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A Study in U.S. Export Beef Competitiveness: Do Cattle Inventories Matter?

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Abstract. This paper examines whether competition in major export markets for United States beef has changed between 1994 and 2015 and whether underlying cattle inventories impact that competition. The two models employed examine price markups and comparative advantage. Both models are estimated as systems of equations taking into account competitors in eight major beef export markets. Structural break tests of key functions of the two models are examined. The findings complement each other showing that inventories do have some impact on competition, but that the markets are mostly highly competitive, and that the level of competition the U.S. faced in 2015 is not significantly different than it was twenty years prior.

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[Note. End of document contains material that will go into online appendix.]

Abstract. This paper examines whether competition in major export markets for United States beef has changed between 1994 and 2015 and whether underlying cattle inventories impact that competition. The two models employed examine price markups and comparative advantage. Both models are estimated as systems of equations taking into account competitors in eight major beef export markets. Structural break tests of key functions of the two models are examined. The findings complement each other showing that inventories do have some impact on competition, but that the markets are mostly highly competitive, and that the level of competition the U.S. faced in 2015 is not significantly different than it was twenty years prior.

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The U.S. beef industry operates in a highly competitive world market. Major competitors for global markets include Canada, Australia, New Zealand, Brazil, Argentina, and Uruguay (USDA-FAS, 2016). The United States maintains a competitive advantage in beef production due to a well-developed infrastructure and a reputation for both quality and safety. However, the United States can be at a disadvantage relative to cost of production. For example, a pound of grass-fed beef can typically be produced at lower cost, where the majority of U.S. beef is grain-fed. Competitive advantages can also be built around the sophisticated use of information. Globally, animal identification and traceability is recognized as an important component of managing animal and human health and food safety (Schroeder and Tonsor, 2012 p. 32). Traceability systems also enhance communication and coordination by delivering information up and down the supply chain to benefit producers, processors, and consumers. Smith et al. (2005) reported that the United States is “lagging behind many countries in developing traceability systems for food in general and especially for livestock, and their products” (p. 174). Of the world’s eight largest exporters, six have in place mandatory cattle animal identification and traceability systems. Only the United States and India have not adopted mandatory national identification and traceability systems (Schroeder and Tonsor, 2012). With this vulnerable position relative to competing export countries the United States could become less competitive and lose access to selected export markets (Murphy et al., 2009; Schroeder and Tonsor, 2012; Pendell, Tonsor, Dhuyvetter, Brester, and Schroeder, 2013). In short, the United States beef industry today faces a highly competitive and developing global market place. Trade relationships, exchange rates, and economic growth rates in other countries all impact the export demand profile. But, are U.S. beef exports facing significantly greater economic competition today than they did in the past, or have those export markets always been intensely competitive?

Objective.

The biological cycle of cattle creates price dynamics that differ from the price determination for other commodities. The objective of this research is to examine international beef exports while taking into account the dynamics of cattle production and marketing. The overarching goal is to determine if competitiveness has changed if any changes are related to cattle cycle dynamics. Biological cycles and their impacts on price determination have been examined in the past (see Rosen, Murphy and Scheinkman; Jarvis) and have been examined in terms of market power in the farm-wholesale chain for cattle (Crespi, Xia and Jones), but how and whether these cycles impact competitiveness in U.S. beef export markets has not been studied. Neither has the impact of coordination on these underlying cycles been examined. This paper examines the global determinants of price discovery for beef, especially U.S. beef, in light of the underlying biological dynamics of cattle production in order to investigate whether U.S. competitiveness in international markets has changed in the past two decades.

Background.

The United States is a global leader not only in the production of beef cattle but also in the development of new ways to produce and market livestock—what has been termed the "industrialization of agriculture" (Boehlje). While all commodities have their peaks and troughs, livestock production is a "notoriously cyclical industry" (Schulz, p. 1), impacted by a biological cycle that affects the production of final meat products because of the feedback between today's breeding stock choices and tomorrow's consumption. The cattle cycle in particular and its impact on prices is well known and has been examined in great detail (see as examples Jarvis; Rosen, Murphy and Scheinkman; Crespi, Xia and Jones; Tonsor and Schulz).

Rosen, Murphy and Scheinkman perhaps best summarized the periodic nature of beef cattle: "The fundamental reason for this is that cattle are both capital and consumption goods. Current breeding and consumption decisions have large effects on future stocks" (p. 468).

Unlike most grains and oilseeds, cattle must be managed in a manner whereby production today necessarily impacts production tomorrow. However, as producers are able to control their stock in ways that allow for better management of the underlying biological cycles through genetic selection, feed rations, market analyses concerning future demand, and greater coordination of the needs along the supply chain, the production becomes more and more like that of other commodities.

Industrial structure has certainly changed in this industry; but, importantly for this research, the structure has changed at different rates. From 1980 to 2010, the U.S. four-firm concentration ratio (CR4) for steer and heifer slaughtering increased 136 percent from a CR4 of 36 to 85 (Crespi, Saitone and Sexton). While concentration in the United States has increased dramatically, so, too, has the degree of coordination through contract procurement. As discussed in Crespi, Saitone and Sexton (p. 679):

> The rate of increase in vertical coordination through contracts in the United States has been most pronounced in the livestock sector, where the

> share of cattle marketed under vertical coordination mechanisms doubled between 1980 and 1998, from about 10% to more than 20%. The pace of vertical coordination has accelerated rapidly since then, with negotiated cash procurement accounting for only 34.1% of cattle transactions in 2009-10.

Indications are that poultry production, through various practices including the managerial movement toward nearly universal vertical integration through management contracting, has all but eliminated the impacts of underlying biological cycles on production (although large shocks to stocks such as the 2015 highly pathogenic avian influenza outbreaks in the Midwest will test this). Hog production, which is moving toward an industry structure that includes greater vertical coordination, is likewise more insulated from such swings. Beef cattle production, on the other hand, is the least coordinated of the three sectors and, arguably (see Bailey), more resistant to such restructuring. Nevertheless, cattle markets too are more integrated vertically today than in years past and seem to be experiencing less cyclical swings in part because of this. Crespi, Xia and Jones found that price adjustments due to producers' expectations are translated more swiftly today into the live cattle price than had occurred in the past, an indication that the price determination for U.S. live cattle at least is more nimble than it had been 20 years ago. This would be expected if the market is more vertically coordinated and the underlying cattle cycle more controlled. Because of the concentration and coordination of supply, examinations of export competitiveness must consider the possibility of market power.

Approach.

The main research question is, simply, whether competition in exports for beef is significantly different than in the past and, if so, in what way? Answering this question in terms of the underlying biological cycle really means answering the following questions:

- Is the United States now or was it at any time a price setter in major export markets for beef?

- Does the United States now or has it had in the past a comparative advantage in export markets for beef?
- Has the underlying biological cattle cycle impacted the competitiveness of U.S. beef?

Each question is limited by data availability, which is especially complicated because the United States is hardly the sole exporter of beef and because trade relationships, market access, exchange rates, etc. all impact trade profiles. To perform the analysis one must take into account what is happening in major export markets vis-à-vis the U.S's main competitors while also accounting for shocks and changes to those markets.

We chose to examine these questions through the use of complementary modeling procedures. First, we employ a trade model developed by Goldberg and Knetter, which has been used extensively to look for price markups over marginal cost in export markets. While our interest is not in market power per se, if the United States has had any competitive advantage, say, due to price leadership or dominant "firm" advantage, then indications ought to emerge in a measure of price markups. We expand on the Goldberg-Knetter price-markup (PM) model in the following ways. We estimate the export markets as systems to examine prices in several markets at once. Second, rather than relying on a static measure of markup as in Goldberg-Knetter, we incorporate livestock inventories into the markup parameterization. Doing so will allow us to examine if markups have changed over time and in what importing nations and how much those changes are due, if at all, to underlying inventories. Then, we also examine the question of U.S. market dominance using a model of revealed comparative advantage (RCA) based upon a model first proposed by Balassa (1977) and reformulated in Balassa (1986). The RCA analysis is used frequently when looking for changes in a country's trade status (see for example the research of and references in Bojnec and Ferto; Gorton, Davidova and Ratinger; Kuldilok, Dawson and Lindgard; Sarker and Ratnasena, and Zheng and Qi).

The above two approaches allow us to look for commonalities that have influenced U.S. export markets for beef over time. It must be remembered that trade, especially in animal-derived products, often is impacted by shocks from trade agreements and phytosanitary emergencies. The result is that exports can change dramatically. The BSE discovery in December 2003 is a pertinent example. From January 2004 through approximately April 2007, U.S. beef trade with many countries vanished (figures 1a and 1b), was restricted, or was intermittent. Even when such dramatic events do not occur, as figure 1 shows, there are months where trade contracts or expands significantly. Not shown are the equivalent trade flows of the countries competing with the United States who experience similar changes.

To ascertain the state of U.S. price leadership or comparative advantage, we argue that it is best to exclude outliers such as disease or other events that cause periods for which important exporters are out of the market. We construct a measure of market "averages" based upon a simulation of the market. In other words, to answer the general question of whether U.S. export competitiveness has changed, we must presume that the U.S. is always involved in its major export markets and its prices are being affected by the "normal" market movements just like all of its competitors. Upon estimating the PM and RCA models, we then use the estimated models to predict what measures of markup and comparative advantage might have been. We can then compare all observations over the time period of our study and compare exporters and importers "as if" they had been present throughout the period.

With these simulations in hand we then look for whether there has been any change over the time period of our analysis. We do this through inspection of the estimated PM and RCA variables as well as through the use of breakpoint tests.

The models.

The two main models utilized in this analysis: 1) a price-markup (PM) model and a 2) revealed comparative advantage (RCA) model.

1. *The price markup model (PM).*

The first model is based upon the founding work of Goldberg and Knetter, and to a lesser extent, Knetter, who examined trade models that could reveal whether there were price markups by exporters over and above the exporters' marginal costs (e.g. "market power"). In this model, such price markups reveal themselves through parameterization. In the original Goldberg-Knetter and Knetter models, that parameterization was static. In our analysis we want to know whether this markup measure varies with changes in underlying stocks.

The original analysis has been used often enough to refer the reader to the derivation of the estimating equation (p. 41 of Goldberg and Knetter). The theoretical model begins like many new empirical industrial organization (NEIO) techniques as a first-order condition from an exporter's profit maximization problem. The benefit of the Goldberg-Knetter framework is that it explicitly models the case of exporters and can take into account underlying costs of production and marketing and, importantly, exchange rate changes. As such, the model is very useful to our specific research questions. In the model, the exporter and/or its trade competitors may act either perfectly or imperfectly competitive and the extent of that competitive action is parameterized in the estimation. The final estimating equation that is derived is of the following form:

$$(1) \qquad \ln P_{ijt} = a_{ij} + L(q_{ij}, S_{j,t-k}; s_{ij}) \ln Q_{ijt} + \sum_j e_{ij} \ln X_{ijt} + \ln C_{ijt}{}' \beta_{ij} + \varepsilon_{ijt}$$

In equation (1), P_{ijt} is the price of beef in US dollars imported by country i from exporter country j in month t. Likewise, Q_{ijt} is the quantity of the associated exported beef. X_{ijt} is the exchange rate of all of the j competing export countries who are selling into market i, calculated in terms of "currency i/currency j" and normalized for all currencies to one at observation one. C_{ijt} is a vector of cost shifters. "ln" designates the natural logarithm, which is required by the Goldberg-Knetter equation for the price, quantity, exchange rates, and cost-related variables.

In the original Goldberg-Knetter formulation, the function we denote $L(q_{ij}, S_{j,t-k}; s_{ij})$ is a single parameter, in other words, an average level of inverse price elasticity known as the Lerner index. However, in our formulation, we will use a dynamic formulation of this markup by estimating not a single parameter, but a function $L(q_{ij},S_{j,t-k;}\ s_j)$, which can change over time. In this Lerner function, $S_{j,t-k}$ is a vector of lagged stocks of cattle supplies in country j. This is of importance because changes to future cattle supplies come about through holding out part of each year's female stock as breeding stock. The decision to increase or decrease the breeding stock then affects future inventories. The estimated parameters in equation (1) are two constants, a_{ij} and q_{ij}; slope parameters, e_{ij} and β_{ij}, and an error term, ε_{ijt}, which is presumed correlated among the j equations per import nation, i. In the model, quantity is presumed endogenous. Taken together, the inclusion of the nonlinear Lerner function, the correlation of the error terms, and the endogeneity of the quantity requires estimation of equation (1) as a system using nonlinear, three-stage least squares.

If a non-competitive advantage exists, then there are price markups above cost. In this case, the Lerner function will be negative and significant; whereas, positive or statistically insignificant values of the Lerner function fail to reject a competitive market situation. Although the model implicitly treats a country's beef export industry as if it were a firm, recall that one goal of the research is ascertaining whether the United States has now or has had in the past any dominant trade status, which can include either price-setting behavior or other forms of market power. If the U.S. exporters as a group or a large enough exporter singly has had such ability (and recall the concentration in the beef packing industry is quite high), the estimation should discern some degree of market power. Whether this is price leadership (Stackleberg) or simple oligopoly is immaterial since we are interested in the degree of any such power in aggregate (if significant market power is discovered, future research can distinguish among cartel, dominant-firm and simple oligopoly behavior, see Carter and MacLaren). As Knetter (p. 202) notes in his own work using aggregate trade data, “The use of industry rather than firm data also raises aggregation issues. If there is more than one firm in the export sector, there are two scenarios under which aggregation is exact: (1) the exporters collude so that industry behavior is equivalent to what would result from a single monopolist or (2) firms’ products are sufficiently different or destination markets are divided between firms such that no significant strategic interaction occurs within the export sector in foreign markets. In other cases, the data can be thought of as characterizing the behavior of a representative firm.” We note that other researchers have proceeded using the Goldberg-Knetter method in the presence of aggregate data (see Felt, Gervais and Larue; Reed and Saghaian).

The revealed comparative advantage model (RCA).

Market power is only one measure of competitive advantage for a nation. In the revealed comparative advantage formulation (RCA) of Balassa, we construct a model that shows how each exporter’s trade-weighted share of the export market has changed over time and correlate it with similar variables as in model (1):

$$(2) \qquad \ln RCA_{ijt} = a_{ij} + S_{j,t-k}{}' s_{ij} + \sum_j e_{ij} \ln X_{ijt} + \ln C_{ijt}{}' \beta_{ij} + \varepsilon_{ijt}$$

Revealed comparative advantage is used as an empirical proxy for Ricardian comparative advantage. The formulation underlying the dependent variable in equation (2) that we shall adopt is that RCA_{ijt} is industry specific, rather than a measure of comparative advantage across all of an exporter nation's traded goods. RCA_{ijt} is the proportion of exporter country *j*'s beef into importer country *i* as a ratio of the proportion of country *j*'s beef in the other main U.S. export destinations. The dependent variable of equation (2) is given in equation (3) where M_{ijt} is the total value (in U.S. dollars) of the meat product exported by country *j* and imported by country *i*.

(3) $$\ln RCA_{ijt} = \ln\left(M_{ijt} / \sum_{i} M_{ijt} \right) - \ln\left(\sum_{j} M_{ijt} / \sum_{i}\sum_{j} M_{ijt} \right)$$

Notice that we are specifically looking for comparative advantages in the most important U.S. meat beef export markets, which arguably biases the study toward finding a U.S. comparative advantage. As constructed, $RCA_{ijt} > 1$ ($\ln RCA_{ijt} > 0$) means that exporter *j* has a comparative advantage over the other exporters in country *i* relative to *j*'s exports to all of the major importing nations. Unlike equation (1), quantities are already encompassed on the dependent variable, so all of the variables on the right of equation (2) are taken as independent, and the model is estimated as a seemingly unrelated (linear) regression system with correlated errors over each destination market, *i*.

Once equations (1) and (2) are estimated, we also perform a series of breakpoint tests to determine, statistically, whether either the predicted Lerner functions or the predicted RCA variables had significant structural shifts during the time period. The identification of regimes in Lerner functions and revealed comparative advantage is not common in the literature. In the literature, these measures have usually been analyzed over a determinate period of time from which the data series are extracted. However, given different market conditions affect these measures at different times, there is a need to characterize data periods to better understand how the U.S.'s position may have changed.

Data.

Based upon examination of trade flows from 1994 to 2015, we chose the eight largest importers of U.S. beef for our analysis.[1] In these eight foreign markets, the U.S. faced a total of eleven major export competitors. Table 1 provides a matrix of the nations examined. The top row shows the 8 major importers of beef. The left column shows the 11 major export competitors along with the U.S. The numbers where the intersection of the importer with the exporter occur show the average monthly metric tons shipped from 1997 to 2015 and thus also show major trading partners. Australia, New Zealand and the United States have shipped to every one of the eight importers. Other exporters supply one or two markets alone.

To save space, many tables have been placed in an online appendix [Provided at the end of this document for the editor and reviewers.]. Appendix Table 1 provides basic statistics. For the price variables in equation (1), we used the monthly value of exports (V) divided by the quantity of exports (T) converted into pounds to derive a dollar per pound price of exports.[2] Quantities are converted into pounds and price per pound is derived by dividing the value by the quantity.[3] One concern here is whether using these export unit values as prices is problematic as beef is exported not as an aggregate commodity but with differentiation. The issue also becomes one of limited data. While the U.S. has available less aggregated data series many of the other export nations in the model do not. We performed a series of vector autoregression (VAR) estimations that compared disaggregated U.S. prices with the export unit values in the various

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[1] We included China in this analysis, which has not recently been a major importer of U.S. fresh beef but does have a significant frozen beef presence and is a major destination of U.S. export competitors.

[2] For example, in Appendix Table 1, the value of product shipped to Hong Kong from Canada is given under the variable name "V_HK_Can" and the tonnage shipped is denoted "T_HK_Can."

[3] In the RCA models, because we cannot divide by zero, we convert tonnage when there is no value from zero to 0.001. This does not impact the value, but does allow for missing observations to be replaced by no value of exports.

import markets to see if the series differed greatly. We concluded that no significant pattern of discord could be determined. While not conclusive and while limited only to the U.S. data that were available, the tests were worthwhile in allowing us to feel some level of confidence that the export unit values at least acted no differently (in terms of their time series properties) than other beef prices over this period. A complete discussion of the test results is provided in an online appendix [and to the reviewers and editor at the end of this document].

The PM model requires measures of marginal cost. We proxy these with the consumer price index for each exporting nation (e.g. "CPI_Ind" is the monthly CPI for India), normalized to one for January 1994 for all currencies, and the corn futures price, "Corn," which is identical for each exporter. We include a simple linear trend (equal to 1 on January 1994) and its square to account for both unobserved cost changes and unobserved changes in industry structure. The major mergers and changes to concentration occurred mostly prior to our earliest observation (1994) and Crespi, Xia and Jones note that in the United States changes in the number of processing facilities throughout the 1990s and 2000s was mostly linear. Further, since we do not have measures of industry structure for countries other than the United States, we use the trends in part to measure trend changes in industry structure while recognizing its limitations. The PM formulation requires the inclusion of exchange rates which are denoted in Appendix Table 1 with X (e.g. "X_SK_NZ" is the South Korean won to the New Zealand dollar monthly average exchange rate; all exchange rates are in importer currency divided by exporter currency). Because of the inclusion of the exchange rates and exporter CPI on the right hand side of the equation, as in Goldberg and Knetter, the dependent-variable prices are neither deflated nor changed into the importer's currency.

The final variables used in the PM and RCA model are the stocking variables. Both Rosen, Murphy and Scheinkman and Crespi, Xia and Jones determined that the key lags in cattle production were one-year and three-year lags. Also following both of these models, we proxy for the breeding stock by subtracting each exporters' total head slaughtered from total domestic head. For the United States the data are derived from USDA National Agricultural Statistics reports. For the other exporters in our study we chose, for consistency, to use FAO annual reports to derive the stocking numbers. Figure 2 shows the cyclic nature of the U.S. cattle inventories (total head, cattle and calf, slaughtered from the total head of cattle in the U.S.) on January 1.

Results for the PM Model.

After each stock calculation is made, its one-year and three-year lag are used in the Lerner formulation for each exporter as follows $L\left(q_{ij}, S_{j,t-k;}s_j\right) = q_{ij} + s_{1ij}S_{j,t-1} + s_{2ij}S_{j,t-3}$. We put no further restrictions on the Lerner function, choosing to leave it as linear in the stocking lags. In this way we do not impose competitive or non-competitive behavior in the model and let the data speak for itself. Because quantity of beef exports is endogenous, we also include cattle inventory lagged two years along with the other right hand side variables as instruments.

Appendix Tables 2 through 9 present the results of the nonlinear, three-stage least squares estimations of the PM models. Each table represents a single import market. Because of the many observations of no trade from one or more of the significant trade partners, we only include months for which the main exporters were all involved. Although unbalanced panel techniques exist, our goal is to predict what the Lerner index was while ignoring shocks such as the BSE import restrictions when the U.S. was out of a market. We do this for all exporters so that whenever a major exporter is out of a market, the observations are dropped in that market for all exporters. As can be seen in the number of observations reported in the tables, although our data is from 1994 to 2015, this resulted in a range of observations from a low of 45 useful months in the South Korean import models to a high of 252 months of observations in the Canadian beef import models. The eight systems shown in Appendix Tables 2 through 9 have the same sets of variables and all have fairly large adjusted R-square values suggesting the fit of the models is good. The variables “L-Constant”, “L-Stock-lag 1” and “L-Stock-lag 3” are the three parameters that are derived from the Lerner function shown above. For the most part, exchange rates, the price indices and the trend terms have significant roles to play in the models’ overall fit. The components of the Lerner functions are less often significant suggesting that while the cattle cycle was important in determining the prices of fed cattle (Crespi, Xia and Jones), in an international export market, they appear to have less impact. Or, more specifically, seem to have less impact in some markets than others. For example, cattle inventories seem to play an important role for New Zealand’s market power whereas any market power the U.S. garners seems to be impacted by specific cattle stock lags only in Canada, China and Hong Kong.

The importance of the components of the Lerner functions vary from model to model. In Table 2, we have calculated the Lerner value for each of the models using the data on cattle stocks in our full sample from January 1994 to December 2015 (264 monthly observations). This predicts what the Lerner value might have been had all of the exporters been in all of the markets over these dates. Recall, under the Goldberg-Knetter framework, a Lerner value that is insignificant or positive means that we cannot reject a null hypothesis of a competitive market. In many of the cases in Table 2, there is no rejection of a competitive market. Indeed, although 60 percent of the markets have the requisite negative sign to indicate that the price in the export market was higher than marginal cost, the overall average value of the Lerner index is quite small at -0.03. The greatest value for market power occurs for Australia selling into the Hong Kong market (-0.46 on average). By comparison, the United States in the Hong Kong market is a mere 0.06: a competitive residual follower. In only two markets would the U.S. be considered dominant in terms of the size of the Lerner function. One of these is the Philippines (-0.35) which has a long history of U.S. special relationships given the large U.S. military presence. The U.S. has the second highest Lerner index in Japan (where Canada has the highest average).

Next we turn to a presentation of the U.S. Lerner indices over time where the impact of the lagged stock variables can be more clearly seen in Figure 3. The U.S. presence in the Mexican, Canadian and Hong Kong import markets are excluded in Figure 3 because at no time was the U.S.'s predicted Lerner for these markets the requisite negative sign for an imperfectly competitive market. Turning to the markets where some price markups might exist for the U.S., we see the impact of the ebbs and flows of cattle supplies most prominently in the Philippines and China and, of these, only in China does it appear that U.S. market power has increased over time. Japan and Taiwan are nearly identical and constant at between -0.1 and -0.15 and South Korea has not changed much from a very small -0.05 over the period. In other words, with the exception of China, any market power for the U.S. is similar to what it has always been in these markets and a good argument could be made that this "power" has never been very much. By these measures, we would conclude that the U.S. export market for beef is any more or less competitive today than it has been since at least the mid-1990s when our data began. With this in mind, we now turn to a more general estimation of competitiveness.

Results of the RCA Model.

Finding little to no market power for the U.S. exports of beef, we now estimate equation (2), the RCA model, to determine how U.S. market comparative advantage has changed. As discussed, these estimates are seemingly unrelated, linear regressions. Like the PM regressions, we will use the estimates over the observations we have and then estimate what the RCA values might have been over the 1994 to 2015 sample period. Appendix Tables 10 through 17 present the results of the SUR models for each import market. Overall fit for each model based upon the adjusted R-square is lower, in some cases much lower, than those of the PM models. We conclude that the independent variables were much less useful in the RCA models as correlates than they were in the PM models. This likely has a lot to do with the fact that quantity exported is a very good predictor of prices in the PM model, but the other variables have no similar known theoretical connection with RCA, thus the poorer fit is not surprising. Table 3 is the counterpart to Table 2 in the previous section and presents the estimates of the predicted value of the dependent variable *lnRCA* from the model. If *lnRCA* is equal to 0 (*RCA*=1), then a nation is deemed to have no more or no less of a comparative advantage than its export competitors. Table 3 shows that the average for all exporters from the models' predictions of the period 1994 to 2015 was -0.19 with a standard deviation of 1.34: not significantly different from zero. In other words, the overall average showed no comparative advantage when taken all together. Values above zero indicate a greater comparative advantage and what Table 3 reveals is the highest comparative advantage appears to be for the U.S. in the South Korean market. This must be taken with circumspection because the regressions for the South Korean market used only 45 of the observations due to excessive market closures and, as will be shown in figure 4 are wildly large in the early part of the data, which corresponds with much of the out-of-sample predictions. Our best guess is that *lnRCA* for South Korea reflects an out-of-sample irregularity.

In the case of the PM models, the lagged cattle stock variables were only singly significant for the U.S. in 3 of the eight models (Canada, China and Hong Kong). In the RCA models, these variables were significant for the U.S. in six of the eight systems (Canada, Hong Kong, Japan, the Philippines, South Korea and Taiwan). Thus while the cattle cycle may not be impacting market power, at least for the United States, it does seem to impact the U.S. comparative advantage. Figure 4 shows the *lnRCA* predictions for the US over the period. Most notable, as discussed, is the very large South Korea predictions in the early sample due to the out-of-sample errors. Ignoring South Korea in the early observations, what Figure 4 shows is that the U.S. comparative advantage in most cases is near to or seems to be returning to a trajectory near *lnRCA* of zero. That this is a story that is consistent with the Lerner simulations of the previous section is telling. Low to no market power complements the findings of competitive measures for comparative advantage. Even in the obvious outlier cases of China, the Philippines and South Korea in figure 4, notice that from about 2005 to 2015 the convergence to no comparative advantage is a movement from a much less competitive position for the U.S. These would only be in conflict with the findings of the Lerner formulations if we could assert that the U.S. had significant market power in the export markets. Instead, the movement over time toward a competitive market in the RCA model is consistent with low values for the Lerner indices in these markets, especially in more recent years.

What these two models indicate is that the null hypothesis that the U.S. is just as competitive today as it has been in the past (at least back to 1994), cannot be easily rejected. The evidence would seem to suggest that today's U.S. beef export market is as competitive for the U.S. as it has even been, with uncertainty over any conclusion for China, the Philippines and South Korea. And as to the inclusion of variables that take the cattle cycle into account, what the two methods show is that the cattle cycle, for the most part, had little impact on market power in the export market, but did seem to impact overall competition as measured by RCA.

Tests for breakpoints in the PM and RCA models.

A frequently used method of analyzing time series data is to test for structural breaks in the data and examine differences in models before and after an event. A structural break can be defined as an event (or events) that caused a significant change in a model's regression parameters. Bai and Perron's (BP; 1998, 2003) procedure is used to estimate structural breaks among the RCA and Lerner predicted values over dates spanning January 1994 through December 2015. This analysis investigates structural changes in the mean process of each series.

We allowed up to five breaks (6 regimes) in the monthly estimates of the Lerner indices and *lnRCA* values from January 1994 to December 2015 using a 15% trimming rate that results in each regime having at least 39 monthly observations.[4] We think that structural changes in these measures are largely driven by supply and demand shocks and exchange rates, therefore this three-plus year period of time would provide enough time for those factors to interact and reveal a new equilibrium.

Results suggest a different number of breaks, at different dates, in each series for each measure. Appendix Table 18 shows estimated break dates and summary statistics in the full period of time and in individual regimes for each Lerner function. Appendix Table 19 shows these results for the (logged) RCA values.

For the Lerner values, the Bai and Perron (BP) test identified a total number of 3 breaks (4 regimes) in exports to South Korea and Taiwan, 2 breaks (3 regimes) in exports to Canada,

[4] For the South Korea data, Bai and Perron's (1998, 2003) procedure was used over dates spanning January 2000 through December 2015.

China, Japan, Mexico, and the Philippines, and no breaks (1 regime) in exports to Hong Kong. Recall, under the Goldberg-Knetter framework, a Lerner value that is insignificant or positive means that we cannot reject a null hypothesis of a competitive market. Full period and individual regimes are positive for Canada, Hong Kong and Mexico. Ignoring these, leaves China, Japan, Philippines, South Korea, and Taiwan with the requisite negative signs over the full period and individual regimes. That the greatest number of breaks happened for South Korea and Taiwan is interesting in that both of these export markets' Lerner indices (see figure 3) have been fairly stable and not large. Combining this observation with the results that the other series had fewer breaks provides evidence that even if the changes in regimes are statistically significant, they do not appear to be economically significant.

For the RCA values, the BP test identified a total number of 5 breaks (6 regimes) in exports to Taiwan, 3 breaks (4 regimes) in exports to Canada, China, Philippines, 2 breaks (3 regimes) in exports to South Korea, 1 break (2 regimes) in exports to Hong Kong, and no breaks (1 regime) in exports to Japan and Mexico. Recall, if *lnRCA* is equal to 0 (*RCA*=1), then a nation is deemed to have no more or no less of a comparative advantage than its export competitors. The RCA values are quite small and as a general rule have moved closer to 0 over time (figure 4).

The structural break tests do not indicate any notable changes that can be distinguished, either for the Lerner indices or the RCA values. Individual markets have seen some movements in these values over time, as evidence by the graphs, although the changes in the values do not suggest any significant changes to competitive pricing. Regime values are comparable to one another and comparable to full period values.

Conclusion.

The main objective of this research was to examine whether the U.S. export markets for beef are significantly different today than they were in the past, specifically in the last two decades. We also wanted to know whether the underlying biological cycle of cattle stocks had any impact on this question. We set up for ourselves three specific questions to try and reach a general conclusion and approached the questions using a variety of tools. We used a price markup (PM) model based upon Goldberg and Knetter's export analysis. We used a revealed comparative advantage (RCA) model based on the work of Balassa. We tested for structural breaks that might suggest that the results predicted from these modeling approaches had significant changes over time. All three approaches revealed similarities.

To the question of, "Is the U.S. now or was it at any time a price leader in important export markets for beef?" we find no support for any significant market power outside of the market for the Philippines and for China and in both of these cases, the market power is small. And in the case of the Philippines, it is declining. To the question, "Does the U.S. now or has it had in the past a comparative advantage in export markets for beef?" only in South Korea might one make this claim and the large comparative advantage twenty years ago appears more likely to be the result of outlier problems from an out-of-sample forecast. In some import markets, it seems that comparative disadvantages for the U.S. are vanishing over time and in nearly all cases it would appear that the U.S. comparative advantage today could be classified "competitive" and we would add not much different than it was 30 years ago. To the question of, "Has the underlying biological cycle of cattle impacted the pricing or competitiveness of U.S. beef?" the Lerner indices indicate that in at least three markets the cattle stocks move the markup, but in the other cases, there was either no market power (Canada, Mexico, Hong Kong), or very little to begin with (Japan, South Korea, Taiwan) and the stocks had only marginal impacts. To consider the known structural event of BSE, we looked at our models in three ways. First, we estimated the PM and RCA models only over observations where all major exporters, including the U.S., were trading. Then we used the estimated models to forecast what the market might have looked like had over the missing observations. Next, we subjected these forecasted values to structural break-point tests to see if events such as the discovery of BSE in the United States did significantly affect them. In all of these tests we could not fail to reject a hypothesis that the U.S. export market today, long after the BSE event, is similar to what it was long before the event or that U.S. domestic prices for either the unit values or the less aggregated series are different than export prices, a suggestion that the law of one price is holding. The combination of the diverse battery of analyses to answer all of these questions, leads us to the conclusion that, as far as beef prices are concerned, the U.S. export markets are competitive and (mostly) uninfluenced by underlying cattle inventory decisions.

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Figure 1a.

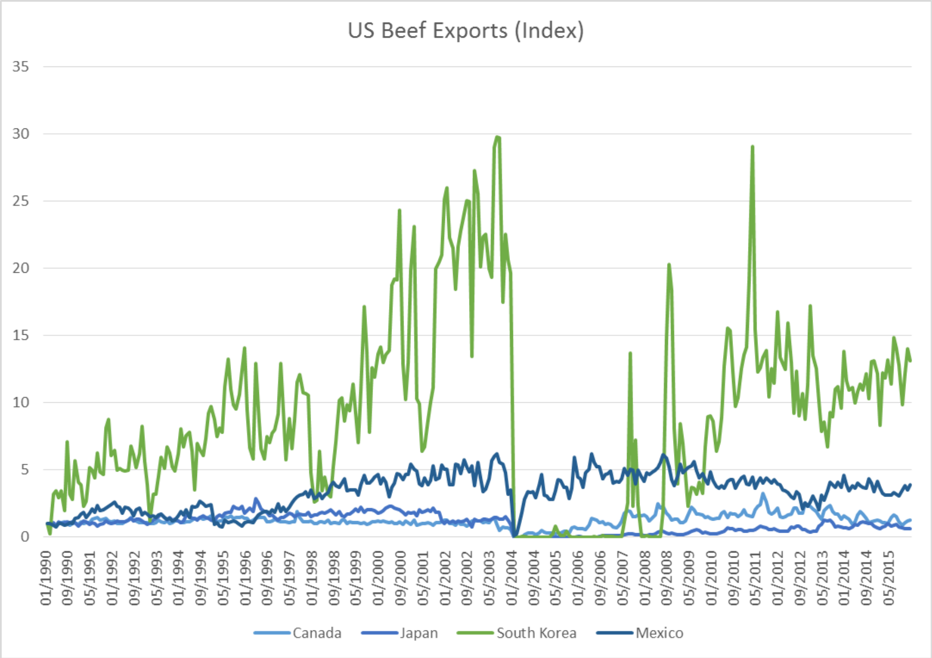

Figure 1b.

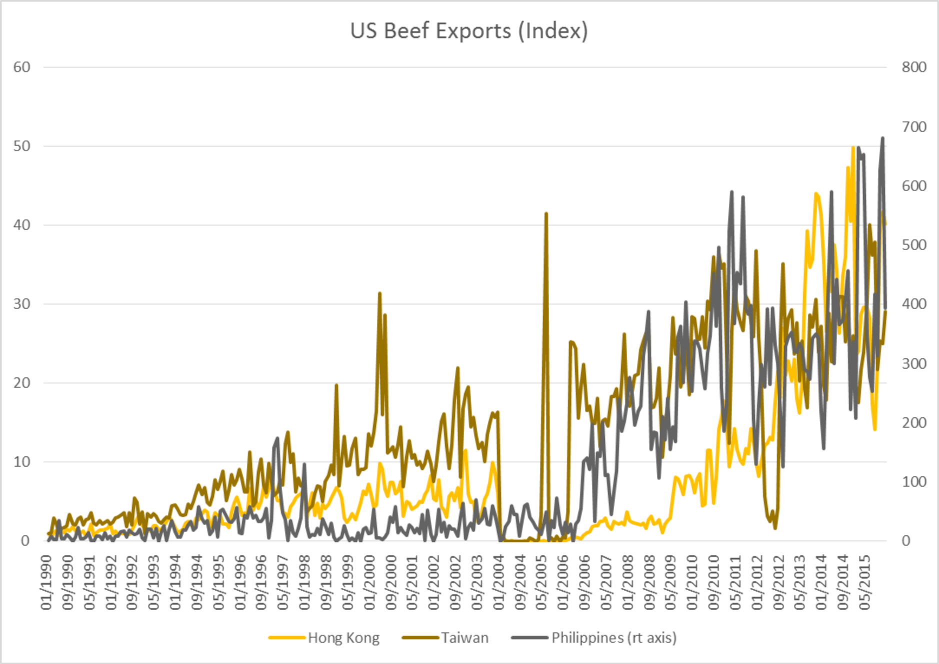

Figure 1. US Exports to Selected Nations. (January 1990=1.00.)

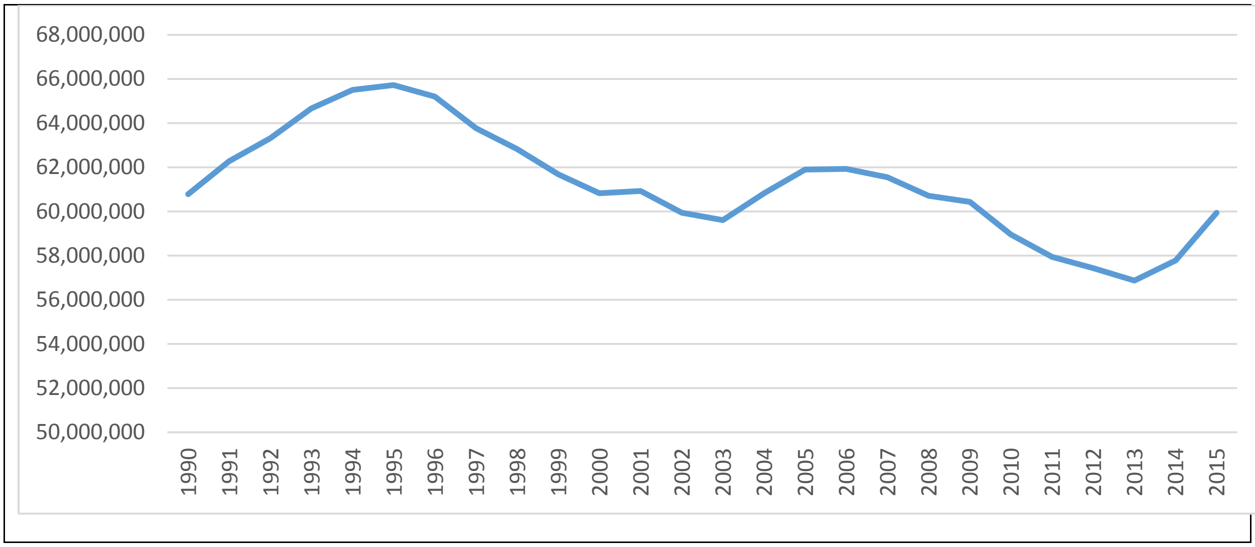

Figure 2. US Annual Inventory of Cattle (Head minus Head Slaughtered).

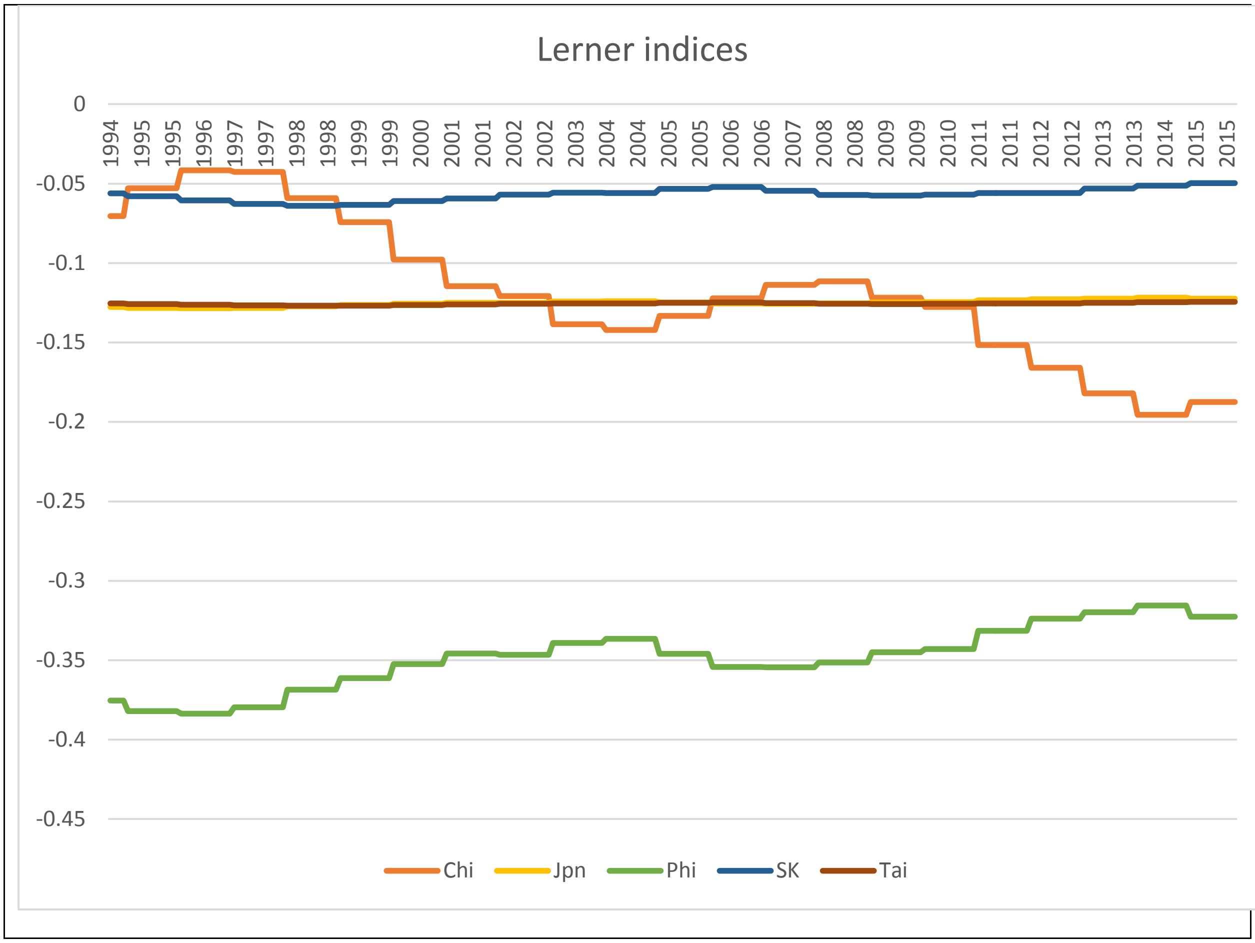

Figure 3. Simulated Lerner Indices for the United States, 1994-2015.

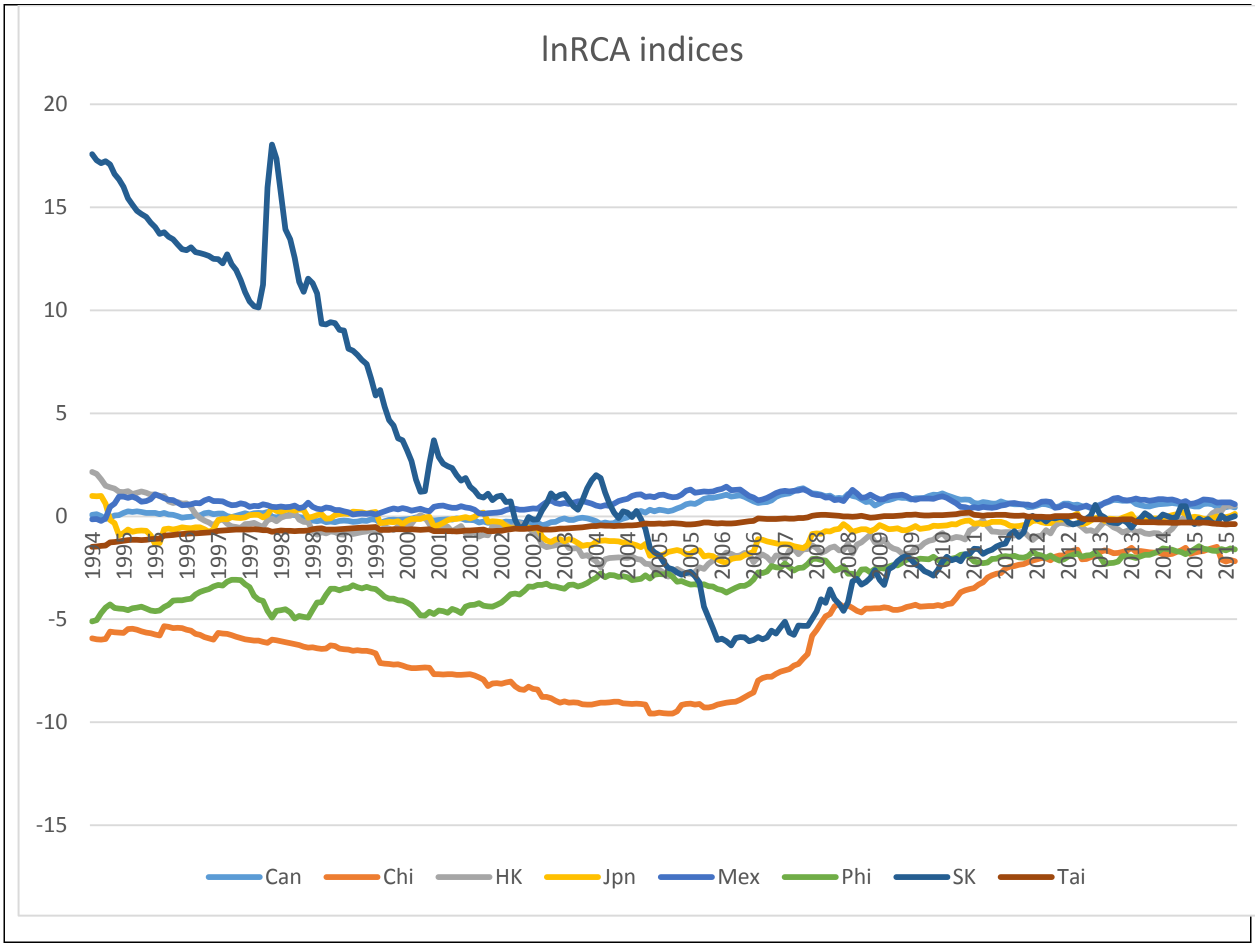

Figure 4. Simulated lnRCA Indices for the United States, 1994-2015.

Table 1. Average Monthly Metric Tons of Beef, 1997-2015.

	IMPORTERS								
EXPORTERS	Canada	China	Hong Kong	Japan	Mexico	Phillip-pines	South Korea	Tai-wan	Total
Argen-tina		2,412	2,258						4,670
Australia	2,354	253	1,547	28,976	440	1,460	10,523	2,789	48,342
Brazil		3,607	12,459			1,066			17,132
Canada			778	1,088	3,067	119	367	171	5,590
India						3,905			3,905
Mexico				675			160		835
New Zealand	2,593	19	665	2,412	271	419	2,482	1,651	10,512
Nicar-agua					106				106
Panama								79	79
Paraguay		2,482							2,482
United States	7,609	194	3,171	17,123	20,686	285	7,772	1,651	58,489
Uruguay	1,239	749							1,988
Total	13,795	9,715	20,878	50,274	24,570	7,253	21,304	6,341	154,131

Source: Author calculations from USDA provided data.

Table 2. Estimated Lerner Indices 1994-2015.

Importer	Exporter	Mean	Std Dev	Lower 95%	Upper 95%
Canada	Argentina	-0.1057	0.0013	-0.1058	-0.1055
	New Zealand	-0.0352	0.0010	-0.0353	-0.0350
	USA	0.0265	0.0014	0.0263	0.0267
China	Argentina	-0.1095	0.0010	-0.1097	-0.1094
	Brazil	-0.3639	0.0302	-0.3675	-0.3602
	USA	-0.1167	0.0446	-0.1221	-0.1113
	Uruguay	0.0572	0.0027	0.0569	0.0576
Hong Kong	Argentina	0.1495	0.0041	0.1490	0.1500
	Australia	-0.4634	0.0087	-0.4644	-0.4623
	Brazil	0.0827	0.0045	0.0821	0.0832
	Canada	0.0930	0.0064	0.0922	0.0938
	New Zealand	-0.1455	0.0008	-0.1456	-0.1454
	USA	0.0619	0.0328	0.0579	0.0659
Japan	Australia	0.0614	0.0015	0.0612	0.0615
	Canada	-0.1456	0.0094	-0.1467	-0.1444
	Mexico	-0.0071	0.0020	-0.0074	-0.0069
	New Zealand	-0.0595	0.0026	-0.0598	-0.0592
	USA	-0.1251	0.0019	-0.1254	-0.1249
Mexico	Australia	0.0162	0.0057	0.0155	0.0169
	Canada	0.0883	0.0058	0.0876	0.0890
	New Zealand	0.0638	0.0186	0.0616	0.0661
	Nicaragua	0.1535	0.0158	0.1516	0.1554
	USA	0.0654	0.0033	0.0650	0.0658
Philippines	Australia	-0.0946	0.0070	-0.0955	-0.0938
	Brazil	-0.0201	0.0033	-0.0205	-0.0197
	Canada	0.2069	0.0097	0.2057	0.2081
	India	-0.1134	0.0017	-0.1137	-0.1132
	New Zealand	0.1135	0.0080	0.1125	0.1145
	USA	-0.3490	0.0196	-0.3514	-0.3466
South Korea	Australia	0.0101	0.0067	0.0093	0.0109
	Canada	-0.0613	0.0672	-0.0695	-0.0532
	Mexico	0.3289	0.0430	0.3237	0.3342
	New Zealand	-0.0971	0.0078	-0.0980	-0.0961
	USA	-0.0568	0.0038	-0.0573	-0.0564
Taiwan	Australia	-0.2152	0.0011	-0.2153	-0.2151
	New Zealand	0.0795	0.0036	0.0791	0.0800
	USA	-0.1256	0.0006	-0.1257	-0.1255
	average	-0.0311	0.0105	-0.0324	-0.0299
	max	0.3289	0.0672	0.3237	0.3342
	min	-0.4634	0.0006	-0.4644	-0.4623

Table 3. Estimated lnRCA Indices 1994-2015.

Importer	Exporter	Mean	Std Dev	Minimum	Maximum
Canada	Argentina	-0.9748	0.8229	-2.5241	0.4372
	New Zealand	0.8000	0.4687	0.0502	1.6183
	USA	0.3182	0.4500	-0.4392	1.3538
China	Argentina	2.3623	0.4592	1.1865	3.1805
	Brazil	0.8356	1.3899	-1.6988	4.8172
	USA	-5.7544	2.5067	-9.5802	-1.4884
	Uruguay	2.4491	0.6481	0.4177	4.7653
Hong Kong	Argentina	1.5388	0.7409	-0.9966	3.5849
	Australia	-1.0958	0.4905	-1.6990	0.9217
	Brazil	2.3990	0.7814	1.1395	4.0914
	Canada	0.1126	0.6504	-1.3096	2.9374
	New Zealand	0.1332	0.9407	-1.1574	2.2989
	USA	-0.7245	1.1196	-2.9313	3.1913
Japan	Australia	0.4111	0.2498	-0.4093	0.6795
	Canada	-0.4110	1.5730	-3.3514	5.4953
	Mexico	0.8029	0.2479	0.3135	1.3209
	New Zealand	-0.3682	0.3369	-0.8697	0.1773
	USA	-0.4957	0.6950	-2.2601	1.2354
Mexico	Australia	-3.7176	0.4542	-4.8089	-2.5686
	Canada	0.7498	1.0577	-2.7056	1.6634
	New Zealand	-2.9068	0.7674	-4.9337	-1.2731
	Nicaragua	2.0231	0.3006	1.5890	2.6036
	USA	0.6454	0.3412	-0.2432	1.4334
Philippines	Australia	0.0022	1.6592	-2.7782	4.8571
	Brazil	-0.0246	1.1791	-4.2672	2.1550
	Canada	-1.7837	0.6251	-3.3968	-0.2568
	India	4.1307	0.3839	3.5662	5.0853
	New Zealand	-0.0875	0.9252	-1.8104	1.6268
	USA	-3.1883	1.1521	-8.3291	-1.3806
South Korea	Australia	-0.7510	1.8978	-4.9426	1.0050
	Canada	-7.1350	12.0987	-36.0213	9.5139
	Mexico	-1.6307	3.1771	-10.2313	8.3370
	New Zealand	-0.0336	0.9354	-2.5051	1.9089
	USA	2.8281	6.9809	-6.2637	19.5098
Taiwan	Australia	0.3292	0.3716	-0.3261	1.3730
	New Zealand	1.3672	0.2329	0.9486	1.7930
	USA	-0.4494	0.4051	-1.6351	0.1780
	average	-0.1971	1.3383	-3.1139	2.6536
	max	4.1307	12.0987	3.5662	19.5098
	min	-7.1350	0.2329	-36.0213	-2.5686

Online Appendices Follow.

Appendix Table 1. Summary of Data Used in PM and RCA Models.

Variable	N	Mean	Std Dev	Description	Time	Source
Corn_Fut	312	3.3	1.5	Corn futures ($/Bu)	Monthly	CME
CPI_Arg	264	2.0	1.1	CPI (1/1994=1.00)	Monthly	IMF-IFS
CPI_Aus	264	1.4	0.2	CPI (1/1994=1.00)	Monthly	IMF-IFS
CPI_Bra	264	17.0	6.9	CPI (1/1994=1.00)	Monthly	IMF-IFS
CPI_Can	264	1.2	0.2	CPI (1/1994=1.00)	Monthly	IMF-IFS
CPI_Ind	264	2.4	1.0	CPI (1/1994=1.00)	Monthly	IMF-IFS
CPI_Mex	264	4.0	1.5	CPI (1/1994=1.00)	Monthly	IMF-IFS
CPI_Nic	264	3.0	1.5	CPI (1/1994=1.00)	Monthly	IMF-IFS
CPI_NZ	264	1.3	0.2	CPI (1/1994=1.00)	Monthly	IMF-IFS
CPI_Pan	264	1.2	0.2	CPI (1/1994=1.00)	Monthly	IMF-IFS
CPI_Par	264	2.9	1.2	CPI (1/1994=1.00)	Monthly	IMF-IFS
CPI_Uru	264	5.3	2.7	CPI (1/1994=1.00)	Monthly	IMF-IFS
CPI_USA	264	1.3	0.2	CPI (1/1994=1.00)	Monthly	IMF-IFS
HEAD_Arg	26	52,139,525.4	3,675,922.0	Head of cattle	Annual	FAO
HEAD_Aus	26	26,982,069.4	1,738,255.5	Head of cattle	Annual	FAO
HEAD_Bra	26	184,612,401.0	24,398,192.7	Head of cattle	Annual	FAO
HEAD_Can	26	12,950,259.2	1,069,028.2	Head of cattle	Annual	FAO
HEAD_Ind	26	199,635,280.0	8,363,055.6	Head of cattle	Annual	FAO
HEAD_Mex	26	31,318,880.8	921,187.5	Head of cattle	Annual	FAO
HEAD_Nic	26	3,308,659.8	392,831.2	Head of cattle	Annual	FAO
HEAD_NZ	26	9,361,481.4	702,559.8	Head of cattle	Annual	FAO
HEAD_Pan	26	1,520,966.4	123,620.2	Head of cattle	Annual	FAO
HEAD_Par	26	10,501,781.9	2,002,133.9	Head of cattle	Annual	FAO
HEAD_Uru	26	11,055,843.6	1,045,520.3	Head of cattle	Annual	FAO
HEAD_USA	26	96,296,442.0	3,967,602.1	Head of cattle	Annual	USDA
SLT_Arg	26	12,786,588.3	1,439,037.2	Head slaughtered	Annual	FAO
SLT_Aus	26	9,235,886.4	613,400.1	Head slaughtered	Annual	FAO
SLT_Bra	26	33,393,153.8	7,053,449.4	Head slaughtered	Annual	FAO
SLT_Can	26	4,468,062.8	603,288.4	Head slaughtered	Annual	FAO
SLT_Ind	26	9,759,226.5	303,089.9	Head slaughtered	Annual	FAO
SLT_Mex	26	8,444,654.8	1,350,364.8	Head slaughtered	Annual	FAO
SLT_Nic	26	557,198.2	202,731.7	Head slaughtered	Annual	FAO
SLT_NZ	26	3,523,373.8	484,144.7	Head slaughtered	Annual	FAO
SLT_Pan	26	330,369.3	57,097.7	Head slaughtered	Annual	FAO
SLT_Par	26	1,197,666.2	195,202.1	Head slaughtered	Annual	FAO
SLT_Uru	26	2,061,115.7	444,335.1	Head slaughtered	Annual	FAO
SLT_USA	26	33,561,421.2	1,629,685.3	Head slaughtered	Annual	USDA

continued

Appendix Table 1. Summary of Data Used in PM and RCA Models-Continued.

Variable	N	Mean	Std Dev	Description	Time	Source
T_Can_Aus	252	2,392.7	1,995.6	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_Can_NZ	252	2,704.0	1,763.5	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_Can_Uru	252	1,121.4	1,384.0	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_Can_USA	252	7,707.2	2,870.2	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_Chi_Arg	228	2,411.7	1,737.8	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_Chi_Aus	228	253.1	526.5	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_Chi_Bra	228	3,607.1	4,206.6	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_Chi_NZ	228	19.0	43.0	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_Chi_Par	228	2,481.9	2,058.2	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_Chi_Uru	228	749.0	663.2	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_Chi_USA	228	193.6	345.2	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_HK_Arg	228	2,258.2	1,028.2	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_HK_Aus	228	1,546.6	856.6	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_HK_Bra	228	12,458.8	10,026.5	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_HK_Can	228	778.5	741.9	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_HK_NZ	228	664.9	372.8	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_HK_USA	228	3,171.0	3,705.5	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_Jap_Aus	264	28,626.5	6,089.2	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_Jap_Can	264	1,038.5	812.8	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_Jap_Mex	264	583.9	697.3	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_Jap_NZ	264	2,392.6	1,106.3	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_Jap_USA	264	19,112.0	13,859.5	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_Mex_Aus	252	409.0	293.8	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_Mex_Can	252	2,796.1	1,991.7	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_Mex_Nic	252	96.6	140.7	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_Mex_NZ	252	250.0	275.9	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_Mex_USA	252	19,538.6	6,591.3	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_Phi_Aus	228	1,459.6	944.3	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_Phi_Bra	228	1,066.4	1,033.5	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_Phi_Can	228	118.8	190.5	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_Phi_Ind	228	3,905.3	1,453.2	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_Phi_NZ	228	418.7	315.2	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_Phi_USA	228	284.5	287.5	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_SK_Aus	240	10,235.9	4,525.8	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_SK_Can	240	364.4	549.1	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_SK_Mex	240	159.9	215.4	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_SK_NZ	240	2,462.4	1,355.1	Metric Tons of Beef Exported	Monthly	USDA/ERS

continued

Appendix Table 1. Summary of Data Used in PM and RCA Models-Continued.

Variable	**N**	**Mean**	**Std Dev**	**Description**	**Time**	**Source**
T_SK_USA	240	7,704.2	5,772.3	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_Tai_Aus	240	2,754.5	661.7	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_Tai_Can	240	165.0	125.9	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_Tai_NZ	240	1,622.6	781.4	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_Tai_Pan	240	75.4	84.3	Metric Tons of Beef Exported	Monthly	USDA/ERS
T_Tai_USA	240	1,613.1	968.4	Metric Tons of Beef Exported	Monthly	USDA/ERS
V_Can_Aus	252	6,275,836.4	4,598,947.1	Value of Beef Exports ($)	Monthly	USDA/ERS
V_Can_NZ	252	6,968,009.0	3,579,784.0	Value of Beef Exports ($)	Monthly	USDA/ERS
V_Can_Uru	252	2,988,688.7	3,765,207.9	Value of Beef Exports ($)	Monthly	USDA/ERS
V_Can_USA	252	37,251,115.5	25,367,795.5	Value of Beef Exports ($)	Monthly	USDA/ERS
V_Chi_Arg	228	8,603,314.2	6,286,587.2	Value of Beef Exports ($)	Monthly	USDA/ERS
V_Chi_Aus	228	1,510,492.9	3,343,287.4	Value of Beef Exports ($)	Monthly	USDA/ERS
V_Chi_Bra	228	11,071,057.4	11,585,143.6	Value of Beef Exports ($)	Monthly	USDA/ERS
V_Chi_NZ	228	29,932.6	80,977.1	Value of Beef Exports ($)	Monthly	USDA/ERS
V_Chi_Par	228	10,572,971.1	11,574,995.9	Value of Beef Exports ($)	Monthly	USDA/ERS
V_Chi_Uru	228	2,772,156.9	2,757,698.2	Value of Beef Exports ($)	Monthly	USDA/ERS
V_Chi_USA	228	1,151,773.2	2,063,726.4	Value of Beef Exports ($)	Monthly	USDA/ERS
V_HK_Arg	228	4,881,585.5	3,569,286.2	Value of Beef Exports ($)	Monthly	USDA/ERS
V_HK_Aus	228	5,219,471.8	4,239,422.6	Value of Beef Exports ($)	Monthly	USDA/ERS
V_HK_Bra	228	34,800,853.9	38,763,849.8	Value of Beef Exports ($)	Monthly	USDA/ERS
V_HK_Can	228	3,435,749.4	3,874,192.0	Value of Beef Exports ($)	Monthly	USDA/ERS
V_HK_NZ	228	2,436,341.8	1,358,259.7	Value of Beef Exports ($)	Monthly	USDA/ERS
V_HK_USA	228	16,528,849.6	24,467,724.5	Value of Beef Exports ($)	Monthly	USDA/ERS
V_Jap_Aus	264	118,955,424.0	38,785,581.6	Value of Beef Exports ($)	Monthly	USDA/ERS
V_Jap_Can	264	4,666,260.6	3,301,069.5	Value of Beef Exports ($)	Monthly	USDA/ERS
V_Jap_Mex	264	3,095,304.8	3,483,949.7	Value of Beef Exports ($)	Monthly	USDA/ERS
V_Jap_NZ	264	10,725,788.9	5,922,417.8	Value of Beef Exports ($)	Monthly	USDA/ERS
V_Jap_USA	264	100,805,127.0	68,103,267.3	Value of Beef Exports ($)	Monthly	USDA/ERS
V_Mex_Aus	252	713,119.9	524,905.9	Value of Beef Exports ($)	Monthly	USDA/ERS
V_Mex_Can	252	9,659,643.6	6,662,350.5	Value of Beef Exports ($)	Monthly	USDA/ERS
V_Mex_Nic	252	237,716.0	560,794.6	Value of Beef Exports ($)	Monthly	USDA/ERS
V_Mex_NZ	252	443,297.6	521,184.9	Value of Beef Exports ($)	Monthly	USDA/ERS
V_Mex_USA	252	64,256,940.3	24,574,265.7	Value of Beef Exports ($)	Monthly	USDA/ERS
V_Phi_Aus	228	3,247,762.1	3,528,403.3	Value of Beef Exports ($)	Monthly	USDA/ERS
V_Phi_Bra	228	1,441,280.5	1,218,782.9	Value of Beef Exports ($)	Monthly	USDA/ERS
V_Phi_Can	228	141,260.2	257,357.3	Value of Beef Exports ($)	Monthly	USDA/ERS
V_Phi_Ind	228	5,889,726.6	3,059,483.7	Value of Beef Exports ($)	Monthly	USDA/ERS

continued

Appendix Table 1. Summary of Data Used in PM and RCA Models-Continued.

Variable	N	Mean	Std Dev	Description	Time	Source
V_Phi_NZ	228	807,303.9	958,695.0	Value of Beef Exports ($)	Monthly	USDA/ERS
V_Phi_USA	228	540,824.0	722,324.8	Value of Beef Exports ($)	Monthly	USDA/ERS
V_SK_Aus	240	40,729,516.4	27,745,802.9	Value of Beef Exports ($)	Monthly	USDA/ERS
V_SK_Can	240	1,123,362.7	1,623,894.0	Value of Beef Exports ($)	Monthly	USDA/ERS
V_SK_Mex	240	480,482.7	696,172.4	Value of Beef Exports ($)	Monthly	USDA/ERS
V_SK_NZ	240	7,896,495.2	5,093,683.4	Value of Beef Exports ($)	Monthly	USDA/ERS
V_SK_USA	240	33,162,380.6	23,701,231.0	Value of Beef Exports ($)	Monthly	USDA/ERS
V_Tai_Aus	240	11,399,309.8	7,187,109.7	Value of Beef Exports ($)	Monthly	USDA/ERS
V_Tai_Can	240	592,069.5	453,285.7	Value of Beef Exports ($)	Monthly	USDA/ERS
V_Tai_NZ	240	6,928,694.2	4,154,869.6	Value of Beef Exports ($)	Monthly	USDA/ERS
V_Tai_Pan	240	248,922.8	334,900.8	Value of Beef Exports ($)	Monthly	USDA/ERS
V_Tai_USA	240	9,434,481.1	6,518,482.5	Value of Beef Exports ($)	Monthly	USDA/ERS
X_Can_Aus	264	1.0	0.1	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_Can_NZ	264	1.1	0.1	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_Can_Uru	264	0.3	0.2	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_Can_USA	264	1.0	0.1	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_Chi_Arg	264	0.5	0.4	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_Chi_Aus	264	1.0	0.1	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_Chi_Bra	264	0.1	0.1	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_Chi_NZ	264	1.0	0.1	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_Chi_Par	264	0.5	0.2	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_Chi_Uru	264	0.3	0.2	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_Chi_USA	264	0.9	0.1	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_HK_Arg	264	0.5	0.4	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_HK_Aus	264	1.1	0.2	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_HK_Bra	264	0.1	0.1	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_HK_Can	264	1.1	0.2	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_HK_NZ	264	1.2	0.2	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_HK_USA	264	1.0	0.0	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_Jap_Aus	264	1.0	0.1	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_Jap_Can	264	1.0	0.1	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_Jap_Mex	264	0.3	0.1	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_Jap_NZ	264	1.1	0.2	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_Jap_USA	264	1.0	0.1	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_Mex_Aus	264	3.8	1.4	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_Mex_Can	264	3.7	1.3	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_Mex_Nic	264	1.4	0.3	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS

continued

Appendix Table 2. Summary of Data Used in PM and RCA Models-Continued.

Variable	N	Mean	Std Dev	Description	Time	Source
X_Mex_NZ	264	4.0	1.5	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_Mex_USA	264	3.4	0.9	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_Phi_Aus	264	1.7	0.5	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_Phi_Bra	264	0.1	0.1	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_Phi_Can	264	1.7	0.4	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_Phi_Ind	264	1.1	0.2	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_Phi_NZ	264	1.8	0.5	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_Phi_USA	264	1.6	0.3	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_SK_Aus	264	1.5	0.3	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_SK_Can	264	1.4	0.3	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_SK_Mex	264	0.4	0.1	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_SK_NZ	264	1.5	0.3	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_SK_USA	264	1.3	0.2	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_Tai_Aus	264	1.3	0.2	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_Tai_Can	264	1.3	0.2	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_Tai_NZ	264	1.4	0.2	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_Tai_Pan	264	1.2	0.1	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS
X_Tai_USA	264	1.2	0.1	Exchange Rate (1/1994=1.00)	Monthly	IMF-IFS

Appendix Table 2. PM Model-Beef Imports into Canada.

	Australia			New Zealand			USA		
Variable	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat
Intercept	1.009	0.891	1.130	1.597	0.550	2.900	-2.657	0.753	-3.530
L-Constant	-0.086	0.051	-1.700	-0.017	0.033	-0.530	0.058	0.055	1.070
L-Stock-lag 1	-6E-10	1E-09	-0.530	-2E-09	1E-09	-1.420	5E-10	6E-10	0.830
L-Stock-lag 3	-5E-10	8E-10	-0.680	2E-09	1E-09	1.250	-1E-09	6E-10	-1.780
Trend	0.005	0.002	2.990	-8E-05	0.001	-0.100	-0.008	0.002	-3.490
Trend-Sqr	-4E-06	4E-06	-0.990	2E-05	2E-06	6.750	1E-05	4E-06	3.140
X_Can_Aus	-0.706	0.328	-2.160	0.054	0.172	0.310	0.031	0.321	0.100
X_Can_NZ	0.719	0.219	3.280	-0.019	0.110	-0.180	0.167	0.184	0.910
X_Can_USA	-0.357	0.195	-1.840	-0.817	0.097	-8.390	-0.628	0.148	-4.240
CPI	-0.009	0.675	-0.010	-1.393	0.461	-3.020	2.955	0.737	4.010
Corn	-0.001	0.013	-0.040	0.003	0.008	0.360	-0.023	0.012	-1.940
Observations	252			252			252		
Adj R-Sqr	0.879			0.942			0.914		

Appendix Table 3. PM Model-Beef Imports into China.

	Argentina			Brazil			USA		
Variable	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat
Intercept	2.116	0.737	2.870	5.604	1.922	2.920	-5.305	2.537	-2.090
L-Constant	-0.093	0.039	-2.420	-0.088	0.253	-0.350	-1.282	0.515	-2.490
L-Stock-lag 1	-2E-10	5E-10	-0.440	4E-10	1E-09	0.280	1E-08	4E-09	2.870
L-Stock-lag 3	-2E-10	5E-10	-0.380	-2E-09	1E-09	-2.140	6E-09	8E-09	0.830
Trend	-0.001	0.005	-0.230	1E-04	0.009	0.010	-0.013	0.016	-0.780
Trend-Sqr	9E-06	2E-05	0.580	1E-04	5E-05	2.450	4E-05	4E-05	1.210
X_CH_ARG	0.233	0.114	2.040	1.008	0.401	2.510	-0.052	0.290	-0.180
X_CH_BRZ	0.471	0.162	2.910	0.138	0.714	0.190	0.453	0.463	0.980
X_CH_USA	-2.858	0.940	-3.040	-6.434	3.084	-2.090	-2.835	3.275	-0.870
X_CH_URU	-0.485	0.258	-1.880	-0.356	0.912	-0.390	0.496	0.764	0.650
CPI	0.115	0.119	0.970	-0.270	0.195	-1.390	6.317	2.756	2.290
Corn	0.035	0.012	2.900	0.002	0.054	0.040	-0.006	0.033	-0.180
Observations	84			84			84		
Adj R-Sqr	0.909			0.549			0.859		

	Uruguay		
Variable	Coef	Std. Err.	t-stat
Intercept	-2.083	1.233	-1.690
L-Constant	0.028	0.103	0.270
L-Stock-lag 1	-1E-09	4E-09	-0.320
L-Stock-lag 3	4E-09	4E-09	1.130
Trend	0.007	0.005	1.390
Trend-Sqr	-5E-05	3E-05	-1.590
X_CH_ARG	0.343	0.125	2.750
X_CH_BRZ	0.511	0.240	2.130
X_CH_USA	-2.288	0.878	-2.610
X_CH_URU	-0.298	0.359	-0.830
CPI	0.577	0.217	2.660
Corn	0.011	0.017	0.660
Observations	84		
Adj R-Sqr	0.883		

Appendix Table 4. PM Model-Beef Imports into Hong Kong.

	Argentina			Australia			Brazil		
Variable	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat
Intercept	-0.537	1.007	-0.530	6.482	1.257	5.160	-1.793	0.629	-2.850
L-Constant	0.099	0.073	1.360	-0.337	0.054	-6.220	0.112	0.049	2.260
L-Stock-lag 1	2E-09	5E-10	3.300	-6E-09	1E-09	-5.490	-6E-10	1E-10	-6.000
L-Stock-lag 3	-3E-10	4E-10	-0.770	-1E-09	1E-09	-1.510	5E-10	1E-10	4.690
Trend	-0.020	0.006	-3.620	0.007	0.004	1.910	0.004	0.003	1.280
Trend-Sqr	7E-05	2E-05	4.560	1E-05	7E-06	1.310	4E-06	6E-06	0.680
X_HK_ARG	0.014	0.070	0.200	0.139	0.064	2.170	0.172	0.039	4.460
X_HK_Aus	0.267	0.398	0.670	-0.040	0.359	-0.110	0.984	0.254	3.880
X_HK_BRZ	0.243	0.111	2.190	0.280	0.099	2.830	0.243	0.068	3.600
X_HK_Can	0.307	0.485	0.630	-0.518	0.453	-1.140	-0.835	0.264	-3.160
X_HK_NZ	-0.457	0.336	-1.360	0.776	0.295	2.640	-0.287	0.202	-1.420
X_HK_USA	3.341	5.778	0.580	1.288	4.910	0.260	-12.561	3.222	-3.900
CPI	-0.280	0.124	-2.260	-0.181	0.959	-0.190	0.019	0.021	0.870
Corn	0.041	0.015	2.770	-0.043	0.014	-2.980	-0.011	0.009	-1.200
Observations	214			214			214		
Adj R-Sqr	0.881			0.878			0.952		
	Canada			New Zealand			USA		
Variable	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat
Intercept	1.186	1.877	0.630	3.512	1.064	3.300	-2.088	2.019	-1.030
L-Constant	-0.006	0.060	-0.100	-0.150	0.044	-3.420	0.770	0.148	5.200
L-Stock-lag 1	9E-09	4E-09	2.480	-1E-09	3E-09	-0.430	1E-08	2E-09	5.910
L-Stock-lag 3	2E-09	4E-09	0.610	2E-09	3E-09	0.660	-2E-08	3E-09	-8.650
Trend	6E-08	7E-03	0.000	5E-03	4E-03	1.210	-2E-02	9E-03	-2.280
Trend-Sqr	3E-05	1E-05	2.000	8E-06	6E-06	1.180	2E-05	2E-05	1.270
X_HK_ARG	0.142	0.097	1.460	0.217	0.062	3.510	0.355	0.139	2.570
X_HK_Aus	-1.025	0.596	-1.720	-0.082	0.315	-0.260	1.034	0.825	1.250
X_HK_BRZ	0.495	0.164	3.030	-0.176	0.102	-1.730	-0.092	0.218	-0.420
X_HK_Can	-0.355	0.687	-0.520	0.045	0.395	0.120	2.123	0.999	2.120
X_HK_NZ	0.658	0.447	1.470	0.677	0.241	2.800	-2.218	0.573	-3.870
X_HK_USA	9.871	8.042	1.230	16.565	4.998	3.310	-57.708	11.455	-5.040
CPI	-1.287	1.955	-0.660	-1.971	1.010	-1.950	3.971	1.941	2.050
Corn	-0.046	0.023	-1.990	0.004	0.015	0.240	-0.007	0.031	-0.210
Observations	214			214			214		
Adj R-Sqr	0.691			0.620			0.585		

Appendix Table 5. PM Model-Beef Imports into Japan.

	Australia			Canada			Mexico		
Variable	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat
Intercept	-2.403	1.311	-1.830	1.994	1.175	1.700	1.223	0.376	3.250
L-Constant	0.040	0.059	0.670	-0.291	0.032	-8.960	-0.093	0.162	-0.570
L-Stock-lag 1	9E-10	7E-10	1.340	1E-08	3E-09	4.050	3E-09	4E-09	0.730
L-Stock-lag 3	3E-10	6E-10	0.590	3E-09	2E-09	1.660	1E-09	4E-09	0.260
Trend	-0.006	0.002	-2.690	-0.020	0.003	-6.410	0.004	0.009	0.470
Trend-Sqr	4E-06	5E-06	0.760	4E-05	6E-06	6.910	-1E-06	1E-05	-0.110
X_Jap_Aus	-0.728	0.336	-2.160	-0.470	0.379	-1.240	-1.615	0.701	-2.300
X_Jap_Can	0.621	0.376	1.650	1.628	0.413	3.940	0.370	0.836	0.440
X_Jap_Mex	0.213	0.100	2.130	-0.328	0.118	-2.780	0.284	0.241	1.180
X_Jap_NZ	0.467	0.235	1.990	-0.622	0.276	-2.250	0.917	0.487	1.880
X_Jap_USA	-0.662	0.159	-4.170	-0.795	0.163	-4.880	0.095	0.469	0.200
CPI	2.236	0.774	2.890	2.117	1.166	1.820	-0.163	0.264	-0.620
Corn	0.006	0.011	0.530	0.004	0.012	0.310	0.012	0.023	0.530
Observations	148			148			148		
Adj R-Sqr	0.825			0.737			0.212		

	New Zealand			USA		
Variable	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat
Intercept	1.391	0.837	1.660	2.801	0.509	5.510
L-Constant	-0.022	0.044	-0.490	-0.078	0.042	-1.880
L-Stock-lag 1	-3E-09	2E-09	-1.730	-7E-10	5E-10	-1.480
L-Stock-lag 3	-4E-09	2E-09	-1.840	-8E-11	6E-10	-0.140
Trend	-4E-04	2E-03	-0.170	-2E-02	2E-03	-7.370
Trend-Sqr	1E-05	4E-06	2.300	3E-05	4E-06	8.520
X_Jap_Aus	-0.651	0.297	-2.190	-0.855	0.242	-3.530
X_Jap_Can	0.294	0.339	0.870	1.067	0.270	3.950
X_Jap_Mex	0.279	0.096	2.910	-0.273	0.091	-3.000
X_Jap_NZ	0.575	0.219	2.630	0.277	0.174	1.590
X_Jap_USA	-0.599	0.160	-3.740	-0.331	0.114	-2.910
CPI	0.067	0.715	0.090	1.169	0.494	2.370
Corn	0.012	0.011	1.150	0.024	0.008	2.990
Observations	148			148		
Adj R-Sqr	0.849			0.800		

Appendix Table 6. PM Model-Beef Imports into Mexico.

	Australia			Canada			New Zealand		
Variable	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat
Intercept	-11.032	2.126	-5.190	-2.030	1.534	-1.320	-6.650	3.427	-1.940
L-Constant	0.070	0.114	0.620	-0.001	0.055	-0.020	-0.198	0.146	-1.350
L-Stock-lag 1	2E-09	2E-09	1.000	8E-09	2E-09	3.230	2E-08	9E-09	2.450
L-Stock-lag 3	-5E-09	2E-09	-2.920	3E-09	2E-09	1.320	2E-08	1E-08	2.220
Trend	0.024	0.016	1.460	-0.005	0.009	-0.520	0.063	0.022	2.860
Trend-Sqr	-8E-05	1E-05	-6.580	2E-05	1E-05	1.430	-1E-04	2E-05	-4.530
X_Mex_Aus	0.206	0.627	0.330	1.585	0.555	2.850	0.755	1.092	0.690
X_Mex_Can	-3.248	0.582	-5.580	-1.448	0.518	-2.790	-4.476	1.135	-3.940
X_Mex_NZ	1.114	0.372	2.990	-0.870	0.349	-2.500	0.339	0.713	0.480
X_Mex_Nic	1.112	1.583	0.700	-1.614	0.772	-2.090	2.061	2.121	0.970
X_Mex_USA	-0.960	1.518	-0.630	1.363	0.703	1.940	-3.317	1.916	-1.730
CPI	9.151	1.975	4.630	0.916	1.654	0.550	4.317	3.445	1.250
Corn	-0.019	0.026	-0.730	-0.033	0.021	-1.530	0.006	0.053	0.120
Observations	193			193			193		
Adj R-Sqr	0.888			0.887			0.790		

	Nicaragua			USA		
Variable	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat
Intercept	-2.539	1.318	-1.930	-1.699	0.864	-1.970
L-Constant	-0.005	0.108	-0.040	0.155	0.057	2.710
L-Stock-lag 1	8E-08	2E-08	3.420	-4E-10	6E-10	-0.720
L-Stock-lag 3	-3E-08	2E-08	-1.180	-1E-09	6E-10	-1.600
Trend	0.035	0.024	1.440	-0.004	0.006	-0.670
Trend-Sqr	1E-05	4E-05	0.260	1E-05	6E-06	1.940
X_Mex_Aus	2.267	1.106	2.050	-0.622	0.322	-1.930
X_Mex_Can	-4.958	1.123	-4.410	0.068	0.340	0.200
X_Mex_NZ	0.450	0.751	0.600	0.453	0.185	2.450
X_Mex_Nic	0.843	2.272	0.370	-0.567	0.515	-1.100
X_Mex_USA	-1.174	1.992	-0.590	0.314	0.492	0.640
CPI	-0.911	0.415	-2.190	0.745	0.903	0.820
Corn	0.007	0.054	0.140	0.012	0.014	0.880
Observations	193			193		
Adj R-Sqr	0.709			0.919		

Appendix Table 7. PM Model-Beef Imports into the Philippines.

	Australia			Brazil			Canada		
Variable	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat
Intercept	3.542	2.131	1.660	1.537	0.600	2.560	5.219	5.581	0.940
L-Constant	-0.023	0.077	-0.290	-0.052	0.057	-0.920	0.104	0.163	0.640
L-Stock-lag 1	2E-09	2E-09	1.100	2E-10	3E-10	0.890	2E-08	1E-08	1.890
L-Stock-lag 3	-6E-09	2E-09	-3.420	-2E-11	2E-10	-0.080	-8E-09	1E-08	-0.640
Trend	-0.035	0.012	-2.860	-0.021	0.007	-3.020	-0.012	0.025	-0.460
Trend-Sqr	9E-05	2E-05	4.600	6E-05	2E-05	2.920	7E-05	6E-05	1.200
X_Ph_Aus	0.004	0.728	0.010	-1.498	0.570	-2.630	-1.646	1.887	-0.870
X_Ph_BRZ	0.795	0.252	3.160	0.533	0.181	2.950	0.720	0.551	1.310
X_Ph_Can	-1.597	0.849	-1.880	0.415	0.507	0.820	-0.556	1.892	-0.290
X_Ph_Ind	0.299	0.496	0.600	-0.141	0.342	-0.410	-0.831	1.109	-0.750
X_Ph_NZ	0.509	0.511	1.000	0.992	0.418	2.380	1.347	1.229	1.100
X_Ph_USA	1.730	0.521	3.320	0.926	0.332	2.790	0.467	1.270	0.370
CPI	1.012	2.741	0.370	0.016	0.047	0.330	-5.999	5.756	-1.040
Corn	0.119	0.031	3.870	0.098	0.019	5.250	0.044	0.076	0.590
Observations	172			172			172		
Adj R-Sqr	0.760			0.858			0.340		
	India			New Zealand			USA		
Variable	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat
Intercept	2.108	1.452	1.450	-6.469	2.215	-2.920	1.162	2.743	0.420
L-Constant	-0.146	0.100	-1.460	0.238	0.098	2.420	0.121	0.447	0.270
L-Stock-lag 1	-1E-10	2E-10	-0.590	-3E-09	5E-09	-0.580	-8E-09	4E-09	-1.880
L-Stock-lag 3	3E-10	4E-10	0.620	-2E-08	8E-09	-2.470	4E-11	5E-09	0.010
Trend	-2E-04	7E-03	-0.030	-0.075	0.012	-6.390	-0.008	0.017	-0.500
Trend-Sqr	3E-05	2E-05	1.210	1E-04	2E-05	6.160	2E-05	4E-05	0.630
X_Ph_Aus	0.080	0.428	0.190	-1.419	0.729	-1.950	-0.922	1.320	-0.700
X_Ph_BRZ	0.607	0.142	4.260	-0.056	0.276	-0.200	-0.090	0.409	-0.220
X_Ph_Can	-0.397	0.461	-0.860	1.011	0.832	1.220	-2.276	1.319	-1.730
X_Ph_Ind	0.004	0.337	0.010	-0.745	0.443	-1.680	1.193	0.870	1.370
X_Ph_NZ	-0.218	0.280	-0.780	1.272	0.476	2.670	1.436	0.880	1.630
X_Ph_USA	0.117	0.298	0.390	1.898	0.474	4.010	-0.580	1.103	-0.530
CPI	-0.184	0.228	-0.810	8.989	2.121	4.240	3.053	2.681	1.140
Corn	0.025	0.017	1.520	0.108	0.033	3.280	0.067	0.057	1.180
Observations	172			172			172		
Adj R-Sqr	0.932			0.851			0.507		

Appendix Table 8. PM Model-Beef Imports into South Korea.

	Australia			Canada			Mexico		
Variable	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat
Intercept	2.381	2.027	1.170	-35.319	16.543	-2.140	9.546	16.730	0.570
L-Constant	0.100	0.132	0.760	-1.099	0.883	-1.240	2.239	1.724	1.300
L-Stock-lag 1	-5E-09	3E-09	-1.590	1E-07	6E-08	1.580	-4E-08	3E-08	-1.220
L-Stock-lag 3	4E-10	7E-10	0.580	2E-08	9E-08	0.260	-5E-08	5E-08	-0.940
Trend	0.056	0.019	3.000	0.136	0.167	0.810	-0.217	0.170	-1.280
Trend-Sqr	-5E-05	4E-05	-1.390	-3E-04	3E-04	-1.030	3E-04	3E-04	0.910
X_SK_Aus	-0.433	0.392	-1.100	-1.558	4.293	-0.360	-5.874	4.005	-1.470
X_SK_Can	-0.112	0.576	-0.190	3.586	6.292	0.570	8.816	6.337	1.390
X_SK_Mex	0.024	0.396	0.060	-2.699	5.197	-0.520	-0.909	3.839	-0.240
X_SK_NZ	0.471	0.673	0.700	4.344	4.179	1.040	0.162	4.247	0.040
X_SK_USA	-0.106	0.369	-0.290	-3.562	3.812	-0.930	-5.258	4.324	-1.220
CPI	-7.832	2.287	-3.430	14.291	9.076	1.570	3.616	2.509	1.440
Corn	0.001	0.013	0.050	-0.195	0.148	-1.310	0.247	0.164	1.510
Observations	45			45			45		
Adj R-Sqr	0.922			0.374			-0.313		

	New Zealand			USA		
Variable	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat
Intercept	-3.086	2.091	-1.480	-5.040	2.378	-2.120
L-Constant	-0.207	0.143	-1.450	0.041	0.183	0.220
L-Stock-lag 1	9E-09	2E-09	3.860	5E-10	3E-09	0.160
L-Stock-lag 3	1E-08	1E-08	0.970	-2E-09	2E-09	-1.120
Trend	0.120	0.030	4.000	0.070	0.024	2.940
Trend-Sqr	-2E-04	5E-05	-4.020	-1E-04	5E-05	-2.800
X_SK_Aus	-0.678	0.526	-1.290	-0.176	0.600	-0.290
X_SK_Can	-0.178	0.909	-0.200	-1.522	0.893	-1.700
X_SK_Mex	0.128	0.579	0.220	0.435	0.597	0.730
X_SK_NZ	0.444	0.543	0.820	0.116	0.593	0.200
X_SK_USA	-0.011	0.454	-0.020	0.161	0.507	0.320
CPI	-7.654	3.077	-2.490	-0.695	1.108	-0.630
Corn	-0.023	0.019	-1.200	-0.032	0.021	-1.570
Observations	45			45		
Adj R-Sqr	0.868			0.918		

Appendix Table 9. PM Model-Beef Imports into Taiwan.

	Australia			New Zealand			USA		
Variable	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat
Intercept	5.369	1.617	3.320	-0.272	0.598	-0.450	1.271	0.999	1.270
L-Constant	-0.220	0.086	-2.550	0.132	0.029	4.520	-0.109	0.091	-1.200
L-Stock-lag 1	1E-09	1E-09	0.820	-4E-09	1E-09	-2.640	9E-11	1E-09	0.100
L-Stock-lag 3	-8E-10	1E-09	-0.820	-5E-09	2E-09	-3.120	-4E-10	1E-09	-0.310
Trend	1E-03	3E-03	0.500	5E-04	1E-03	0.320	2E-03	5E-03	0.380
Trend-Sqr	3E-05	5E-06	6.270	1E-05	3E-06	4.060	-7E-06	6E-06	-1.020
X_TAI_Aus	0.849	0.353	2.400	-0.355	0.172	-2.060	-0.984	0.463	-2.120
X_TAI_NZ	-0.380	0.292	-1.300	0.569	0.132	4.330	0.714	0.372	1.920
X_TAI_USA	-0.895	0.336	-2.670	-1.064	0.158	-6.720	-1.205	0.402	-3.000
CPI	-1.943	0.864	-2.250	-0.631	0.500	-1.260	1.112	1.051	1.060
Corn	-0.060	0.018	-3.430	0.020	0.009	2.290	0.046	0.020	2.300
Observations	217			217			217		
Adj R-Sqr	0.880			0.908			0.419		

Appendix Table 10. lnRCA Model-Beef Imports into Canada.

	Australia			New Zealand			USA		
Variable	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat
Intercept	-4.197	3.011	-1.390	-0.927	2.179	-0.430	-10.023	4.151	-2.410
Stock-lag 1	1E-07	5E-08	1.980	2E-07	9E-08	2.320	1E-07	4E-08	3.430
Stock-lag 3	-8E-08	5E-08	-1.660	5E-08	1E-07	0.400	6E-09	5E-08	0.130
Trend	-0.032	0.009	-3.580	-0.002	0.005	-0.540	-0.004	0.009	-0.440
Trend-Sqr	5E-05	1E-05	3.250	-7E-06	1E-05	-0.640	2E-05	1E-05	1.170
X_Can_Aus	1.517	1.259	1.200	2.229	0.858	2.600	-2.425	1.277	-1.900
X_Can_NZ	-1.151	0.758	-1.520	-1.127	0.557	-2.020	0.410	0.799	0.510
X_Can_USA	5.023	0.466	10.790	2.188	0.454	4.820	-2.628	0.635	-4.140
CPI	5.512	3.205	1.720	0.924	2.391	0.390	1.324	3.025	0.440
Corn	-0.077	0.050	-1.540	-0.040	0.040	-1.000	-0.056	0.049	-1.140
Observations	228			228			228		
Adj R-Sqr	0.719			0.597			0.510		

Appendix Table 11. lnRCA Model-Beef Imports into China.

Variable	Argentina Coef	Std. Err.	t-stat	Brazil Coef	Std. Err.	t-stat	USA Coef	Std. Err.	t-stat
Intercept	4.575	1.730	2.650	11.932	6.235	1.910	-25.244	15.215	-1.660
Stock-lag 1	6E-08	2E-08	2.230	4E-08	3E-08	1.290	-8E-08	1E-07	-0.730
Stock-lag 3	-9E-08	2E-08	-3.570	-9E-08	2E-08	-3.950	4E-07	2E-07	2.060
Trend	-0.024	0.020	-1.220	-0.053	0.015	-3.630	-0.070	0.019	-3.710
Trend-Sqr	2E-06	6E-05	0.030	3E-04	7E-05	4.200	2E-04	5E-05	3.330
X_CH_Arg	0.780	0.406	1.920	1.028	0.613	1.680	-0.229	0.591	-0.390
X_CH_BRZ	0.772	0.560	1.380	-1.746	0.859	-2.030	-0.818	0.851	-0.960
X_CH_USA	-7.684	3.203	-2.400	-4.340	4.549	-0.950	-20.522	4.257	-4.820
X_CH_Uru	-2.898	0.827	-3.510	-0.284	1.229	-0.230	1.233	1.435	0.860
CPI	0.647	0.467	1.380	-0.625	0.249	-2.510	2.809	5.217	0.540
Corn	0.058	0.040	1.460	0.118	0.078	1.500	0.115	0.066	1.760
Observations	84			84			84		
Adj R-Sqr	0.633			0.631			0.914		

Variable	Uruguay Coef	Std. Err.	t-stat
Intercept	11.188	4.212	2.660
Stock-lag 1	-2E-07	2E-07	-0.760
Stock-lag 3	-3E-07	2E-07	-1.440
Trend	-0.050	0.021	-2.420
Trend-Sqr	2E-04	1E-04	1.920
X_CH_Arg	1.480	0.520	2.850
X_CH_BRZ	2.569	0.855	3.000
X_CH_USA	3.719	3.695	1.010
X_CH_Uru	-6.821	1.373	-4.970
CPI	-0.672	0.900	-0.750
Corn	0.028	0.063	0.450
Observations	84		
Adj R-Sqr	0.406		

Appendix Table 12. lnRCA Model-Beef Imports into Hong Kong.

	Argentina			Australia			Brazil		
Variable	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat
Intercept	0.351	1.124	0.310	3.176	1.553	2.040	1.833	0.801	2.290
Stock-lag 1	-1E-07	2E-08	-4.240	4E-08	3E-08	1.520	2E-09	5E-09	0.420
Stock-lag 3	5E-08	2E-08	2.330	4E-09	2E-08	0.170	3E-08	5E-09	5.950
Trend	0.006	0.018	0.340	-0.015	0.007	-2.310	-0.039	0.007	-5.780
Trend-Sqr	-6E-05	5E-05	-1.150	4E-05	1E-05	3.550	1E-05	2E-05	0.810
X_HK_Arg	-0.491	0.210	-2.340	-0.302	0.107	-2.830	-0.206	0.109	-1.890
X_HK_Aus	-1.050	1.170	-0.900	2.182	0.606	3.600	1.199	0.728	1.650
X_HK_BRZ	-1.296	0.336	-3.860	0.476	0.151	3.150	0.356	0.184	1.940
X_HK_Can	1.769	1.298	1.360	-0.054	0.759	-0.070	1.798	0.747	2.410
X_HK_NZ	-0.649	1.007	-0.640	-2.797	0.465	-6.010	-2.387	0.564	-4.230
X_HK_USA	36.473	16.987	2.150	27.527	8.292	3.320	18.905	9.009	2.100
CPI	0.235	0.375	0.630	-2.224	1.576	-1.410	0.187	0.057	3.270
Corn	0.049	0.044	1.120	-0.015	0.024	-0.620	-0.024	0.025	-0.970
Observations	214			214			214		
Adj R-Sqr	0.738			0.705			0.862		

	Canada			New Zealand			USA		
Variable	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat
Intercept	-7.673	4.032	-1.900	1.319	2.365	0.560	10.545	6.997	1.510
Stock-lag 1	7E-07	1E-07	6.590	1E-07	9E-08	1.230	-4E-08	6E-08	-0.610
Stock-lag 3	-5E-07	1E-07	-4.790	-6E-08	1E-07	-0.600	1E-07	8E-08	1.550
Trend	-0.010	0.015	-0.660	-0.034	0.009	-3.830	-0.097	0.019	-4.970
Trend-Sqr	-6E-06	3E-05	-0.220	5E-05	2E-05	2.920	3E-04	3E-05	8.080
X_HK_Arg	-0.192	0.229	-0.840	-0.189	0.147	-1.290	-1.143	0.303	-3.780
X_HK_Aus	-3.006	1.393	-2.160	2.958	0.732	4.040	-1.705	1.885	-0.900
X_HK_BRZ	1.540	0.346	4.450	-0.073	0.230	-0.320	-0.325	0.510	-0.640
X_HK_Can	3.532	1.590	2.220	-0.864	0.919	-0.940	8.490	2.279	3.730
X_HK_NZ	0.515	1.049	0.490	-2.999	0.563	-5.330	-4.898	1.308	-3.740
X_HK_USA	0.486	18.807	0.030	8.823	11.890	0.740	69.625	25.386	2.740
CPI	8.863	4.497	1.970	2.085	2.390	0.870	-8.953	4.514	-1.980
Corn	0.070	0.055	1.280	0.040	0.036	1.120	0.212	0.073	2.920
Observations	214			214			214		
Adj R-Sqr	0.599			0.853			0.519		

Appendix Table 13. lnRCA Model-Beef Imports into Japan.

	Australia			Canada			Mexico		
Variable	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat
Intercept	-3.504	0.720	-4.870	23.777	4.822	4.930	7.004	1.491	4.700
Stock-lag 1	9E-09	9E-09	1.000	-4E-07	2E-07	-1.660	-1E-07	3E-08	-3.120
Stock-lag 3	2E-08	8E-09	2.190	9E-07	2E-07	5.000	-1E-07	3E-08	-4.420
Trend	0.003	0.002	1.180	-0.031	0.020	-1.600	-0.012	0.006	-1.830
Trend-Sqr	-3E-05	4E-06	-7.050	2E-04	4E-05	5.210	2E-05	7E-06	2.810
X_Jap_Aus	0.344	0.261	1.320	3.618	2.098	1.720	0.451	0.477	0.950
X_Jap_Can	-0.016	0.257	-0.060	-0.967	2.155	-0.450	-0.457	0.506	-0.900
X_Jap_Mex	-0.377	0.141	-2.670	4.173	1.351	3.090	1.175	0.283	4.150
X_Jap_NZ	-0.059	0.178	-0.330	-4.666	1.480	-3.150	-0.604	0.328	-1.840
X_Jap_USA	0.320	0.187	1.710	-4.125	1.629	-2.530	-1.267	0.341	-3.710
CPI	2.640	0.706	3.740	-21.058	5.623	-3.750	0.548	0.208	2.640
Corn	-0.005	0.008	-0.670	-0.024	0.068	-0.350	-0.034	0.015	-2.240
Observations	132			132			132		
Adj R-Sqr	0.767			0.487			0.784		

	New Zealand			USA		
Variable	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat
Intercept	-2.161	1.478	-1.460	-14.768	4.361	-3.390
Stock-lag 1	-8E-09	7E-08	-0.120	-1E-07	6E-08	-2.300
Stock-lag 3	-8E-08	7E-08	-1.120	5E-07	6E-08	7.100
Trend	-0.005	0.005	-0.950	0.016	0.015	1.080
Trend-Sqr	4E-06	1E-05	0.390	5E-05	2E-05	2.280
X_Jap_Aus	-1.931	0.606	-3.190	0.565	1.421	0.400
X_Jap_Can	2.422	0.644	3.760	-3.042	1.509	-2.020
X_Jap_Mex	-0.080	0.343	-0.230	3.534	0.943	3.750
X_Jap_NZ	0.906	0.420	2.160	-0.391	1.008	-0.390
X_Jap_USA	-1.513	0.452	-3.350	-0.270	1.003	-0.270
CPI	2.274	1.595	1.430	-4.553	3.005	-1.510
Corn	-0.023	0.021	-1.100	0.007	0.047	0.140
Observations	132			132		
Adj R-Sqr	0.718			0.662		

Appendix Table 14. lnRCA Model-Beef Imports into Mexico.

	Australia			Canada			New Zealand		
Variable	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat
Intercept	-18.512	4.387	-4.220	-5.085	3.586	-1.420	-8.238	5.637	-1.460
Stock-lag 1	2E-07	6E-08	3.130	4E-07	9E-08	4.170	4E-07	2E-07	1.810
Stock-lag 3	-6E-08	6E-08	-0.970	-1E-08	9E-08	-0.160	7E-07	3E-07	2.660
Trend	-0.118	0.042	-2.830	-0.028	0.026	-1.090	0.011	0.056	0.200
Trend-Sqr	3E-05	3E-05	0.960	-2E-07	3E-05	-0.010	-9E-05	5E-05	-1.940
X_Mex_Aus	3.038	1.436	2.120	3.310	1.385	2.390	1.524	2.204	0.690
X_Mex_Can	-5.836	1.321	-4.420	-1.921	1.322	-1.450	-6.053	2.178	-2.780
X_Mex_NZ	-0.400	0.859	-0.470	-2.070	0.809	-2.560	0.370	1.396	0.260
X_Mex_Nic	-12.190	3.626	-3.360	-6.901	2.470	-2.790	-8.096	5.986	-1.350
X_Mex_USA	14.061	3.495	4.020	8.087	2.306	3.510	6.614	5.711	1.160
CPI	17.591	5.135	3.430	0.902	4.277	0.210	0.697	6.630	0.110
Corn	-0.109	0.059	-1.840	0.001	0.059	0.020	-0.158	0.100	-1.590
Observations	185			185			185		
Adj R-Sqr	0.496			0.526			0.398		

	Nicaragua			USA		
Variable	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat
Intercept	3.346	0.338	9.890	-3.198	6.231	-0.510
Stock-lag 1	-1E-08	1E-07	-0.120	5E-09	6E-08	0.090
Stock-lag 3	2E-07	9E-08	1.670	-7E-08	7E-08	-0.940
Trend	-0.035	0.009	-3.850	-0.006	0.032	-0.170
Trend-Sqr	5E-05	1E-05	4.530	-1E-05	3E-05	-0.430
X_Mex_Aus	0.926	0.389	2.380	-3.082	1.762	-1.750
X_Mex_Can	-0.121	0.393	-0.310	3.430	1.834	1.870
X_Mex_NZ	-0.138	0.235	-0.590	1.624	1.104	1.470
X_Mex_Nic	-1.035	0.970	-1.070	3.281	3.577	0.920
X_Mex_USA	0.927	0.895	1.040	-3.305	3.458	-0.960
CPI	0.327	0.108	3.020	7.444	4.813	1.550
Corn	-0.034	0.018	-1.930	-0.084	0.079	-1.070
Observations	185			185		
Adj R-Sqr	0.801			0.231		

Appendix Table 15. lnRCA Model-Beef Imports into the Philippines.

Variable	Australia Coef	Std. Err.	t-stat	Brazil Coef	Std. Err.	t-stat	Canada Coef	Std. Err.	t-stat
Intercept	-17.807	5.014	-3.550	-8.236	2.479	-3.320	-17.904	10.020	-1.790
Stock-lag 1	9E-08	6E-08	1.460	3E-08	1E-08	2.210	-8E-07	2E-07	-3.440
Stock-lag 3	7E-09	6E-08	0.110	-2E-08	1E-08	-1.880	6E-07	3E-07	2.390
Trend	-0.101	0.026	-3.840	0.072	0.023	3.100	-0.050	0.047	-1.080
Trend-Sqr	4E-05	5E-05	0.810	-2E-04	7E-05	-2.380	4E-05	1E-04	0.340
X_Ph_Aus	5.877	1.621	3.630	-9.658	1.989	-4.860	-0.979	3.471	-0.280
X_Ph_BRZ	1.177	0.559	2.100	-0.864	0.651	-1.330	-1.258	1.035	-1.220
X_Ph_Can	-5.863	1.898	-3.090	2.543	1.894	1.340	-0.478	3.505	-0.140
X_Ph_Ind	-4.482	1.055	-4.250	2.858	1.258	2.270	2.037	2.087	0.980
X_Ph_NZ	-4.521	1.107	-4.080	6.161	1.313	4.690	2.811	2.299	1.220
X_Ph_USA	5.749	1.114	5.160	-2.868	1.225	-2.340	-1.374	2.399	-0.570
CPI	25.898	5.441	4.760	0.038	0.178	0.220	17.850	10.612	1.680
Corn	0.063	0.069	0.910	-0.043	0.069	-0.620	0.127	0.139	0.910
Observations	172			172			172		
Adj R-Sqr	0.793			0.737			0.216		

Variable	India Coef	Std. Err.	t-stat	New Zealand Coef	Std. Err.	t-stat	USA Coef	Std. Err.	t-stat
Intercept	5.178	2.591	2.000	-4.860	5.158	-0.940	-17.895	8.845	-2.020
Stock-lag 1	8E-09	5E-09	1.500	5E-08	2E-07	0.290	-5E-08	9E-08	-0.530
Stock-lag 3	-8E-09	1E-08	-0.590	2E-07	2E-07	0.920	2E-07	9E-08	1.830
Trend	-0.014	0.013	-1.070	-0.032	0.031	-1.010	0.053	0.029	1.850
Trend-Sqr	3E-05	4E-05	0.760	4E-05	6E-05	0.650	-8E-05	6E-05	-1.310
X_Ph_Aus	1.328	0.750	1.770	6.586	2.023	3.260	3.368	2.277	1.480
X_Ph_BRZ	-0.637	0.265	-2.410	0.246	0.720	0.340	-1.260	0.673	-1.870
X_Ph_Can	0.675	0.838	0.810	-3.846	2.261	-1.700	-5.329	2.317	-2.300
X_Ph_Ind	-1.033	0.595	-1.740	-2.193	1.277	-1.720	2.630	1.429	1.840
X_Ph_NZ	-1.312	0.506	-2.590	-4.680	1.333	-3.510	1.047	1.557	0.670
X_Ph_USA	-0.313	0.556	-0.560	2.074	1.362	1.520	-3.686	1.690	-2.180
CPI	-0.287	0.431	-0.670	6.185	5.688	1.090	0.952	4.628	0.210
Corn	-0.073	0.030	-2.470	0.100	0.088	1.140	-0.174	0.096	-1.810
Observations	172			172			172		
Adj R-Sqr	0.395			0.608			0.618		

Appendix Table 16. lnRCA Model-Beef Imports into South Korea.

	Australia			Canada			Mexico		
Variable	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat
Intercept	-6.413	3.957	-1.620	-54.923	38.883	-1.410	-29.003	36.933	-0.790
Stock-lag 1	-1E-07	1E-07	-0.830	-2E-06	1E-06	-2.010	2E-07	5E-07	0.380
Stock-lag 3	-4E-08	3E-08	-1.660	5E-06	2E-06	2.900	1E-06	9E-07	1.130
Trend	0.098	0.038	2.570	0.734	0.308	2.390	-0.257	0.263	-0.980
Trend-Sqr	-2E-04	7E-05	-2.710	-0.001	0.001	-2.140	3E-04	5E-04	0.590
X_SK_Aus	-1.782	0.782	-2.280	-2.385	8.075	-0.300	4.569	6.537	0.700
X_SK_Can	-0.487	1.147	-0.430	-16.052	11.088	-1.450	2.464	11.004	0.220
X_SK_Mex	1.324	0.780	1.700	22.726	6.837	3.320	-14.956	5.978	-2.500
X_SK_NZ	0.203	0.789	0.260	-2.349	7.866	-0.300	12.908	7.378	1.750
X_SK_USA	0.083	0.665	0.120	-5.632	6.998	-0.800	12.030	6.369	1.890
CPI	-0.598	3.765	-0.160	-26.238	17.516	-1.500	3.148	4.366	0.720
Corn	0.022	0.026	0.830	-0.206	0.275	-0.750	-0.486	0.228	-2.130
Observations	45			45			45		
Adj R-Sqr	0.847			0.543			0.809		

	New Zealand			USA		
Variable	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat
Intercept	18.085	4.925	3.670	62.413	18.021	3.460
Stock-lag 1	-4E-08	1E-07	-0.330	-3E-07	2E-07	-1.860
Stock-lag 3	-8E-07	4E-07	-1.780	5E-08	2E-07	0.330
Trend	0.046	0.081	0.570	-0.414	0.104	-3.980
Trend-Sqr	-9E-06	1E-04	-0.060	0.001	2E-04	4.360
X_SK_Aus	-0.482	1.294	-0.370	4.814	2.585	1.860
X_SK_Can	5.204	2.073	2.510	1.672	3.954	0.420
X_SK_Mex	-1.487	1.386	-1.070	-1.437	2.693	-0.530
X_SK_NZ	0.955	1.307	0.730	7.391	2.599	2.840
X_SK_USA	-3.332	1.165	-2.860	2.781	2.090	1.330
CPI	-18.380	7.671	-2.400	-5.417	5.487	-0.990
Corn	-0.070	0.049	-1.440	-0.053	0.088	-0.600
Observations	45			45		
Adj R-Sqr	0.612			0.750		

Appendix Table 17. lnRCA Model-Beef Imports into Taiwan.

	Australia			New Zealand			USA		
Variable	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat	Coef	Std. Err.	t-stat
Intercept	0.294	1.386	0.210	6.490	1.256	5.170	-9.472	2.831	-3.350
Stock-lag 1	5E-08	3E-08	1.520	2E-07	6E-08	3.310	5E-08	3E-08	1.400
Stock-lag 3	-6E-08	3E-08	-2.440	-6E-08	7E-08	-0.820	9E-08	4E-08	2.010
Trend	-0.035	0.005	-6.580	0.009	0.004	2.480	0.026	0.010	2.620
Trend-Sqr	7E-05	6E-06	10.860	9E-06	7E-06	1.280	-4E-05	1E-05	-2.900
X_TAI_Aus	1.318	0.499	2.640	-0.019	0.490	-0.040	-0.080	0.938	-0.080
X_TAI_NZ	-1.719	0.422	-4.070	-0.504	0.373	-1.350	0.298	0.749	0.400
X_TAI_USA	1.967	0.466	4.220	-0.868	0.459	-1.890	-0.945	0.813	-1.160
CPI	2.897	1.558	1.860	-6.127	1.396	-4.390	-1.777	2.278	-0.780
Corn	-0.020	0.025	-0.800	0.051	0.026	1.990	0.016	0.043	0.370
Observations	205			205			205		
Adj R-Sqr	0.519			0.427			0.326		

Appendix Table 18. Results of the BP Structural Break Tests: Lerner Functions

Variable	Break Dates	Full Period	Regime					
		a	a_1	a_2	a_3	a_4	a_5	a_6
$Lerner_{Canada,USA}$	Mar-97, Dec-01	0.027***	0.027***	0.024***	0.027***			
		(0.0001)	(0.0001)	(0.0002)	(0.0001)			
$Lerner_{China,USA}$	Dec-99, Dec-10	-0.117***	-0.057***	-0.122***	-0.177***			
		(0.003)	(0.003)	(0.003)	(0.007)			
$Lerner_{Hong\ Kong,USA}$		0.062***						
		(0.002)						
$Lerner_{Japan,USA}$	Dec-99, Dec-10	-0.125***	-0.128***	-0.125***	-0.123***			
		(0.0001)	(0.0001)	(0.0001)	(0.0003)			
$Lerner_{Mexico,USA}$	Dec-00, Sep-12	0.065***	0.061***	0.066***	0.071***			
		(0.0002)	(0.0003)	(0.0001)	(0.0004)			
$Lerner_{Philippines,USA}$	Dec-98, Dec-10	-0.349***	-0.378***	-0.348***	-0.323***			
		(0.001)	(0.001)	(0.002)	(0.002)			
$Lerner_{South\ Korea,USA}$	Mar-97, Dec-01, Sep-12	-0.057***	-0.059***	-0.062***	-0.056***	-0.052***		
		(0.0002)	(0.0003)	(0.0003)	(0.0005)	(0.001)		
$Lerner_{Taiwan,USA}$	Mar-97, Dec-01, Sep-12	-0.126***	-0.126***	-0.127***	-0.125***	-0.125***		
		(0.00004)	(0.00005)	(0.00005)	(0.0001)	(0.0002)		

Notes: Statistical significance at the 5% level was used for the BP test statistics in deriving the break dates. Standard errors in (). Single, double, and triple asterisks (*, **, ***) indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Appendix Table 19. Results of the BP Structural Break Tests: Revealed Comparative Advantage

		Full Period	Regime					
Variable	Break Dates	a	a_1	a_2	a_3	a_4	a_5	a_6
$lnRCA_{Canada,USA}$	Jun-98, Jun-05, Dec-10	0.318***	0.078***	-0.156***	0.890***	0.569***		
		(0.028)	(0.020)	(0.038)	(0.047)	(0.024)		
$lnRCA_{China,USA}$	Jun-00, Dec-07, Mar-11	-5.754***	-6.090***	-8.468***	-4.358	-1.965***		
		(0.154)	(0.089)	(0.023)	(0.206)	(0.143)		
$lnRCA_{Hong Kong,USA}$	Mar-97	-0.725***	1.169***	-1.053***				
		(0.069)	(0.333)	(0.217)				
$lnRCA_{Japan,USA}$		-0.496***						
		(0.043)						
$lnRCA_{Mexico,USA}$		0.645***						
		(0.021)						
$lnRCA_{Philippines,USA}$	Aug-02, Dec-06, Mar-10	-3.188***	-4.316***	-3.212***	-2.427***	-1.902***		
		(0.071)	(0.229)	(0.093)	(0.065)	(0.084)		
$lnRCA_{South Korea,USA}$[a]	Dec-04, May-10	-1.079***	1.408**	-3.956***	-0.516			
		(0.184)	(0.607)	(0.336)	(0.339)			
$lnRCA_{Taiwan,USA}$	Mar-97, Jun-00, Sep-03, Dec-06, Sep-12	-0.449***	-1.144***	-0.641***	-0.652***	-0.379***	0.010	-0.243***
		(0.025)	(0.047)	(0.023)	(0.023)	(0.025)	(0.027)	(0.058)

Notes: [a] Statistical significance at the 5% level was used for the BP test statistics in deriving the break dates. Standard errors in (). Single, double, and triple asterisks (*, **, ***) indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Online Appendix. Results of the U.S. Export Price Test.

The PM and RCA analyses use the unit value of exports as an export price. This is a concern if the constructed export price is somehow fundamentally different from the actual underlying prices which, in the case of beef, are made up of various qualities. In the case of the U.S., we do have access to disaggregated price data, but in the case of other exporting nations, these data are not easy to obtain. To test whether the export unit prices are fundamentally different from other prices, following Granger, we estimated a series of 4 equation vector autoregression[5] (VAR) models as specified in: $P_{kt} = \sum_{L=1}^{3} \sum_{j} \beta_{kmL} P_{mt-L} + \sum_{z} \alpha_{kz} Z_{zt} + u_{kt}$.

Here, P_{kt} stands for one of k = 1-4 prices where the subscript "k" is defined over a set of disaggregated prices and the export unit value: k={Choice, Select, By Product, Export}.[6] The set "m" has the same elements as "k." The VAR has 3 lags; β_{kmL} are the coefficients for the lagged prices. Z_{zt} is a set of exogenous variables that has an intercept and monthly dummies for January-November. u_{kt} is a random error term. If the export unit values do not act "differently" than the less aggregated price series, we conclude that they are in this sense "no different" and, thus, justifiable.

One may test for leader-follower behavior by testing restrictions on the β_{kmL} coefficients. For example, if $\beta_{kmL} = 0$ when k = *export* and m= {Choice, Select, By Product} and L=1,2,3,

[5] Some analysts use the term vector error correction (VEC). There is a simple linear transformation between a VAR and a corresponding VEC. The VEC format has some advantages in dealing with "unit roots" and when there are unit roots can be estimated in two stages. See Engle and Granger (1987).

[6] The beef byproduct value is a farm-level calculation. We modified its value slightly to reflect the packer-level value of byproducts. See Hahn (2004) for an explanation of how ERS turns wholesale level byproduct sales into farm-level sales. Contact the author Hahn for an explanation of the inversion of this relationship. The two cutouts are calculated and published by the USDA's Agricultural Marketing Service (AMS) while the byproduct value is calculated by the USDA's Economic Research Service (ERS) using AMS data. The byproduct credit includes estimates of the value of offal.

then the export unit value does not follow the domestic prices. (Making the export values not follow the domestic prices imposes 9 restrictions on the VAR model.) If $\beta_{kmL} = 0$ when k = {Choice, Select, By Product}, m={*export*}, and L=1,2,3, then the domestic prices do not follow the export unit values. This is also a 9-degree-of-freedom restriction. In addition to test restrictions on the β_{kmL} coefficients, we also required that the domestic price errors and import price errors be uncorrelated when we have leader-follower behavior. This adds another 3 test restrictions to the model. We can distinguish 4 cases with these tests. If both sets of hypotheses are rejected, then we have a case where the 4 prices jointly influence each other. There are no leaders or followers. If one is rejected and the other accepted, then one set of prices leads and the other follows. The leading set of prices will be those whose "not following" restrictions are accepted (or fail to be rejected). Finally, if both sets of restrictions are accepted, then we have a case where the two sets are independently determined.

Most of the VAR-based studies of international price transmission are done with cointegrated data; prices that share a unit root. Mathews et al. have a VAR that looks at weekly Choice, Select, Byproduct and Cattle prices and finds that these are cointegrated. Rather than the typical error correction approach to dealing with cointegration we have estimated our VAR using the Eigen-vector approach used in Mathews et al. This approach was first done in Taha and Hahn (2014). Mathews et al.'s VAR has only 1 lag; Taha and Hahn's 2 lags. Taha and Hahn relate their approach to the more commonly used "error correction" format and note that their approach is generic to models with an arbitrary number of lags. One implication of Mathews et al.'s estimates is that the unit root in the Choice cutout and in the Select cutout can be eliminated by subtracting the Select price from the Choice price. We imposed that restriction on our VAR estimates.

Because we are looking at only U.S. exports, we could take advantage of a longer data set, and our sample runs from January 1990 to December 2015. We also want to control for the known break in the series due to the BSE event. The United States found its first case of BSE in late December 2004. Starting in January 2005, U.S. beef exports to many destinations virtually stopped. In order to deal with this disruption we followed Taha and Hahn's approach and divided our sample into 3 periods. Our pre-BSE period runs from January 1990 to December 2004. We had a transition period, January 2005-October 2006, when there were no 0 level exports to any of the U.S.'s major destinations after this period. Our post-BSE period runs from November 2006 to December 2015. We estimated pre-BSE VAR and post-BSE VAR, but did not use any of the information from the transition period. We estimated equations for U.S. export destinations of Canada, Hong Kong, Japan, South Korea, Mexico, Taiwan, and also for the World[7]. All models were estimated using maximum-likelihood estimation. The tests are done using the likelihood ratio tests, where we compared the likelihood of the constrained models to the least constrained models. These tests are asymptotically chi-square.

We used the least-constrained models to see if the pre- and post-BSE coefficients are the same, including the covariance matrices. These restrictions were rejected implying that the pre- and post-BSE domestic and export price relationships are different. Appendix Table 20 shows the test results on the models. The top half shows the pre-BSE sample tests and the bottom half shows the post-BSE tests. The destinations are sorted from least to most restrictive on the "independent evolution" models. Appendix Table 20 only shows the "alpha" or significance level associated with each test. We are using the conventional 5% value to reject the null

[7] We selected these destinations as they had no 0-level trade in pre- and post-BSE parts of our sample. Other major destinations had too many gaps in the data to allow for proper estimation.

hypothesis. One of the issues with this type of testing is that the more tests one performs the more likely one is to come across a value that is statistically significant even if the all the tested hypotheses are true. One way to deal with this issue is the use of Holm-Bonferroni correction, (Holm 1979.) The idea behind this correction is that testing two true hypotheses makes large values of the test statistic roughly twice as likely. Testing three hypotheses makes large values 3 times as likely, and so on. One sorts the hypotheses from the largest to smallest significance levels. If the first test's alpha is larger than 5%, you accept that hypothesis. If its alpha is under 5% you reject that and the following terms. If the first passes and the 2nd test's alpha is greater than 5%/2 or 2.5% you accept that one, and so on.

The insignificant tests based on the Holm Bonferroni correction are in bold text in Appendix Table 20. In the pre-BSE sample, we find four of the seven export unit values appear to be independent of the domestic prices. The three that appear to have some dependencies are World, Mexico, and Canada. Appendix Table 20 also shows the tests for the "export follows" and "domestic follows" cases. We cannot reject either restriction for the World or Mexico, giving us an ambiguous result. In the pre-BSE period, Canada has a consistent story: we can reject independence, its values appear to be uninfluenced by the U.S. domestic prices but the export prices have a significant effect on U.S. domestic prices.

The lower half of Appendix Table 20 shows the test results for the post-BSE period. As before, export prices in Japan and South Korea appear to be independent of the domestic prices. Hong Kong was apparently independent pre-BSE, but may have some dependencies in the post-BSE period. The export-follow and domestic-follow tests for Hong Kong give us another ambiguous result. Canadian and World export values show statistically significant joint interactions with domestic prices in the post-BSE periods. Taiwan's prices lead domestic prices; Mexican prices follow domestic prices.

What we can conclude from the results in Appendix Table 20 is unclear. One of the weaknesses of our VAR-based tests is that the export products and domestic products need not align particularly well. Some of this apparent independence is likely to be a function of data issues. More detail on the domestic or export prices could be helpful. USDA AMS publishes cutout statistics by primal cut: chuck, brisket, rib, short plate, loin, flank, and round. Expanding the domestic price set may lead to changes in the results. More detail on export values by cut would also be helpful; getting that data would be challenging. All in all, however, the results give no indication that U.S. domestic versus export beef prices exhibit either a general leader or follower behavior. The story arising from the models is that pre- and post-BSE, something changed in the relationship between domestic and export prices but no consistent pattern emerges suggesting that one set of prices differs significantly from another, in terms of some consistent pattern of leader-follower behavior, in any of the U.S. export markets. The Granger tests give credence to our using unit values as there is no difference between using these export values as prices versus using other prices of cuts.

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Appendix Table 20. VAR Model Tests for Leader-Follower Relations.

market	domestic and export are independent chi-square alpha	HB[1,2] criteria	rank	export follows chi-square alpha	HB criteria	rank	domestic follows chi-square alpha	HB criteria	rank
Pre BSE									
South Korea	**31.56%**	5.00%	1	**70.36%**	5.00%	1	**18.22%**	5.00%	1
Hong Kong	**3.46%**	2.50%	2	**47.13%**	2.50%	2	**1.28%**	1.00%	5
Taiwan	**3.41%**	1.67%	3	**26.93%**	1.67%	3	**1.82%**	1.25%	4
Japan	**1.61%**	1.25%	4	**6.71%**	1.00%	5	**11.62%**	2.50%	2
World	0.76%	1.00%	5	**3.96%**	0.83%	6	**3.92%**	1.67%	3
Mexico	0.11%	0.83%	6	**10.03%**	1.25%	4	**1.14%**	0.83%	6
Canada	0.01%	0.71%	7	**1.10%**	0.71%	7	0.10%	0.71%	7
Post BSE									
Japan	**9.33%**	5.00%	1	**34.49%**	2.50%	2	**15.41%**	5.00%	1
South Korea	**5.05%**	2.50%	2	**44.63%**	5.00%	1	**3.33%**	1.67%	3
Hong Kong	1.35%	1.67%	3	**3.87%**	1.25%	4	**5.62%**	2.50%	2
Taiwan	0.31%	1.25%	4	0.27%	1.00%	5	**3.21%**	1.25%	4
Canada	0.00%	1.00%	5	0.04%	0.83%	6	0.36%	1.00%	5
World	0.00%	0.83%	6	0.02%	0.71%	7	0.01%	0.83%	6
Mexico	0.00%	0.71%	7	**5.89%**	1.67%	3	0.00%	0.71%	7

Notes: 1. HB stands for Holm Bonferroni correction for multiple independent hypothesis tests. 2 Bold numbers in the chi-square alpha columns are those that are insignificant given the HB correction.