Clearly, Abakaliki is not integrated with the rest of the system, despite the fact that it is a major supplier of yams to southeastern Nigerian markets.[10] In theory, local differences in supply should produce an

[10] Raphael Igwebuike, who studied farming systems in the Abakaliki area in 1973, says that the area "has been a significant exporter of food to the overcrowded parts of Eastern Region," and that Abakaliki rice and yams are now exported to urban centers as far away as Lagos and Ibadan (Igwebuike, pp. 14–15). The responsiveness of Abakaliki farmers to market opportunities is confirmed by an earlier study of the rice marketing by Delane Welsch. Rice cultivation was first introduced to Eastern Nigeria in the Abakaliki area in 1942 and by 1950 "a complete marketing system for rice evolved" (Welsch, p. 329). In 1963 the Abakaliki area accounted for two-thirds of the Eastern Region's rice production. Welsch also provides a clue to the fragmentation in markets implied by the analysis in this paper. He reports that Abakaliki town had only a small market and traders bought from many village markets and from many

Table 2.–Regression Results for Yams in Eastern Nigeria, 1957–66*

Market	b_2	IMC	F-statistic[a]
Aba	.14	2.50	3.20[b]
Abakaliki	.33	2.61	6.60[b]
Afikpo	-.06[c]	5.44	7.40[b]
Ahoada	.10[c]	3.56	2.16[d]
Enugu	-.03[c]	1.53	2.07[d]
Ikom	.07[c]	6.00	1.69
Nsukka	-.09[c]	3.44	4.49[b]
Ogoja	.26[c]	1.08[e]	3.56[b]
Orlu	-.21[c]	2.80	1.45

*Segmentation and short-run integration rejected for all.
[a]Absence of local seasonality (hypothesis 3).
[b]Absence of local seasonality rejected at 1 percent level.
[c]Not significant from 0 at 5 percent level.
[d]Absence of local seasonality rejected at 5 percent level.
[e]Indicates b_3 was not significant at 5 percent level and not used in figuring IMC.

Table 3.—Statistically Significant Seasonal Dummy Coefficients
(T-statistics in parentheses)

Market	Apr.	May	June	July	Sep.	Nov.
Aba	.18	.19	.18	.15		
	(2.73)	(2.89)	(2.69)	(2.13)		
Abakaliki			.30	.53		-.23
			(2.57)	(4.14)		(-2.00)
Afikpo	.25	.28	.38	.47		
	(2.54)	(2.74)	(3.54)	(3.91)		
Ahoada					-.20	-.17
					(-2.77)	(-2.41)
Enugu					-.20	-.21
					(-2.17)	(-2.30)
Ikom		—	—	—	—	—
Nsukka					-.24	-.21
					(-2.74)	(-2.55)
Ogoja		.25			-.35	
		(1.89)			(-2.51)	
Orlu		—	—	—	—	—

village markets and from the farmers'compounds as well (Welsch, pp. 333-34).

integrated system because they give traders incentives to move supplies between cities (at least for a time). Apparently this did not occur with yams in Eastern Nigeria.

CONCLUSION

The Ravallion model appears to be a significant improvement on earlier methods for testing the nature of market integration, even though it ultimately requires as much attention to interpretation and field evidence as earlier methods. The simple correlation coefficients for yams and the divided data for gari provided the same results regarding integration; however, the Ravallion model gives a much broader range of results than earlier bivariate correlations, and for a few of the gari cities it directly contradicts the correlation results (and properly so according to other field evidence). Further, the Ravallion model does not appear to be susceptible to common trends and it also seems capable of distinguishing between two different forms of integration. [11]

The rationale for applying the model to data already studied was to see if it produced results consistent with previous field inquiries and perhaps added new information. The test of the model proved that it does both.

The experiment offers some confidence that the Ravallion model can provide insights into marketing situations where less is known. Clearly, however, two empirical tests do not provide full verification of the approach. Moreover, there remain some obvious problems. Determining appropriate reference prices and variable specifications will be a problem in situations where a broad understanding of the market is limited. Simultaneous equation bias will always exist in theory, necessitating instrumental variables or faith that it is not "too large." The model's parameters are likely to be sensitive to the time length of the data, especially in a well functioning market. It seems probable that the response to the current period's change in the reference market price and the spatial differential are more likely to occur in the current time period the longer the period a single observation spans, for example, monthly versus weekly data. These responses are likely to affect the b_1 and b_2 coefficients in Equation (10), clouding the interpretation of those parameters. This possibility suggests weekly data are more appropriate than monthly or quarterly data; however, surveys are usually not taken that frequently in developing countries.

Finally, even though the model appears to handle well the criticisms pertaining to false integration produced by common time trends, it may not stand up well where the direction of commodity flow between rural and urban areas reverses with the season (Timmer, 1974). The model would reject integration in such situations even when it should not. Shifter variables might be designed to capture the changing direction of trade, but they would also require a change

[11] Table 2 shows a few cases where b_2 is reasonably close to 1 yet the IMC is quite high.

in the interpretation of the parameters. A resolution of this problem is far from clear.

Despite its problems, the model is an improvement on the correlation coefficient. It allows for the testing of a wider range of hypotheses with less chance of error. Further development of the Ravallion approach therefore merits attention on both theoretical and empirical grounds.

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