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Distinguishing Between Equilibrium and Integration in Markets Analysis

by

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Working Paper #99-8

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August 1999
ISSN 1098-9218
Working Paper 99-8

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August 1999 revised version

Seniority of authorship is shared equally. We thank DeeVon Bailey, Bob Baulch, Jean Paul Chavas, Adele Cutler, Paul Fackler, Terry Glover, Matt Holt, Steve Meyer, Dawn Thilmany, and participants at the 1999 annual meeting of the American Agricultural Economics Association for valuable comments and discussions and Erica Lai for excellent research assistance. All remaining errors are ours alone. This research was made possible by the financial support of the National Pork Producers Council.

DISTINGUISHING BETWEEN EQUILIBRIUM AND INTEGRATION IN MARKETS ANALYSIS

Abstract: This paper introduces a new market analysis methodology based on maximum likelihood estimation of a mixture distribution model incorporating price, transfer cost, and trade flow data. Not only does this method obviate statistical problems associated with conventional price analysis methods, it also permits differentiation between market integration and competitive market equilibrium. The model generates estimates of the frequency of alternative regimes, combinations of which provide useful, intuitive measures of intermarket tradability, competitive market equilibrium, perfect integration, segmented equilibrium, and segmented disequilibrium. An application to trade in soybean meal among Pacific Rim economies demonstrates the usefulness of the method.

Keywords: international trade, law of one price, market integration, spatial equilibrium

Spatial market relationships can be described by either prices or quantities. Many economists establish the appropriate aggregation of spatial units by reference to trade volumes. Declarations about global economic integration likewise rest largely on observations about increasing cross-border flows. These quantity based measures of tradability are one important class of indicator of market integration. Other economists employ price data to assess the comovement among prices from spatially distinct markets. Ubquitous tests of the absolute or relative versions of the law of one price and of intermarket price convergence are prime examples of this second class of price-based indicators of market integration.

Yet both classes of indicators have important shortcomings. Integration analysis based on trade volumes typically cannot establish whether equilibrium arbitrage conditions hold, and thus whether trade is socially efficient. Meanwhile, prevailing price analysis methods – e.g., correlation coefficients, Granger causality, cointegration, error correction – tell us little or nothing about actual trading behavior. Moreover, price analysis techniques are unreliable under a variety of conditions, including when trade is discontinuous or bidirectional, and when transactions costs are nonstationary (Dahlgran and Blank 1992, Barrett 1996, Baulch 1997, McNew and Fackler 1997, Fackler and Goodwin forthcoming). Unfortunately, such conditions are common.

As a step toward advancing the inferential capacity of market integration testing methods, we introduce a new methodology based on maximum likelihood estimation of a mixture distribution model incorporating price, transfer cost, and trade flow data. This new method permits distinction between *market integration*, reflecting the tradability of products between spatially distinct markets, irrespective of the existence or absence of spatial market equilibrium, and *competitive market equilibrium*, in which extraordinary profits are exhausted by competitive pressures to yield socially efficient allocations, regardless of whether this results in physical trade flows between markets. These two concepts are conflated in traditional market analysis methods.

The paper is structured as follows. First we review the conceptual foundation of our approach, the crucial assumptions of existing market integration testing methods, and the mechanics of the technique this paper introduces. We then describe a new set of monthly soybean meal price, trade flow, and transfer cost time series we constructed for Canada, Japan, Taiwan, and the United States. This parsimonious data set includes bidirectional and discontinuous trade flows, and nonstationary price and transfer cost series, the very characteristics that bedevil existing price analysis methods. We then show that in these data, the new method yields conclusions that differ markedly from those generated by conventional market analysis methods. The resulting insights are helpful, for example, in enhancing analysts' ability to identify either potential strategic trading behavior or of nontariff trade barriers that affect the competitiveness of subject import markets.

Distinguishing Between Equilibrium and Integration

A core point of this paper is the necessity of separating the concepts of equilibrium and integration in markets analysis. The two are not synonymous in spite of current praxis. A good definition of market integration is the influence of one market by another through the Walrasian transfer of excess demand. When two markets are integrated, supply and demand in the one market affect the price and/or transactions volume in the other. This definition of integration is closely related to the concepts of tradability or contestability (Baumol 1982). By this definition, markets can be (imperfectly) integrated even when imperfectly competitive or inefficiently restricted by trade barriers or collusion, whether or not physical flows occur between the markets, and whether or not price in one market responds (especially one-for-one) to shocks in the other.

This more practical and intuitive defintion of market integration does not equate to competitive equilibrium. Following the familiar logic of spatial equilibrium models, two markets, i and j, are in long-run competitive equilibrium, meaning that marginal profits to intermarket arbitrage equal zero, when $P_{it} \leq \tau(P_{it}, P_{jt}, c_{ijt}) + P_{jt}$, with P_{it} the price at location i in time t, and τ the transactions costs of spatial arbitrage, which may be a function of prices (e.g., in the case of *ad valorem* or variable rate tariffs or insurance) and the exogenous costs of transport between the two locations at time t, c_{ijt}. The equilibrium condition binds with equality when trade occurs. But when trade does not occur, the constraint may be slack so there may be no correlation among market prices in spite of the existence of competitive equilibrium.[1] When two markets are both integrated and in long-run competitive equilibrium, they may be classified as "perfectly integrated," the special case on which the existing market integration literature focuses, as shown by Goldberg and Knetter's (1997) recent review. Tests of the law of one price (LOP), for example, are a test of the perfect integration hypothesis, not a test of (perhaps imperfect) integration or of (perhaps segmented) competitive equilibrium.

Two observations are important at this juncture. First, the above relation is a static equilibrium condition but market relationships are inherently time-varying. If the two markets are not on perfectly synchronized cycles, for example, trade flow reversals will be the norm, with τ positive in some periods, negative in others. And trade is commonly discontinuous when transactions costs get large, so the equilibrium relation will bind with equality in some periods and be slack in others. Moreover, since prices and transactions costs are time series data, one must worry about the stationarity of each series before engaging in statistical inference. The same phenomena that give rise to nonstationary patterns in price series – permanent technology or demand shocks, or the introduction or termination of taxes or regulatory controls by governments – may also render transfer cost series nonstationary. For these reasons, market relationships commonly defy linear representation of time series data presumed stationary, as the next section emphasizes.

Second, existing markets analysis methods rely entirely on the price and transactions cost data reflected in the spatial equilibrium condition (Barrett 1996, Goldberg and Knetter 1997). If arbitrageurs are profit-maximizers, trade flow data convey useful information – traders' revealed preferences – about the perceived profitability of intermarket arbitrage. Such arbitrage inherently renders markets integrated although it does not ensure long-run competitive equilibrium. For example, if traders believe there are first mover advantages (quasi-option value to waiting), they might (not) undertake arbitrage despite negative (positive) current period returns. If markets are imperfectly competitive, whether due to coordination between firms or market restrictions emplaced by government, profits may persist.

These basic insights suggest a need to disentangle analysis of physical market integration from that of long-run competitive equilibrium between markets. Existing markets analysis methods fail to do this because they generally employ only price data, sometimes accompanied by cost information. Conventional approaches to testing for spatial market integration rely heavily (often entirely) on measuring the comovement of prices in different markets. However, prices in two non-integrated locations may respond similarly to exogenous covariates, such as inflation or climatic conditions. The existence of price comovement between spatial markets is thus not a sufficient condition for deducing either integration or equilibrium among the examined markets.

Nor does the absence of strong comovement in regional price series imply inefficient market segmentation. It may be socially optimal for trade to be episodic rather than continuous, a case of segmentation in equilibrium. Or it may be that transactions costs are more volatile than the underlying price series, as in the case of trade flow reversals.

Most extant methods of markets analysis – bivariate correlation coefficients, Granger causality tests, Ravallion's method and other error correction models, cointegration testing – fall prey to several flawed assumptions (Barrett 1996, Li 1997, McNew and Fackler 1997, Fackler and Goodwin forthcoming). They assume (i) no common trends (e.g., inflation, population growth, production seasonality, a common third trading partner) within price series that may give rise to spurious correlation, (ii) strictly additive and stationary transactions costs (i.e., $\tau(P_{it}, P_{jt}, c_{ijt})$ reduces to $\tau(c_{ijt})$), or (iii) continuous and unidirectional trade. For example, discontinuous trade between distinct markets in the face of stochastic intermediation costs renders equilibrium intermarket price relationships piecewise linear, causing bias and inconsistency in the linear methods prevailing in the literature (McNew 1996). Moreover, none of the existing methods make use of data on trade flows, so they are inherently unable to distinguish competitive equilibrium from integration among distinct markets. By Barrett's (1996) taxonomy, markets analysis remains stuck in level I and level II methods, having not yet moved to level III methods integrating price, transfer cost, and trade flow data.[2]

The method we introduce builds on a recent literature that exploits both price and transactions cost data in the analysis of markets. Switching regimes models, notably Baulch's (1997) parity bounds model (PBM), compare observed intermarket price differentials against observed costs of intermarket transport, thereby estimating the probability that markets are in competitive equilibrium (Spiller and Huang 1986, Sexton, Kling, and Carman 1991, Baulch 1997). This approach hurdles the problems of discontinuous trade, and time-varying and potentially nonstationary transactions costs that bedevil pure price analysis methods. But it still conflates the concepts of equilibrium and integration. Price differentials less than transfer costs are identified as "integration" even when there is no flow of product and no transmission of price shocks between the two markets. Conversely, markets are classified as "segmented" whenever price differentials exceed transfer costs, regardless of whether there are observed trade flows. PBM and related switching regimes models that do not exploit trade flows data really study only equilibrium conditions, not integration as we think it best defined: the Walrasian transfer of excess demand.

While the switching regimes approach makes important advances on pure price analysis techniques, there nonetheless remains significant room for improvement. Since we can never observe all possible transactions costs involved in trade (e.g., subjective risk premia, discount rates, quasi-option values), trade flow information can offer indirect evidence of the effects of unobservable or omitted transactions costs, thereby providing fuller information with which to analyze market relationships. It is common, for example, to find that trade does (not) occur even when price differentials are less than (exceed) transfer costs – defined as the observable portion of transactions costs – implying that some unobservable effects (e.g., trade barriers, unmeasured transactions costs, information gaps, strategic behaviors) exist and influence intermarket trade. If markets are imperfectly competitive, there may be positive rents associated with arbitrage in equilibrium and if one or both markets experience shocks, arbitrage conditions may be violated during market disequilibrium. Contracting and transport lags also force traders to make commitments before final transactions prices are realized, so that in stochastic markets, *ex post* market outcomes may mistakenly suggest (in)efficiency when the real issue is imperfect information. One should be cautious about *ex post* assessment of zero profit conditions that apply to *ex ante* decisions. In short, if traders are rational profit-maximizers, trade flow data convey additional information about market integration beyond that offered by observable price and transfer cost data. So it makes sense to exploit such data in markets analysis.

Extending the PBM model to include trade flow data,our approach identifies six distinct regimes and then estimates a mixture model that estimates the probability (λ_i) that the market relationship falls into each of the six feasible regimes. Trade is either observed (odd numbered regimes) or not (even numbered regimes). Price differentials may equal transfer costs (regimes 1 and 2), implying binding arbitrage conditions and tradability, regardless of whether trade occurs or not. Or price differentials may exceed transfer costs (regimes 3 and 4), implying the existence of positive profits to intermarket arbitrage. Finally, when price differentials do not fully cover transfer costs (regimes 5 and 6), trade brings negative profit to arbitrageurs. Letting P^i and P^j be the prices in locations *i* and *j*, respectively, T_{ji} be the observable transfer costs from *j* to *i*, and $\sum_i\lambda_i=1$, the six regimes are summarized in Table 1 and depicted graphically in Figure 1.

Intermarket tradability occurs whenever trade is observed or the intermarket arbitrage condition is binding, so that traders are indifferent between trading or not. So $(\lambda_1+\lambda_2+\lambda_3+\lambda_5)$ is an estimate of the frequency of intermarket tradability. Competitive equilibrium occurs whenever the intermarket arbitrage (zero trader profit) condition holds, i.e., with estimated frequency $(\lambda_1+\lambda_2+\lambda_6)$. Two markets are thus perfectly integrated with frequency $(\lambda_1+\lambda_2)$, inefficiently integrated with frequency $(\lambda_3+\lambda_5)$, in segmented equilibrium with frequency λ_6, and in segmented disequilibirium (neither integrated nor in long-run competitive equilibrium) with frequency λ_4. Market segmentation, the complement of intermarket tradability, occurs with frequency (λ_4+λ_6). These conditions, which fall out naturally from this estimation method, describe most of the market characteristics of interest to analysts, policymakers, and traders.

The regimes of most concern to economists are typically those not corresponding to long-run competitive equilibrium. In regime 3, trade occurs and appears to earn positive marginal profits. This implies either (1) insufficient market arbitrage, due either to formal or informal trade barriers or to temporary disequilibria that generate rents, or (2) the existence of significant unobservable transactions costs that fill in the gap between the price differential and observable transfer costs. In regime 4, apparent positive profits go unexploited by traders. The plausible explanations for this observation are the same as for regime 3. Parallel logic holds in regime 5, where transfer costs exceed price differentials yet trade occurs despite negative estimated marginal profits. This is either due to temporary disequilibria (e.g., due to information and contracting lags) or to the existence of significant unobservable transactions benefits (e.g., first mover advantages) accruing to traders.

These alternatives point to two different possible interpretations of the estimated regime frequencies, λ_k. First, if measured transfer costs accurately reflect transactions costs faced by traders, the equilibrium and integration interpretations offered earlier prevail. Alternatively, under the maintained hypothesis of constant zero profits, (i) the ratio $\lambda_4/(\lambda_1+\lambda_2+\lambda_6)$ is the proportion of nontrading periods due to unobservable transactions costs and nontariff trade barriers, and (ii) the ratio λ_4/λ_3 (λ_5/λ_6) is an indicator that increases with the significance of unobservable transactions costs (benefits). Under this second interpretation, however, one is not *testing* for market equilibrium. Rather, a zero-profit equilibrium is assumed and one is trying to estimate a measure of the impact of unobservable costs and benefits of intermarket arbitrage. We favor the former interpretation but recognize there may be circumstances under which the latter may be appropriate and of interest.

Under the approach we introduce, the observed distribution of prices is understood as a mixture of observations drawn from different distributional regimes. We have only partial information as to the particular regime from which a given observation is drawn, just the binary observation of trade or no trade. So we estimate a mixture model, maximizing the likelihood associated with regime frequencies found in sample, conditional on knowing whether trade occurs or not and the distribution assumption made about the errors associated with each regime. Since the categorical information regarding trade is known, ours is a partially-exogenous switching regimes model. We assume all regimes are subject to iid normal sampling and measurement error, v_t, with zero mean and variance σ^2_v. Regimes 3-6 also include a one-sided error, u_t, that is independent of v_t and is iid half-normal with variance σ^2_u. The half-normal error is added to (subtracted from) $T_{ji} + v_t$ for regimes 3 and 4 (5 and 6). Using the density of the sum of a normal random variable and a truncated normal random variable (Weinstein 1964), the distribution functions for the observations in each regime are:

$$f_t^1 = f_t^2 = \frac{1}{\sigma_v}\phi\left[\frac{Y_t - T_t}{\sigma_v}\right] \quad (1)$$

$$f_t^3 = f_t^4 = \left[\frac{2}{(\sigma_u^2 + \sigma_v^2)^{1/2}}\right]\cdot\phi\left[\frac{Y_t - T_t}{(\sigma_u^2 + \sigma_v^2)^{1/2}}\right]\left[1 - \Phi\left[\frac{-(Y_t - T_t)\sigma_u / \sigma_v}{(\sigma_u^2 + \sigma_v^2)^{1/2}}\right]\right] \quad (2)$$

$$f_t^5 = f_t^6 = \left[\frac{2}{(\sigma_u^2 + \sigma_v^2)^{1/2}}\right]\cdot\phi\left[\frac{Y_t - T_t}{(\sigma_u^2 + \sigma_v^2)^{1/2}}\right]\left[1 - \Phi\left[\frac{(Y_t - T_t)\sigma_u / \sigma_v}{(\sigma_u^2 + \sigma_v^2)^{1/2}}\right]\right] \quad (3)$$

where T_t and Y_t are intermarket transfer costs and price differentials, respectively, at time t, ϕ is the standard normal density function and Φ is the standard normal cumulative distribution function. The likelihood of observing the sample price, transfer cost, and trade data can therefore be written:

$$L = \prod_{t=1}^{T} \left\{ A \cdot [\lambda_1 f_t^{\,1} + \lambda_3 f_t^{\,3} + \lambda_5 f_t^{\,5}] + (1-A) \cdot [\lambda_2 f_t^{\,2} + \lambda_4 f_t^{\,4} + \lambda_6 f_t^{\,6}] \right\} \tag{4}$$

where A is a dummy variable for the occurrence of trade: A=1 if trade is observed and A=0 otherwise. The probabilities of each regime and the variances σ^2_u and σ^2_v can be estimated by maximizing the logarithm of equation (4), subject to the constraints that $\lambda_k \geq 0\ \forall k$, and $\sum_k \lambda_k = 1$.[3] Baulch's (1997) PBM is a special case of our model that applies when there is no variation in trading status (i.e., A=1 all periods or A=0 all periods), in which case the only available information comes from price and transfer cost data.

Intermarket transfer costs, T_t, commonly depend on the direction of trade since tariffs vary across countries and backhaul freight rates are commonly lower on some routes than are standard freight rates going the opposite direction. Asymmetric transfer costs implies one must estimate direction-specific regime probabilities, i.e., one vector $\boldsymbol{\lambda}^{\mathbf{ij}}$ related to product moving from market i to market j and a second vector, $\boldsymbol{\lambda}^{\mathbf{ji}}$, related to movements in the opposite direction. In general, $\boldsymbol{\lambda}^{\mathbf{ij}}-\boldsymbol{\lambda}^{\mathbf{ji}} \neq \mathbf{0}$, meaning there will not be a unique probability vector describing integration and equilibrium between two distinct markets since direction-specific regime probabilities may differ. This is not a problem for measures of tradability, which is inherently a unidirectional concept. A product is tradable between two markets when it can or does flow from either one to the other.

Bidirectional tradability is unnecessary for there to be transmission of Walrasian excess demand between markets. By contrast, equilibrium is an omnidirectional concept, in which the spatial equilibrium conditions should prevail in both directions (e.g., a segmented equilibrium one direction, and perfect integration the other). When only one of the two markets employs nontariff barriers to trade, equilibrium may hold in only one of two directions. By these criteria, we use the maximal direction-specific values of intermarket tradability and perfect integration in describing those market conditions between two (prospective) trading partners.[4] By contrast, we use the bounds created by the two direction-specific results in describing the frequency of spatial market equilibrium. The width of that band is itself suggestive of the underlying efficiency of arbitrage between the markets. In general, $\lambda_k^{ij} \neq \lambda_k^{ji}$, so there will not be a unique probability vector describing integration and equilibrium between two distinct markets since direction-specific regime probabilities may differ. The two vectors offer bounds, however, on the characteristics of interest describing the intermarket relationship, as shown in Table 2.

Our method obviously does not accommodate any dynamics in intermarket price and trade relationships. This has the benefit of obviating problems of exogeneity and stationarity that bedevil time series analytical techniques applied to markets analysis (Barrett 1996, Baulch 1997, McNew and Fackler 1997, Fackler and Goodwin forthcoming). Like switching regimes models (Spiller and Huang 1986, Sexton et al. 1991, Baulch 1997), one could compare leading or lagging prices, or generate a sequence of regime frequency estimates, $\boldsymbol{\lambda}^{ij}_{t+s}$, where s ranges from some negative to some positive number, analogous to the cross-correlation function generalization of binary correlation coefficients. But our method involves inherently static estimation and is therefore ill-suited to answering questions about the speed or extent of convergence to tradability or equilibrium. The data frequency applied must be such that the estimation results can be meaningfully interpreted. Data at monthly frequency, such as we use in the next section's application, would seem appropriate since one would expect traders to respond within thirty days to emerging profit opportunities.[5]

An Empirical Application: Pacific Rim Soybean Meal Markets

We demonstrate our method with an application to soybean meal markets around the Pacific Rim. Soybean meal is a reasonably homogeneous product and the world's primary source of vegetable oil and livestock feed. The United States is the world's largest producer, consumer, and exporter of soybean meal. Japan is the largest single importer of soybean meal, and trade in the product is increasingly focused on the Pacific Basin. We gathered monthly price data, 1990-96, for Japan, Taiwan, the U.S., and Canada.[6] The last observation month differs among the countries, so there are slight differences in the number of observations used to compare among different market pairs. We also used detailed customs data to compile monthly trade volume and transfer cost series, including the costs of ground transport from the domestic price location, ocean freight, insurance, loading/unloading costs, and tariffs. We are unaware of any other study that uses either such comprehensive time series data on the costs of commerce or trade data combined with price and transfer cost data.

The data show that the soybean meal markets of the Pacific Rim systematically violate assumptions on which conventional market analysis methods depend. Trade is commonly bidirectional and discontinuous (Table 3). Furthermore, transfer costs were found to be nonstationary I(1) series in nine of the ten cases studied here, with one Canada-to-U.S. transfer costs stationary at the ten percent significance level. [7] At least one of those assumptions – unidirectional, continuous trade or stationary transfer costs – is violated in every direction-specific market pair. Common market analysis methods (e.g., bivariate correlation coefficients, Granger causality, Ravallion's model, and cointegration) yield divergent results in these data because each is impacted differently by violation of their core underlying assumptions (Li 1997). In the lone case where trade is continuous and transfer costs are stationary, between Canada and the United States, all the conventional methods (i.e., bivariate correlation coefficients, Granger causality, cointegration) suggest perfect market integration.[8] In all the other market pairs, transfer costs are nonstationary and we consistently find only two of four methods will generate an equivalent assessment of market performance. Such inferential inconsistency across methods underscores the fragility of markets analysis using existing methods based on untenable assumptions about the nature of trade flows and transfer costs. Trade is continuous in only two market pairs (Canada to Japan and U.S. to Canada), so our results also generally diverge from the PBM results, which assume continuous trade (or the continuous absence of trade).

Table 4 presents the estimation results, which demonstrate empirically several of the conceptual points made earlier. First, there are commonly differences according to the direction of trade between two markets. This is to be expected when one country consistently holds comparative advantage over the other and so trade flows are directionally imbalanced, as in the case of the United States and either Japan or Taiwan. Such differences likewise emerge when only one country in the pair employs nontariff barriers to trade, as does Japan.

Second, the distinction between tradability and equilibrium becomes immediately apparent. Competitive equilibrium conditions are frequently violated despite active arbitrage, as reflected in positive and statistically significant estimates of λ_3 and λ_5 on flows from both Canada and the United States to Japan, from Japan and Taiwan to the United States. Conversely, a no trade competitive equilibrium (λ_6) often holds in one direction when one trading partner is at serious comparative disadvantage to the other, as in the case of relations from either Japan or Taiwan to the United States.

Third, segmented disequilibrium (λ_4), in which positive expected profits to arbitrage go entirely unseized, appears exceedingly rare. Intermarket trade, although by no means constant, responds to profit opportunities, even in the face of transfer costs and trade barriers. The absence of trade, however, does not mean that the product is not tradable between the two markets, as manifest by commonplace positive and statistically significant estimates for λ_2, the estimated frequency of no-trade spatial equilibrium in which the arbitrage constraint is binding. Even when trade is absent, Pacific soybean meal markets appear contestable and therefore tradable.

Table 5 presents probability estimates for the intermarket conditions defined in Table 2. Soybean meal is effectively always tradable between these markets. Only flows from Japan to Canada and the U.S. and from Taiwan to the U.S. were tradable with less than 97 percent frequency, and their counterpart frequency estimates in the opposite direction were always at least 99 percent. Likewise, competitive market equilibrium prevails 90 percent or more of the time among all market pairs not including Japan. Trade barriers and strategic behavior appear to result in substantial inefficiency in trading relations with Japan, where positive marginal rents to soybean meal importing (λ_3>0) occur far more frequently than in any other market. Nonetheless, trading at a loss accounts for almost three-quarters of all periods of market disequilbrium ($\lambda_5/(\lambda_3+\lambda_4+\lambda_5)$). Constant perfect market integration ($\lambda_1+\lambda_2=1$) holds for three direction-specific relations (Canada to U.S., Canada to Taiwan, and U.S. to Taiwan), reflecting the efficiency and tradability of these markets, conditions not reflected in the results of conventional market integration testing methods that rest upon assumptions that do not hold in practice.

Conclusion

This paper presents an attempt to bridge price-based and quantity-based approaches to the study of market integration by introducing a new methodology using maximum likelihood estimation of a mixture distribution model incorporating price, transfer cost, and trade flow data. We show how this new method permits construction of intuitive and useful indicators of the frequency of intermarket tradability, competitive market equilibrium, perfect market integration (a tradable competitive equilibrium), segmented equilibrium, and segmented disequilibrium. In other words, this new methods permits useful distinction between *market integration*, reflecting the tradability of products between spatially distinct markets, irrespective of the existence or absence of spatial market equilibrium, and *competitive market equilibrium*, in which extraordinary profits are exhausted by competitive pressures to yield socially efficient allocations, regardless of whether this results in physical trade flows between markets. These two concepts are conflated in traditional market analysis methods. Moreover, unlike widely used price analysis techniques, this method is well-suited to market linkages exhibiting time-varying, nonstationary or nonadditive transfer costs and with discontinuous or bidirectional trade, as are found in the Pacific Rim soybean meal data set used as an example.

Table 1. The Six Intermarket Regimes

	$P_i - P_j = T_{ji}$	$P_i - P_j > T_{ji}$	$P_i - P_j < T_{ji}$
Trade	λ_1	λ_3	λ_5
No trade	λ_2	λ_4	λ_6

Table 2. Indicators of Intermarket Conditions

Characteristic	
Intermarket tradability	$\max(\lambda_1^{ij}+\lambda_2^{ij}+\lambda_3^{ij}+\lambda_5^{ij}, \lambda_1^{ji}+\lambda_2^{ji}+\lambda_3^{ji}+\lambda_5^{ji})$
Perfect market integration	$\max(\lambda_1^{ij}+\lambda_2^{ij}, \lambda_1^{ji}+\lambda_2^{ji})$
Intermarket segmentation	$\min(\lambda_4^{ij}+\lambda_6^{ij}, \lambda_4^{ji}+\lambda_6^{ji})$
Spatial market equilibrium	$[\min(\lambda_1^{ij}+\lambda_2^{ij}+\lambda_6^{ij}, \lambda_1^{ji}+\lambda_2^{ji}+\lambda_6^{ji}), \max(\lambda_1^{ij}+\lambda_2^{ij}+\lambda_6^{ij}, \lambda_1^{ji}+\lambda_2^{ji}+\lambda_6^{ji})]$
Inefficient integration	$[\min(\lambda_3^{ij}+\lambda_5^{ij}, \lambda_3^{ji}+\lambda_5^{ji}), \max(\lambda_3^{ij}+\lambda_5^{ij}, \lambda_3^{ji}+\lambda_5^{ji})]$
Segmented equilibrium	$[\min(\lambda_6^{ij}, \lambda_6^{ji}), \max(\lambda_6^{ij}, \lambda_6^{ji}, \min(\lambda_4^{ij}+\lambda_6^{ij}, \lambda_4^{ji}+\lambda_6^{ji}))]$
Segmented disequilibrium	$[\min(\lambda_4^{ij}, \lambda_4^{ji}), \max(\lambda_4^{ij}, \lambda_4^{ji}, \min(\lambda_4^{ij}+\lambda_6^{ij}, \lambda_4^{ji}+\lambda_6^{ji}))]$

Table 3. Soybean Meal Trade Frequencies, 1990-96

From\To	U.S.	Canada	Japan	Taiwan
U.S.	-	100%	81.5%	54.3%
Canada	88.9%	-	100%	20.2%
Japan	38.3%	78.6%	-	NA
Taiwan	12.3%	58.3%	NA	-

Note: The frequency of bidirectional trade in soybean meal between the United States and Taiwan (Japan) is 7.4% (30.8%). The frequency of bidirectional trade in soybean meal between Canada and Taiwan is 10.7%.

Table 4. FIPBM Testing Results for Pacific Rim Soybean Meal Markets

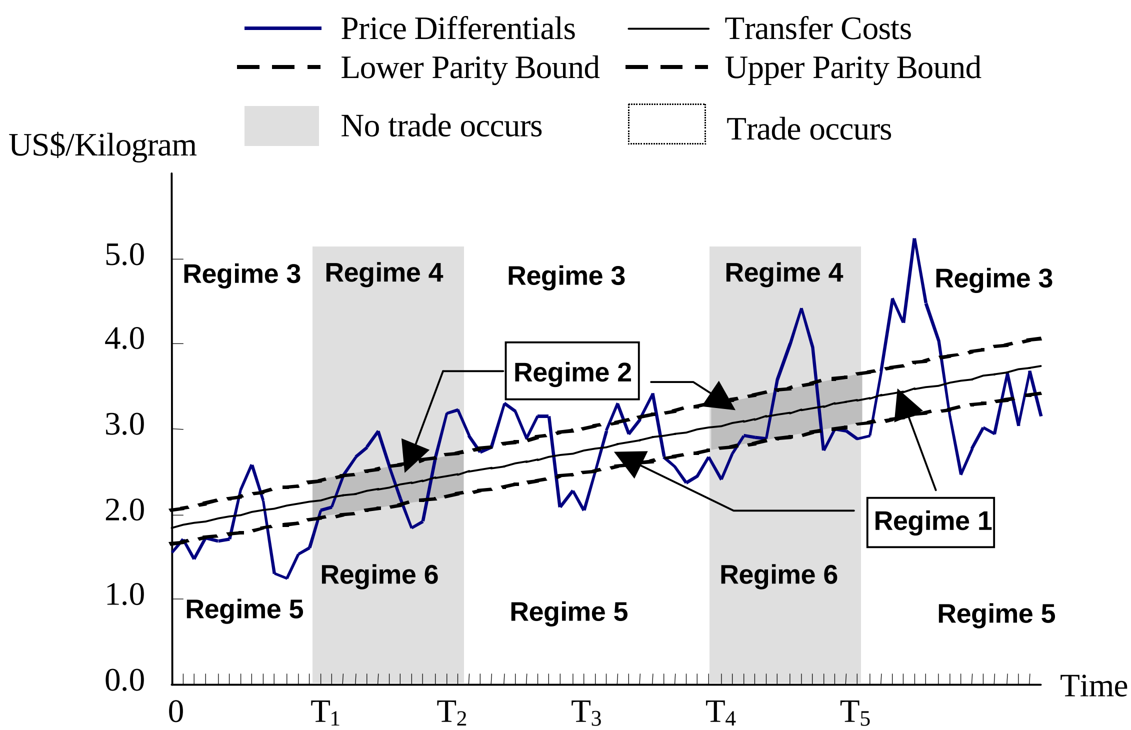
Countries			Trade				No Trade			
From		To	λ_1	λ_3	λ_5	λ_2	λ_4	λ_6	σ_u	σ_v
¶ US	→	CA	0.92* (0.06)	0.01 (0.00)	0.07* (0.01)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.195	0.018
CA	→	US	0.88* (0.03)	0.00 (0.00)	0.00 (0.00)	0.12* (0.03)	0.00 (0.00)	0.00 (0.00)	0.324	0.077
TW	→	CA	0.53* (0.07)	0.02 (0.03)	0.01 (0.02)	0.41* (0.06)	0.02 (0.02)	0.01 (0.02)	0.12 E-5	0.359
CA	→	TW	0.22* (0.05)	0.00 (0.00)	0.00 (0.00)	0.78* (0.05)	0.00 (0.00)	0.00 (0.00)	0.368	0.207
¶ CA	→	JP	0.01 (0.00)	0.17 (0.35)	0.82* (0.06)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.013	0.088
JP	→	CA	0.77* (0.05)	0.01* (0.00)	0.01 (0.04)	0.01 (0.05)	0.01 (0.04)	0.19* (0.00)	1.415	0.475
US	→	JP	0.14 (0.31)	0.33* (0.05)	0.34* (0.05)	0.18* (0.05)	0.01 (0.01)	0.00 (0.00)	0.44 E-6	0.065
JP	→	US	0.01 (0.01)	0.01 (0.01)	0.39* (0.10)	0.01* (0.03)	0.01 (0.13)	0.57* (0.13)	0.30 E-5	0.513
US	→	TW	0.52* (0.05)	0.00 (0.00)	0.00 (0.00)	0.48* (0.05)	0.00 (0.00)	0.00 (0.00)	0.184	0.030
TW	→	US	0.01* (0.00)	0.01 (0.02)	0.09* (0.03)	0.01* (0.00)	0.01 (0.02)	0.87* (0.03)	6.855	0.386

¶ results consistent with PBM since trade is continuous.
Standard errors (computed using Gallant-Holly method) are in parentheses.
* statistically significantly different from zero at the 95% confidence level.
Rows may not sum to one due to rounding error.

Table 5. Probability Estimates of Intermarket Conditions

	Perfect Market Integration	**Intermarket Tradability**	**Segmented Disequilibrium**	**Market Equilibrium**
Market Pair	$\lambda_1+\lambda_2$	$\lambda_1+\lambda_2+\lambda_3+\lambda_5$	λ_4	$\lambda_1+\lambda_2+\lambda_6$
JP - CA	0.78	1.00	0.00	[0.01, 0.97]
TW - CA	1.00	1.00	0.00	[0.95, 1.00]
US - CA	1.00	1.00	0.00	[0.92, 1.00]
JP - US	0.32	0.99	0.01	[0.32, 0.59]
TW - US	1.00	1.00	0.00	[0.89, 1.00]

Figure 1: A Stylilzed Depiction of the Relationships Between Price Differentials, Transfer Costs, and Trade Flows



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Endnotes

1. Goldberg and Knetter (1997: 1245), reflecting the bulk of the literature, claim that "[a]ny perfectly competitive market is characterized by the condition that price equals marginal cost. Therefore a perfectly competitive market must be integrated." The claim in the second sentence relies on the assumption of an interior solution, i.e., continuous tradability. When corner solutions occur – as manifest by no trade – segmented equilibria are possible. Since trade can also occur without perfect competition – as in the case of binding quotas – equilibrium is neither necessary nor sufficient for integration, nor vice versa.

2. Barrett's (1996) hierarchical taxonomy labels as "level I" methods those approaches that use only price data for inference about market conditions. Level II methods combine price and transactions cost data, the combination of which permits more robust inference about market relationships. Level III methods combine price, transactions cost and trade flows data and allow the greatest analytical flexibility.

3. Some readers will notice that this likelihood function, like that of other stochastic switching regression models, may suffer convergence problems because the gradients approach singularity at the edge of the parameter space. In practice, the edge of parameter space is encountered with some frequency. This manifests itself readily in unusually high t-statistics since $\sigma_{\lambda i}$ goes to zero as λ_i goes to either boundary (zero or one). We find this most commonly occurs in the case of λ_6, segmented equilibrium.

4. Equivalently, the minima are the most appropriate estimates for market segmentation between a pair of markets ($\lambda_4+\lambda_6$).

5.Another way to view the tradeoff is between risk of aggregation bias arising from the use of lower frequency data, versus risk of specification bias arising from (at least piecewise) linear approximation of quite nonlinear relationships in higher frequency data. The key point is there exists no unambiguously preferable method of markets analysis. The one we introduce here simply permits a variety of intuitive interpretations previously unavailable.

6. Details on all data sources and their comparability are reported in Barrett et al. (1997). The data are available from the authors by request.

7. All the transfer cost series are nonadditive in that there is some multiplicative component attributable to ad valorem tariffs or graduated insurance or freight schedules. ADF test results available from the authors by request.

8. Details of all the test results are reported in Li (1997).

August 1999

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