Economic Development and the Determinants of Market Integration: The Case of the Brazilian Rice Market

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August, 2001

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1. Introduction

Most of the literature on spatial market integration in the 1990s focused on the question of whether or not prices in distinct locations are cointegrated. Many papers also addressed the question of how quickly prices adjust between pairs of locations. More recently, research on market integration has begun to explore these two issues in the context of switching regime models that explicitly account for the discontinuities that transactions costs can induce. Surprisingly absent from this literature are studies that seek to identify the factors that increase market integration. In a comprehensive survey of more than 60 empirical papers, for example, Fackler and Goodwin (2000) only identified 4 studies that addressed this issue.[1] The objective of this paper is to begin the process of filling this gap in the literature by providing a conceptual framework for analyzing the determinants of market integration, and by offering an empirical application with data from Brazil. As we demonstrate below, this is a research agenda with potentially rich policy implications and important lessons for economic development.

In contrast to the dichotomous approach that is common in this literature, whereby markets are either deemed integrated or not, we believe that the question of market integration is most usefully posed in terms of a continuum of degrees of integration (González-Rivera and Helfand, 2001). The basic idea is that given a set of locations, not all of them belong to the same economic market, and among those that do belong to the market, some will be more integrated than others. Reflecting this view, our methodology consists of three stages. In a first stage, we seek to determine the *extent*, or geographical boundaries, of the market. Next, we establish a ranking from less to more integrated among the locations that were found to belong to the same economic market. This is what we call the *degree* of integration. In a final stage, which is the principal focus of this paper, we explore the determinants of the degree of integration.

Higher degrees of market integration can have important implications for economic development. The process of increasing the degree of integration of isolated markets, or of locations that are only weakly integrated into a national market, can bring significant benefits for local residents. It can raise the incomes of producers by permitting increased specialization and trade, and it can improve the welfare of risk averse consumers by reducing the variability of prices for goods that were previously non-tradable. To the extent that rapidly adjusting and well functioning microeconomic markets are an important ingredient for macroeconomic growth, increased market integration can bring wider benefits as well. Thus, it is pertinent to inquire what the necessary conditions are to increase the degree of integration. Some of these conditions may relate to public investments in physical and human capital, such as roads or schools, thus making market integration one of the externalities associated with their provision.

To this end, we provide a taxonomy of determinants of the degree of integration. In contrast to the papers by Goletti and co-authors (1993, 1995, 1995), which privilege the physical determinants of market integration (distance, infrastructure, and production), we provide a more general framework related to transactions costs. Our principal hypothesis is that the smaller the transactions costs that separate locations, the higher the degree of integration. Thus, in the same way that high transactions costs in rural areas of developing countries create imperfections in the markets for credit, insurance, labor or land (Hoff, Braverman, and Stiglitz, 1993), our study seeks to investigate these effects in the spatial context of a product market.

There are numerous factors that can lower transactions costs and increase the degree of integration. These should be distinguished according to their impact on the transactions costs that affect trade flows versus those that influence information flows. In addition to physical capital, market characteristics, and policies, we argue that human capital has an important role to play. Although this point has not been addressed in the literature on market integration, it is a natural extension of research in other areas on the importance of human capital. In the literature on agricultural productivity, for example, human capital has been shown to increase productivity, the probability of technological adoption, and the profitability of newly adopted technologies (Lockheed et al., 1980). Similarly, in the growth literature, human capital is treated not only as an input, but also as a potential source of increasing returns to scale (Bardhan 1995, Barro and Sala-i-Martin, 1995). With regard to market integration, higher levels of human capital should increase the productivity of activities related to the marketing of goods, and should facilitate the speed and accuracy of information flows within the market. Both effects serve to lower transactions costs.

The remainder of the paper is organized as follows. In section 2 we present the methodology used to estimate our dependent variable, the degree of market integration. We then briefly review the construction of principal components, which will be applied to the explanatory variables. To the extent possible, we incorporate a wide range of variables to capture the multiple determinants of the degree of integration. We are aware that some of these variables are proxies, many are highly correlated, and all are subject to measurement error. We adopt a principal components approach, as in Adelman and Morris (1995), to overcome substantial multicolinearity and to mitigate the problems of measurement error. The use of principal components permits a richer description of the interrelationships among the factors associated with greater market integration, but this comes at the cost of a loss of precision about the specific contribution of individual variables. In Section 3 we present the taxonomy of determinants of the degree of integration. We apply the methodology to the Brazilian rice market in Section 4. Section 5 provides conclusions.

2. Methodology for Constructing the Dependent and Independent Variables

The Dependent Variable: Persistence Profiles and the Degree of Integration

In this section we summarize the relevant portions of the methodology used in González-Rivera and Helfand (2001) to analyze market integration. In that paper we focused on the limitations of a bivariate approach to the study of market integration, and proposed a measure of degree of integration. We use that measure here as the dependent variable in the analysis of the determinants of the degree of integration.

Our definition of the extent of the market relies on two related dimensions: trade and information. For a market to be called integrated, we require that the set of locations share both the same traded commodity and the same long run information. Formally, a market with n geographically distinct locations will be considered integrated if the following two conditions are satisfied:

(1) There must be physical flows of goods connecting all n locations either directly or indirectly.

(2) The n locations must have a corresponding vector of prices $P_t = \{p_{1t}, p_{2t} \ldots\ldots p_{nt}\}$ that can be decomposed as $p_{it} = a_i f_t + \tilde{p}_{it}$, i = 1…n, and $a_i \neq 0$, where f_t is the integrating factor that characterizes the permanent (long run) component of the price, and $\tilde{p}_{it}$ is the transitory (short run) component for each location.

The basic elements of this definition are the existence of trade and that f_t is common to all series of prices. This definition provides an operational framework to search for the geographical boundaries of an integrated market. First, we identify the set of locations that is connected either directly or indirectly through continuous unidirectional trade. Second, we search for those locations that share the same long run information. In a cointegration framework, this condition is equivalent to requiring the existence of one and only one integrating factor that is common to all series of prices. Since cointegrating vectors and integrating factors are intimately related, the existence of *one and only one* integrating factor for all prices implies that (i) prices must be cointegrated, and (ii) there must be n-1 cointegrating vectors. Condition (2) in our definition is the common factor representation of a multivariate cointegrated system of prices with n-1 cointegrating vectors. Searching for just one common factor is equivalent to searching for n-1 cointegrating vectors. This is a key point of our methodology. In our approach, the *economic market* is not given a priori by the set of locations where a good is produced and/or consumed. Nor is the existence of cointegrated prices sufficient to find the market. It needs to be found through a multivariate search for a single common factor. In the case of the Brazilian rice market, we have 19 locations but we show that only 15 belong to the same economic market.

The search for the largest set of locations that share n-1 cointegrating vectors is conducted in a multivariate framework: the reduced rank VAR proposed by Johansen (1988, 1991). According to the Granger representation theorem, a cointegrated system can be written as a Vector Error Correction (VEC) model

(1) $$\Delta P_t = \mu + \Pi P_{t-1} + \Gamma_1 \Delta P_{t-1} + \Gamma_2 \Delta P_{t-2} + \ldots + \Gamma_{p-1} \Delta P_{t-p+1} + \varepsilon_t$$

where Γ_i and Π are n x n matrices and, if there are n-1 cointegrating vectors, Π has reduced rank n -1. The matrix Π can be written as $\Pi = \alpha\beta'$, where α is an n x (n-1) matrix of coefficients, and β is an n x (n-1) matrix of cointegrating vectors. Using this expression for Π, we have $\Pi P_{t-1} = \alpha\beta' P_{t-1} = \alpha Z_{t-1}$. The error correction term, also known as short run disequilibrium, is $Z_{t-1} = \beta' P_{t-1}$, and α is the matrix of adjustment coefficients. The elements of the matrix β cancel the common unit roots in P_t and, in the long run, link the movements of the elements of P_t.

Johansen's test for the number of cointegrating vectors focuses on testing the rank of Π. To determine which locations belong to the same market, we recommend starting with the maximum set of locations, n, and testing for n-1 cointegrating vectors. We do this by performing Johansen's likelihood ratio test based on the trace statistic. If the number of cointegrating vectors is less than n-1, we need to identify those locations that should be removed from the system. In order to do so we implement a sequential procedure. We start with a core of m locations ($m < n$) and test for the number of cointegrating vectors. If the number is m - 1 we add an additional location. With m + 1 locations, either the new one shares a common trend with the previous m locations or it does not. In the first case, we should find m cointegrating vectors, while in the second, we should continue to find m - 1, thus adding a second common trend to the m + 1 locations. If we find one common trend, we repeat the procedure by adding locations one at a time. If not, we exclude the location that added a second trend and repeat the procedure until the number of locations is exhausted.

When the extent of the market has been found, we enter into the second stage of the analysis which consists of assessing the degree of integration of each location. We define the degree of integration between locations that belong to the same market as the reaction time to remove disequilibria. Impulse response functions are a measure of reaction time that are commonly used in the literature. An important drawback of these functions is that they are not uniquely identifiable when shocks to the system are correlated. We proposed a different measure called a persistence profile (Pesaran and Shin, 1996) that is uniquely identifiable. A persistence profile characterizes the response of a cointegrating relation $\mathrm{Z_t} = \beta'\mathrm{P_t}$ to a system-wide, rather than to an individual, shock.

With n-1 cointegrating vectors, the long run equilibrium among prices can be written as

(2) $$p_{it} = \beta_{0i} + \beta_{1i} p_{nt} + z_{it} \quad i = 1,2,....n-1$$

where z_{it} is the short-run disequilibrium of the i-th cointegrating relation, which is transitory in nature, and $(1, -\beta_{1i})$ is the cointegrating vector. In equilibrium, we expect that z_{it}=0. A shock to any variable or set of variables produces a short term disequilibrium $|z_{it}|>0$. Since z_{it} is stationary, the effect of the shock will be transitory and the long run equilibrium relation will eventually be restored.

A persistence profile measures the reaction time of each long run equilibrium relation to absorb a system-wide shock, where the response is measured in units of variance. At time *t*, the variance-covariance matrix of the shock ε_t is Ω. We study the propagation through time (*t*+1, *t*+2. …) of the variance of the shock, conditioning on information up to time *t*-1. Thus, with an initial shock to the economy at time *t*, and considering the information up to time *t*-1, the persistence profile focuses on the *incremental* variance of the disequilibrium error at time *t+k*, as the time horizon increases by one period. In stationary systems, a shock will eventually die out. This implies that its incremental variance becomes smaller as time passes and approaches zero as time goes to infinity. Pesaran and Shin (1996) define the (unscaled) persistence profile as

(3) $$H_Z(k) = Var\left(Z_{t+k} \middle| \psi_{t-1}\right) - Var\left(Z_{t+k-1} \middle| \psi_{t-1}\right) \qquad k = 0, 1, 2\ldots$$

where ψ_{t-1} is the information set containing information up to time *t*-1, $Var\left(Z_{t+k} | \psi_{t-1}\right)$ is the variance of Z_{t+k} conditional on the information set, and k is the time horizon.

The construction of persistence profiles permits us to establish a consistent ranking of the degree of integration of locations based on their reaction times. Our dependent variable in the analysis of the determinants of market integration is the median persistence profile for each pair of locations. It is defined as the number of periods necessary for 50% of the adjustment towards the long run equilibrium to take place.

Summarizing the Explanatory Variables: Principal Components

In section 3 we describe a set of variables that can potentially explain the degree of integration. In practice, these variables are highly correlated and, consequently, multicollinearity will be a problem that will impede the discovery of the factors that are associated with a high degree of integration. For this reason, we turn to the use of principal components as a multivariate technique that permits translating a large set of correlated variables into a smaller set of uncorrelated variables that contains almost the same amount of information as the original variables (Jolliffe, 1986).

A principal component is defined as a linear combination of the original variables such that its variance is maximized subject to certain constraints. Formally, let x be a vector of p variables whose variance-covariance matrix is Σ. The j-th principal component of Σ is defined as

$$y_j = \sum_{i=1}^{p} \alpha_{ji} x_i = \alpha'_j x \qquad j = 1,2...p$$

where the vector α_j is such that the variance of y_j, $\mathrm{var}(y_j) = \alpha'_j \Sigma \alpha_j$, is maximized subject to the following constraints

$$\text{(i) } \alpha'_j \alpha_j = 1, \qquad \text{(ii) } \alpha'_j \alpha_k = 0 \qquad k \neq j$$

Constraint (ii) imposes orthogonality among the p principal components. This constrained maximization involves solving for the eigenvalues and eigenvectors of Σ. We need to solve

$$(\Sigma - \lambda_j I_p)\alpha_j = 0$$

where λ_j is an eigenvalue of Σ and α_j is the corresponding eigenvector. The maximum value of the variance is

$$\mathrm{var}(\alpha'_j x) = \alpha'_j \Sigma \alpha_j = \alpha'_j \alpha_j \lambda_j = \lambda_j$$

where λ_j is the *largest* eigenvalue of Σ and α_j the corresponding eigenvector.

The principal components are ranked such that the first accounts for the largest variance, and the last principal component accounts for the smallest variance, that is, $\lambda_1 > \lambda_2 > ... > \lambda_p$. The sum of the variances of the p principal components is equal to the sum of the variances of the original variables. Principal components can also be calculated from the correlation matrix of the variables *x*. The use of the correlation matrix is advisable when the original variables have very different variances. Otherwise, the variables with the largest variance tend to dominate in the initial principal components. In the empirical application we use the correlation matrix to calculate the principal components. In this case, $\sum_{j=1}^{p} \lambda_j = p$.

When analyzing the principal components, it is helpful to know the correlation of each original variable with each principal component. A high correlation of a variable with a particular principal component gives a meaningful interpretation to that component. The correlations of the variables with the *j*-th principal component are called "loadings". It can be shown that the loadings are calculated as $\sqrt{\lambda_j}\alpha_j$. It is easy to see that the eigenvector α_j and the loadings convey the same information. In the following section we report the loadings.

3. Determinants of the Degree of Integration: Conceptual Framework

There are multiple factors that can increase the spatial integration of a market. In general, these factors operate by lowering the transactions costs (TC) related to the flow of goods and information between locations. In a spatial context, TC capture the economic distance between locations. They tend to rise with physical distance, the time required to transfer goods and information, and other factors that impede the flows between locations.[2] Higher TC increase the probability that goods markets will be segmented because it becomes more likely that a region will have its own local supply and demand intersect within the price band generated by TC. Yet even when a region is integrated with the rest of the market, the fact that it is more expensive to transfer goods and information to or from this location implies that price adjustments to supply and demand shocks are likely to take more time. Consequently, our principal hypothesis is that the smaller the transactions costs, the higher the degree of integration.

The issue of how to fully and accurately measure the TC associated with the flow of goods and information is by no means trivial.[3] TC should be conceived of quite broadly as including commissions related to product search and transfer, legal costs stemming from contract negotiation and enforcement, financial costs, taxes, transportation costs, and the opportunity cost of time allocated to searching for information. In what follows we discuss the ways in which the costs and speed of moving goods and information across locations can be influenced by a) physical capital, b) human capital, c) supply, demand, and trade, d) policies, and e) other factors. When appropriate, we identify how these variables relate differentially to the farm, local, and inter-regional levels of a market.

Physical Capital

Distance increases the transactions costs associated with the flow of goods, and to a lesser extent, information. Increasing the quantity of different forms of physical capital is probably the most direct way to lower these costs. Table 1 provides examples of several of the most important types of capital that can facilitate both types of flows. Since the marketing of agricultural products begins on the farm, infrastructure that eases access to, and loading of, goods on the farm provides the first building block of the system. Many agricultural goods are stored off of the farm in rural areas, and thus local roads, storage, and marketing infrastructure are also important components of the physical capital that permits goods to flow. Finally, the quantity and quality of the infrastructure that connects one region to another--generally highways--is also an important component of the system. Because many types of physical capital, such as roads, are provided by local, state, and federal governments, there is an important role for policy that we will return to.

Physical capital is also essential to reduce the costs and increase the speed of information flows. While information circulates by word of mouth and through informal channels in the rural areas of developing countries, the importance of radios, televisions, and telephones is increasingly important. In part due to high illiteracy rates, rural radio and television shows are two of the most important mechanisms for farmers to obtain information about agricultural markets. Telephones, in contrast, are much less common among farm households, but are essential for traders located in rural areas to coordinate the flow of goods and to share information with traders located in other regions. Again, there are substantial investments in infrastructure, such as rural electrification, that can create an entry point for policy.

Human Capital

Human capital has played a prominent role in many fields of economics. Public and private investments in education (used as a proxy for human capital) are often estimated to have extremely high returns (Psacharopoulos, 1994), human capital intensive development strategies have been shown to be associated with more equitable development outcomes (Griffin, 1989), and human capital is seen as contributing to long term growth both because it is an input and a potential source of increasing returns to scale (Bardhan 1995, Barro and Sala-i-Martin, 1995). In this section we contend that a strong argument can be made for extending the literature on human capital to the topic of market integration.

In the agricultural sectors of developing and developed countries, education levels have been widely and strongly associated with higher levels of productivity and with faster rates of adoption of new technologies. In a survey of studies spanning 37 farm level data sets from 13 countries, for example, Lockheed et al. (1980) conclude that education had a positive effect on the productivity of small farmers in 31 of the 37 cases. The authors also refer to numerous studies using aggregate county and state level data that have reached similar conclusions. The relationship between education and agricultural productivity is complex. Alternative types of education (formal, non-formal, and informal) are thought to influence productivity directly through a "worker" effect and indirectly through an "allocative" effect.[4] Important components of the allocative effect are the ability to absorb new information and to adopt new technologies. Higher levels of education not only increase the probability of adopting new technologies, but are also necessary for the success of the technologies once adopted. The positive effects of farmer education on productivity should not be limited to agriculture alone, but should carry over to the other activities that farmers are involved in.

Based on the broad consensus in the literature about the positive effects of human capital on productivity and on the ability to process information, we hypothesize that higher levels of human capital should contribute to increasing the productivity of the sector that is responsible for the flow of goods, and to increasing the accuracy and speed with which information flows across space. Both effects should lower TC. To the extent that farmers are involved in the initial phases of marketing, then higher levels of human capital on farms should be associated with both higher agricultural productivity and higher productivity in marketing. To the extent that the flow of goods is coordinated through intermediaries, cooperatives, or directly by industry, then differences in human capital across these groups should generate differential levels of productivity in the marketing of agricultural goods.

Trade, Supply, and Demand

There are a number of factors related to supply, demand, and trade that are likely to influence the degree of integration. We limit ourselves here to briefly discuss several of these. First, a larger volume of trade should lead to a higher degree of integration because it contributes to reducing TC. The work by Barros and Filho (1990) on marketing margins for agricultural products in Brazil, for example, demonstrates that per unit transportation costs ($/ton/km) are an inverse function of volume. There are quantity discounts due to factors such as the use of larger trucks, lower per unit costs of loading and unloading larger quantities, and reduced logistical costs.[5] The effect of scale on TC could also matter for supply and demand. Second, Goletti et al. (1995) hypothesized that pairs of importers and exporters should be more integrated than pairs of locations with the same trade status. While it is true that dissimilar pairs should have a higher propensity to trade with each other than locations that are only linked indirectly though a third location, trade is not synonymous with the degree of integration. Our previous work on the Brazilian rice market revealed a considerable amount of interdependence among groups of producers and groups of consumers. Thus, it is possible that proximity, or the volume of trade, matter much more than trade status for the flow of information and price adjustment.

Policy

There are many policies that can influence the degree of integration. Table 1 lists several of the most important. Their relative importance should vary considerably across products and countries. Because many of the types of physical and human capital that we have been discussing contain elements of public goods, sometimes with strong positive externalities, public investments in them are an important component of a strategy to increase the spatial flow of goods and information. These investments contribute to increasing market integration, and this should be viewed as part of the process of economic development.

In terms of goods flows, tax policy that discriminates against inter-regional trade, such as state level sales taxes in Brazil that are higher for out of state goods, can reduce the degree of integration. Credit for the marketing of agricultural goods, in contrast, can provide liquidity that contributes to inter-regional flows. Goletti et al. (1995) hypothesized that the volatility and unpredictability of government stock policies contributed to reducing market integration in Bangladesh. There is evidence of similar complaints in the Brazilian literature concerning the disincentives to production and storage created by erratic agricultural policies (Lopes, 1979). However, many of these policies are national in scope and it is not clear how they would differentially affect certain regions. Policies that vary across regions, such as the predominance of public storage in one region and private storage in another, are more likely to have a differentiated effect on the degree of integration across locations.

With regard to the flow of information, extension agents are often an important source of market information for agricultural producers. However, extension agents are relatively expensive, and their principal focus relates to the flow of technical information. Governments that desire to disseminate market information in rural areas can do so much more cost effectively through daily or weekly radio and television programs. Governments can also stimulate the development of commodity and futures markets as a mechanism for providing information, liquidity, and insurance to market participants. The Brazilian government has been pursuing this approach in recent years. It is possible that futures markets may gain importance for traders and large agricultural producers. They are, however, likely to be inaccessible and too complicated for the majority of agricultural producers in most developing countries.

Other Factors

The structure and competitiveness of the marketing sector are additional factors that are likely to influence the degree of integration. Inter-regional marketing activities, for example, can take place through traders, cooperatives, industry, or the government. While it is not clear which of these should achieve the lowest trade and information costs, it is possible that regional differences in the predominance of one or another of these agents could reduce the degree of integration. Similarly, it is not obvious what the effect of a lack of competition should be on the degree of integration. On the one hand, a more concentrated marketing structure might achieve certain economies of scale in trade and information that could lead to lower costs. On the other hand, less competitive markets could restrict flows in order to raise prices and profits. Goodwin and Schroeder (1991) examined this question in the context of U.S. regional cattle markets in the 1980s. They found that increasing cointegration of these markets coincided with increasing concentration of the cattle slaughtering industry. More empirical research on these issues is clearly warranted.

A final factor that is worth exploring is social capital. There is a burgeoning literature on the importance of social capital for economic development.[6] Social capital relates to trust and networks that allow people to cooperate. It is sometimes viewed as a factor of production (like physical or human capital), and sometimes as a factor that can lower the transactions costs of information flows, monitoring, and enforcement. Measured with a variety of proxies, it has been shown to have a positive effect on the growth rate of county level per capita income in the U.S. (Rupasingha et al., 2000), to have a positive effect on the incomes of households in rural villages of Tanzania (Narayan and Pritchett, 1999), and to have a positive effect on the productivity and flows of technical information of entrepreneurs in the Ghanaian manufacturing sector (Barr, 2000). To the extent that social capital in the form of networks can increase technical information flows and productivity, or in the form of trust can lower transactions costs and facilitate trade flows, then it is relevant to a study of the degree of market integration.

4. The Determinants of Spatial Integration in the Brazilian Rice Market

Description of the Dependent and Independent Variables

In González-Rivera and Helfand (2001), a portion of the methodology described in Section 2 was applied to monthly rice prices from 19 states in Brazil for the period 1970:1-1997:8. To avoid duplication, we summarize the relevant findings from that study. Regarding the extent of the market, we concluded that 15 of the 19 states belonged to the same economic market for rice. We then went on to analyze the pattern of interdependence across locations as revealed through a multivariate vector error correction model. Finally, we provided an analysis of the degree of integration of 14 states in relation to the state of São Paulo.

In order to fully characterize the degree of integration between all 105 pairs of states in the market, we began the empirical analysis for this paper by estimating the vector error correction model for the market 15 times. Each time we used a different state as a reference in the cointegrating vectors. From each run, we were able to estimate the persistence profiles for the reference state in relation to the other 14 states. At the end, we had estimated 210 persistence profiles, only 105 of which were unique.

The profiles capture the estimated reaction time for a pair of locations to absorb a system-wide shock and restore the long run equilibrium relations. Figure 1 shows four profiles over a twenty month horizon. The four profiles are for Minas Gerais (MG), Goiás (GO), Bahia (BA), and Maranhão (MA), all in relation to the state of São Paulo. The profiles indicate that disequilibria between Minas Gerais and São Paulo, for example, are removed rather quickly, while this is not the case for Maranhão and São Paulo. When there is a system-wide shock that affects the long run equilibrium between São Paulo and Minas Gerais, 45 percent of the adjustments take place in the first month, and nearly 80 percent within three months. Disequilibria between Goiás and São Paulo are removed a bit slower, with only 68 percent of the adjustments occurring within three months. Maranhão actually overshoots at first, and after three months 70 percent of the effect of the shock remains.

While the profiles capture the entire path of adjustment for a given pair of states, it is useful to construct a statistic to summarize the information in the graph. For this purpose, we calculated the median persistence, or half-life, of the effect of the shock for each pair of states. The median profile measures the number of months necessary for 50 percent of the adjustments to take place. This information is summarized in Table 2. Considering all 105 pairs, on average it takes 2.45 months to remove half of the effect of a shock to the equilibrium price relations in the Brazilian rice market. There is, however, considerable variation. Mato Grosso and Goiás, two exporting states in the Center-West of the country, are the pair with the smallest median profile (0.73 months). Maranhão and Pernambuco, an exporter and an importer that are both located in the Northeast, are the pair with the largest median profile (4.96). One state, Minas Gerais, has median profiles smaller than 2 months in relation to 10 of the 14 remaining states. The median profiles for Maranhão, in contrast, are larger than 4 months in 9 cases. These are the differences that we seek to explain below.

Table 2 also provides descriptive statistics for the 17 explanatory variables that are included in the analysis. With reference to Section 2, we have included state level data related to physical capital, human capital, and supply, demand, and trade. The narrowing of our focus reflects, in part, the difficulties that we faced in finding relevant data. It also reflects the view that these are the structural determinants of the spatial differences in the degree of integration, whereas the other factors either vary less across space or were only relevant for sub-periods of our sample. Credit policy, for example, was an important instrument from the mid-1970s through the mid-1980s, but much less central before and after this period (Helfand, 2001). Similarly, support price policy was used extensively in the 1980s, but less so in the 1970s and

1990s (Helfand and Rezende, 2001). Given that the profiles reflect the average behavior of a 27 year period, to the extent possible we have attempted to measure the explanatory variables in a way that would be broadly representative of the same period. In many cases this meant taking an average of census data from 1970, 1980, and 1991. The precise definitions and data sources are listed in the footnotes to the Table.

The first group of variables in Table 2 relates directly to the costs of moving goods and information across states. *Linear distance* between capital cities is a proxy for inter-state transportation costs. Because we are working at a rather high level of aggregation, with state level data, this variable will contain a considerable amount of measurement error. This is especially true for states that are close to each other because intra-state distances could dominate the distance between capital cities. We attempt to reduce the severity of this problem by introducing a dummy variable for states that are neighbors. It reflects the fact that locations that share a border are likely to be proximate in ways that average linear distance does not capture. The next variable measures average *transportation costs* paid by farmers for agricultural goods within each state. This is partly a reflection of the types of goods that are most commonly transported in each state, such as cattle versus coffee, but should also provide an indication of the quality of the infrastructure within each state. *Federal highways*, which are almost all paved, are intended to capture the quality of inter-state infrastructure. For intra-state infrastructure, the density of roads (km of roads/km^2 of area) is probably a better measure than the extension (km). For inter-state infrastructure, this is not as clear. Large states might be well connected to other regions with one or two good highways, even though the density is quite low. For this reason, we use the national share of federal highways as well as the density within each state. Per capita *phone terminals*, as well as per capita long distance *phone calls*, are two proxies for physical capital related to the flow of information across states. Finally, we have included an index (relative to the national average) for the *value of transportation* within each state. This measures the revenue of highway transportation firms relative to the GDP of each state. The idea was to capture the density of the marketing sector. Increased marketing activity in a given state, even if it is not specifically related to rice, should be associated with lower transactions costs.

The simple correlations of the variables in this first group with the median profiles all have the expected sign. The final column of Table 2 shows that distance and transport costs are positively correlated with the median profiles, implying slower adjustment and a lower degree of integration. Highways, telephones, and transport density all have negative correlations, implying that they are associated with faster adjustment and a higher degree of integration.

The next group of variables in Table 2 relates to rice production, consumption, and trade. *Rice production, population* (as a proxy for rice consumption), and *rice trade* are all measured as a share of their respective national totals. These are intended to capture the potential cost reductions in the flow of goods and information associated with scale. These variables are only weakly correlated with the median profiles.

The third group of variables seeks to capture human capital at alternative levels of the market. *Rice yields* reflect the average level of production technology used in each state. Based on the large body of international research demonstrating a strong positive relationship between human capital and productivity, it is likely that yields are highly correlated with the level of human capital of the farmers involved in rice production. While this is clearly not an ideal measure, it is the only rice specific proxy that the data permit us to construct. *Rural schooling* measures the average years of schooling of adults in rural areas, and the density and the national share of *illiteracy* measure the rate and mass of the illiterate population in each state. Again, all correlations are of the expected sign, with the mass of illiterates exhibiting a notably weaker correlation with the median profiles than the other variables.

The final three variables in Table 2, *agricultural GDP per capita, agricultural GDP* as a share of the GDP in each state, and *GDP per capita*, provide alternative ways of measuring the level of development in each state. These are intended to capture residual differences in the quantity and quality of the marketing infrastructure in each state that could lower transactions costs and increase the degree of integration. Higher levels of income per capita, and lower shares of agricultural in GDP, are associated with higher degrees of integration.

Because each observation on the dependent variable refers to a relationship between a pair of states, the explanatory variables must be defined in a similar fashion. Thus, in the analysis that follows, for each of the 105 pair-wise combinations we have summed the explanatory variables from the corresponding states.

Principal Components and Their Relationship to the Degree of Integration

The upper portion of Table 3 shows the loadings in the first 10 principal components (PCs) that were constructed from the 17 explanatory variables. The proportion of the variance in the original set of variables that is explained by each PC is shown toward the bottom of the Table. The bottom row of the Table shows the estimated coefficients from a regression of the median profiles on the PCs.

The first principal component, PC1, by itself explains 36% of the variance contained in the original variables. PC2 explains an additional 15%, and together the first five PCs explain 85%. If our goal were simply to summarize the 17 variables, rather than to explain the median profiles, then it might be adequate to use only the first five PCs. However, there might be a set of variables that only accounts for a small fraction of the variance in the original 17 variables, but that is an important determinant of the degree of integration. For this reason, we chose to retain the first 10 PCs. Together they explain 99% of the variance of the original variables.

The analysis of the PCs is simplified by keeping several facts in mind. First, the loadings can be interpreted as correlations. Second, by identifying the maximum loading in each row, one can determine the PC with which a particular variable is most closely associated. We have done this and placed a border around the variables mostly closely associated with each of the first five principal components. We have parsimoniously placed broken borders around the variables most closely associated with the remaining 5 PCs. Third, the relative magnitude of the loadings determines the relative importance of the variables within each PC. As a general practice, we will restrict our attention to loadings that are at least half the size of the largest loading in a PC.

The first PC represents the level of development. In addition to GDP per capita and agricultural GDP per capita, the most important variables in this PC are high levels of human capital (as expressed through low rates of illiteracy and high levels of rural schooling), high levels of physical capital related to information flows (the density of telephones and long distance phone calls), and high densities of transportation activities. The loadings for three additional variables are also high, even though they are more closely associated with other PCs. Thus, higher levels of development are also associated with low shares of agriculture in GDP, large populations (which is also a proxy for rice demand), and large volumes of rice trade.

The bottom row of the Table reports the results of a linear regression of the median profiles on the 10 PCs. The adjusted R^2 from this regression is 0.49, indicating that our determinants explain a substantial portion of the state level differences in the degree of market integration. The coefficient on PC1 is negative and significant at the 1% level. The interpretation is that higher levels of development are strongly associated with smaller median profiles and, thus, higher degrees of integration. We prefer to talk about “association” rather than “causality” because we believe that these variables are mutually determined. Increasing the degree of spatial market integration is an important component of the process of development.

In some cases market integration might lead other dimensions of economic development, and in other cases it could follow.

The fact that the level of development is highly correlated with the degree of integration would be even more important if we could show that this were true after controlling for the factors most commonly thought to determine market integration--distance and transportation costs. These are the variables that are mostly closely associated with PC5. The regression coefficient on PC5 is positive and significant at the 1% level, indicating that an increase in this PC is associated with slower adjustment and a lower degree of integration. Thus, as we would expect, larger distances, higher transactions costs, and fewer highways are all associated with slower adjustment. Along these lines, lower densities of highways and of transportation activities also have relatively large loadings in this PC.

The second principal component can be identified with large rice consuming states. They are characterized by large populations, a large number of people with low levels of human capital (illiteracy), and low shares of agriculture in GDP. To a lesser extent, this PC also reflects low agricultural income per capita and low levels of communications infrastructure. This PC does not have a significant statistical relationship with the degree of integration.

The third principal component captures three types of variables. The most important variable is the level of productivity in rice production (used as a proxy for human capital). This is followed by a contrast between the density of highways and the level. Finally, the PC is associated with large populations that contain a large mass of illiterates. The coefficient on this PC is positive and statistically significant at the 10% level. Thus, in addition to PC1, this provides further support for the view that human capital matters for the degree of integration. Increasing the level of human capital in production, and reducing the size of the illiterate population, could both contribute to increasing the degree of integration.

PC4 has a very clear interpretation. It relates to large producing states that also engage in a substantial amount of trade. Secondarily, these states are characterized by low levels of communications infrastructure, large distances from other states, and perhaps for this reason, high shares (though not densities) of federal highways. PC4 has a positive and statistically significant relationship with the degree of integration, suggesting that the volumes of production and trade do not appear to lower transactions costs and increase the degree of integration.

The most important loadings in PC6, PC7, and PC8 relate to the variables distance, transportation costs, highways, and value of transportation. These repeat much of what was already captured in PC1 through PC5, and none of these PCs are statistically significant. The last two PCs are statistically significant and provide additional support for the view that states with wealthier agricultural sectors and higher levels of human capital in production are more integrated (PC9), and states with a higher share of agriculture in GDP are less integrated (PC10).

5. Conclusions

The objective of this paper was to argue for a shift in the focus of the literature on market integration. We believe that research in this area should move beyond the determination of which locations belong to a unified economic market and the estimation of how quickly these locations transmit prices and adjust to shocks. These are important steps, but there is much more that can be done. If, as appears to be the case, there is a consensus that market integration is associated with desirable development outcomes, then the challenge is to identify the factors that contribute to increased integration. We proposed a conceptual framework for analyzing these factors, and explored their importance in the context of the Brazilian rice market.

There are two principal lessons of our study. The first relates to the multiple determinants of the degree of integration, and the second to the relationship between economic development and market integration. With regard to the first issue, we argued that the degree of integration is principally a function of the transactions costs related to the flows of goods and information. Physical capital, such as roads and telephones, is necessary to reduce transactions costs, but by itself is unlikely to be sufficient for achieving a high degree of market integration. Among the other determinants of integration, we emphasized human capital. Higher levels of human capital should increase the productivity of the agents who are responsible for the flow of goods at all levels of the market, and should increase the speed and accuracy of the flow of information. Our empirical analysis provided support for this view. Thus, while it is unlikely that governments would choose to investment in human capital for the purpose of integrating markets, this could constitute an important externality. More research is called for to understand the ways in which human capital, physical capital, and other factors jointly determine transactions costs and market integration.

With regard to economic development and market integration, we found that a principal component representing the level of development was strongly associated with the degree of integration in the rice market. In addition to income per capita, this component was highly correlated with measures of human capital (illiteracy and rural schooling), variables related to communications infrastructure, and the relative size of the transportation sector. Thus, in the same way that less developed regions have been shown to have greater imperfections in their factor markets, our study provides evidence of similar effects in a product market. More developed states in Brazil had more integrated rice markets. An important question that remains for future research relates to the direction of causality between market integration and economic development. In some cases a higher degree of market integration might contribute to economic development, while in others cases it could be a by-product of the development process.

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[*] This paper was written as part of a larger project on spatial economics called NEMESIS (WWW.NEMESIS.ORG.BR). The project is based at IPEA in Rio de Janeiro and has been supported by a grant from the Brazilian government under a program called PRONEX. We also thank the Center for Agricultural Studies at the Getúlio Vargas Foundation for providing us with the producer prices of rice.

[1] See Goodwin and Schroeder (1991), Goletti (1993), Goletti and Christina-Tsigas (1995), and Goletti et al. (1995).

[2] The relationship between TC and time could be reversed in the case of a product that were transported by more than one mode, such as truck and airplane. In such as case, higher TC might reflect the costs of increased speed. With most agricultural commodities this is not likely to be a serious problem. In the Brazilian agricultural sector, for example, almost all inter-state trade is done by truck.

[3] See Lin and Nugent (1995) for a general discussion of TC and economic development, Barrett (1999) for a discussion of transactions costs in the context of agricultural markets, and *Companhia de Financiamento da Produção* (1983) for a snapshot of transfer costs in Brazil in the early 1980s.

[4] These terms come from Welch (1970). Our discussion draws from Cotlear (1990). Formal education consists primarily of schooling, informal education includes activities such as apprenticeships and contacts with extension agents, and non-formal education—learning-by-doing—encompasses a wide variety of forms through which individuals learn, such as direct experience and indirect exposure.

[5] The authors also show that per unit costs fall with distance, largely because loading and unloading a truck can be thought of as a fixed cost that is spread over the length of the journey.

[6] See Woolcock and Narayan (2000), Paldam (2000), and Paldam and Svendsen (2000) for interesting reviews of this literature.