Exchange Rate Pass-Through and Its Relation to Market Power:

Reinterpretation of the Degree of Exchange Rate Pass-through

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Abstract

We propose a different perspective for interpretation of exchange rate pass-through: a relatively lower (higher) degree of pass-through implies a competitive (less competitive) market. Using three different wheat exporting countries, the United States, Canada, and Australia, and two importing countries, Japan and Korea, we are not likely to reject our hypothesis. In the competitive market (Japan), the exporting countries determine their prices based on changes in the competing country's price, and as a result, there is a close-to-zero degree of exchange rate pass-through. However, a lower degree of price competition and a significantly higher degree of exchange rate pass-through are found in a less competitive market (Korea).

Keywords: Cointegration Analysis, Exchange Rate Pass-through, Price Competition, Wheat Market

Introduction

There have been an increasing number of studies concerning price adjustment behaviors of traders in international commodity markets; in particular, the issue of price adjustment of firms in response to changes in exchange rates has garnered attention (Mann, 1986; Giovannini, 1988; Kasa, 1992; Yang, 1995; Feenstra, et al., 1996). Many of the studies have found less-than-complete exchange rate pass-through, suggesting reasons such as product characteristics, trade barriers, market share, initial sunk cost, and the degree of competition (Krugman, 1987; Dornbusch, 1988; Baldwin, 1988; Froot and Klemperer, 1989; Feenstra, 1989; Fisher, 1989; Menon, 1996).

Imperfect competition has been frequently counted as a main reason for the low degree of exchange rate pass-through (Krugman, 1987). Because an exporting firm carefully observes and responds to competing firms' behavior in a market, especially a competitive market, information about the competing firms' behavior should be assessed in the analysis of exchange rate pass-through to achieve a more specific implication of the intensity of market competition, as indicated in Goldberg and Knetter (1999) and Gross and Schmitt (2000). Thus, an empirical analysis which does not consider rival firms' behavior is not consistent with the basic concept of the Nash equilibrium, and the results are only suggestive of the nature and of importance of imperfect competition.

Two distinct studies are found which incorporate the price decisions of all competitors in a specific market: Goldberg and Knetter (1999) and Gross and Schmitt (2000). Goldberg and Knetter developed a theoretical model to estimate the intensity of competition (or market power) in a specific market. Using exchange rates of competitors as cost shifters, they identified the residual demand elasticity of a firm in a market that enables a measurement of the market power of the firm. Their model does not, however, suggest a proper interpretation of exchange rate

pass-through regarding the intensity of market competition. This is because it does not consider a firm's own exchange rates but competitors' exchange rates and other cost shifters instead.[1]

Meanwhile, Gross and Schmitt utilized the price decisions of all competitors in an imported automobile market in Switzerland. They found a relatively low degree of exchange rate pass-through and attribute the incomplete pass-through mainly to the imperfect competition in the market as it was depicted by the influential study, Krugman (1987). Caution is, however, needed in construing incomplete pass-through when there exists competing firms in a market. Competing firms, which export highly substitutable products to a foreign country, take into account competitors' behavior, and as a result, their markup price cannot fully adjust to changes in the exchange rate. In this case, it is difficult to conclude that the low degree of exchange rate pass-through is mainly due to imperfect market competition. Rather, it can likely be attributed to perfect competition because the firm responds to the rival firms' behavior. On the other hand, if the firm executes its market power, then it does not consider other prices and determine its price based on the exchange rate changes. Thus, the degree of exchange rate pass-through is likely higher than the former case.

We propose the following hypothesis. If a firm faces perfect market competition, its price is completely explained by the price of competitors in the market, and the degree of exchange rate pass-through should be almost zero. In contrast, if the firm faces imperfect market competition, the prices of competitors are not likely to explain the firm's import price, and we observe almost full exchange rate pass-through. Therefore, greater explanatory power of other firms' prices on a firm's import price and less exchange rate pass-through imply less market power. Less explanatory power held by other firms' prices on a firm's import price and higher exchange rate pass-through imply higher market power.

The objective of this study is, therefore, to draw new interpretation of the exchange rate pass-through and its relation to the intensity of market competition. By analyzing both the dynamic properties of the exchange rate pass-through and the pricing decisions of all competitors, we can derive more accurate estimates of exchange rate pass-through and more thoughtful economic implications of the nature of competition in a market.

To test the hypothesis, we analyze the Japanese and Korean wheat market and compare the results between the two countries for the following reasons. First, Japan and Korea are the two largest consistent wheat-importing countries in Asia and they import from the same major exporting countries: the U.S., Canada, and Australia. Japan and Korea import almost 6 million and 1.5 million tones per year, respectively, from the United States, Canada, and Australia during the period of 1989 to 2000. Because only 10% of consumption is supplied domestically in Japan and there is no domestic production in Korea, both countries have been heavily dependent on wheat imports. However, there are fundamental differences between the marketing systems of the two markets. Japanese wheat imports are operated by a state trading agent, the Japanese Food Agency (JFA), which regulates all wheat trade in Japan. On the other hand, due to a trade liberalization program, wheat imports in Korea have been unregulated since 1990 even though there have been decreasing tariff rates (5% prior to 1993 and 3% to 1.8% for 1995 to 2004). Because of the similarity of the production statuses and the discrepancy between the marketing systems, these two countries are suspected of having different types of market competition. For example, because of state trading in Japan, they allocate import quotas to the three exporting countries based on their own wheat import plan, suggesting that Japan may have monopsony power as indicated in Love and Murniningtyas (1992) and Carter, et al. (1999), though Carter, et al. did not reject perfect competition. According to Pick and Park (1991), Yang

and Lee (2001) and Cho, et al. (2002), the United States is, however, likely to have monopoly power in the Korean wheat market.

This study consists of two parts. First, the model, which examines the degree of exchange rate pass-through and price competition, is estimated by a cointegration analysis developed by Johansen and Juselius (1994) to accommodate the properties that both prices and exchange rates are non-stationary and that the prices of the competitors are interdependent and simultaneously determined regardless of the economic size of countries. The analysis also has the advantage of resolving the over-identification problem. To strengthen our hypothesis, alternative models, measuring market power, are estimated. For example, a model is developed to test market structure for the Japanese wheat market: monopsony versus competitive. However, to test imperfect market competition among the wheat importing countries, the model developed by Knetter (1989) is also estimated.

The organization of this study is as follows. The next section discusses about interpretation of exchange rate pass-through in relation to the intensity of market competition by using the residual demand. Then empirical models are discussed, followed by the explanation of the data and important preliminary estimation results. The empirical results of our tests on the price rivalry effect and exchange rate pass-through are addressed along with the results of the market power tests. The final section summarizes the principal findings and the implications of the research.

Interpretation of Measures of Exchange Rate Pass-Through: A Discussion

A low degree of exchange rate pass-through is commonly believed to be due to imperfect competition, or existence of market power of an exporting firm in a foreign market. Under the assumption of *constant marginal cost*, the export (import) price in foreign currency is often found to partially adjust to changes in exchange rates, which is interpreted as an incomplete

mark-up adjustment of the firm, and thus deviations from perfect competition (Goldberg and Knetter, 1997). However, the low degree of exchange rate pass-through also occurs in a perfectly competitive market. In this case, the firm is a price taker and should sell its products at the market price if it wants to stay in the market even though exchange rates move unfavorably. Thus, almost zero exchange rate pass-through occurs.[2] These two seemingly contradictive views are not, in fact, contradictory but matters of considering other players' information in the market. For instance, in the first case, a particular firm's behavior in the market is solely examined without regard to the competing firm's information. However, in the later case, the behavior of competing firms is implicitly considered through the market clearing price. Therefore, it needs to be cautioned to draw the implication of the degree of exchange rate pass-through relating to market power when considering competing firm's behavior in a market, which is closer to a complete economic model.

In this section, we propose a different implication of the degree of exchange rate pass-through regarding the intensity of market competition using two extreme cases of a market. However, our idea is easily generalized from the cases.

Consider a firm who exports its products to a foreign market and competes with other firms who export similar products to the market. Using the concept of the residual demand used by Becker and Bresnahan (1988) and Goldberg and Knetter (1999), we can explain the relationship between the degree of exchange rate pass-through and the intensity of market competition. The residual demand curve is defined as the difference between the market demand and the competitive fringe's supply curves, summarizing constraints placed on behavior by competing firms in the market.

Using the relationship between the elasticity of the residual demand curve and the firm's price-cost margin, which measures the firm's market power, it is easy to derive the relationship between pass-through and market power. The elasticity of the residual demand determines the size of the price-cost margin: (1) the flatter the demand curve, the lower the margin; (2) the steeper the curve, the higher the margin.

The residual demand curve will be completely flat, implying zero margin and mark-up, when a firm is completely constrained in the exercise of market power by the existence of competitors. In this case, the price does not depend on its own quantity but is completely determined by the prices of its competitors, indicating zero exchange rate pass-through. Because the firm faces completely flat (or elastic) demand, changes in its marginal cost do not affect its import price, so there is no direct relationship between import price and exchange rate (Figure 1).

In contrast, if the firm completely exercises its market power even when there exist competitors in the market, the firm changes its price based on its own quantity and not the price of its rivals. If the market demand is almost perfectly inelastic, the firm has a capacity constraint, say at Q_0. Because the firm faces completely vertical demand, changes in its marginal cost are fully reflected in changes in its price, indicating changes in exchange rates drive the price to change by the exact amount of the change in exchange rates (Figure 2).[3]

In reality, the residual demand should be neither perfectly elastic nor inelastic. The idea we suggest through these two cases is that the degree of exchange rate pass-through is positively related to the intensity of market competition when considering rivalry firm's behavior in the market. More specifically, (1) if a firm faces an almost flat residual demand (no market power; no markup), its import price can be totally explained by price of other competitors in the market, and exchange rate pass-through should be almost zero; (2) if a firm faces an almost vertical

residual demand (monopolistic power with almost perfectly inelastic demand; high markup), prices of other competitors in the market cannot explain the firms' import price, and the effect of exchange rates is fully transmitted to the price. Thus, there is full exchange rate pass-through. Therefore, less explanatory power of other firms' price on a firm's import price and higher exchange rate pass-through imply the firm's higher market power and higher markup. In contrast, higher explanatory power of other firms' price on the firm's import price and less exchange rate pass-through imply less market power and markup of the firm

Empirical Model Specification for Exchange Rate Pass-Through

Recently Goldberg and Knetter (1999) developed a one-equation model which is a function of residual demand to estimate the interesting summary statistics of the demand for a specific firm. This model resolves the problem of estimating all the underlying parameters of demand, cost, and conduct variables in the system of equations, which requires publicly inaccessible specific firm-level data in the international agricultural market and the specific functional forms of the equations. An advantage of using the one-equation model is that it captures the joint impact of the entities of interest on market power through the elasticity of the residual demand curve. In this section, we briefly describe their model and modify it to examine the degree of own exchange rate pass-though to import prices regardless of an endogeneity problem. The model empirically utilized in our study corresponds with a recently developed time-series model by Gross and Schmitt (2000), who used a sub-game perfect equilibrium model.

Consider the case that there are *N* competitors selling similar goods in a single importing country. In this case, each exporter, *i*, faces the following demand system:

$$P_i = D(Q_i, \boldsymbol{P}_j, Y, \delta) \text{ where } i \neq j . \quad (1)$$

P_i and Q_i are the price and quantity, respectively, of the export good, for a specific firm *i*; $\boldsymbol{P}_j$ is a vector of the prices of export goods for all other competitors in a market; Y is income of the

importing country; and $\boldsymbol{\delta}$ is a vector of the coefficients to be estimated. To avoid potential identification problem due to the simultaneity of the variables, Goldberg and Knetter considered the supply relation for all other competitors in the market:

$$P_i = C_1(Q_i, W_i, Z_i, \Gamma_i) - D_1(Q, Y, \delta)Q_i\theta_i, \tag{2}$$

where Q is the vector of all firms' quantities; $C_1(\cdot)$ is the marginal cost of the firm; D_1 is the partial derivative of the demand function with respect to export quantity; W_i is a vector of factor prices paid by firm *i*; Z_i are other variables that shift costs; Γ_i are unknown parameters; and θ_i is a conduct parameter. With (1) and (2) for all other competitors in the market, we have the following reduced form of an equation:

$$P_i = P_i^*(Q_i, W_N, Z_N, \Gamma_N, \theta_N, Y, \delta), \tag{3}$$

where *N* denotes the union of all competitors. Put (3) into (1), we have the following residual demand:

$$P_i = D(Q_i, \boldsymbol{P}_j^*(\cdot), Y, \delta), \text{ where } i \neq j \text{ or} \tag{4}$$

$$P_i = D^R(Q_i, W_N, Z_N, \Gamma_N, \theta_N, Y, \delta), \tag{5}$$

where D^R represents the residual demand curve. The elasticity of D^R with respect to Q_i implies the market power of the firm over product *i*'s price, taking into account the adjustment of all other firms' prices and quantities. Regarding (4) and (5), several issues should be addressed.

First, in many cases of international agricultural markets, it is not plausible to collect Q_i, especially high frequency level data (quarterly, monthly), and hence, it is not possible to directly estimate the residual demand elasticity. However, because the objective of this study is to examine the degree of exchange rate pass-through and its relation to market power, we would interpret the market integration by investigating the relationship between exchange rates and

import prices as explained in the previous section. In fact, exchange rates, as a cost shifter, explain most variation in quantity Q_i as explained in Goldberg and Knetter (1999).

Second, because the prices of competitors are affected by Q_i, which is an endogenous variable, Goldberg and Knetter (1999) used (5) instead of (4). If the identification problem matters when Equation (4) is estimated, it can be directly resolved with a different econometric method, which does not suffer from an endogenous problem. Then Equation (4) becomes the time-series model, which coincides with the one used by Gross and Schmitt, as follows:

$$P_i = D(S_i, \boldsymbol{P}_j^*, Y, \delta) \text{, where } j \neq i \tag{6}$$

S_i is the exchange rate between export and import countries' currency. An advantage of using (6) is that it examines the exchange rate pass-through by considering relevant information for all competitors. Caution should be needed to interpret the degree of exchange rate pass-through: the lower the degree the closer to perfect competition, while the higher the degree the more market power the firm executes. In addition, all the variables, except the exchange rate and income of the destination market, are determined simultaneously, which is more consistent with the concept of a non-cooperate simultaneous game. Therefore, a stochastic (or time-series) analysis must be appropriate. Exchange rates and income are treated as exogenous variables, affecting import prices but not influenced by the prices in return.[4]

The last issue is about substitutability and *product differentiation*: substitutability between products will be higher within a highly differentiated product-group. As Bodnar, et al. (2002) proved, the impact of higher substitutability between products is to moderate the exchange rate pass-through into the import prices. The increase in substitutability raises the elasticity of demand faced by the firm, and as a result, smaller price changes are necessary to achieve the new profit-maximizing level of sales in the foreign market. Thus, if product

differentiation is not taken into account in a model, the implication of exchange rate pass-through is likely misleading.

According to the International Grains Council's *World Grain Statistics*, the United States exports four different types of wheat to Japan: dark northern spring (14%), hard red winter (13%), hard red winter ordinary (12%), and soft white wheat, while Canada and Australia export hard red spring wheat (13.5%) and white wheat, respectively.[5] Each of these types of wheat can be treated as a differentiated product that competes with other types of wheat that have a protein, implying similar purpose of usage. For example, the U.S. dark northern spring wheat (14%) might compete with Canadian hard red spring wheat (13.5), and the U.S. white wheat might compete with Australian white wheat. Thus, we differentiated wheat products into two groups based on similar attributes: the first (the U.S. dark northern spring wheat and Canadian hard red spring wheat) as hard red wheat (*hw*) and the second (the U.S. white wheat and Australian white wheat) as white wheat (*ww*) that aims at Udon noodle markets, assuming that it is highly substitutable between exporting countries within a differentiated product-group but not likely substitutable between the groups due to different qualities, making different purpose of usage. The higher the substitutability among exporting countries, the more competition among the countries. To accommodate the diverse wheat types, Equation (6) must be modified as follows:

$$P_i^v = D(S_i, \boldsymbol{P}_j^{*v}, Y, \delta) \tag{7}$$

where v denotes the respective wheat types: *hw* and *ww*.[6] An advantage of using (7) is a direct investigation of the relationship within wheat types as well as between exporting countries.

Empirical Model Specification for Measurement of Market Power[7]

To examine the intensity of market competition in the Japanese wheat market, monopsony versus competitive market, we develop a simple model, which is a dual representation of the one in Knetter (1989).

Suppose that the Japanese Food Agency (JFA) is the only purchaser of wheat from the exporting countries, it recognizes that the amount of wheat it demands will influence the price that it has to pay for it, and it sells wheat to the Japanese domestic market. Then, this relationship can be summarized as its profit maximization problem as follows:

$$\max_{x} p^d f(x) - w(x)x, \tag{8}$$

where p^d is the Japanese wheat domestic price, $f(x)$ is the wheat production function for the Japanese domestic market, and $w(x)$ is a supply function such that if the JFA wants to purchase x units of wheat it must pay a price of $w(x)$ to the exporting countries. Then, solving the first order condition for (8) is represented as wheat import price,

$$w = MC\left(\frac{\varepsilon}{\varepsilon + 1}\right), \tag{9}$$

where ε is the elasticity of the supply function and is positive, and *MC* represents the marginal cost. Because the *markdown* ($\varepsilon/\varepsilon + 1$) is less than one, w must be less than the marginal cost. Thus, if the JFA executes its market power, the import price (w) must be less than a market price. If the Japanese market is competitive, then $\varepsilon = \infty$, meaning that the elasticity does not vary across the exporting countries (flat supply function). As a result, the import price (w) must be equal to *MC*.

In order to estimate (9), the cross-sectional-time-series model as in Knetter (1989) is as follows:

$$\ln w_{it} = \alpha_t^w + \delta_i^w + \gamma_i^w \ln s_{it} + \varepsilon_{it} \tag{10}$$

where α_t^w is the time effect, δ_i^w is the country effect, and ε_{it} is the error term. As proposed in Knetter (1989) and Pick and Park (1991), we can use (10) to distinguish the types of market competition. First, in a competitive market, import prices are the same for all exporting

countries because there is no country effect, indicating $\delta_i^w = 0$. In the competitive market, changes in the bilateral exchange rates do not affect the import prices, so that $\gamma_i^w = 0$. Second, in an imperfectly competitive market, the import prices must be different across the exporting countries, and changes in the exchange rates are fully passed-through to the import prices (the supply elasticity, ε, varies over the exporting countries). Thus, $\delta_i^w \neq 0$ and $\gamma_i^w \neq 0$.

To examine the market power that the exporting countries may have across the importing countries, Japan and Korea, we adopt the model developed by Knetter. The model is as follows:

$$\ln p_{it} = \alpha_t^p + \delta_i^p + \gamma_i^p s_{it} + \varepsilon_{it} \tag{11}$$

where *p* is wheat import price. The interpretation about market competition is the same as above and more details are in the Knetter (1989) and Pick and Park (1991).

Data

Quarterly data are used between 1980:I and 2000:IV for Japan and 1993:I and 1999:III for Korea. [8] Three variables are needed: import prices from respective exporting countries, the United States (*u*), Canada (*c*), and Australia (*a*); nominal exchange rates between respective exporting countries and importing countries; and importing countries' income.

For Japan, wheat import prices from respective exporting countries (p^{uj}, p^{cj}, p^{aj} in respective groups) are average quarterly prices based on the monthly prices, drawn from the International Grains Council's *World Grain Statistics*. For the hard red wheat group, the prices of U.S. dark northern spring wheat and of Canadian hard red spring wheat are collected. For the white wheat group, the prices of U.S. white wheat and Australian white wheat are collected. The prices are quoted at nearest shipment position and denoted in Japanese yen per ton. For Korea, however, we are not able to differentiate wheat products imported to the Korean market because of limited data availability. An average price of all wheat types is used for the Korean market

(p^{uk}, p^{ck}, p^{ak}), which is provided by *Monthly Report of Trade Statistics* by Korea National Statistics Office.

The monthly price series provided by *World Grain Statistics* have a small number of missing observations. To approximate the missing observation, the *super smoothing* is used (Friedman, 1984). There were more than three consecutive missing observations and more than eighteen data points missing out of two hundred forty in monthly prices. It should be noted that such a procedure might not introduce the potential for biases and inconsistencies in the estimation and subsequent statistical inferences.

Nominal exchange rates (s^u, s^c, s^a) are defined as the wheat exporting countries' currencies per respective importing countries' currencies, Japanese Yen and Korean Won. Exchange rates are provided by the Economic Research Service (ERS) in the U.S. Department of Agriculture (USDA). Real GDP data for both Japan and Korea are collected from International Financial Statistics. Note that both exchange rates are assumed and tested to be exogenous in determining import prices and that all the variables are converted into logarithms.

Initial Investigation

We test nonstationarity of the individual time series using the Augmented Dickey-Fuller test (ADF) and the Philips-Perron test (PP) with intercept and trend to avoid possible problems caused by heteroskedasticity in the variables. In addition, the stationarity test based on the LR test (χ^2) is conducted due to low power of distinguishing slow mean reverting from nonstationarity.[9] The results of these tests indicate that the variables contain unit root for both Japan and Korea data, meaning that these variables are not mean reverting but become $I(1)$, stationary, at a 95% significance level.

Two stationary and one stationary relationships among the prices are identified in Japan (one relation for each group) and Korea, respectively, based on the maximum eigenvalue test and the trace tests at a 95% significance level. Because the tests are asymptotic distributions and can be an inaccurate approximation to the small sample distribution, these cointegration relationships are confirmed by both the eigenvalue of the companion matrix and the long-run speed adjustment in the VECM. The normalized valid cointegrating vectors explained by the long-run coefficients in the VECM are as follows: for the white wheat group in which the United States and Australia compete,

$$p^{uwj} = 0.751 p^{awj} + 0.004\tau, \tag{12}$$

where p^{uwj} and p^{awj} are U.S. and Australia white wheat import prices in Japan, respectively, and τ is a time trend; and for the hard red wheat group in which the United States and Canada compete,

$$p^{uhj} = 0.707 p^{chj}, \tag{13}$$

where p^{uhj} and p^{chj} are U.S. and Canada hard red wheat prices in Japan, respectively. Both U.S. prices (p^{uwj} and p^{uwj}) are positively related to the pries of respective competing countries in each wheat group. The finding of cointegration implies that U.S. prices and the prices of respective competing countries tend to move proportional to each other over long-horizons and do not drift "too far".

In the Korean wheat market, the hypothesis of one cointegrating vector cannot be rejected at the 95% significance level based on the likelihood ratio statistic that is 6.46 with $\chi^2(5)$. The normalized cointegrating vectors are as follows:

$$p^{ak} = 0.361 p^{uk} + 0.171 p^{ck} + 0.018\tau, \tag{14}$$

where p^{ak}, p^{uk}, and p^{ck} are Australian, U.S. and Canadian wheat import prices in Korea, respectively. The cointegrating vector (14) identifies a stable time-trend relationship among

prices and indicate that Australian price (p^{ak}) is associated with positive movement in U.S. price (p^{uk}) and Canadian price (p^{ck}).

For both Japanese and Korean markets, the *co*-movement of competing prices indicates that exporting countries take account of the other parties' prices to determine their prices in the long-run. Although it is too early to determine, the larger coefficients of the long-run relationship in the Japanese wheat market presage of more price rivalry among competitors in the Japanese wheat market than in the Korean market. According to Gross and Schmitt (2000) and Feenstra, et al. (1996), the stable long-run relationship among prices can be interpreted that the wheat exporters may aim at long-run market shares in the wheat markets.

Results

We divide the discussion of the results in two parts. First, we examine the degree of exchange rate pass-through through short-run dynamic analysis using the vector error correction model (VECM) and long-run impulse response analysis using the vector moving average representation (VMAR). Second, we investigate the intensity of market competition in respective markets to strengthen our hypothesis: low degree of exchange rate pass-through implies close-to perfect competition while high degree of pass-through implies imperfect competition.

Price Rivalry Relationship and Exchange Rate Pass-Through

Short-run Dynamics

Using the identified parameters of the cointegration relation (β and α), the short-run relationship parameters in the VECM are estimated. Since the exchange rates are weakly exogenous, the model is re-estimated conditional on the variable. By removing insignificant coefficients of the variables based on a likelihood ratio test, the model is estimated by using full-

information maximum likelihood estimation (FIML). The results of short-run exchange rate pass-through are presented in Tables 1 and 2.

Higher price competition among exporting countries is found in Japanese and less competition in Korean markets. In the Japanese wheat market (Table 1), all coefficients of prices are positive for both wheat groups, indicating they have an incentive to follow respective competitor's price changes. The price rivalry relationships between the competing countries indicate that white wheat is highly substitutable between the United States and Australia, as is hard red wheat between the United States and Canada, suggesting that price competition occurs when wheat is highly substitutable between exporting countries. For example, U.S. white wheat price responds to a 100% increase in Australian price by 21.3% to 41.1% over three quarters, while Australian white wheat price reacts to a similar increase in U.S. price by 24.0% to 34.4% over two quarters. For hard red wheat, U.S. price responds to Canadian price change by 17.2% to 43.3%, while Canadian price reacts to U.S. price changes by 22.5% to 35.9%.

In the Korean wheat market (Table 2), however, price competition among exporters is not as competitive as in the Japanese wheat market. Although the coefficients of prices are all positive, the degree of competition is less than it is in Japanese wheat market. In addition, the speed of response is at most two quarters. For example, U.S. wheat price only responds to changes in Australian price by 12.5% to 18.2%, and Canadian wheat price reacts to U.S. and Australian prices by 19.1% and 15.9%, respectively. Only Australian price is indicative of significant price competition with the two other exporters over two quarters, but the response sizes are less than 20.0%.

We recognize that this finding is partially due to limits of data availability: wheat products are not differentiated as in the Japanese market, and a short sample time period is used.

However, the different magnitudes of the price rivalry relationships in Japan and Korea is, at least, suggestive of the level of price competition between exporting countries. To strengthen this finding, we further examine the intensity of market competition and find consistency between the two results, which is explained in the later section.

When taking competitor's behavior into account, the exchange rate pass-through is expected to partially penetrate to import prices. The coefficients of changes in each exporting country's own exchange rates are all negative in the respective markets, indicating that an appreciation of an exporting country's currency relative to the importing country's currency leads to an increase in the corresponding price, represented in the importing country's currency. In the Japanese wheat market, a significantly low degree of exchange rate pass-through is found for both wheat groups as shown in Table 1. For example, U.S. white wheat price, represented in Japanese yen, responds positively 7.4% in first quarter delayed to 100% appreciation of own currency relative to Japanese yen, and the impact decays to 4.3% over three quarters, while own currency appreciation raises Australian price by 10.3% to 9.8% over two quarters. For hard red wheat, the relative appreciation of own currency increases U.S. price, represented in Japanese yen, by 3.2% to 5.2% and Canadian price by 4.7% to 2.5% over three quarters. These levels of exchange rate pass-through are, however, much lower than the level of pass-through in the Korean wheat market (Table 2). U.S. wheat price reacts positively 40.5% to 31.6% to relative appreciations of own currency, Canadian price responds by 44.8% to 26.0%, while Australian price responds by more than 30.0%.

Long-run Impulse Response

To verify the consistency of our finding over time, the exchange rate pass-through and price rivalry relationship are examined in the long-run, and the results are presented in Tables 3

and 4. The tables report the long-run impulse response function in the VMAR for a unitary change of shock given to each variable. The significance of each entry, represented by coefficients in bold, indicates that the shock given to each variable exhibits a permanent effect on each price.

A positive and remarkable symmetry in the size of long-run response of prices indicates that there exists the price rivalry relationship for highly substitutable wheat between exporting countries in the Japanese market: the United States and Australia for white wheat and the United State and Canada for hard red wheat (Table 3). For example, 100% increases in respective U.S. and Australian white wheat prices causes the competitor's price to increase by around 25%, while the United States and Canada follow a 100% increase in their competitor's hard red wheat prices by increasing their price around 30%. Smaller magnitudes of price rivalry relationship are found in the Korean wheat market, as found in the short-run (Table 4). The United States is more perceptive about Australian price: it increases its price by 22.6% in reaction to a 100% increase in Australian price, while Australia responds by 17.7% to U.S. price change. Canadian and Australian prices symmetrically react 16.7% and 15.1% to each other. However, as in the short-run, a change in Canadian price does not influence U.S. wheat price in the Korean market: a 100% increase in Canadian price causes U.S. price to increase by only1.20%.

In the long-run, different sizes of the degree of pass-through are found in the two markets, as found in the short-run. A significantly low degree of exchange rate pass-through is found in the Japanese wheat market (Table 3), while a much higher degree of pass-through is found in the Korean market (Table 4). For example, as shown in Table 3, 100% appreciation of each exporting country's currency relative to Japanese yen increases U.S. and Australian white wheat price, represented in Japanese yen by 4.6% and 8.7%, respectively, and U.S. and Canadian

hard red wheat price by only 5.4% and 4.5%, respectively, in the Japanese wheat market. Meanwhile, around 33% of exchange rate pass-through to Korean wheat import prices, represented in Korean won, occurs in response to 100% appreciation of each exporting country's currency relative to Korean won.

The discrepancy between the two markets implies that our hypothesis is not likely to be rejected, and as a result, it is possible for the exporting countries to find their optimal prices by taking into account changes in competing countries' prices, slowing the exchange rate pass-through to the prices when the market is competitive like the Japanese wheat market in this study. Exporting countries are, however, less concerned about their competing countries' prices when a market is less competitive, and as a result higher exchange rate pass-through occurring, as in the Korean wheat market.

Intensity of Market Competition

For the argument above to be properly interpreted in relation to exchange rate pass-through and market competition, we further investigate the intensity of market competition in respective markets. Models (10) and (11) are estimated using OLS with dummy variables as in Knetter (1989) and Pick and Park (1991).

Tables 5 and 6 report the estimates of country (δ_i) and exchange rate effects (γ_i) for the two markets. In the Japanese wheat market (Table 5), neither δ nor γ are not significant at 95% significance level, so we cannot reject the null hypothesis of perfect market competition for the sample period. Using Model (10), we are not able to find Japanese monopsony power for purchasing wheat, which supports our hypothesis of high price rivalry relationship, slowing the exchange rate pass-through to import prices when the market is close to perfectly competitive. Although direct comparison is not likely plausible because of utilization of different data set and model, our result is contrary to one found in Love and Murniningtyas (1992), who found

monopsony power in the Japanese wheat market, but partly supports Carter, et al. (1999), who did not reject perfect market competition nor monopoly power in the Japanese wheat market.

Table 6 shows the *likely* results of monopoly power of the exporting countries across the markets. Because the price data for Korea is an average price of all wheat types, the same price data for Korea are used over the two groups of wheat types according to Japanese wheat imports, so that the results are only suggestive of price rivalry and exchange rate pass-through relation. In contrast to previous studies that did not differentiate wheat types, we found that exporting countries that can discriminate price across the destination markets are different across wheat types. For white wheat, the null hypothesis of perfect market competition should be rejected for Australia, indicating that Australia has a certain level of market power relative to the United States in the Korean wheat market. Meanwhile, the United States is found to have a certain level of market power for hard red wheat by discriminating price across destination markets, Japan and Korea, relative to Canada.

Conclusions

We investigate the price decision behavior of wheat exporting countries, the United States, Canada, and Australia, in response to changes in exchanges rates when the competing firms export highly substitutable wheat products to Japanese and Korean wheat markets. The Japanese and Korean markets are selected and the results for the two countries are compared because the two countries are the largest wheat importers in Asia and they import from the same three countries, but the marketing systems in the two countries are different: state trade in Japan versus privatized trade in Korea.

We found wheat type specific price competition in the Japanese market for both short- and long-run: the United States versus Australia in the case of white wheat and the United States versus Canada for hard red wheat. Because each wheat type is highly substitutable between the

exporting countries in the competitive market, the respective country determines its price based on changes in competing country's price, and as a result, a close-to-zero degree of exchange rate pass-through occurs. In the case of the Korean wheat market, however, less degree of price competition and significantly higher degree of exchange rate pass-through are found, indicating that the Korean market is less competitive than the Japanese market. Estimation on the intensity of market competition is conducted to strengthen our findings above: the Japanese wheat market is found to be competitive rather than monopsonistic, while Australia and the United States are found to have market power for respective wheat types, white wheat and hard red wheat, in the Korean wheat market.

Overall, this study may contribute to a better understanding of the degree of exchange rate pass-through by incorporating substitutability between wheat products and competing firms' prices, as indicated in Goldberg and Knetter (1999) and Gross and Schmitt (2000), and its relation to the intensity of market competition. In contrast to the prevailing belief that low degree of pass-through is due to imperfect market competition, we conclude that lower the degree of exchange rate pass-through, the higher the market competition, when price interdependency among exporting countries matters. In a highly competitive market such as the Japanese wheat market, the price of the exporting firm is more likely to be explained by the prices of competitors in the market, slowing down the exchange rate pass-through. On the other hand, in a less competitive market such as the Korean market, the prices of competitors are less likely to explain the firm's price, so the degree of exchange rate pass-through is higher than the Japanese market.

Table 1. Short-run Dynamics for Japanese Wheat Market

		Δp^k_{t-1}	Δp^k_{t-2}	Δp^k_{t-3}	Δs_{t-1}	Δs_{t-2}	Δs_{t-3}	Δy_{t-1}	Δy_{t-2}	Δy_{t-3}	*ecm*
White Wheat	Δp^u	0.411 (1.67)	0.276 (1.98)	0.213 (3.51)	-0.074 (-1.90)	-0.056 (-2.26)	-0.043 (-1.92)	0	0	0.315 (2.01)	0.298 (3.12)
	Δp^a	0.240 (2.96)	0.344 (1.96)	0	-0.103 (-1.83)	-0.098 (-1.95)	0	0.076 (1.80)	0	0	0.229 (2.56)
		Δp^k_{t-1}	Δp^k_{t-2}	Δp^k_{t-3}	Δs_{t-1}	Δs_{t-2}	Δs_{t-3}	Δy_{t-1}	Δy_{t-2}	Δy_{t-3}	*ecm*
Hard Red Wheat	Δp^u	0.433 (1.97)	0.172 (1.691)	0	-0.032 (-2.27)	-0.066 (-1.95)	-0.052 (-2.02)	0	0.215 (1.83)	0.265 (1.76)	0.221 (3.00)
	Δp^c	0.359 (2.02)	0.249 (2.57)	0.225 (3.07)	-0.047 (-2.22)	-0.069 (-2.23)	-0.025 (-2.18)	0	0.215 (1.743)	0	0.209 (3.25)

Note that *k* denotes competing countries, and *s* denotes own exchange rates. *ecm* in respective wheat group indicates error correction model (12) and (13), respectively.

Table 2. Short-run Dynamics for Korean Wheat Market

	Δp^c_{t-1}	Δp^c_{t-2}	Δp^a_{t-1}	Δp^a_{t-2}	Δs_{t-1}	Δs_{t-2}	Δy_{t-1}	Δy_{t-2}	*ecm*
ΔP^u	0	0	0.189 (3.64)	0.125 (2.033)	-0.405 (-2.07)	-0.316 (-2.304)	0	0	0.270 (2.70)
	Δp^u_{t-1}	Δp^u_{t-2}	Δp^a_{t-1}	Δp^a_{t-2}	Δs_{t-1}	Δs_{t-2}	Δy_{t-1}	Δy_{t-2}	*ecm*1
ΔP^c	0.191 (4.48)	0	0.159 (2.78)	0	-0.448 (-2.38)	-0.260 (-1.79)	0.172 (2.63)	0.139 (1.83)	0.304 (4.01)
	Δp^u_{t-1}	Δp^u_{t-2}	Δp^c_{t-1}	Δp^c_{t-2}	Δs_{t-1}	Δs_{t-2}	Δy_{t-1}	Δy_{t-2}	*ecm*
ΔP^a	0.172 (2.21)	0.106 (1.849)	0.181 (2.92)	0.118 (2.39)	-0.341 (-2.392)	-0.319 (-2.172)	0	0	0.233 (3.05)

Table 3. Long-run Impulse Response in Japanese Wheat Market

			Shocks given to			
			p^u	p^a	s	y
White Wheat	Response	p^u	0.341 (2.716)	0.262 (2.849)	-0.046 (-2.610)	-0.248 (-0.169)
		p^a	0.257 (1.998)	0.250 (2.674)	-0.087 (-2.312)	0.040 (1.096)
			Shocks given to			
			p^u	p^c	s	y
Hard Red Wheat	Response	p^u	0.421 (2.261)	0.303 (2.718)	-0.054 (-2.716)	0.108 (3.144)
		p^c	0.325 (2.509)	0.486 (1.139)	-0.045 (-2.463)	0.117 (1.302)

Note that s denotes own exchange rates. Significant responses to own prices are not in bold.

Table 4. Long-run Impulse Response in Korean Wheat Market

		Shocks given to				
		p^u	p^c	p^a	s^k	y
Response	p^u	0.342 (1.423)	0.097 (0.565)	0.226 (2.557)	-0.330 (-2.244)	0.075 (1.111)
	p^c	0.120 (2.532)	0.386 (1.553)	0.167 (2.929)	0.342 (2.553)	0.181 (1.988)
	p^a	0.177 (2.495)	0.151 (1.971)	0.372 (1.218)	-0.327 (-2.614)	0.099 (1.490)

k Denotes respective countries.

Japanese Monopsony Power

$$\ln W_{it} = \alpha_t + \delta_i + \gamma_i s_{it} + \varepsilon_{it} \tag{15}$$

Table 5. Japanese Monopsony Power

		δ^w	γ^w
White Wheat	U.S.	-0.118 (-0.393)	-0.039 (-1.393)
	Australia	0.081 (0.408)	0.026 (1.090)
Hard Red Wheat	U.S.	0.022 (0.073)	0.023 (0.836)
	Canada	-0.013 (-0.054)	-0.021 (-1.069)

Numbers in parentheses are t-statistics.

Table 6. Market (Monopoly) Power Between Japanese and Korean Wheat Market

			δ^p	γ^p
White Wheat	U.S.	Japan	-0.014 (-0.027)	0.357 (1.330)
		Korea	-0.453 (-0.207)	-0.357 (-1.330)
	Australia	Japan	0.302 (1.568)	-0.644 (-1.189)
		Korea	0.790 (1.893)	-0.710 (-3.643)
Hard Red Wheat	U.S.	Japan	0.661 (1.226)	0.244 (0.891)
		Korea	1.393 (2.404)	-1.087 (-8.358)
	Canada	Japan	-0.028 (-0.913)	-0.050 (-1.092)
		Korea	1.469 (1.269)	-0.046 (-0.713)

Numbers in parentheses are *t*-statistics.

Figure 1 (a)

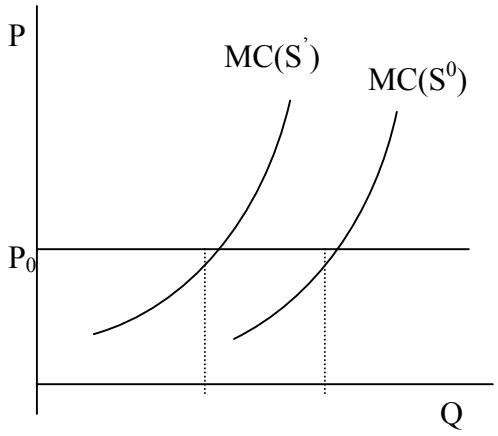

Figure 2 (a)

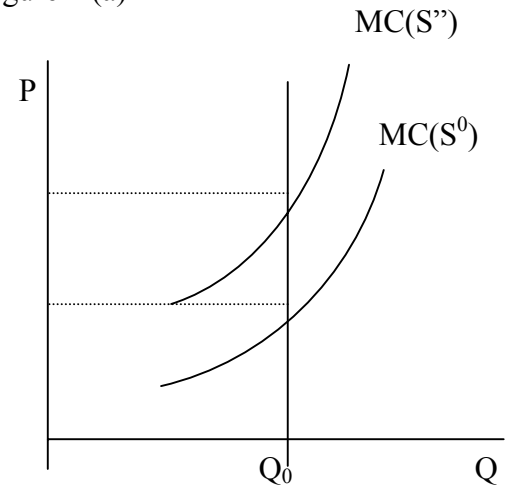

Figure 1 (b)

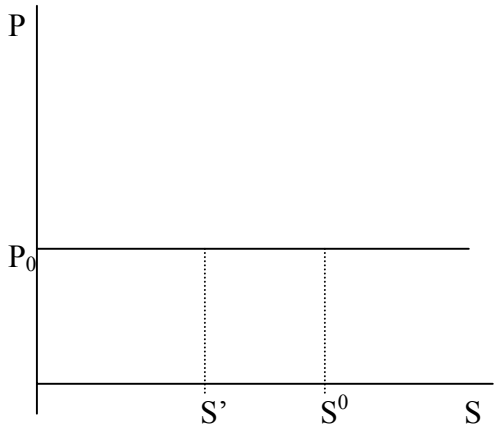

Figure 2 (b)

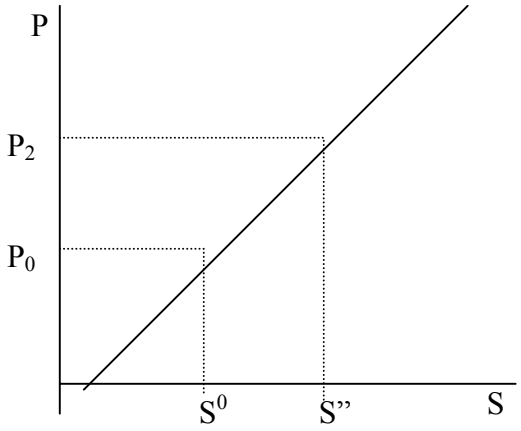

Figure 1 (a) explains that changes in marginal cost ($MC(S^0) \rightarrow MC(S')$), which is the function of exchange rates (S), does not affect the price when the firm faces the elastic residual demand curve. Figure 1 (b) explains the relationship between the exchange rates and the price, which is driven from Figure 1 (a) through the marginal cost movement. In the case of the flat residual demand, the relationship between the exchange rates and the price is depicted as horizontal, implying zero exchange rate pass-through. Meanwhile, Figure 2 (a) explains that changes in marginal cost ($MC(S^0) \rightarrow MC(S")$) are fully reflected in the price changes ($P_0 \rightarrow P_1$) when the firm fully exercise its market power, facing inelastic demand curve. Figure 2 (b) shows one-to-one relationship between the exchange rate and the price when the firm exercises the market power. The relationship is depicted as 45 degree line, implying full exchange rate pass-through.

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Notes

[1] Own exchange rate is defined as the ratio between an exporting firm's currency and an importing country's currency, while competitors' exchange rates are defined as the ratio between rivalry-exporting firms' currency and importing country's currency as defined in Goldberg and Knetter (1999).

[2] Then there are two the questions: The first one why they stay in the market even though there is no gain. There are some answers. For instance, it stays because the market share is important (Froot and Klemperer, 1988); because initial investment costs are big (Baldwin and Krugman: 1988); because of the capacity constraint, simply do dumping. Then, the next question is how they can stay. There are some answers; the firm has some markup in different markets; in the case of the agricultural trade, domestic subsidy.

[3] Because the elasticity of exchange rate pass-through, the effect of the exchange rate on the import price in foreign currency, should be in a limited range ($0 \leq \varepsilon \leq 1$) Bodnar, G. M., B. Dumas, and R. C. Marston. "Pass-through and Exposure." *Journal of Finance* 57(2002): 199-231., the relationship between the exchange rate and the price should lie between zero degree and 45 degree line as shown in Figures 1 and 2.

[4] This is an appropriate assumption, specifically for exchange rates. The exchange rate is found to be weakly exogenous in the U.S. agricultural sector (Kim and Koo, 2002)

[5] Numbers in parentheses represent the level of protein.

[6] Because of data availability, it is not possible to differentiate wheat Korea imports from those three countries, and as a result, product differentiation is not considered in the Model (7).

[7] If quantity data is available, then the residual demand model (5) should generate better estimates of market competition. However, because of data limitation in the two markets, alternative models testing market power should be utilized.

[8] We limit our data starting 1980 because (1) there are many missing observations of Australian white wheat import prices and inconsistency in U.S. dark northern spring wheat before 1975; (2) quarterly GDP data are available from 1980; and (3) the U.S. dollar has significantly appreciated relative to other currencies during the last two decades, which might affect wheat trade with the importing counties. In addition, we would like to thank Prof. Seung-Ryong Yang and his former student Won-Jin Lee at the Department of Food and Resource Economics in Korea University for providing Korean price data.

[9] See Johansen and Juselius (1992), Juselius and MacDonald (2000b), and Kim and Koo (2002) for the LR test of Unit Root.