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Factor and Product Market Tradability and Equilibrium in Pacific Rim Pork Industries

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This study uses a new market analysis methodology to examine price and trade relationships in eight Pacific Rim factor and product markets central to the Canadian and U.S. pork industries. The new method enables direct estimation of the frequencies with which a variety of market conditions occur, including competitive equilibrium, tradability, and segmented equilibrium. While extraordinary profit opportunities emerge episodically in a few niche markets, the vast majority of the markets studied are highly competitive—exhibiting zero estimated marginal profits to spatial arbitrage at monthly frequency—and internationally contestable. With a few notable exceptions due primarily to nontariff barriers, and despite significant remaining tariffs in some niches, the Pacific Rim is effectively a single market for pork producers and processors today.

Key words: corn, feed, hogs, international trade, law of one price, market integration, meats, soybean meal, spatial equilibrium

Introduction

Ongoing structural shifts in the North American pork industry raise important questions regarding the nature of international hog, feed, and pork markets. Canadian and United States pork production and processing are both increasingly industrialized, and each nation is now a net pork exporter. Since the gains in international competitiveness for Canadian and U.S. pork producers and processors seem increasingly likely to come from lowering unit costs through exploitation of emerging economies of scale (Houghton), the definition and development of accessible markets is central to the long-term health of the industry in both countries. And because the biggest pork markets and the fastest growth in consumption and trade are found in the Pacific Rim countries of Asia and North America, this region is of particular interest to Canadian and U.S. suppliers, helping prompt significant expansion of processing capacity in western North America (Hayenga et al.). In this analysis, we therefore study price and trade relationships in feed, hog, and pork markets among the major Pacific pork economies.

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Economists and industry and government decision makers commonly want to know whether two spatially separate markets are "integrated," and there is a substantial literature in economics (perhaps especially in agricultural economics) on such spatial price analysis. Yet in the past few years, a number of studies have shown that prevailing market integration testing methods based on price analysis—e.g., correlation coefficients, Granger causality, cointegration, or error correction mechanisms which relate prices in one market to prices in another—are unreliable under a variety of conditions because they rely on strong, often unrealistic, assumptions about trading behavior and the costs of commerce. When trade is discontinuous or bidirectional, or when transactions costs are considerable or nonstationary, these methods[1] uniformly fail to be able to distinguish between rejection of the null economic hypothesis of spatial market equilibrium and rejection of the assumptions underpinning model specification (Dahlgran and Blank; Barrett 1996, 1999; McNew; Baulch; McNew and Fackler; Fackler and Goodwin). Such conditions are common in the face of intra-industry trade due to economies of scale and product differentiation, seasonality in demand and supply, and trade policy reforms and technological change in shipping, storage, and communications. And as we demonstrate below, such conditions prevail in the Pacific Rim markets we study.

The challenge then facing economists is how to proceed with market analysis in the face of weaknesses in existing empirical methods. There have been several notable innovations in recent years, and this study applies the most recent of these to the case of Pacific Rim pork industry markets. Baulch introduced a novel approach to market integration testing which he labeled the parity bounds model (PBM). Baulch's PBM uses both price and shipping cost data in maximum-likelihood estimation of a model that relaxes several untenable assumptions underpinning traditional price analysis, specifically the problems of discontinuous trade and nontrivial costs of commerce. But as applied by Baulch, PBM still falls prey to problems of nonstationary transactions costs and bidirectional trade. Moreover, as Barrett (1996) argues, failure to take advantage of the information available in trade flow data still limits the inferential capacity of the parity bounds model.

Li and Barrett, building on Baulch's PBM, introduce what appears to be the first method to exploit information on prices, trade volumes, and intermarket marketing costs. The Li-Barrett method (LBM) further relaxes the assumptions bedeviling traditional price analysis methods and PBM, notably bidirectional trade and nonstationary costs of commerce. Moreover, the LBM permits distinction between *market integration* and *competitive market equilibrium*, two distinct concepts that are too often confused, as we explain in more detail in the next section. This analysis applies the LBM to a new, rich data set on factor and product markets for the pork industries of several Pacific Rim economies.

Estimating Market Condition Frequencies

The LBM is an informationally richer model allowing more informative and accurate inference. Its strength lies in its capacity to use the information from multiple data sources to distinguish between related but distinct concepts of *market equilibrium* and

[1] Barrett (1996) presents a hierarchical classification of markets analysis methods based on the nature of the data used. Level I methods use only price data and are most susceptible to specification error. Level II methods combine price and transactions cost data. Level II methods are relatively recent innovations and represent the current frontier. Level III methods, combining price, transactions costs, and trade flows data, were predicted to offer greater flexibility and inference. This paper appears to be the first published work employing a level III method.

market integration. The two are not synonymous in spite of current praxis. As Barrett (1999) and Fackler and Goodwin contend, the concept of market integration refers to intermarket transfer of Walrasian excess demand, as reflected in trade flows or, slightly more broadly, to a product's tradability between two markets. Integration is a quantity-based measure (e.g., is there spillover from one market to the next?) from which one cannot reliably undertake inference about efficiency and welfare (e.g., are there unexploited profits?). When two markets are integrated, supply and demand in the one market affect the price and/or transactions volume in the other.

The observation of trade flows is therefore a sufficient statistic for integration. By this definition, markets can be (imperfectly) integrated even when imperfectly competitive or inefficiently restricted by trade barriers or collusion, and whether or not price in one market responds (especially one-for-one) to shocks in the other. Barrett (1999) argues that this quantity-based definition of market integration corresponds more closely to popular understanding of the concept, and therefore helps economists communicate our findings more clearly to intended end-users in industry and government.

This definition of market integration is less far-reaching than conventional measures that rest on satisfaction of a zero marginal profit equilibrium condition and can therefore say something about efficiency and welfare. Following the familiar logic of competitive 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}.[2]

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.[3] In contrast, if the equilibrium condition binds with equality despite the absence of trade, then tradability holds (i.e., the markets are integrated). Although trade flows are not observed, if the marginal profit to spatial arbitrage is zero, traders should be indifferent as to whether or not they undertake trade. This feature indicates that the product is tradable between the two markets even if it is not traded. In that one circumstance, market integration obtains in the absence of observed trade flows because the broader concept of tradability is still satisfied.

So the concept of market integration depends on the tradability of product between two markets (for which recorded trade flows are sufficient but not necessary). The concept of competitive spatial equilibrium, on the other hand, depends on price, transactions costs, and trade flow data in order to establish whether there exist unexploited positive profits to arbitrage, whether arbitrage is a money-losing proposition, and whether price differentials should track transactions costs exactly or be bounded from above by them.

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[2] Transport costs are treated as exogenous to traders' decisions, as if shipment volumes didn't matter. The general equilibrium effects of traders' decisions in the presence of economies of scale in transport, perhaps manifest as nonlinear pricing, merit some attention as well in follow-up work.

[3] Goldberg and Knetter (p. 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.

When two markets are both integrated and in long-run competitive equilibrium, they may be classified as "perfectly integrated." This is the special case on which the existing market integration literature focuses.[4] Tests of the law of one price (LOP), or of purchasing power parity, or of cointegration between price series are implicitly tests of the more restricted perfect integration hypothesis, not tests for (perhaps imperfectly competitive) market integration or of (perhaps segmented) competitive equilibrium. The core reason is that conventional market integration tests rely exclusively on price data, and so cannot shed light on the quantity-based concept of market integration nor can they provide reliable inference on equilibrium conditions that depend as well on transactions cost and trade flow data.

The LBM method we use here builds on Baulch's parity bounds model (PBM), which compares observed intermarket price differentials against observed costs of intermarket transport, thereby estimating the probability that markets are in competitive equilibrium. The PBM approach hurdles the problems of discontinuous trade and time-varying transactions costs that bedevil pure price analysis methods. But because Baulch's method relies on a single cross-sectional observation of transactions costs, subsequently deflated across many periods, it imposes the assumption of stationarity on the costs of commerce.

Moreover, absent trade flow data, PBM 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. Not only do price differentials less than transfer costs not reflect market integration if there is no product flow or price transmission, but neither does such a situation reflect long-run competitive market equilibrium if there are trade flows since these generate negative profits to arbitrage. Conversely, markets are classified as "segmented" whenever price differentials exceed transfer costs, regardless of whether there are observed trade flows.

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 additional 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., nontariff trade barriers, unmeasured transactions costs, information gaps) exist and influence intermarket trade. 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.

In keeping with the spatial equilibrium condition identified earlier, the Li-Barrett method (LBM) therefore makes use of all three types of data: prices, transfer costs, and trade flows. This method interprets the observed time-series distribution of market prices as a mixture of observations drawn from different distributional regimes corresponding to distinct market conditions which may vary over time. There exist six distinct market regimes. Trade is either observed (our odd-numbered regimes) or not (our even-numbered regimes). The existence of trade is sufficient to demonstrate integration.

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[4] Goldberg and Knetter provide an excellent recent review of this literature in the context of international trade. Fackler and Goodwin offer a broader treatment of the spatial price analysis literature.

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	Perfect Integration with Trade (λ_1)	Inefficient Integration (positive marginal profits to arbitrage) (λ_3)	Inefficient Integration (negative marginal profits to arbitrage) (λ_5)
No trade	Perfect Integration without Trade (λ_2)	Segmented Disequilibrium (λ_4)	Segmented Equilibrium (λ_6)

Recall, too, that when trade is observed, price differentials should exactly equal transfer costs in equilibrium, so trade flow data help establish whether markets are in competitive equilibrium. 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 marginal profits to intermarket arbitrage or unexploited profits in the case of no-trade regime 4. Finally, when price differentials do not fully cover transfer costs (regimes 5 and 6), trade brings negative profit to arbitrageurs, inducing a no-trade segmented equilibrium in the case of regime 6. 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 $\Sigma_{k=1}^{6} \lambda_k = 1$, the six regimes are summarized in table 1.

In estimating the probability of observing the kth regime (λ_k), we have only partial information: the binary observation of trade or no trade. So we estimate a mixture model, maximizing the likelihood associated with the regime frequencies found in the sample, conditional on knowing whether trade occurs or not and the distribution assumption made about the measurement errors associated with each regime. We assume all regimes are subject to i.i.d. normal sampling and measurement error, v_t, with zero mean and variance σ_v^2. Regimes 3–6 also include a one-sided error, u_t, that is independent of v_t and is i.i.d. half-normal with variance σ_u^2. 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), the distribution functions for the observations in each regime are:

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

(2) $$f_t^3 = f_t^4 = \left[\frac{2}{(\sigma_u^2 + \sigma_v^2)^{½}}\right] \cdot \phi\left[\frac{Y_t - T_t}{(\sigma_u^2 + \sigma_v^2)^{½}}\right]\left[1 - \Phi\left[\frac{-(Y_t - T_t)\sigma_u/\sigma_v}{(\sigma_u^2 + \sigma_v^2)^{½}}\right]\right],$$

and

(3) $$f_t^5 = f_t^6 = \left[\frac{2}{(\sigma_u^2 + \sigma_v^2)^{½}}\right] \cdot \phi\left[\frac{Y_t - T_t}{(\sigma_u^2 + \sigma_v^2)^{½}}\right]\left[1 - \Phi\left[\frac{(Y_t - T_t)\sigma_u/\sigma_v}{(\sigma_u^2 + \sigma_v^2)^{½}}\right]\right],$$

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:

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

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_u^2 and σ_v^2 can be estimated by maximizing the logarithm of equation (4), subject to the constraints that $\lambda_k \geq 0 \,\forall\, k$, and $\Sigma_k \lambda_k = 1$.[5] The σ_v^2 parameter estimates reflect the width of the confidence band surrounding the parity bounds, and therefore reflect the precision with which one can estimate satisfaction of the zero marginal profit equilibrium condition. Estimates of λ_1 and λ_2 should therefore not be interpreted as measures of the probability that price differentials exactly equal transfer costs, but rather of the probability that the two are equal up to a zero mean Gaussian error having variance σ_v^2.

This method permits construction of several useful indicators of the frequency with which particular market conditions prevail. *Intermarket tradability* ($\lambda_1 + \lambda_2 + \lambda_3 + \lambda_5$) occurs whenever trade is observed or the intermarket arbitrage condition is binding, so that traders are indifferent between trading or not. *Competitive equilibrium* ($\lambda_1 + \lambda_2 + \lambda_6$) occurs whenever the intermarket arbitrage (zero marginal trader profit) condition holds. 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 disequilibrium* (neither integrated nor in long-run competitive equilibrium) with frequency λ_4. These conditions describe essentially all market conditions of interest to economists and their business and trade policy clients.

The regimes of most concern to economists are typically those reflecting violations of long-run competitive equilibrium. In regime 3, trade occurs and appears to earn positive marginal profits. This implies either (*a*) insufficient market arbitrage, due perhaps to formal or informal nontariff trade barriers or to temporary disequilibria (e.g., due to informational or contracting lags) that generate rents, or (*b*) the existence of significant unmeasured transactions costs that fill in the gap between the price differential and observable transfer costs (e.g., for quality assurance, certification for meeting importing country sanitary and phytosanitary standards, risk premia, or information costs). In regime 4, apparent positive profits go wholly unexploited by traders. The plausible explanations for this observation are the same as for regime 3, but the behavioral effect is extreme. Parallel logic holds in regime 5, where transfer costs exceed price differentials yet trade occurs despite negative estimated marginal profits. This may be due either 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.

While price differentials are symmetric (in absolute value) between any two markets, intermarket transfer costs (T_t) commonly depend on the direction of trade since tariffs

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[5] Baulch's PBM is a special case of our model that applies when there is no variation in trading status (i.e., $A = 1$ in all periods or $A = 0$ in all periods), in which case the only available information comes from price and transfer cost data.

vary across countries and backhaul freight rates are sometimes lower than the standard freight rates going the opposite direction. Asymmetric transfer costs imply the need to estimate direction-specific regime probabilities, i.e., one vector (λ^{ij}) related to product moving from market i to market j, and a second vector (λ^{ji}) related to movements in the opposite direction. In general, $\lambda^{ij} - \lambda^{ji} \neq \mathbf{0}$, meaning there will not be a unique probability vector describing both integration and equilibrium between two distinct markets since direction-specific regime probabilities may differ.

This is not a problem for measures of tradability, since tradability 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. If there exist positive marginal profits going either direction, potential Pareto improvements exist. So one really needs to know if spatial equilibrium conditions obtain in both directions. The existence of nontariff trade barriers (e.g., quotas or regulatory barriers) in one country can easily lead to equilibrium in one direction (into the open market) but disequilibrium in the other direction (into the restricted market).

Since tradability and perfect integration are unidirectional concepts, we therefore use the maximal direction-specific values of intermarket tradability and perfect integration in describing those market conditions between two (prospective) trading partners.[6] But since equilibrium is an omnidirectional concept, 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.

Finally, we should point out that the LBM estimator handles only bilateral relationships. It does not take account of likely correlations between various market pairs for a given commodity (e.g., nontariff barriers in place in country 1 apply to imports from either country 2 or country 3), nor does it exploit likely correlations between various products for a given market pair (e.g., an embargo on pork affects each cut simultaneously). Generalization of the LBM procedure into a full information maximum-likelihood approach is conceptually appealing but rather difficult in practice, given the multidimensional boundaries on the parameter space in these models and the need to then make further arbitrary assumptions about the nature of the joint distributions between various regimes across products and/or markets. Since oversight of the likely correlations merely reduces efficiency but does not introduce bias or inconsistency, we leave this task as an interesting future extension.

Pacific Rim Pork Industry Markets Data

We assembled comparable monthly time-series data on prices, trade flows, and estimated intermarket transactions costs over the years 1990–96 for eight commodities from eight countries. The commodities consisted of feedgrains (corn and soybean meal), slaughter hogs, chilled carcass, and chilled pork cuts (bellies, hams, loins, ribs).[7] The eight countries

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

[7] Since the mid-1980s, chilled meats have overtaken frozen meats in international commerce, apparently because consumers prefer the quality of chilled over frozen meat.

included Australia, Canada, Japan, Korea, Mexico, the Philippines, Taiwan, and the United States. 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. This section explains the data series, but greater detail is available in Barrett et al.

It would be hard to overstate either how painstaking was the process of compiling reasonably comparable product-level time series or how ultimately imperfect these measures are. We began by collecting price series at monthly frequency for products as homogeneous as we could find. Thus we can be as precise as yellow #2 corn (although the grade distinction is not made in either the Philippines or Taiwan), 48% protein soybean meal, 90–120 kilogram barrows and gilts, skinless fresh bellies, etc.

Nonetheless, the price series are not perfectly comparable because definitions differ slightly across countries (e.g., Mexico reports prices of fresh back ribs, while the other countries report prices for spare ribs), timing and aggregation differ across countries (e.g., belly prices in Mexico are the average of the weekly highest frequency prices, in Canada they are the average of Saturday prices, and in Taiwan they are the average of three three-day periods per month), and level in the marketing channel (quasi-farmgate, wholesale, or retail, although most of the series are wholesale). Local prices were converted into U.S. dollars using monthly average exchange rates. So there is a certain amount of uncontrollable measurement error in the intermarket price differentials used in estimation. Insofar as measurement errors are symmetric and random, they should be picked up by the error term (σ_v^2) that defines the width of the parity bounds relating price differentials and measured transactions costs.

Trade flow data were gathered from published customs data for Canada, Japan, Taiwan, and the United States. The customs classifications are typically not as precise as the product definitions in the price series. For example, rather than 48% soybean meal, the most disaggregated level of trade data just refer to soy flour and meal. The likely main effect of this modest disjuncture is to introduce some aggregation bias manifest as bidirectional trade in what are actually imperfectly homogeneous products, possibly leading to some upward bias in estimates of market integration if the frequency of trade is overstated due to aggregation of several products.

Next we estimated transfer costs as the sum of domestic transport costs, international freight charges, insurance and loading/offloading costs, and any applicable tariffs. As a result, our transfer cost series are higher, more variable, and more complete than the transport cost series available from the International Wheat Council, the Baltic Exchange, or the U.S. Department of Agriculture/Agricultural Marketing Service's (USDA/AMS') *Ocean Freight Rate Report.* If transfer costs other than transport charges (e.g., insurance or ad valorem tariffs) are correlated with the underlying price series, our more comprehensive measures obviate statistical problems of simultaneity bias that may plague even those other studies that have attempted to account for transport costs, much less those that use only price data.

Domestic transport costs were constructed by identifying precisely the location from which each national price series was gathered (e.g., Omaha for U.S. hogs and pork, or Decatur for U.S. soybean meal) and computing the cost of moving the product from this site to Pacific Coast ports (usually Seattle) using truck, rail, or barge costs kindly provided by the Agricultural Marketing Service. We were unsuccessful in obtaining analogous series for Canada or Mexico, and so imputed domestic transport costs to the coast for these series using the U.S. rates per kilometer-metric ton. Insofar as Canada subsidized interprovincial freight costs for some of these products during much of the period, this likely introduces some upward bias in transfer costs with respect to Canada. It should not be an issue for products for which the Canadian price series are from British Columbia (e.g., carcasses and slaughter hogs), but will be relevant for the other products. The Australian and Asian price series are all at port or port regions, so we ignore any domestic transport in those countries.

International freight, insurance, and loading/offloading (CIF) costs were derived from U.S. customs data tapes on U.S. imports for specific products. We took arithmetic averages across all ports of entry in the case of shipments from Canada and Mexico, and across Pacific ports of entry in the case of the Australasian countries. Since CIF costs are not available for U.S. exports, we assume symmetry for a given product and route (e.g., nontariff costs for hams from the U.S. to Canada equal to those for hams from Canada to the U.S.), ignoring the possibility of differences between forward and back-haul rates or insurance. Since the U.S. does not import each of these commodities from each country studied, we sometimes had to proxy using similar commodities or neighboring countries (e.g., costs of importing lamb from Australia as a proxy for costs of importing pork from Australia). Canadian nontariff CIF costs to and from Asia were assumed identical to costs to and from Seattle since Vancouver is the primary Canadian port for this trade.

The final component of the transfer cost series is tariffs.[8] These were computed on an average kilogram basis based on the prevailing trade volume (where a tariff rate quota system was in place) using published ad valorem and specific tariff schedules collected from consulates and the U.S. Department of Commerce. All changes in tariffs during the study period are thus fully reflected in the transfer cost series used.

Data are not available for precisely the same periods across countries or commodities. Indeed, data are not available on some commodities for some countries. So the number of observations vary across commodity-specific country pairs, and the number of country pairs available differ among commodities in the estimation results that follow.

Data Characteristics and Estimation Results

Our data show the standard assumptions of constant, trivial transactions costs and continuous trade frequently do not hold. Under such conditions, inference becomes unreliable in conventional price analysis methods based on correlation coefficients, Granger causality, cointegration testing, and error correction mechanisms (Barrett 1996, 1999; McNew; Baulch; McNew and Fackler). For example, trade discontinuity implies a nonlinear or piecewise linear relationship between price series, and bidirectional trade implies product differentiation, variation in direction of flow (implying the estimated sign of τ, the transactions cost term in the linear spatial equilibrium model, implicitly switches between negative and positive), or both. Yet continuous, unidirectional trade characterizes less than 6% of the commodity-specific market pairs for which we gathered data. This assumption holds only for trade in primal pork cuts between Japan and

[8] Quota rents are not added to transfer costs in our model. State trading regimes that significantly but implicitly tax or subsidize exports are also ignored because we use domestic prices and international trading costs, with no adjustment for distortionary pricing (whether of the product or of shipping services) by state trading companies.

Taiwan. And since we could not collect reliable transfer cost series between Japan and Taiwan, not one of the 88 commodity-specific market pairs to which we apply LBM fully satisfies the trade flow and transfer cost assumptions on which conventional methods rest. Hence the rationale is supported for using LBM to obviate the statistical hazards of traditional price analysis techniques.

Discontinuous trade or trade flow reversals frequently arise due to perturbations in the costs of market arbitrage, including trade policy reforms. Our data show that transfer costs are time-varying and that ad valorem tariffs and graduated insurance or freight schedules generate a nontrivial positive correlation between the measured transfer cost and price series, so omission of the transfer costs likely leads to simultaneity bias in parameter estimates derived from pure price analysis techniques. Moreover, transfer costs are frequently substantial, nonstationary, or both.

Figures 1 and 2 present histograms depicting the frequency distribution of mean transfer cost to export country domestic price ratios for commodity- and direction-specific market pairs, respectively. These ratios represent the mean proportional mark-up necessary to break even on shipments from the exporting country to the importing country. Predictably, transfer costs tend to be greatest as a proportion of price for low value-to-weight commodities (i.e., feedgrains) and for longer distances traveled. Mean transfer costs were only 1.8% of export country domestic price for intra-North American trade in chilled pork products, but averaged 221% of export country domestic price for trans-Pacific trade in feedgrains.

What is perhaps most striking is that the direction of trade often matters, too. Mean transfer costs are considerably higher going from North America to Asia than vice versa (figure 2) due to differences in tariff rates since we assume symmetry in the nontariff component of transfer costs. For example, Japanese tariffs alone on live slaughter hogs averaged 39% of the U.S. domestic price. Similarly, while transfer costs for loins averaged but 1.4% of export price going from Canada to the United States or vice versa, and only 6% (6.1%) from Japan to Canada (the U.S.), transfer costs averaged 121.6% (192.5%) of export price going the opposite direction across the Pacific, from Canada (the United States) to Japan![9] Trade policy clearly matters as much as transport costs, yet has been largely ignored in the market integration studies we have found.[10]

Given secular trends toward liberalized trade through permanently lower tariff rates, it is intuitive that many international transfer cost time series should be nonstationary.[11] Indeed, augmented Dickey-Fuller tests find that 12 of 14 feedgrains' transfer cost series are nonstationary; more precisely, one cannot reject the null hypothesis of nonstationarity at the 90% significance level.[12] Transfer costs from North America to Japan are nonstationary for *each* commodity over the 1990–96 period. This observed

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[9] During the period 1990–96, Canada imposed no tariffs on imported pork or slaughter hogs. The United States imposed a specific duty of 2.2¢ per kilogram on primal pork cuts, but no duty on carcasses or slaughter hogs. Pork from Canada to the United States became duty free under the North American Free Trade Agreement (NAFTA), placed into effect in January 1994 by Presidential Proclamation 6641 of December 15, 1993. Taiwan imposed a 15% (10%) ad valorem duty on pork and carcasses (on slaughter hogs). Japan employed a more complex variable rate schedule under which specific duties apply over some ranges, ad valorem tariffs over others, all tied to variable trigger prices.

[10] In contrast, trade economists tend to study the effects of policy-related barriers to international commerce without explicitly checking whether competitive equilibrium holds between markets.

[11] There is also evidence that macroeconomic shocks may also add to international trade costs through their effects on the incidence of sea piracy, which occurs disproportionately in Asian waters and has risen sharply in the wake of the East Asian crisis (Sullivan and Jordan).

[12] Detailed test results are available from the authors by request.

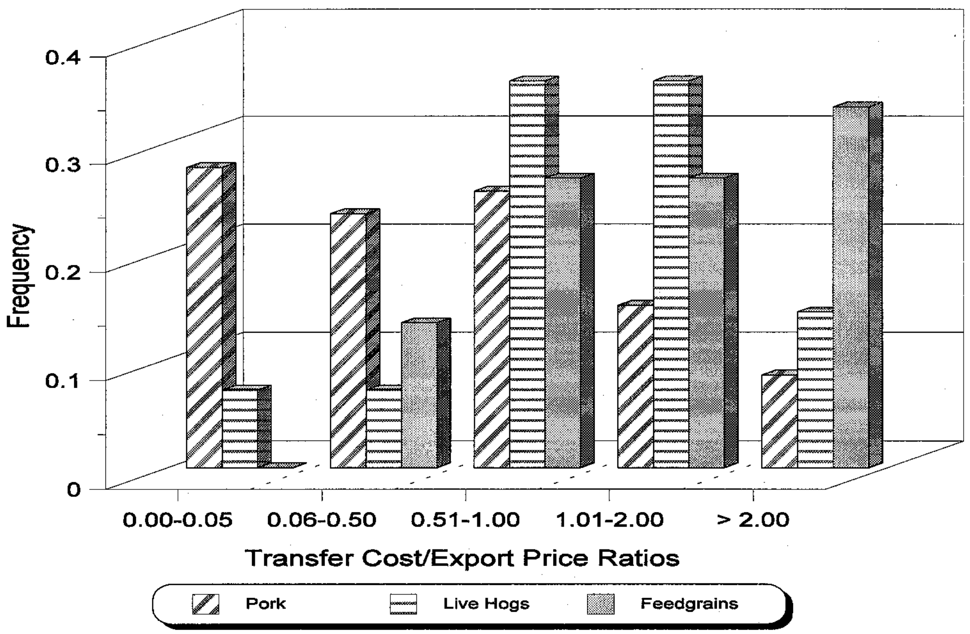

Figure 1. Transfer cost proportions by commodity type

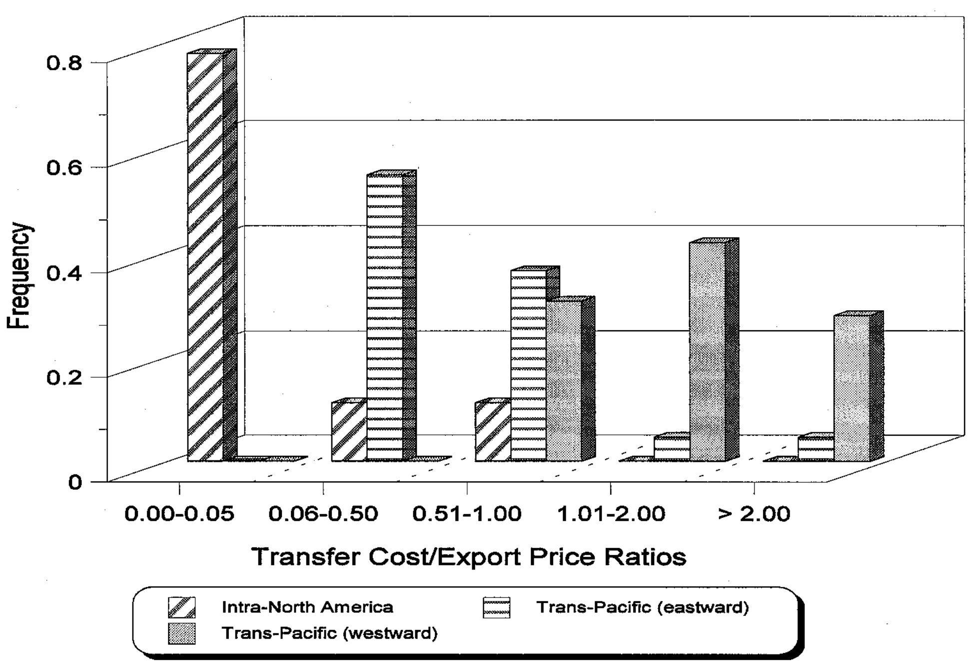

Figure 2. Transfer cost proportions by geography of trade

nonstationarity in measured transfer costs likely reflects three structural changes. First, there have been significant improvements in shipping technologies that have given rise to steady reductions in real transport costs per ton-mile, so the mean transfer cost has been changing over time. Second, energy costs are an important factor in shipping costs and there were several sharp, persistent movements in oil prices during the 1990–96 period. Third, although reforms under the World Trade Organization (WTO) did not go into effect in these markets during the period under study, there were other changes in tariff policy (for example, Japan's switch from its "differential tariff" system to a "gate price" system in 1995).

Transfer costs for meat and live hogs were more commonly stationary than those for feedgrains, probably due to the relatively smaller role of tariff reduction in these commodities since many animal product trade restrictions are nontariff technical barriers that have been less subject to liberalization to date (Hillman; Thilmany and Barrett). With agricultural trade liberalization expected to feature prominently in the next round of multilateral WTO negotiations, this issue is unlikely to disappear any time soon. Thus market analysts must adopt methods better suited to the underlying conditions of international trade and its associated costs.

Table 2 presents the LBM estimation results, several of which stand out. First, loss-making trade (λ_5) is extremely uncommon, occurring at 10% or greater frequency in only 3/88 cases, all in soybean meal trade involving Japan. Few traders appear willing to absorb losses, even temporarily, in order to maintain or expand market share. Instead, segmented equilibrium (λ_6) prevails 91.5% of the time when price differentials are insufficient to cover observable market intermediation costs, as in just over one-quarter of all these commodity-, direction-, and period-specific observations.[13]

Recall from figures 1 and 2 that transfer costs are often considerably greater than the f.o.b. export price. Segmented equilibrium is to be expected in the face of large wedges driven between markets' prices by tariffs, shipping costs, or both. While comparative disadvantage manifested as segmented equilibrium never occurs with positive and statistically significant probability for either U.S. or Canadian producers of these eight commodities, it occurs for half the primal cuts from Taiwan, two-thirds from Mexico, and all the meat (cuts and carcass) from Japan. In general, the comparative disadvantage of Japan, Korea, Mexico, the Philippines, and Taiwan in feedgrains, hogs, and pork is apparent from the asymmetric frequency with which those source markets are in segmented equilibrium from the Canadian and United States markets. Production and processing costs are much higher in those countries, leading to higher domestic prices and frequent imports (when not impeded by trade barriers) from Canada and the United States.

Second, segmented disequilibrium (λ_4), where no trade occurs in spite of the apparent existence of positive profits, likewise appears rarely—only 3% of the time overall, and with 5% or greater frequency in only three cases: bellies and loins from the U.S. into Taiwan, and slaughter hogs from the U.S. into Canada. This likely reflects the fact that trade in higher-value-added products and live animals tends to be most subject to nontariff trade barriers, and that few such barriers fully prohibit trade. The observation that unprofitable trade or segmented disequilibrium occurs only 5% of the time is strong empirical confirmation of the profit-making behavior of international traders operating in these markets.

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[13] This comparison is made by dividing the point estimate by the sum of the estimates across a category [e.g., $\lambda_5/(\lambda_5 + \lambda_6)$].

Table 2. LBM Estimation Results

Direction of Trade[a]	TRADE λ_1	TRADE λ_3	TRADE λ_5	NO TRADE λ_2	NO TRADE λ_4	NO TRADE λ_6	Std. Errors σ_u	Std. Errors σ_v
Bellies:								
US → CA	1.00*	0.00	0.00	0.00	0.00	0.00	1.158	0.986
CA → US	0.99*	0.01	0.00	0.00	0.00	0.00	0.121	1.236
US → TW	0.00	0.00	0.00	0.01	0.98*	0.00	1.264	0.039
TW → US	0.00	0.00	0.00	0.01	0.01	0.98*	4.202	0.465
US → MX	0.01*	0.98*	0.00	0.01	0.00	0.00	3.095	0.469
MX → US	0.01*	0.01*	0.00	0.01	0.00	0.97*	3.114	0.496
CA → TW	0.00	0.00	0.00	0.99*	0.00	0.00	0.427	0.492
TW → CA	0.00	0.00	0.00	0.01	0.01	0.97*	2.105	3.140
Hams:								
US → CA	0.98*	0.01*	0.01	0.00	0.00	0.00	0.517	0.055
CA → US	0.89*	0.04	0.01	0.05	0.01	0.00	0.284	0.024
US → TW	0.00	0.00	0.00	0.99*	0.01	0.00	0.996	1.004
TW → US	0.01	0.00	0.00	0.00	0.01	0.99*	1.785	1.495
PH → US	0.01	0.00	0.00	0.98*	0.00	0.00	0.002	0.847
US → PH	0.01	0.00	0.00	0.99*	0.00	0.00	0.053	0.737
CA → TW	0.01	0.00	0.00	0.99*	0.00	0.00	1.347	0.769
TW → CA	0.00	0.00	0.00	0.01	0.01	0.98*	0.381	0.646
Loins:								
US → CA	0.99*	0.00	0.01*	0.00	0.00	0.00	0.058	0.681
CA → US	0.99*	0.00	0.01*	0.00	0.00	0.00	0.677	0.665
JP → US	0.00	0.00	0.00	0.00	0.00	0.99*	0.179	1.944
US → JP	0.01*	0.98*	0.00	0.01	0.00	0.00	1.217	1.540
CA → TW	0.01*	0.00	0.00	0.99*	0.00	0.00	1.107	1.221
TW → CA	0.01	0.00	0.00	0.99*	0.00	0.00	1.726	2.094
JP → CA	0.00	0.00	0.00	0.01	0.01	0.98*	1.734	0.393
CA → JP	0.01	0.98*	0.00	0.00	0.01	0.00	1.193	0.244
US → MX	0.01*	0.98*	0.00	0.01	0.00	0.00	0.448	0.290
MX → US	0.01	0.00	0.00	0.01	0.00	0.98*	0.451	0.445
US → TW	0.01	0.21*	0.00	0.01	0.77*	0.00	1.554	0.168
TW → US	0.01	0.01	0.00	0.97*	0.00	0.00	4.554	1.748
Spareribs:								
US → CA	0.10	0.89*	0.00	0.01	0.00	0.00	0.265	0.083
CA → US	0.41*	0.02	0.00	0.56*	0.01	0.00	0.000	0.466
CA → TW	0.01	0.00	0.00	0.99*	0.00	0.00	0.000	0.585
TW → CA	0.01	0.01	0.00	0.98*	0.00	0.00	0.778	2.524
US → MX	0.01	0.98*	0.01	0.00	0.00	0.00	0.934	0.588
MX → US	0.01*	0.01	0.00	0.99	0.00	0.00	0.482	1.130
US → TW	0.20*	0.01*	0.00	0.78*	0.01	0.00	0.000	0.504
TW → US	0.01	0.01	0.00	0.97*	0.00	0.00	0.005	0.279
Carcasses:								
US → CA	0.14*	0.00	0.00	0.86*	0.00	0.00	0.578	0.330
CA → US	0.98*	0.01*	0.00	0.01	0.00	0.00	0.165	0.139

(continued . . .)

Table 2. Continued

Direction of Trade[a]	TRADE λ_1	λ_3	λ_5	NO TRADE λ_2	λ_4	λ_6	Std. Errors σ_u	σ_v
Carcasses (continued):								
US → JP	0.79*	0.01*	0.00	0.20*	0.00	0.00	0.000	1.308
JP → US	0.01	0.01	0.00	0.01	0.01	0.95*	0.404	0.699
US → AU	0.01	0.00	0.00	0.99*	0.00	0.00	0.000	1.203
AU → US	0.01	0.00	0.00	0.99*	0.00	0.00	0.711	1.485
US → KO	0.01*	0.00	0.00	0.97*	0.01	0.00	1.015	0.038
KO → US	0.01	0.01	0.00	0.97*	0.01	0.00	0.000	2.934
CA → JP	0.14*	0.01	0.00	0.84*	0.01	0.01	0.001	1.356
JP → CA	0.00	0.00	0.00	0.01	0.01	0.97*	0.423	0.662
Slaughter Hogs:								
US → CA	0.01	0.18*	0.01*	0.30	0.50*	0.00	0.123	0.121
CA → US	0.99*	0.01	0.00	0.00	0.00	0.00	0.030	0.315
CA → TW	0.00	0.00	0.00	0.99*	0.00	0.00	1.358	0.954
TW → CA	0.00	0.00	0.00	0.02	0.00	0.97*	0.448	0.279
US → TW	0.00	0.00	0.00	0.99*	0.00	0.00	0.759	0.376
TW → US	0.01	0.00	0.00	0.00	0.00	0.99*	2.319	0.728
US → AU	0.00	0.00	0.00	0.98*	0.00	0.00	0.000	0.670
AU → US	0.01	0.00	0.00	0.99*	0.00	0.00	0.029	1.845
US → JP	0.32*	0.00	0.00	0.67*	0.01	0.00	0.638	0.456
JP → US	0.00	0.00	0.00	0.01	0.00	0.99*	3.214	2.986
CA → JP	0.04	0.00	0.01	0.95*	0.00	0.00	0.765	0.443
JP → CA	0.00	0.00	0.00	0.99*	0.00	0.00	0.000	2.728
US → KO	0.01	0.00	0.00	0.99*	0.00	0.00	0.412	0.577
KO → US	0.00	0.00	0.00	0.01	0.00	0.99*	0.001	2.178
CA → KO	0.02	0.01	0.00	0.97*	0.00	0.00	0.003	0.782
KO → CA	0.00	0.00	0.00	0.01	0.00	0.98*	0.004	1.956
US → PH	0.01	0.01	0.00	0.98*	0.00	0.00	0.000	2.038
PH → US	0.01	0.00	0.00	0.98*	0.01	0.00	0.016	1.636
CA → PH	0.01*	0.00	0.00	0.99*	0.00	0.00	2.173	0.370
PH → CA	0.01*	0.01*	0.03	0.01	0.00	0.93*	0.000	1.468
AU → CA	0.00	0.00	0.00	0.99*	0.00	0.00	0.427	1.599
CA → AU	0.01*	0.02	0.01	0.96*	0.01	0.00	1.892	0.338
Corn:								
US → CA	0.96*	0.03	0.01	0.00	0.00	0.00	0.180	0.095
CA → US	0.65*	0.04	0.01	0.29*	0.01	0.00	0.000	0.103
US → TW	0.31*	0.01	0.00	0.67*	0.01	0.00	0.000	0.229
TW → US	0.01*	0.00	0.00	0.00	0.00	0.99*	0.458	0.431
US → PH	0.20*	0.00	0.00	0.80*	0.00	0.00	3.825	0.659
PH → US	0.01	0.00	0.00	0.00	0.00	0.98*	0.433	0.477
CA → TW	0.01	0.00	0.00	0.99*	0.00	0.00	4.611	0.230
TW → CA	0.00	0.00	0.00	0.97*	0.01	0.00	0.701	0.012
CA → PH	0.01	0.00	0.00	0.99*	0.00	0.00	0.000	0.853
PH → CA	0.01*	0.03	0.01	0.93*	0.02	0.00	0.299	0.082

(continued . . .)

Table 2. Continued

Direction of Trade[a]	TRADE λ_1	TRADE λ_3	TRADE λ_5	NO TRADE λ_2	NO TRADE λ_4	NO TRADE λ_6	Std. Errors σ_u	Std. Errors σ_v
Soybean Meal:								
US → CA	0.91*	0.01	0.06*	0.00	0.00	0.00	0.195	0.018
CA → US	0.88*	0.00	0.00	0.12*	0.00	0.00	0.324	0.077
TW → CA	0.53*	0.02	0.01	0.41*	0.02	0.01	0.000	0.359
CA → TW	0.22*	0.00	0.00	0.78*	0.00	0.00	0.368	0.207
CA → JP	0.01	0.17	0.82*	0.00	0.00	0.00	0.013	0.088
JP → CA	0.77*	0.01*	0.01	0.01*	0.01*	0.19*	0.415	0.475
US → JP	0.14	0.33*	0.34*	0.18*	0.01	0.00	0.000	0.065
JP → US	0.01*	0.01	0.39*	0.01*	0.01	0.57*	0.000	0.513
US → TW	0.52*	0.00	0.00	0.48*	0.00	0.00	0.184	0.030
TW → US	0.01*	0.01*	0.09*	0.01	0.01*	0.87*	6.855	0.386

Notes: An asterisk (*) denotes statistically significantly different from zero at the 95% confidence level. Due to rounding errors, rows do not always sum to one.

[a] AU = Australia, CA = Canada, JP = Japan, KO = Korea, MX = Mexico, PH = Philippines, TW = Taiwan, and US = United States.

Segmented disequilibrium and inefficient integration with positive apparent profits (λ_3) are most likely the consequence of nontariff barriers to trade (e.g., quotas, sanitary and phytosanitary restrictions, and private or public technical barriers) that create positive rents to trade by restricting the free flow of commodities between nations. Such rents exist about 11% of the time overall in these markets, but with more than 22% frequency in the case of primal cuts (bellies, hams, loins, and spareribs). This reflects the relatively greater propensity for nontariff barriers to apply to higher-value-added, processed products, like chilled meats, than to raw commodities, like corn, for which $\lambda_3 + \lambda_5$ occurred with only 1.5% frequency. Significantly positive estimates for λ_3 or λ_4 appear almost exclusively for imports into Japan, Mexico, and Taiwan, reflecting the relatively great propensity of those three countries to employ nontariff trade barriers.[14]

In several cases the λ_2 estimates—for the no trade equilibrium within the parity bounds—appear rather high. This seems attributable to large standard errors (σ_v) on those particular estimates, and probably comes at the cost of lower estimates of λ_6, the segmented equilibrium. We therefore suspect the estimates reported here overstate the frequency with which bidirectional tradability holds and, equivalently, understate the frequency with which Canadian and U.S. producers and processors exhibit comparative advantage over their counterparts in the other six economies. Overestimates of λ_2 at the expense of underestimates of λ_6 have no effect, however, on the point estimates for satisfaction of either competitive spatial equilibrium or (unidirectional) intermarket tradability.

Tables 3–5 offer summary descriptions of the estimated frequencies of particular market conditions prevailing. The most striking result is that intermarket tradability

[14] Of course, these results might also be partly attributable to subtle noncomparability of cuts that makes intermarket price comparison difficult.

Table 3. Estimates of Intermarket Condition Frequencies for Canada

Product	Other Market	Perfect Market Integration $(\lambda_1 + \lambda_2)$	Intermarket Tradability $(\lambda_1 + \lambda_2 + \lambda_3 + \lambda_5)$	Market Equilibrium $(\lambda_1 + \lambda_2 + \lambda_6)$
Bellies	Taiwan	0.99	0.99	(0.98, 0.99)
	United States	1.00	1.00	(0.99, 1.00)
Hams	Taiwan	1.00	1.00	(0.99, 1.00)
	United States	0.98	1.00	(0.94, 0.98)
Loins	Japan	0.01	0.99	(0.01, 0.99)
	Taiwan	1.00	1.00	(1.00, 1.00)
	United States	0.99	1.00	(0.99, 0.99)
Spareribs	Taiwan	1.00	1.00	(0.99, 1.00)
	United States	0.97	1.00	(0.11, 0.97)
Carcasses	Japan	0.98	0.99	(0.98, 0.99)
	United States	1.00	1.00	(0.99, 1.00)
Slaughter Hogs	Australia	0.99	1.00	(0.97, 0.99)
	Korea	0.99	1.00	(0.99, 0.99)
	Philippines	1.00	1.00	(0.95, 1.00)
	Taiwan	0.99	0.99	(0.99, 0.99)
	United States	0.99	1.00	(0.31, 0.99)
Corn	Philippines	1.00	1.00	(0.94, 1.00)
	Taiwan	1.00	1.00	(0.97, 1.00)
	United States	0.96	0.99	(0.94, 0.96)
Soybean Meal	Japan	0.78	1.00	(0.01, 0.97)
	Taiwan	1.00	1.00	(0.95, 1.00)
	United States	1.00	1.00	(0.91, 1.00)

is effectively ubiquitous, occurring with at least 99% frequency in 42/44 commodity-specific market pairs. There is no question that the factor and product markets of Pacific Rim pork industries are integrated in the sense of tradability.

The LBM estimation results also underscore the distinction between tradability and equilibrium. While equilibrium prevails with at least 96% frequency in 43/44 commodity- *and* direction-specific market pairs (i.e., the upper bound on market equilibrium is at least 96%), disequilibrium commonly appears in one direction. Given the unidirectional nature of disequilibrium, we find it hard to believe that this could reflect imperfect competition, save for that generated by nontariff barriers that generate quota rents. Moreover, when compared against evidence on nontariff barriers to trade (e.g., Roberts and DeRemer), there is a strong correspondence between the observation of reasonably frequent disequilibrium in our estimates and the existence of unilateral nontariff trade barriers, mostly by Japan and Mexico, but also (for a couple of products only) for Canada and Taiwan. For the limited range of products under study here, Australia, Korea, and the Philippines appear relatively unfettered by nontariff barriers or imperfect competition impeding attainment of competitive market equilibrium.

Table 4. Estimates of Intermarket Condition Frequencies for the U.S.

Product	Other Market	Perfect Market Integration $(\lambda_1 + \lambda_2)$	Intermarket Tradability $(\lambda_1 + \lambda_2 + \lambda_3 + \lambda_5)$	Market Equilibrium $(\lambda_1 + \lambda_2 + \lambda_6)$
Bellies	Canada	1.00	1.00	(0.99, 1.00)
	Mexico	0.02	1.00	(0.02, 0.99)
	Taiwan	0.01	0.01	(0.01, 0.99)
Hams	Canada	0.98	1.00	(0.94, 0.98)
	Philippines	1.00	1.00	(0.99, 1.00)
	Taiwan	0.99	0.99	(0.99, 1.00)
Loins	Canada	0.99	1.00	(0.99, 0.99)
	Japan	0.02	1.00	(0.02, 0.99)
	Mexico	0.02	1.00	(0.02, 1.00)
	Taiwan	0.98	0.99	(0.02, 0.98)
Spareribs	Canada	0.97	1.00	(0.11, 0.97)
	Mexico	1.00	1.00	(0.01, 1.00)
	Taiwan	0.98	0.99	(0.98, 0.98)
Carcasses	Australia	1.00	1.00	(1.00, 1.00)
	Canada	1.00	1.00	(0.99, 1.00)
	Japan	0.99	1.00	(0.97, 0.99)
	Korea	0.98	0.99	(0.98, 0.98)
Slaughter Hogs	Australia	1.00	1.00	(0.98, 1.00)
	Canada	0.99	1.00	(0.31, 0.99)
	Korea	1.00	1.00	(1.00, 1.00)
	Philippines	0.99	1.00	(0.99, 0.99)
	Taiwan	0.99	0.99	(0.99, 0.99)
Corn	Canada	0.96	0.99	(0.94, 0.96)
	Philippines	1.00	1.00	(0.99, 1.00)
	Taiwan	0.98	0.99	(0.98, 1.00)
Soybean Meal	Canada	1.00	1.00	(0.91, 1.00)
	Japan	0.32	0.99	(0.32, 0.59)
	Taiwan	1.00	1.00	(0.89, 1.00)

Equilibrium nonetheless prevails at least two-thirds of the time in all products, and effectively continuously in carcass, corn, and ham markets. The intersection of tradability and equilibrium, constant perfect market integration ($\lambda_1 + \lambda_2 = 1$), holds in only 17/44 market pairs. Traditional price analysis methods implicitly test only for constant perfect market integration. Given that traditional methods' rejection of the null hypothesis of efficient market integration cannot be disentangled from rejection of the assumptions imposed in their model specification, we take this finding as a strong indication that the mass of empirical evidence against spatial market equilibrium (i.e., rejecting the law of one price) probably reflects specification error at least as much as it reflects significant impediments to the functioning of competitive international agricultural markets. Hence there is clearly a need to move toward informationally richer methods of market analysis.

Table 5. Mean Estimates of Intermarket Condition Frequencies by Product

Product	Perfect Market Integration ($\lambda_1 + \lambda_2$)	Intermarket Tradability ($\lambda_1 + \lambda_2 + \lambda_3 + \lambda_5$)	Market Equilibrium ($\lambda_1 + \lambda_2 + \lambda_6$)
Bellies	0.50	0.75	0.75
Hams	0.99	1.00	0.99
Loins	0.50	0.99	0.67
Spareribs	0.99	1.00	0.76
Carcasses	0.99	1.00	0.99
Slaughter Hogs	0.98	1.00	0.94
Corn	0.99	1.00	0.98
Soybean Meal	0.82	1.00	0.76

Notes: The first two numeric columns are the unweighted arithmetic means of the maximal direction-specific estimate from each country pair. The last column is the unweighted arithmetic mean of the direction-specific estimates.

Conclusions and Extensions

This analysis applies a new approach to the study of spatial market relationships using maximum-likelihood estimation of a mixture distribution model incorporating price, transfer cost, and trade flow data. This method generates 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. Moreover, the approach employed here, unlike conventional market analysis methods, is robust to time-varying, nonstationary, or nonadditive transfer costs and to discontinuous or bidirectional trade, conditions that commonly prevail in the eight Pacific Rim commodity markets we study.

The estimation results yield a number of important findings with respect to the factor and product markets of Pacific Rim pork industries. First, these products are highly tradable among the eight economies we study. Market integration is nearly ubiquitous and constant. Second, spatial equilibrium holds significantly more often than not, although there remain a number of niches where the marginal profits to spatial arbitrage remain positive, largely reflecting binding nontariff barriers to trade, particularly those imposed by Japan and Mexico. Third, while spatial equilibrium is commonplace, in many cases that is attributable to large intermarket transfer costs that drive a substantial wedge between market prices, effectively segmenting markets. High tariffs, typically by Asian importing countries, account for a large share of these measurable transactions costs. So continued tariff reduction would no doubt increase trade (although not necessarily the frequency with which spatial market equilibrium holds) and reduce deadweight losses associated with trade restrictions.

A number of important extensions can be made to the model presented here. One is methodological. One could exploit the likely correlation among products and trading partners to generate more precise estimates of regime frequencies. Given the relatively large values of many of the σ_v estimates of the width of the parity bounds, this might help pin down integration and segmentation frequencies with much greater precision, although it would be unlikely to affect the estimated frequency with which competitive spatial equilibrium obtains.

Another important extension is historical. To what extent are there structural breaks in the relationships between national markets for particular products? With respect to policy reforms involving changes in tariff rates or other measurable costs, our method already accounts for them. But in the past few years (largely after our study period of 1990–96), there have been concerted efforts to reduce nontariff barriers (including through tariffication, e.g., the conversion of quotas to tariff rate quotas) while there have also been increased concerns about the introduction of regulatory barriers to trade as a backlash against tariff reduction (Thilmany and Barrett). Rather than just estimating unconditional period averages for the various market regimes, it might be interesting to look at the intertemporal pattern of such measures using rolling bandwidth estimates or statistical tests for structural breaks.

Finally, an important implicit message of this work is the value of improved inference made possible by better information on prices, trade flows, and the costs of international commerce. As analysts increasingly recognize the importance of incorporating data on transfer costs and trade flows in market analysis, we hope that government statistical agencies will begin to invest in generating regular, reliable, and internationally comparable series. The short, imperfect, and incomplete series we generated enable the use of informationally richer models offering more interesting and more accurate inference. The profession's capacity to make significant advances in international market analysis depends fundamentally on the availability of such data series.

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