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# Integrating Marginal Cost into Pricing-to-market Models for U.S. Agricultural Products

Sayed H. Saghaian

Assistant Research Professor, Department of Agricultural Economics, University of Kentucky

Michael R. Reed

Professor, Department of Agricultural Economics, University of Kentucky

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## The Issue

This article investigates the markup pricing behaviour of U.S. exporters of agricultural products. Agricultural products studied are feed, flour, frozen potatoes, frozen orange juice, five categories of beef, five categories of pork, and two categories of chicken. The popular pricing-to-market (PTM) approach of Krugman (1987) is used to examine market power and imperfect competition for the markets under study. The PTM model can directly investigate whether there is any evidence of market power in international trade. The sensitivity of U.S. export prices to exchange rate fluctuations may indicate price discrimination and imperfect competition in the international markets. The PTM approach is popular because of its relatively simple specification and empirical testing.

## Implications and Conclusions

We use a modified version of Knetter's fixed-effects panel model, which allows for lagged adjustments in export prices similar to Kasa's (1992) model. Domestic wholesale prices are included in the model as a measure of marginal costs instead of the typical dummy variable scheme. The empirical results indicate there is evidence of markup

pricing for U.S. agricultural products in some of the international market destinations in our sample. Markups over marginal cost were found for Ireland, the Netherlands, Portugal, and Spain for feed; Japan for orange juice; Hong Kong for frozen potatoes; Canada, Japan, and Mexico for some of the beef and pork types; and Canada, Hong Kong, Mexico, and Singapore for some chicken types.

## Background

This article investigates the markup pricing behaviour of U.S. exporters of agricultural products. The popular pricing-to-market (PTM) approach of Krugman (1987) is used to examine market power and imperfect competition for the markets under study. Krugman first noticed price discrimination among export markets when he observed exporters didn't always change their prices to foreign customers as exchange rates changed. He coined the term "pricing-to-market" for instances where exporters used fluctuating exchange rates to charge different prices by destination for the same product.

The PTM model can directly investigate whether there is any evidence of market power in international trade. The sensitivity of U.S. export prices to exchange rate fluctuations may indicate price discrimination and imperfect competition. The PTM approach is popular because of its relatively simple specification and empirical testing (Knetter, 1989, 1993, and 1994; Marston, 1990; Pick and Park, 1991; Pick and Carter, 1994; Park and Pick, 1996; Patterson, Reca, and Abbot, 1996; Goldberg and Knetter, 1997; Glauben and Loy, 2002; Gil-Pareja, 2002). Agricultural products studied in this article are feed, flour, frozen potatoes, frozen orange juice, five categories of beef, five categories of pork, and two categories of chicken. Among these products, meats make up by far the most significant portion of U.S. exports, and data sources allow analysis of many differentiated products.

U.S. meat exports have increased at a phenomenal rate during the last decade. Red meat exports climbed from 407 thousand tons in 1990 to 1.22 million tons in 2000, a 200 percent increase.[1] Poultry meat exports climbed from 596 thousand tons in 1990 to 2.85 million tons in 2000, a 375 percent increase (figure1). No agricultural export category has grown faster than poultry meat for the United States over that time period. Only a few export categories have grown faster than red meat.

Many factors have led to this rapid growth rate. U.S. poultry production has increased and prices have stayed low for many years, encouraging exports. Transportation technology now allows the United States to ship fresh red meat to East Asian destinations and still meet demanding shelf-life requirements. Trade liberalization has lowered U.S. red meat prices in many destinations. Income growth has naturally led to increased meat demand in many middle-income countries, while job growth and improved opportunities outside agriculture have reduced meat production in many countries. Finally, the fact that the United States is free of foot-and-mouth disease, while many parts of the world have seen outbreaks, has further favoured U.S. red meat exports.

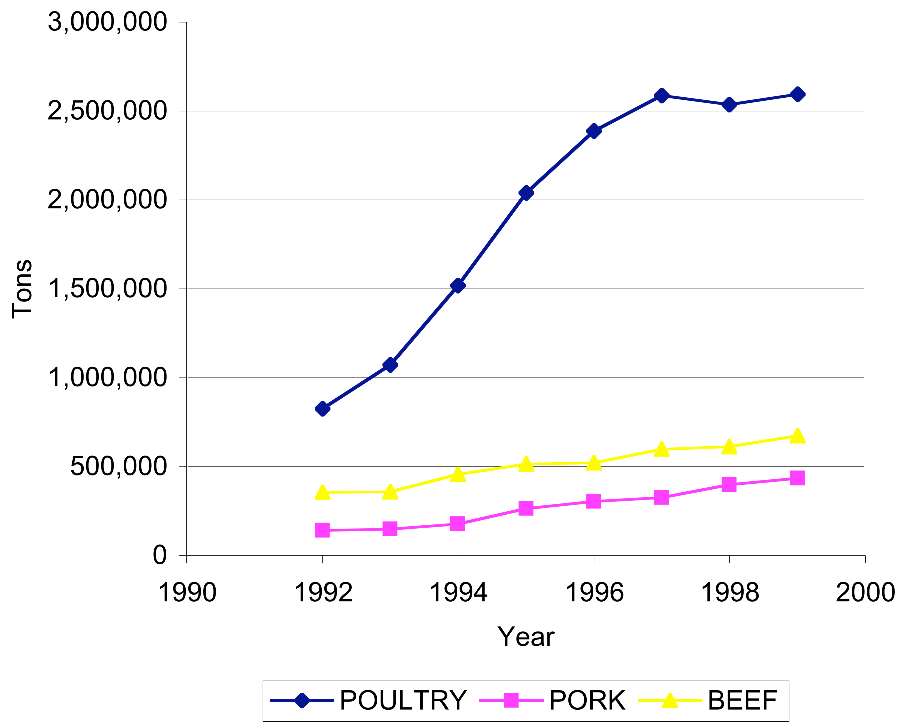


**Figure 1** U.S. meat exports

The United States exports $1 billion to $1.5 billion in feed each year. The major U.S. feed export markets are in Western Europe (England, Ireland, the Netherlands, Portugal, and Spain). Wheat flour exports range from $110 million to $160 million per annum. The major export markets for flour are Canada, Haiti, and Mexico on a continuous basis, and several African countries on a discontinuous basis. Some of these exports are sold on a concession basis and are used to alleviate famine in poverty-stricken countries.

Developed countries are important markets for frozen potatoes. Exports are usually about $340 million per year and are concentrated in Canada, Hong Kong, Japan, and Mexico. U.S. frozen orange juice has fallen in most recent years, averaging approximately $130 million per annum after growing rapidly in the early and mid 1990s and stabilizing in the last four years. The major destination markets for U.S. frozen orange juice are Belgium, Canada, Japan, Korea, and the Netherlands.

In this study, we use a modified version of Knetter's fixed-effects panel model to study PTM behavior. Our specification allows for lagged adjustments in export prices similar to Kasa's (1992) model. Domestic wholesale prices are included in the model as a measure of marginal costs instead of the typical dummy variable scheme. The empirical results indicate there is evidence of markup pricing for U.S. agricultural products in some international market destinations from our sample.

## The Model

Knetter (1989) derives a price discrimination–markup relationship from a set of first-order conditions for the profit maximization problem of an exporter who faces residual export demand in selling to *N* foreign destinations:

(1) $$p_{it} = c_t \left( \frac{\varepsilon_{it}}{\varepsilon_{it} - 1} \right) \quad i = 1,...,N \text{ and } t = 1,...,T ,$$

where $p_{it}$ is the export price to destination $i$, $c_t$ is the marginal cost of production in period *t*, and $\varepsilon_{it}$ is the elasticity of the residual demand in destination market $i$ facing the exporter in terms of the importer's local currency price.

The estimation model is a fixed-effect regression model applied to pooled, time series–cross sectional data for a given exporting country:

(2) $$\ln(p_{it}) = \theta_t + \lambda_i + \beta_i \ln(e_{it}) + u_{it} ,$$

where $\theta_t$ is a set of time-related dummy variables, $\lambda_i$ is a set of country-effect dummy variables, $e$ is the nominal exchange rate in units of the import-country currency, and $u_{it}$ is a regression disturbance.

The empirical specification tests pricing behavior by using the time-related dummy variables to measure marginal costs, since data on such costs are difficult to obtain. The underlying premise of this substitution is that marginal costs may shift over time but will not vary across different destination markets. Knetter (1989) argues that the time dummy variables will capture all of these changes in marginal costs. This allows the researcher to concentrate on the $\lambda_i$s and $\beta_i$s when investigating market segmentation, product differentiation, and PTM.

A potential problem with this empirical specification is that the time-related dummy variables may explain more than just changes in marginal costs. The suspicion is that they may be correlated with the exchange rate, thus limiting the explanatory power of the exchange rate variables and distorting the investigation of PTM. To address this concern, we need to test for multicollinearity with our data set on U.S. agricultural exports. Hence, we first investigate whether time-related dummy variables in Knetter's model are correlated with the exchange-rate variables by regressing the exchange-rate variables on the time-related dummies and all other independent variables of the model in equation (2).

It is well known that the major undesirable consequence of multicollinearity is that the variances of the parameter estimates are inflated. The OLS procedure is not given enough independent variation in a variable to calculate with confidence the effect it has on the dependent variable. As a result, the parameter estimates are not efficient and do not provide reliable estimates of the parameters, so hypothesis testing is not powerful.

To detect multicollinearity between the time dummy variables and exchange rate we use the inverse of the correlation matrix. The diagonal elements of this matrix are the variance inflation factors (VIFs) and are given by $(1\text{-}R^2)^{-1}$, where $R^2$ is from regressing the exchange rate variable on all the other independent variables. High VIFs will result if $R^2$

**Table 1** Variance Inflation Factors (for the period January 1995 to March 2003)

| Category | $R^2$ | $(1-R^2)^{-1}$ |
|---|---|---|
| feed | 0.99998 | 45454.5 |
| flour | 0.99939 | 1639.3 |
| frozen potatoes | 0.99976 | 4098.4 |
| orange juice | 0.99985 | 6493.5 |
| beef[1] | 0.99977 | 4424.8 |
| beef[2] | 0.99976 | 4149.4 |
| beef[3] | 0.99975 | 4000.0 |
| beef[4] | 0.99975 | 4000.0 |
| beef[5] | 0.99975 | 4000.0 |
| pork[6] | 0.99976 | 4115.2 |
| pork[7] | 0.99976 | 4237.3 |
| pork[8] | 0.99952 | 2070.4 |
| pork[9] | 0.99954 | 2173.9 |
| pork[10] | 0.99978 | 4587.2 |

[1] boneless, non-processed, fresh and chilled beef
[2] non-processed, fresh and chilled beef with bone
[3] frozen, boneless carcasses of beef
[4] boneless, processed frozen beef
[5] frozen carcasses of beef with bone
[6] meat of swine, processed, frozen
[7] meat of swine, processed, fresh or chilled
[8] meat of swine, non-processed, frozen
[9] hams, shoulders and cuts thereof, of swine, bone in, non-processed, frozen
[10] meat of swine, non-processed, fresh or chilled

is near unity, hence suggesting muticollinearity (Kennedy, 1994). Table 1 presents the results of multicollinearity tests for the period 1995 (01) to 2000 (03). The $R^2$ values for the 14 product categories are very close to unity, which indicates the exchange-rate variables are highly correlated with the set of time-related dummy variables in our data set. As a result, the parameter estimates of the exchange rate variables in the model in equation (2) are not precise and reliable estimates of the parameters are not possible.

Therefore, we use a modified version of Knetter's pooled, cross section–time series model:

(3) $$\ln(p_{it}) = \lambda_i + \alpha_i \ln(p_{it-1}) + \beta_i \ln(e_{it}) + \gamma_t \ln(wp_t) + u_{it},$$

where $p$ is export unit value in dollars, $\lambda_i$ s are destination country effects, $wp$ is marginal cost (wholesale prices) in the exporting country, $u$ is the regression disturbance, and $i$ and $t$ index destination and time period, respectively. In this model, equation (2) is modified to allow for lagged adjustments in export prices, similar to Kasa's model, and domestic wholesale prices are included to measure marginal costs instead of the time-related dummy variables. The incorporation of marginal costs into the analysis adds the possibility that export markets are integrated, but still distinct from the domestic market. Further, the inclusion of lagged adjustments will allow us to investigate price transmission from the U.S. market to the export markets. Kasa found that the transitory component in exchange rates (the degree that exchange rates differ from their long-run equilibrium) makes a difference for the length of adjustment.

## The Data

The data used in this study are based on the U.S. monthly values and quantities of exports to selected destination countries[2] for harmonized system (HS), ten-digit categories for feed, flour, frozen potatoes, orange juice, and a number of meats. The data source is the Foreign Agricultural Service (FAS) of the U.S. Department of Agriculture (USDA). The beef categories and their respective commodity codes include non-processed boneless fresh or chilled (0201306000), non-processed bone-in fresh or chilled (0201206000), non-processed boneless frozen (0202306000), processed boneless frozen (0202303550), and non-processed bone-in frozen beef (0202206000) for the period 1990 (01) to 1998 (12). The pork categories and their respective commodity codes include non-processed frozen (0203294000) for the period 1994 (01) to 1999 (02), processed frozen (0203292000) for the period 1990 (01) to 1999 (02), non-processed bone-in frozen (0203229000) for the period 1990 (01) to 1998 (12), non-processed fresh or chilled (0203194000) for the period 1990 (01) to 1999 (02), and processed fresh or chilled pork (0203192000) for the period 1990 (01) to 1997 (12).

The chicken categories and their respective commodity codes are frozen chicken cuts (0207140000) for the period 1996 (01) to 1996 (12) and frozen chicken cuts, other (0207140090) for the period 1997 (01) to 2000 (03). The data set used for feed, flour, frozen potatoes, and orange juice covers the period 1995 (01) to 2000 (03). The quantity and value data were used to generate the price (unit value) variable. Unfortunately, due to the lack of data we could not choose the same time period for all the categories, though that would have been preferred. The data set also includes bilateral nominal exchange rates (from *International Financial Statistics* published by the International Monetary Fund (IMF)) and wholesale prices (from USDA, Economic Research Service (ERS)).

## Empirical Estimation and Results

Since our model specification uses pooled, cross section–time series data, we are concerned about both cross-section heteroskedasticity and contemporaneous correlation. Hence we estimate the unknown structural parameters in our model using the SUR weighted least squares (sometimes referred to as the Parks estimator) in the Eviews software package.

Three different scenarios can be expected with this model (Goldberg and Knetter, 1997; Knetter, 1993). If the international export markets are competitive and integrated, all export prices will equal a common underlying marginal cost with zero markup and there will be no residual variation in export prices that are correlated with country effects or exchange rates. The $\lambda_i$ s and $\beta_i$ s will still equal zero if markets are imperfectly competitive but integrated. If markets are imperfectly competitive and segmented, which may involve price discrimination across destination markets, the results will depend on the nature of the demand elasticity facing exporters.

If exporters are facing a constant elasticity of demand, then export price will be equal to marginal cost plus a fixed, destination-specific markup over marginal cost. Country effects will capture the differences in destination-specific markups, leading to statistically significant $\lambda_i$ s, but $\beta_i$ s will be zero. If exporters face changing demand elasticity as exchange rates change, export prices will depend on local currency prices, which will lead to statistically significant $\beta_i$ s as well. This will be an indication of market segmentation and price discrimination.

### *Results for the Beef Categories*

Table 2 presents the results of the model for the beef categories. The fitted model explained 54 to 93 percent of the variation in the export prices, depending on the beef category. In the presence of a lagged dependent variable on the right hand side, the Durbin-Watson *d* statistics are no longer valid. However, the Durbin-Watson *h* statistics indicated there was no autocorrelation.

The adjustment processes, $\alpha_i$ s, were for the most part highly statistically significant. The lagged price played a large explanatory role for different destinations, indicating that it takes more than one period (a month in this case) for prices to adjust to changed economic conditions. The statistically significant coefficients ranged from 33 to 83 percent for the different beef categories, but most were above 50 percent. The incorporation of a Kasa-type adjustment process helped to explain export-pricing behavior of beef exports.

Almost one-half (8 out of 18) of the exchange rate coefficients were significantly different from zero. They were statistically significant in three beef categories for Canada, indicating that export price to this higher income market depended on the local currency price. Those coefficients were all negative and ranged from 28 to 57 percent. This shows there is price discrimination and incomplete exchange rate pass-through for the Canadian beef market. The high degree of PTM for Canada in some beef cuts may be due to the proximity of the Canadian market and to the fact that there is less competition facing U.S. exporters. Many U.S. meat packers own facilities in Canada and there are few Canadian-owned packers.

All three coefficients for Korean beef were significantly different from zero, but they were fairly low, in the range of 20 to 26 percent, which suggests that the Korean import price reflected the change in the exchange rate more completely than did the Canadian import price. The Korean beef market was highly controlled by the government during the

**Table 2** Regression Results for U.S. Beef Exports

| | Boneless, non-processed, chilled beef | | | Non-processed, chilled beef w. bone | | |
|---|---|---|---|---|---|---|
| **Destination** | $\alpha$ | $\beta$ | $\lambda$ | $\alpha$ | $\beta$ | $\lambda$ |
| Canada | 0.81*** | -0.13 | -0.78** | 0.53*** | -0.57** | 1.12 |
| | (8.30) | (-0.82) | (-2.06) | (3.10) | (-2.31) | (1.43) |
| Japan | 0.70*** | -0.23*** | 0.53 | 0.81*** | -0.03 | 0.64 |
| | (13.50) | (-3.88) | (1.3) | (19.60) | (-0.26) | (0.82) |
| Mexico | 0.65*** | -0.02 | -0.66 | 0.13 | -0.01 | 1.20 |
| | (9.40) | (-0.92) | (-1.57) | (1.16) | (-0.35) | (1.50) |
| *WP* | 0.21** | | | -0.05 | | |
| | (2.78) | | | (-0.37) | | |
| $R^2$ | | 0.93 | | | 0.75 | |
| DW | | 2.09 | | | 2.13 | |
| | **Frozen, boneless beef carcasses** | | | **Boneless, processed, frozen beef** | | |
| | $\alpha$ | $\beta$ | $\lambda$ | $\alpha$ | $\beta$ | $\lambda$ |
| Canada | 0.63*** | -0.28* | -1.10** | 0.33*** | -0.10 | -3.10*** |
| | (9.17) | (-1.75) | (-2.19) | (3.18) | (-0.33) | (-3.27) |
| Japan | 0.83*** | 0.01 | -1.45** | 0.77*** | -0.10 | -3.20*** |
| | (15.30) | (0.14) | (-2.81) | (10.00) | (-0.81) | (-3.43) |
| Mexico | 0.55*** | -0.02 | -1.10** | 0.53*** | -0.01 | -3.40*** |
| | (5.96) | (-0.62) | (-2.13) | (6.03) | (-0.30) | (-3.62) |
| Korea | 0.45*** | -0.20*** | 0.40 | 0.01 | -0.26* | -1.10 |
| | (6.36) | (-3.31) | (0.54) | (0.92) | (-2.63) | (-0.82) |
| *WP* | 0.31*** | | | 0.69*** | | |
| | (3.32) | | | (4.29) | | |
| $R^2$ | | 0.74 | | | 0.95 | |
| DW | | 2.20 | | | 1.96 | |
| | **Frozen carcasses of beef with bone** | | | | | |
| | $\alpha$ | $\beta$ | $\lambda$ | | | |
| Canada | 0.09 | -0.40* | -0.30 | | | |
| | (0.87) | (-1.63) | (-0.36) | | | |
| Japan | 0.62*** | 0.01 | -1.42* | | | |
| | (6.88) | (0.08) | (-1.64) | | | |
| Mexico | 0.03 | 0.17*** | -0.99 | | | |
| | (0.33) | (3.71) | (-1.13) | | | |
| Korea | 0.56*** | -0.22* | 0.22 | | | |
| | (6.80) | (-2.10) | (0.17) | | | |
| *WP* | 0.36* | | | | | |
| | (2.20) | | | | | |
| $R^2$ | | 0.57 | | | | |
| DW | | 2.18 | | | | |

Note: Values in parentheses are t-values. One asterisk denotes significance at the 10 percent level, two asterisks denote significance at the 5 percent level, and three asterisks denote significance at the 1 percent level.

observation period. Evidently U.S. exporters do not pass through all their exchange rate changes because of that structure. They likely wanted to maintain their market share so they would be ready when the Korean beef market liberalized in 2001.

The exchange rate coefficients for Japan and Mexico were statistically insignificant for four of the beef categories, meaning PTM had not occurred. Liberalization of beef markets in Japan and Mexico may have diminished price discrimination in these locations, and as a result there is less pricing-to-market as exchange rates change. The exchange rate coefficients have mostly negative signs for different destinations, which means U.S. exporters tend to stabilize local currency prices because demand schedules are elastic and the optimal markups of U.S. exporters change as the exchange rate changes. Overall, there is evidence of market segmentation in the Canadian and Korean beef markets.

The empirical results show the country effects, $\lambda_i$ s, were statistically significant for Canada and Japan for three beef categories and for Mexico for two beef categories. No $\lambda_i$ s were significantly different from zero for Korea. This suggests U.S exporters apply destination-specific markups over marginal cost to Canada and Japan, the two high-income markets. This would also be consistent with price discrimination by beef exporters to those destinations. Statistically significant country effects may also be a reflection of quality differences stemming from underlying differences in tastes or incomes. All of the $\lambda_i$ s that are significantly different from zero are negative and most are for frozen beef. This result would be consistent with U.S. exporters giving discounts to these countries to preserve or increase market share.

The coefficient for the U.S. domestic wholesale price is statistically significant for four of the beef categories and has the expected positive sign, ranging from 21 to 78 percent, which indicates wholesale beef prices are a good measure of marginal costs.[3] The significance and magnitude of the wholesale price coefficients show that beef export prices incorporate some of the price swings present in domestic U.S. prices, but not all of the wholesale price variation is passed through. Wholesale beef prices had a pronounced downward trend during the study period, so gross margins for beef exports were increasing based on these results. This leads us to believe that beef export markets, in general, are somewhat segmented from U.S. beef markets.

### *Results for the Pork Categories*

Table 3 presents the regression results of the model for the pork categories. For the specified model for the pork categories, the goodness of fit, as measured by R-squared, ranges from 41 to 93 percent and the Durbin-Watson *h* statistics indicate serial correlation was not a problem. The results for $\alpha_i$ s again suggest a strong relationship between export prices and their lagged values for the five pork categories. Pork exporters are adjusting more slowly to price changes in Canada and Japan than in Mexico or Korea; this situation is identical to the findings for the beef market. The estimated coefficients for Canada range from 41 to 71 percent, those for Japan from 45 to 74 percent, those for Mexico from

**Table 3** Regression Results for U.S. Pork Exports

| | **Swn mt, prosd, frz[1]** | | | **Swn mt, prosd, frsh/c[2]** | | |
|---|---|---|---|---|---|---|
| **Destination** | $\alpha$ | $\beta$ | $\lambda$ | $\alpha$ | $\beta$ | $\lambda$ |
| Canada | 0.41*** | -0.36 | 0.56 | 0.57*** | -0.91*** | 0.28 |
| | (4.66) | (-1.41) | (0.96) | (8.95) | (-4.03) | (0.53) |
| Japan | 0.45*** | -0.08 | 0.96 | 0.74*** | 0.04 | -0.07 |
| | (3.47) | (-0.57) | (1.16) | (3.92) | (0.38) | (-0.12) |
| Mexico | 0.16** | -0.02 | 0.70 | ---- | ---- | ---- |
| | (1.93) | (-0.54) | (1.24) | ---- | ---- | ---- |
| *WP* | 0.06 | | | 0.07 | | |
| | (0.48) | | | (0.68) | | |
| $R^2$ | | 0.46 | | | 0.93 | |
| DW | | 2.05 | | | 1.99 | |
| | **Swn mt, nprosd, frz[3]** | | | **Hm/sh, w/b, nprosd, frz[4]** | | |
| | $\alpha$ | $\beta$ | $\lambda$ | $\alpha$ | $\beta$ | $\lambda$ |
| Canada | 0.71*** | -0.52 | 0.04 | ---- | ---- | ---- |
| | (4.16) | (-0.57) | (0.05) | ---- | ---- | ---- |
| Japan | 0.68*** | -0.33 | 1.53 | 0.72*** | 0.06 | -0.47 |
| | (4.60) | (-1.26) | (1.12) | (6.15) | (0.35) | (-0.51) |
| Mexico | 0.39*** | 0.23** | -0.38 | 0.43*** | 0.01 | -0.05 |
| | (2.76) | (2.21) | (-0.54) | (6.10) | (0.08) | (-0.07) |
| Korea | -0.05 | -0.43** | 3.31*** | ---- | ---- | ---- |
| | (-0.69) | (-2.90) | (2.53) | ---- | ---- | ---- |
| *WP* | 0.08 | | | 0.11 | | |
| | (0.55) | | | (0.71) | | |
| $R^2$ | | 0.41 | | | 0.48 | |
| DW | | 2.08 | | | 2.09 | |
| | Swn mt, nprosd, frsh/c[5] | | | | | |
| | $\alpha$ | $\beta$ | $\lambda$ | | | |
| Japan | 0.56*** | -0.16 | -0.98 | | | |
| | (3.23) | (1.16) | (-1.22) | | | |
| Mexico | 0.51*** | -0.06 | -2.10*** | | | |
| | (8.72) | (-1.53) | (-3.17) | | | |
| *WP* | 0.53*** | | | | | |
| | (3.70) | | | | | |
| $R^2$ | | 0.90 | | | | |
| DW | | 2.18 | | | | |

Note: Values in parentheses are t-values. One asterisk denotes significance at the 10 percent level, two asterisks denote significance at the 5 percent level, and three asterisks denote significance at the 1 percent level.

[1] meat of swine, processed, frozen
[2] meat of swine, processed, fresh or chilled
[3] meat of swine, non-processed, frozen
[4] hams, shoulders and cuts thereof, of swine, bone in, non-processed, frozen
[5] meat of swine, non-processed, fresh or chilled

16 to 51 percent, and those for Korea from 5 to 43 percent. Exporters may be willing to absorb small changes in their margins before prices are changed in order to preserve market share or volume.

The exchange rate coefficients, $\beta_i$ s, were significantly different from zero for only three destinations in the five pork categories (out of 13 coefficients), indicating little PTM by pork exporters. Two of the significant exchange rate coefficients had a negative sign, which implies that if the importing country's currency depreciated, its import price in dollar terms would fall. All the $\beta_i$ s were less than one in absolute value, ranging from 23 to 91 percent, showing incomplete exchange rate pass-through. Canada's exchange rate coefficient of –0.91 shows nearly complete sterilization, which may indicate U.S exporters want to keep their prices (in Canadian dollars) stable. Overall, the empirical results reveal that there is much less PTM in pork than in beef export markets.

The results for the country effects, $\lambda_i$ s, also indicate that there is not much price discrimination or product heterogeneity in pork export markets. For the five pork categories, only two country effects are statistically different from zero, one for Korea and another for Mexico. Korea had a positive sign for its country-effect coefficient and Mexico had a negative sign, suggesting that Korea imports higher-priced pork for that category. Overall, the results show that export prices vary less by country in pork than beef export markets.

The parameter estimates for the U.S. domestic wholesale price variable were found to be statistically significant for only one of the five pork categories, which shows variations in U.S. wholesale pork prices do not explain variations in unit export prices. The significant coefficient was 53 percent, with the expected positive sign, which implies export prices for that category are responding moderately to wholesale price changes. Wholesale pork prices were quite volatile during this period. Yet during the last two years represented in the data set, which coincided with the pronounced increase in U.S. pork exports, there was a sharp downward trend in prices. These results, therefore, indicate that U.S. pork exporters were generally enjoying much higher margins on their exports since 1997.

### *Results for the Chicken Categories*

The major export markets for U.S. chicken meat are Canada, China and Hong Kong, Japan, Mexico, Russia, and Singapore. Table 4 summarizes the regression results of the model for U.S. chicken meat exports. The model fits the data well, explaining 70 and 94 percent of the variation in export prices for the two categories. The Durbin-Watson *h* statistics for the two categories exceed the upper-limit critical value in the bounds test, indicating serial correlation did not present a problem. Remember that these estimates cover a much shorter data period than the estimates for beef or pork.

The empirical results showed most of the estimated coefficients for lagged export prices were not statistically different from zero, indicating prices passed through quickly.

**Table 4** Regression Results for U.S. Chicken Exports

| | Chkn, cts/off, frz[1] | | | Chkn, other, frz[2] | | |
|---|---|---|---|---|---|---|
| **Destination** | $\alpha$ | $\beta$ | $\lambda$ | $\alpha$ | $\beta$ | $\lambda$ |
| Canada | 0.53** | 1.18 | -0.48 | -0.26 | 1.30 | -2.65*** |
| | (1.91) | (0.41) | (-0.43) | (-0.87) | (1.06) | (-2.69) |
| China | 0.13 | -11.20 | 23.00 | 0.03 | -16.98 | 32.55 |
| | (0.55) | (-0.8) | (0.77) | (0.21) | (-0.30) | (0.27) |
| Hong Kong | 0.10 | 45.10 | -92.90 | 0.75** | -0.04 | -3.03 |
| | (0.25) | (0.74) | (-0.74) | (1.84) | (-0.002) | (-0.05) |
| Japan | -0.12 | -0.05 | 0.09 | 0.06 | -0.21 | -1.97 |
| | (-0.12) | (-0.04) | (0.02) | (0.15) | (-0.45) | (-0.85) |
| Mexico | 0.18 | 0.99 | -2.50 | 0.36 | -0.60 | -1.96 |
| | (0.40) | (0.86) | (-1.08) | (0.97) | (-1.14) | (-1.47) |
| Russia | 0.25 | 0.93** | -1.93*** | -0.02 | -0.50* | -2.67*** |
| | (1.08) | (1.90) | (-2.44) | (-0.22) | (-1.61) | (-2.49) |
| Singapore | 0.19 | -5.46 | 1.71 | 0.36*** | -0.16 | -2.85*** |
| | (0.37) | (-0.71) | (0.62) | (2.51) | (-0.24) | (-2.84) |
| *WP* | 0.09 | | | 0.74*** | | |
| | (0.67) | | | (3.17) | | |
| $R^2$ | | 0.94 | | | 0.70 | |
| DW | | 1.73 | | | 1.98 | |

Note: Values in parentheses are t-values. One asterisk denotes significance at the 10 percent level, two asterisks denote significance at the 5 percent level, and three asterisks denote significance at the 1 percent level.

[1] meat and edible offal, of chicken, cuts and offal, frozen

[2] meat and edible offal, of chicken, cuts and offal, frozen, other

Three coefficients were significantly different from zero (one each for Canada, Russia, and Singapore). All the $\beta_i$ coefficients were also statistically insignificant (except for the Russian coefficient), indicating PTM did not exist. PTM and price discrimination were observed only for Russia, where U.S. chicken meat is often sold at subsidized rates. These results suggest that markets are integrated across export destinations. Export prices are determined on a longer-run basis, less subject to short-run market fluctuations. This is not surprising, since chicken production and marketing have always been more vertically integrated than beef and pork.

The empirical results show that chicken meat export markets are competitive and integrated among destinations. The results show that the country effects for Canada, Russia, and Singapore were significantly different from zero, reflecting some product differentiation. The empirical results of the wholesale price variable are quite different between the two equations, even though both categories have similar export volumes. For one chicken category there is no apparent relationship between wholesale prices and export prices, yet for the other category there is a significant and positive relationship between wholesale prices and U.S. export prices. Wholesale chicken prices were quite variable during the observation periods, but there was no clear trend. For one product category exporters chose to keep export prices rather stable, while in the other they chose to pass wholesale prices forward.

### *Results for Feed, Flour, Frozen Potatoes, and Frozen Orange Juice*

We used wholesale prices of corn as a measure of marginal cost for feed, wheat for flour, potatoes for frozen potatoes, and oranges for frozen orange juice. Table 5 summarizes the results. The estimated wholesale prices of corn and wheat were significantly different from zero, with expected positive signs and values of 31 and 17 percent, respectively. The other estimated wholesale prices were statistically insignificant.

The adjustment processes, $\alpha_i$ s, were for the most part highly statistically significant, especially for feed and frozen potatoes. The lagged price played an important role for different destinations, indicating that prices take more than a month to adjust to changed economic conditions. The estimated coefficients were mostly in the 50 percent range except for export markets for orange juice that were in the teens-to-30 percent range for the different destinations. The estimated results of the country effects for these categories were mixed, with almost half of country coefficients (8 out of 17) being significantly different from zero. Since these categories are for the most part homogeneous with very little quality differentiation present, the results suggest exporters use other factors such as significance of the market, disposable income, or market proximity as means of market segmentation.

The empirical results showed that the bilateral exchange rate coefficients were statistically insignificant for all export destinations for flour, and only one coefficient was significantly different from zero for frozen potatoes (Hong Kong) and one for orange juice (Japan), implying very little pricing-to-market behavior in these markets. These results showed most of the $\beta_i$ coefficients (four out of five) were significantly different from zero for feed (except for United Kingdom), with the estimated coefficients ranging from 25 to 35 percent. Hence, there is a clear indication of some PTM and price discrimination in the feed market.

**Table 5** Results for Feed, Flour, Frozen Potatoes, and Orange Juice

| | Feed | | | | Orange juice | | |
|---|---|---|---|---|---|---|---|
| **Destination** | $\alpha$ | $\beta$ | $\lambda$ | **Destination** | $\alpha$ | $\beta$ | $\lambda$ |
| Ireland | 0.66*** | -0.35* | -1.23*** | Belgium | 0.62*** | 0.42 | -1.81 |
| | (9.41) | (-1.79) | (-5.28) | | (6.14) | (0.99) | (-1.19) |
| Netherlands | 0.52*** | -0.29** | -1.21*** | Canada | 0.22 | 0.04 | 0.43 |
| | (6.88) | (-2.45) | (-6.46) | | (0.67) | (0.04) | (1.17) |
| Portugal | 0.48*** | -0.41** | 0.58 | Japan | 0.14 | -1.37*** | 5.93*** |
| | (6.51) | (-2.89) | (0.89) | | (1.14) | (-3.75) | (3.52) |
| Spain | 0.58*** | -0.26* | 0.01 | Korea | 0.32*** | 0.21 | -1.71 |
| | (7.54) | (-1.84) | (0.01) | | (3.63) | (1.29) | (-1.47) |
| England | 0.53*** | 0.59 | -1.06*** | Netherlands | -0.15 | -0.41 | -0.73 |
| | (7.63) | (1.41) | (-4.29) | | (-0.84) | (-1.16) | (-2.74) |
| *WP* | 0.31*** | | | *WP* | -0.04 | | |
| | (6.61) | | | | (-0.93) | | |
| $R^2$ | 0.88 | | | $R^2$ | 0.79 | | |
| DW | 2.21 | | | DW | 2.08 | | |
| | **Flour** | | | | **Frozen potatoes** | | |
| **Destination** | $\alpha$ | $\beta$ | $\lambda$ | **Destination** | $\alpha$ | $\beta$ | $\lambda$ |
| Canada | 0.46* | -0.46 | -0.72** | Canada | 0.46* | -0.42 | -0.19 |
| | (1.81) | (-0.60) | (-2.32) | | (1.62) | (-0.44) | (-0.47) |
| Haiti | 0.68*** | -0.11 | -0.31 | Hong Kong | 0.34** | 128.4*** | 263.6*** |
| | (6.88) | (-0.39) | (-0.39) | | (2.91) | (4.76) | (4.77) |
| Mexico | 0.16 | 0.06 | -1.41*** | Japan | 0.83*** | -0.178 | 0.60 |
| | (1.44) | (0.46) | (-3.75) | | (6.51) | (-0.60) | (0.42) |
| | | | | Mexico | 0.57*** | 0.12 | -0.76 |
| | | | | | (3.68) | (0.53) | (-1.31) |
| *WP* | 0.17** | | | *WP* | 0.14 | | |
| | (2.24) | | | | (1.26) | | |
| $R^2$ | 0.49 | | | $R^2$ | 0.63 | | |
| DW | 2.15 | | | DW | 1.85 | | |

Note: Values in parentheses are t-values. One asterisk denotes significance at the 10 percent level, two asterisks denote significance at the 5 percent level, and three asterisks denote significance at the 1 percent level.

## Summary and Conclusions

The United States is a major exporter of many agricultural products in the world, with a significant market share. The question addressed in this article is whether U.S. exporters apply this market prominence in international markets and price discriminate with respect to the destination markets. The PTM model and analysis of movements in export unit values test whether changes in export prices are due to price discrimination and are related to changes in the importers' currencies relative to the U.S. dollar. The phenomenon of pricing-to-market is most easily observed when exchange rates change, giving exporters an opportunity to change their markup over costs (or profit). When the currency of an importing country depreciates (falls in value), exporters may adjust their export price by decreasing their markup so the price to their foreign customers doesn't change. When the currency of an importing country appreciates, exporters would then increase their markup for foreign customers (and their profits). The products under investigation in this study are meats (beef, pork, and chicken products), feed, flour, frozen potatoes, and orange juice.

The empirical results show that U.S. exporters exercise more market power for beef and feed products than for pork, chicken, flour, frozen potatoes, or orange juice. Exporters are also slow to adjust their export prices when economic conditions change. They seem to transmit only a portion of the fluctuations in U.S. domestic prices into their export markets. In some of the markets where liberalization has taken place (Japan and Mexico) there is less price discrimination, while there is some evidence of pricing-to-market taking place in other markets. This pricing behavior may come about because U.S. exporters want to maintain their market share in these markets. An important consideration is the finding that gross margins for exporters have improved throughout the period, so that they may have market power that they can exercise in all markets.

In the meat categories, the observations for the pork export markets are different from those for the beef categories. There is much less evidence of pricing-to-market for pork, but the relationship between wholesale prices and export prices is also very weak. Gross margins for pork exports have increased dramatically in recent years as the United States has begun to export large quantities of pork. This would mean that U.S. pork exporters are able to price discriminate between domestic sales and exports, but they do not discriminate among export destinations. The empirical results for chicken meat also imply that U.S. exporters do not price discriminate among export destinations, and markets adjust rapidly to changes, though export prices are slow to transmit as wholesale price changes in one case.

It is clear from this study that international markets, except for beef and feed markets, are price-integrated in the sense that price differences among countries are minimal; however, it is also clear that exporters are able to increase their margins as U.S. wholesale prices fall. The price instability in the U.S. market is not always passed forward to the international market, but when it is, it is passed forward to all international markets. The fact that export prices are more stable than domestic U.S. prices, though, might mean U.S. exporters want to smooth price changes over a longer time period. Reducing export prices when wholesale prices are low and then increasing export prices after wholesale prices rebound might be detrimental to long-run market shares. This will be easier to investigate using future periods when wholesale prices rebound.

## Endnotes

[1]Tons are in metric units.

[2]We chose to look at pricing strategies for countries that are major destinations for U.S. exports. These obviously vary by product type and meat cut.

[3]The only beef category where the wholesale price was not significantly different from zero was also the category with the lowest export levels (about 10 percent of the highest-volume category). This might mean that the volumes are small enough that packers are less concerned about wholesale prices.

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