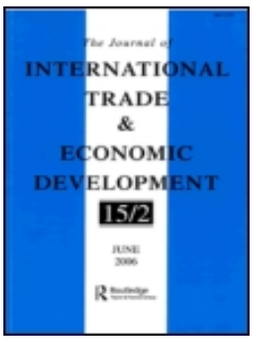

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Pass-Through Elasticity, Substitution and Market Share: the Case for Sheep Meat Exports

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ABSTRACT *This paper empirically examines the exchange rate pass-through elasticity, using sheep meat exports from the two major exporters, Australia and New Zealand. The results show the coexistence of incomplete and complete pass-through in the international sheep meat industry. The Australian sheep meat exporters have a relatively smaller market share than New Zealand and are not able to exercise monopoly power. New Zealand producers, on the other hand, can increase their mark-ups in those destination countries where they have a large market share.*

KEY WORDS: Exchange rate, market share, pass-through elasticity

Introduction

Monopolistic export producers with some market power in a segmented market are argued to practise pricing-to-market (PTM) by adjusting their destination-specific mark-ups (price over a marginal cost) in reaction to the exchange rate fluctuations in different markets. Trade models including a concept of intra-industry trade show that fluctuations in the bilateral exchange rate are not fully passed through to the import prices of commodities traded. This phenomenon is labelled as incomplete exchange rate pass-through, and is apparent in international trade.

For example, over the two years from the second quarter of 1995 to the first quarter of 1997, the New Zealand export price to Japan decreased by 16

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per cent, while its dollar appreciated by 40 per cent against the Japanese yen over the same period. In the years 1997–2000, the unprecedented depreciation of the New Zealand currency against the Japanese yen dramatically brought down the value of New Zealand dollar by 60 per cent. However, the export price to Japan increased by a moderate 40 per cent. This simple example reveals that the magnitudes of swings in the export prices are considerably less than those in the exchange rates of the exporting countries. Krugman (1987) asserted that exporters react to the exchange rate changes, in terms of export price in imperfect competitive market structure, to maintain or increase market share in the importing country.

The following article from *The Press*[1] for instance explains one of such phenomena in an international market in the New Zealand automobile import industry.

> New Zealand's vehicle market leader Toyota says buyers should not expect a drop in car prices despite a strengthening New Zealand dollar against the Japanese yen. ... Toyota New Zealand chairman Bob Field said the weaker yen would take pressure off the motor industry which had been under a lot of 'margin pressure' due to a weak New Zealand dollar for the past year. This is just making it a bit more comfortable, Mr Field said. However that comfort was not likely to extend to reduce car prices. I think the stronger dollar, and weaker yen won't really change prices that much at all. ... Toyota makes up over 18 per cent of the total new car market. Nearly half of all market leaders, or 47 per cent, source their cars from Japan.

Empirical studies conducted for such large economies as the US, Germany, and Japan, in general support the pricing-to-market and incomplete pass-through phenomena. Marston (1990) finds that Japanese manufacturing firms pass through their export prices to the United States only 50 to 60 per cent of the exchange rate movements. Menon (1995) reports that at least 50 per cent of exchange rate pass-through to the import prices for the US, Germany and Japan. Feenstra *et al.* (1996) employ the Phillips–Loretan procedure for long-run equilibria because of the non-stationarity of the variables and find a strong evidence of PTM in the automobile industry from Germany, the UK and the US.

For small open economies, it is assumed that exporters are price takers. They face an exogenously determined export price in foreign currency, which implies the complete pass-through. However, several empirical studies find that export producers in small open economies with some market power have the ability to affect prices. Dwyer *et al.* (1994) find that exchange rate pass-through is complete for the prices of imports and manufactured exports in the long run; however, in the short run it is incomplete. Tongzon and Menon (1993) show that at the aggregate level the PTM elasticity is

close to 0.7 but it is in general lower at the more disaggregate level. Lee (1997) illustrates that, on average, only 62 per cent of exchange rate fluctuations are passed through to Korean imports and the degree of pass-through is affected by a domestic market concentration in Korea. For Swedish exports of machinery and transport equipment, exporters absorb about 26 per cent of an exchange rate change in their profit margin (Athukorala and Menon, 1995). Griffith and Mullen (2001) discovered that the Ricegrowers' Cooperative Limited in New South Wales, Australia, has been able to exercise its monopoly market power by varying mark-ups over different markets.

The major theoretical approaches to PTM phenomena are the adjustment cost's explanation and monopolistic competition from the supply side and the market share argument from the demand side. The source of mark-up variations can be explained by the importance of incomplete market structure and the size of the market share (Feenstra *et al*., 1996). If the markets are segmented and the industry is imperfectly competitive, then monopolistic firms will find that PTM is profitable. When firms have larger market shares in their domestic markets than in foreign markets, the foreign sales are more affected by firms' pricing. When more firms produce a given industry output, each firm's share of the industry output will be smaller, and so each firm will incur higher average costs of production.

Exporters have an incentive to reduce the mark-up to the importers whose market shares are relatively large when importers' currencies have depreciated against the exporter's currency. If one exporter maintains his mark-up as the importer's currency depreciates while his competitors moderately reduce the destination price, then the importers are likely to substitute other varieties for the relatively more expensive variety, which, in turn, will affect the market share. Therefore, exporters will stabilize prices in terms of the buyer's currency to maintain their market shares in the presence of competitors who are exporting the similar but differentiated products (Krugman, 1987). The pass-through elasticity varies across industries as explained above due to such different environments as market shares, substitutability of differentiated products, and level of competition.

While most studies analysed the exchange rate pass-through by investigating manufacturing products, this paper aims to contribute to the literature on exchange rate pass-through by empirically examining the relationship between the effect of exchange rate fluctuations on importing prices of sheep meat and market shares. Other variables, such as competitor's price and marginal costs, are also considered, utilizing sheep meat export data from the two major exporting countries in the world market; Australia and New Zealand. Sheep meat from the two countries are relatively less differentiated compared to manufacturing goods, which makes it free from the debate about the level of disaggregation and the magnitude of pass-through elasticity.

The world sheep meat production is dominated by China with 36.9 per cent and then by the European Union and India with 13.3 per cent and 13.05 per cent in 2000 (Table 1). Even though the total sheep meat production from Australia and New Zealand represents only about 16 per cent of world production, Australia and New Zealand together accounted for 93.6 per cent of world exports in 2000, where the European Union and Japan were the major sheep meat importing countries. The sheep meat exporters in Australia have dominant market share in Japan and the US; however, New Zealand exporters have relatively larger market shares in Canada, Germany, Hong Kong, Korea, the Netherlands, and the UK (Tables 4(a) and 5(a)). The EU remains New Zealand's most important market for sheep meat, taking around one half of total exports by volume and two-thirds by value.

Model and Methodology

Demand Side

We allow the exchange rate pass-through to depend on the degree of substitutability between the export goods from different destinations. Agents have a choice between the two differentiated goods imported from New Zealand and Australia. They decide an optimal consumption of each good: $u = u(x,s)$, where x is the quantity of good from New Zealand and s is the quantity of good from Australia.

The constant elasticity of substitution (CES) utility function that allows substitution between these products is most suitable (Bodnar *et al*., 2002) and agents in each destination will maximize their utilities

$$u(x, s) = [\alpha x^{\eta} + (1 - \alpha) s^{\eta}]^{1/\eta} \tag{1}$$

Table 1. Relative shares of world sheep meat production and exports

	Production				*Exports*			
Country	*1994*	*1997*	*1999*[(p)]	*2000*[(f)]	*1994*	*1997*	*1999*[(p)]	*2000*[(f)]
EU	17.43	13.82	13.66	13.29	0.60	0.47	0.24	0.24
UK	5.47	5.17	5.06	4.88	0.36	0.23	0.12	0.12
India	9.56	12.40	12.93	13.05	0.97	2.11	1.33	1.70
China	25.65	30.59	37.12	36.87	0.12	1.29	0.73	0.73
Australia	9.86	9.21	8.71	8.81	38.77	36.42	45.34	46.06
New Zealand	7.97	8.25	6.99	6.92	56.52	54.80	48.37	47.52

Source: Counsellor and attaché reports, official statistics and results of office research, Website: Foreign Agricultural Services (FAS), Commodity and Marketing Programs, Dairy, Livestock and Poultry Division.
(p) Preliminary
(f) Forecast

subject to the budget constraint, $y = p(x)x + p(s)s$.

The α and η are the parameters for preference and substitutability, y the total expenditure on x and s, and $p(j)$ the import price denoted in destination currency ($j = x,s$). It is conventionally assumed that $\alpha \in (0,1)$, and $\eta \leqslant 1$.

The elasticity of substitution between x and s, μ is equal to $\frac{1}{1-\eta} \geq 0$. As is well known, when $\mu = 1$ ($\eta = 0$), the agents have a Cobb–Douglas utility form and when $\mu \to \infty$ ($\eta \to 1$), they have a perfect substitutability with a linear form. The inverse demand functions for x and s denoted in importer's currency are in the following form:

$$p(x) = \frac{\alpha x^{(\eta-1)} y}{\alpha x^{\eta} + (1-\alpha) s^{\eta}} \tag{2a}$$

$$p(s) = \frac{(1-\alpha) s^{(\eta-1)} y}{\alpha x^{\eta} + (1-\alpha) s^{\eta}}. \tag{2b}$$

The regular demand functions for x and s can be derived as follows:

$$x = y \left[p(x) + (p(x))^{1/(1-\eta)} (p(s))^{\eta/(\eta-1)} \left(\frac{1-\alpha}{\alpha} \right)^{1/(1-\eta)} \right]^{-1} \tag{3a}$$

$$s = y \left[p(s) + (p(x))^{\eta/(1-\eta)} (p(s))^{1/(1-\eta)} \left(\frac{1-\alpha}{\alpha} \right)^{1/(\eta-1)} \right]^{-1}. \tag{3b}$$

From equation (2a) and (2b), we can derive the partial elasticities of demand as functions of market share ϕ and substitutability parameter η,

$$\begin{bmatrix} \frac{\partial \ln p(x)}{\partial \ln x} & \frac{\partial \ln p(x)}{\partial \ln s} \\ \frac{\partial \ln p(s)}{\partial \ln x} & \frac{\partial \ln p(s)}{\partial \ln s} \end{bmatrix} = \begin{bmatrix} \eta(1-\phi) & -\eta(1-\phi) \\ -\eta\phi & \eta\phi - 1 \end{bmatrix} \tag{4a}$$

and

$$\begin{bmatrix} \frac{\partial \ln x}{\partial \ln p(x)} & \frac{\partial \ln x}{\partial \ln p(s)} \\ \frac{\partial \ln s}{\partial \ln p(s)} & \frac{\partial \ln s}{\partial \ln p(s)} \end{bmatrix} = \frac{1}{1-\eta} \begin{bmatrix} \eta\phi - 1 & \eta(1-\phi) \\ \eta\phi & \eta(1-\phi) - 1 \end{bmatrix}, \tag{4b}$$

where $\phi = \frac{p(x)x}{y} = \frac{\alpha x^{\eta} y}{\alpha x^{\eta} + (1-\alpha) s^{\eta}}$.

Supply Side

Profit maximizing export producers from New Zealand and Australia sell sheep meat to n foreign destination markets, indexed by i, and the market

segmentation does not allow any arbitrage condition. We assume that each producer believes that the other will not change the price that it is quoting. An exporter in New Zealand selling the product x will maximize its profit in t:

$$\max_{p(x)_i} \sum_i e_i^{nz} p_i(x) x_i - c\left(\sum_i x_i, r(e_i^{nz})\right), i = 1, \cdots, n, \tag{5}$$

subject to

$$x_i = d^x(p_i(x), p(s)_i, y_i : \alpha, \eta)$$

where $p_i(x)$ is the destination price from New Zealand to the ith destination market (i.e. Korean won), $x_i = d^x(p_i(x),p(s)_i,y_i : \alpha,\eta)$ the quantity demanded by the destination market i. The exchange rate e_i^{nz} is defined as New Zealand dollar price per unit of foreign currency (i.e. NZD/won). The total cost function $c(\cdot)$depends on the quantity demanded by the destination market and input price r denoted in the exporter's currency. In a small open economy it is common to assume that changes in exchange rate will cause the fluctuations in the input price.

The first-order condition for the New Zealand profit maximization problem of equation (5) is

$$p_i(x) = \frac{mc(e_i^{nz})}{e_i^{nz}} \left(\frac{\partial \ln x_i / \partial \ln p_i(x)}{1 + \partial \ln x_i / \partial \ln p_i(x)}\right) i = 1, \cdots, n, \tag{6}$$

where mc is the marginal cost which can depend on the exchange rate e_i^{nz} and $[\partial \ln x_i / \partial \ln p_i(x)]$ is the price elasticity of demand for x in the ith destination. The equilibrium solution for New Zealand case will be the following,

$$p_i(x) = \frac{mc(e_i^{nz})}{e_i^{nz}} \left(\frac{\phi_i - (1/\eta_i)}{\phi_i - 1}\right). \tag{7}$$

The pass-through (PT) elasticity can be expressed from equation (7) by taking a derivative of $p_i(x)$ with respect to e_i^{nz} and assuming that the marginal cost also depends on the exchange rate:

$$\frac{\partial \ln p_i(x)}{\partial \ln e_i^{nz}} = \left[\frac{\partial \ln mc}{\partial \ln e_i^{nz}} - 1 + \frac{\phi_i (1 - \eta_i)}{(\phi_i - 1)(\eta_i \phi_i - 1)} \frac{\partial \ln \phi_i}{\partial \ln e_i^{nz}}\right] \left[1 + \frac{\phi_i (\eta_i - 1)}{(\phi_i - 1)(\eta_i \phi_i - 1)} \frac{\partial \ln \phi_i}{\partial \ln p_i(x)}\right]^{-1}. \tag{8}$$

The changes in the marginal cost are common to all destination countries but they vary over time since the commodity exported from a source country

is assumed to be identical across destination markets. The changes in an exchange rate will lead to the changes in an exporter's price and the part of these changes can be caused by changes in the mark-up in each destination, which is country specific. The magnitudes of the changes in mark-ups resulting from the exchange rate fluctuations are determined by the exchange rate elasticity of market share and price elasticity of market share since $\frac{\partial \ln K_i}{\partial \ln e_i^{nz}} = \frac{\phi_i (1-\eta_i)}{(\phi_i - 1)(\eta_i \phi_i - 1)} \frac{\partial \ln \phi_i}{\partial \ln e_i^{nz}}$ and $\frac{\partial \ln K_i}{\partial \ln p_i(x)} = \frac{\phi_i (\eta_i - 1)}{(\phi_j - 1)(\eta_i \phi_i - 1)} \frac{\partial \ln \phi_i}{\partial \ln p_i(x)}$, where K_i is the mark-up in the ith destination charged by exporters, i.e. $K_i = \frac{\partial \ln x_i / \partial \ln p_i(x)}{1 + \partial \ln x_i / \partial \ln p_i(x)}$.

Therefore, the pass-through elasticity of equation (8) can also be represented by the import price elasticity of mark-up and exchange rate elasticity of mark-up:

$$\frac{\partial \ln p_i(x)}{\partial \ln e_i^{nz}} = \left[\frac{\partial \ln mc}{\partial \ln e_i^{nz}} - 1 + \frac{\partial \ln K_i}{\partial \ln e_i^{nz}}\right] \left[1 - \frac{\partial \ln K_i}{\partial \ln p_i(x)}\right]^{-1}. \tag{9}$$

Analogously, the first-order condition for the profit maximization problem of the Australian exporter is

$$p(s)_i = \frac{mc(e_i^{au})}{e_i^{au}} \left(\frac{\partial \ln s_i / \partial \ln p(s)_i}{1 + \partial \ln s_i / \partial \ln p(s)_i}\right) \tag{10}$$

and the equilibrium solution will be

$$p(s)_i = \frac{mc(e_i^{au})}{e_i^{au}} \left(\frac{1 - \eta_i(1 - \phi_i)}{\eta_i \phi_i}\right) = \frac{mc(e_i^{au})}{e_i^{au}} \left(\frac{\phi_i - (1 - 1/\eta_i)}{\phi_i}\right). \tag{11}$$

The pass-through (PT) elasticity can be expressed from equation (10) by taking a derivative of $p_i(s)$ with respect to e_i^{au} and assuming that the marginal cost also depends on the exchange rate:

$$\frac{\partial \ln p_i(s)}{\partial \ln e_i^{au}} = \left[\frac{\partial \ln mc}{\partial \ln e_i^{au}} - 1 + \frac{(\eta_i - 1)}{\{\eta_i (\phi_i - 1) + 1\}} \frac{\partial \ln \phi_i}{\partial \ln e_i^{au}}\right] \left[1 + \left(\frac{\eta_i - 1}{\eta_i(\phi_i - 1) + 1}\right) \frac{\partial \ln \phi_i}{\partial \ln p_i(s)}\right]^{-1} \tag{12}$$

If the demand functions were derived from the CES utility specification with a large elasticity of substitution between two varieties, the optimal mark-up set by the exporter would fall when the importer's currency depreciates and the exporter would raise the optimal mark-up when there is a depreciation of the exporter's currency (PTM phenomena). This in turn will lead the exchange rate pass-through to be incomplete.

Based on the equilibrium condition (7) for New Zealand, the price is determined by the exchange rate, marginal cost, market share and a price of

substitute, and we will estimate the following equation in a double log-linear form:

$$\begin{aligned}\ln p_{it}(x) =& \alpha_i + \beta_i \ln e_{it}^{nz} + \gamma_i \ln p_{it}(s) + \delta_i \ln \phi_{it}^{nz} + \tau_t \ln mc_t^{nz} + u_{it},\\ & i = 1, \cdots, n \quad t = 1, \cdots, T.\end{aligned} \tag{13}$$

Since the price of the competitor of New Zealand (i.e. Australia's price) in the *i*th destination at time *t* $p_{it}(s)$ is endogenous in equation (13), we employ the method of instrumental variables (IV), which entails finding an alternative variable that is uncorrelated with u_{it}. The predicted values $\hat{p}_{it}(s)$ of a regression of $p_{it}(s)$ on the exchange rate, market share, and marginal cost can be substituted for $p_{it}(s)$:

$$\ln \hat{p}_{it}(s) = \hat{\alpha}_i + \hat{\beta}_i \ln e_{it}^{au} + \hat{\delta}_i \ln \phi_{it}^{au} + \hat{\tau}_t \ln mc_t^{au}$$

We finally estimate a system of equation (13) with replacement of $p_{it}(s)$ by $\hat{p}_{it}(s)$:

$$\begin{aligned}
&\ln p_{1t}(x) = \alpha_1 + \beta_1 \ln e_{1t}^{nz} + \gamma_1 \ln \hat{p}_{1t}(s) + \delta_1 \ln \phi_{1t}^{nz} + \tau_t \ln mc_t^{nz} + u_{1t},\\
&\ln p_{2t}(x) = \alpha_2 + \beta_2 \ln e_{2t}^{nz} + \gamma_2 \ln \hat{p}_{2t}(s) + \delta_2 \ln \phi_{2t}^{nz} + \tau_t \ln mc_t^{nz} + u_{2t}\\
&\vdots\\
&\ln p_{nt}(x) = \alpha_n + \beta_n \ln e_{nt}^{nz} + \gamma_n \ln \hat{p}_{nt}(s) + \delta_n \ln \phi_{nt}^{nz} + \tau_t \ln mc_t^{nz} + u_{nt}
\end{aligned} \tag{14}$$

where $t = 1,\ldots,T$.

Similarly we estimate the following equation for Australian case:

$$\begin{aligned}
&\ln p_{1t}(s) = \alpha_1 + \beta_1 \ln e_{1t}^{au} + \gamma_1 \ln \hat{p}_{1t}(x) + \delta_1 \ln \phi_{1t}^{au} + \tau_t \ln mc_t^{au} + u_{1t}\\
&\ln p_{2t}(s) = \alpha_2 + \beta_2 \ln e_{2t}^{au} + \gamma_2 \ln \hat{p}_{2t}(x) + \delta_2 \ln \phi_{2t}^{au} + \tau_t \ln mc_t^{au} + u_{2t}\\
&\vdots\\
&\ln p_{nt}(s) = \alpha_n + \beta_n \ln e_{nt}^{au} + \gamma_n \ln \hat{p}_{nt}(x) + \delta_n \ln \phi_{nt}^{au} + \tau_t \ln mc_t^{au} + u_{nt}
\end{aligned} \tag{15}$$

where $t = 1,\ldots,T$.

We employ the seemingly unrelated regression (SUR) method to obtain an efficient estimation for a system of equations (14) and (15) and we assume that disturbances of the system are contemporaneously correlated (Zellner, 1962).[2] However, Breusch (1978) – Godfrey (1976) serial correlation Lagrange multiplier (LM) test statistics on the disturbances of a system of regression equations (14) and (15) indicate the existence of serial correlation (Tables 2 and 3).

Parks (1967) argues that when the disturbance terms of a system of equations exhibit both contemporaneous and serial correlation, the estimators from the SUR model are not efficient. We allow the error terms

Table 2. Estimation of Import Price of New Zealand Sheep Meat (SUR Model)

						Breusch-Godfrey LM Test Statistics	
Country	α	β	γ	δ	*AIC* [(1)]	*AR(1)*	*AR(2)*
Canada	-0.94^{***} (< 0.001)	-0.39^{***} (< 0.001)	2.56^{**} (< 0.001)	0.26^{**} (90.31)	-0.956	9.916^{**}	4.437*
Germany	-1.74^{***} (-56.06)	-0.002 (-0.21)	0.23^{***} (45.46)	0.61^{***} (208.6)	-2.40	0.139	0.082
Hong Kong	2.45^{***} (95.23)	-0.10^{***} (-7.34)	0.10^{***} (14.42)	0.05^{***} (26.09)	-1.95	0.040	0.073
Japan	2.37^{***} (17.15)	0.18^{***} (9.19)	0.32^{***} (19.46)	0.21^{***} (59.71)	-1.43	6.994^{**}	3.109*
Korea	-4.09^{***} (-64.35)	-0.59^{***} (-139.39)	1.18^{***} (221.75)	-0.36^{***} (-100.23)	-0.15	0.064	0.939
Netherlands	3.59^{***} (41.47)	-0.24^{***} (-7.59)	0.41^{***} (175.34)	-0.67^{***} (-152.14)	0.36	0.061	0.572
UK	0.35 * (1.88)	0.29^{***} (8.56)	0.88^{***} (60.01)	-0.13^{***} (-2.61)	-1.29	0.013	0.087
US	0.27^{***} (3.56)	-0.38^{***} (-57.07)	-0.001 (-0.21)	0.38^{***} (41.01)	0.29	12.56^{***}	5.79^{**}

[(1)] Akaike Information Criteria

Figures in parentheses are p-values. The superscripts *, ** and *** indicate the 10%, 5% and 1% significance levels, respectively.

Table 3. Estimation of import price of Australian sheep meat (SUR Model)

Country	α	β	γ	δ	*AIC* [(1)]	*Breusch-Godfrey LM Test Statistics*	
						AR(1)	*AR(2)*
						0.608	0.302
Germany	1.05 *** (< 0.001)	− 2.34 *** (< 0.001)	− 1.57 *** (< 0.001)	− 0.42 *** (< 0.001)	1.17	9.833**	4.447*
Hong Kong	0.22 *** (< 0.001)	0.03 *** (< 0.001)	3.12 *** (< 0.001)	− 0.17 *** (< 0.001)	− 2.14	2.285	1.041
Japan	2.16 *** (< 0.001)	− 0.74 *** (< 0.001)	4.39 *** (< 0.001)	− 1.17 *** (< 0.001)	− 2.33	1.165	0.619
Korea	− 8.41 *** (< 0.001)	− 1.62 *** (< 0.001)	14.60 *** (< 0.001)	− 0.42 *** (< 0.001)	1.11	10.02**	4.590**
Netherlands	− 0.42 *** (< 0.001)	− 1.03 *** (< 0.001)	1.84 *** (< 0.001)	0.26 *** (< 0.001)	0.18	2.074	1.384
UK	1.62 *** (< 0.001)	0.25 *** (< 0.001)	0.24 *** (< 0.001)	− 0.36 *** (< 0.001)	− 1.56	0.324	3.316*
US	13.65 *** (< 0.001)	− 0.15 *** (< 0.001)	2.13 *** (< 0.001)	− 3.16 *** (< 0.001)	− 1.65	3.798*	2.957*

(1) Akaike Information Criteria

Figures in parentheses are p-values. The superscripts *, ** and *** indicate the 10%, 5% and 1% significance levels, respectively.

u_{it} in the equations (14) and (15) to have a first-order autoregressive AR(1) error structure with contemporaneous correlation between cross-sections, i.e. $u_{it} = \rho_i u_{i,t-1} + \varepsilon_t$, $E(u_{it}^2) = \sigma_{ii}^2$, $E(u_{it}u_{jt}) = \sigma_{ij}^2$, $E(\varepsilon_{it}) = 0$, $E(u_{i,t-1}\varepsilon_{jt}) = 0$, $E(\varepsilon_{it}\varepsilon_{jt}) = \phi_{ij}$, $E(\varepsilon_{it}\varepsilon_{js}) = 0(s \neq t)$ and $E(u_{it}u_{jt}) = \sigma_{ij}^2 = \phi_{ij}/(1 - \rho_i\rho_j)$. The covariance matrix is estimated by a two-stage procedure leading to the estimation of model regression parameters by the generalized least squares (GLS) method. Thus, the covariance matrix for the vector of random errors $\underline{u}$ can be expressed as follows:

$$E(\underline{u}\underline{u}') = V = \begin{bmatrix} \sigma_{11}^2\underline{\Omega}_{11} & \sigma_{12}^2\underline{\Omega}_{12} & \cdots & \sigma_{1N}^2\underline{\Omega}_{1N} \\ \sigma_{21}^2\underline{\Omega}_{21} & \sigma_{22}^2\underline{\Omega}_{22} & \cdots & \sigma_{2N}^2\underline{\Omega}_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ \sigma_{N1}^2\underline{\Omega}_{N1} & \sigma_{N2}^2\underline{\Omega}_{N2} & \cdots & \sigma_{NN}^2\underline{\Omega}_{NN} \end{bmatrix} = \sigma_{ij}^2 \otimes \underline{\Omega} \qquad (16)$$

where

$$\underline{\Omega}_{ij} = \begin{bmatrix} 1 & \rho_j & \cdots & \rho_j^{T-1} \\ \rho_i & 1 & \cdots & \rho_j^{T-2} \\ \vdots & \vdots & \ddots & \vdots \\ \rho_i^{T-1} & \rho_i^{T-2} & \cdots & 1 \end{bmatrix}.$$

The matrix V is estimated by a two-stage procedure, and coefficients are then estimated by GLS.

Data and Empirical Results

Data

The free on board (FOB) unit values and total expenditures of the sheep meat (SITC 0112: Meat of sheep and goats, fresh, chilled or frozen) were collected from the International Trade by Commodities Statistics (OECD, 2001). The FOB price is then converted into destination currency, and this paper labels it as import price.[3] Market share is calculated by the ratio of the expenditure on the New Zealand sheep meat to the total expenditure on sheep meat imported from the world in each importing country. The nominal spot exchange rates are taken from International Financial Statistics (IMF, 2002). The producer price index for 'inputs in sheep and beef farming industry' from PC-INFOS (Statistics New Zealand, 2002) is used as the proxy for the marginal cost. The time-series data span is 11 years (1991 – 2001) and the frequency is annual. Trade between the two major exporters and eight major destinations (Canada, Hong Kong, Germany, Japan, Korea, the US, the UK, and the Netherlands) is considered.

Exchange Rate Pass-Through

Tables 4(a,b) and 5(a,b) present the results by Parks' method from the system of estimating equations (14) and (15) for New Zealand and Australia, respectively. The *F*-tests for α in Tables 4(a) and 5(a) show that the null hypotheses that price effects for all the destinations are equal ($\alpha_2 = \alpha_3 = \ldots = \alpha_8$) are rejected in both models. This indicates that there is strong evidence against the competitive market model. The *F*-tests for β indicate that the null hypotheses for the non-existence of pass-through elasticity ($\beta_1 = \beta_2 = \ldots = \beta_8 = 0$) are also rejected at a 1 per cent significance level in both samples.

For the New Zealand case, Table 4(a) shows that the effects of exchange rates on import prices β (which is attributed to pass-through elasticity) are always negative and the coefficients are significant at the 1 per cent level for six destinations out of eight. The negative sign indicates that depreciation of the New Zealand currency decreases its sheep meat import price in major importing countries. Those significant pass-through elasticities range from -0.39 (Canada) to -1.12 (Hong Kong) and the null hypothesis of a complete pass-through (i.e. H_0: $\beta = -1$) in each destination is rejected at a 5 per cent significance level for Canada, Korea, the UK, and the US, which indicates strong evidence of incomplete pass-through in those destinations.[4] The smallest change happens in New Zealand's exports to Canada. When the New Zealand dollar depreciates against the Canadian dollar by 1 per cent, its import price of sheep meat in Canada decreased by only 0.39 per cent (in Canadian dollars). For Hong Kong and Japan, the same null hypotheses of full pass-through were not rejected, which implies that, while the two economies' coefficients are -1.12 and -1.08, there is no evidence that they are significantly different from -1.[5] In other words, 'full pass-through' was observed for the two economies. This result indicates that when New Zealand's currency depreciates by 1 per cent, the price of its sheep meat in these two economies decreases by about 1 per cent. As demand would not decrease by a 1 per cent reduction in price, this pass-through will increase the total revenue of New Zealand's exporters from these two markets.

The significant positive responses of New Zealand exporters to their competitor's (Australia) price on sheep meat (γ) in most destinations except in Hong Kong (and Japan, for which the coefficient is insignificant) represent the co-movement in the pricing strategy on the export price between New Zealand and Australia. The coefficient for the average market share ($\bar{\phi}$) in each destination reflects how New Zealand charges its price at destination according to its market share, all other things being equal. Among the six economies with significant coefficients, five economies – Germany, Japan, Korea, the Netherlands and the United States – have negative coefficients, which implies that, in general, there is a negative relationship between New Zealand's meat exporters' mark-up to the prices and the market shares they take. The only exception is the United Kingdom.

Table 4. (a) Estimation of import price of New Zealand sheep meat

Country	$\bar{\phi}^{(1)}$	α	β	γ	δ	ρ
Canada	60.45	–	-0.39^{***} (-5.84)	0.09^{*} (1.79)	0.03 (0.80)	-0.26
Germany	69.90	2.34^{***} (5.49)	-0.02 (-0.16)	0.14^{**} (2.64)	-0.57^{***} (-6.13)	-0.39
Hong Kong	40.75	4.49^{***} (13.04)	-1.12^{***} (-9.25)	-0.79^{***} (-7.66)	0.06 (0.80)	-0.29
Japan	43.55	8.57^{***} (18.29)	-1.08^{***} (-13.18)	-0.11 (-1.58)	-0.90^{***} (-7.02)	0.21
Korea	58.35	6.10^{***} (8.53)	-0.57^{***} (-6.71)	0.06 (0.57)	-0.27^{***} (-5.84)	0.21
Netherlands	43.15	1.65^{**} (2.38)	-0.19 (-0.61)	0.003 (0.002)	-0.42^{**} (-2.31)	0.06
UK	82.33	-3.26^{***} (-3.16)	-0.41^{***} (-3.32)	0.43^{***} (4.50)	0.55^{**} (2.48)	-0.42
US	29.79	1.98^{**} (3.28)	-0.68^{***} (-4.40)	0.40^{***} (4.72)	-0.60^{***} (-3.19)	-0.54
F-tests		$H_0 : \alpha_2 = \alpha_3 = \cdots = \alpha_8$, F-value = 50.08^{***}; Pr > F = 0.0001				
F-tests		$H_0 : \beta_1 = \beta_2 = \cdots = \beta_8 = 0$, F-value = 45.57^{***}; Pr > F = 0.0001				

(1) They are the average market shares of New Zealand as a percentage in each destination.
Figures in parentheses are *t*-statistics. The superscripts *, ** and *** indicate the 10%, 5% and 1% significance levels, respectively.

Table 4. (b) Marginal cost effects (New Zealand)

Year	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*
τ	-0.02^{***}	0.002	0.001	-0.01^{**}	0.02^{***}	0.03^{***}	-0.002	0.04^{***}	0.03^{***}	0.05^{***}
	(-4.67)	(0.47)	(0.25)	(2.57)	(3.30)	(5.86)	(-0.35)	(7.49)	(3.78)	(5.75)

Figures in parentheses are *t*-statistics. The superscripts *, ** and *** indicate the 10%, 5% and 1% significance levels, respectively.

It may reflect the monopolistic status of New Zealand in the country; the market share of New Zealand in the United Kingdom is incomparably high – as high as more than 82 per cent on average throughout the period. There have been consistent and stable (increasing) effects of the marginal cost of producing sheep meat (Table 4b).

For the Australian case (Table 5a), the pass-through elasticities β are negative for every destination except for the Netherlands (where the coefficient is not significant). The coefficients for six destinations – Canada, Hong Kong, Japan, Korea, the United Kingdom and the United States – are significant at the 1 per cent level. The null hypothesis of a complete pass-through in each destination is rejected at a 5 per cent significance level for Japan, Korea, the United States and the United Kingdom. This indicates that the fluctuation of exchange rates did not completely pass through in Japan, Korea and the United States. In the case of the United Kingdom, a 1 per cent depreciation of New Zealand currency decreases its price at destination by more than 1 per cent (1.67 per cent). However, we cannot reject the null hypothesis of complete pass-through in Canada and Hong Kong.[6]

The significant and positive coefficients on the competitor's price from Australia and New Zealand (γ) in Germany and the United States reveal that New Zealand and Australia employ similar strategies on the export price to those markets. The coefficient for the Netherlands, however, is negative, meaning that in the Netherlands' market, the pricing strategies of New Zealand and Australia move in different directions. The relationship between the import price and market share in each destination (δ) shows that the pricing strategy of sheep meat exporters in Australia (with a relatively smaller international market share than New Zealand) is not consistent apparently. For the economies such as Germany, Hong Kong and the Netherlands, the relationship is positive, while for Japan, the United Kingdom and the United States, it is negative. Marginal costs of producing sheep meat in Australia have been consistently rising (Table 5b).

Exchange Rate Pass-Through and Market Share

One of major issues related to pass-through elasticity is the relationship between market share and the pass-through elasticity. Conventional

Table 5. (a) Estimation of import prices of Australia sheep meat

Country	$\bar{\phi}^{(1)}$	α	β	γ	δ	ρ
Canada	34.83	–	-0.97^{***} (-7.03)	0.04 (0.30)	-0.05 (-0.72)	-0.26
Germany	6.68	-0.78^{***} (-2.78)	-0.19 (-0.83)	0.54^{***} (3.20)	0.12^{*} (1.99)	-0.39
Hong Kong	18.33	0.89^{**} (2.25)	-1.24^{***} (-7.03)	0.29^{***} (3.03)	0.15^{**} (2.45)	-0.29
Japan	54.90	7.38^{***} (6.64)	-0.62^{***} (-4.05)	-0.19 (-1.49)	-0.47^{*} (-1.88)	0.21
Korea	38.59	6.63^{***} (12.87)	-0.39^{***} (-2.97)	-0.10 (-1.12)	-0.04 (-1.14)	0.21
Netherlands	3.93	-0.54^{**} (-2.17)	0.27 (1.16)	-0.34^{**} (-2.12)	0.18^{***} (9.85)	0.06
UK	8.05	-0.07 (-0.19)	-1.67^{***} (-4.36)	0.02 (0.06)	-0.34^{*} (-1.75)	-0.42
US	69.56	12.02^{***} (14.71)	-0.41^{***} (-3.52)	0.33^{**} (2.40)	-3.02^{***} (-15.24)	-0.54
F-tests		$H_0 : \alpha_2 = \alpha_3 = \cdots = \alpha_8$, F-value = 62.95^{***}; Pr > F = 0.0001				
		$H_0 : \beta_1 = \beta_2 = \cdots = \beta_8 = 0$, F-value = 13.90^{***}; Pr > F = 0.0001				

(1) They are the average market shares of New Zealand as a percentage in each destination.
Figures in parentheses are *t*-statistics. The superscripts *, ** and *** indicate the 10%, 5% and 1% significance levels, respectively.

Table 5. (b) Marginal cost effects (Australia)

Year	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*
τ	0.02^{***}	0.05^{***}	0.05^{***}	0.06^{***}	0.10^{***}	0.12^{***}	0.16^{***}	0.19^{***}	0.19^{***}	0.26^{***}
	(6.13)	(12.02)	(15.65)	(10.89)	(19.2)	(19.05)	(30.83)	(26.97)	(34.22)	(25.28)

Figures in parentheses are *t*-statistics. The superscripts *, ** and *** indicate the 10%, 5% and 1% significance levels, respectively.

economic wisdom explains that the relationship must be either linear or quadratic. In the case of a linear relationship, it is expected that an exporter with a larger market share practises its monopolistic power and does not change destination price substantially when the exchange rate fluctuates. A quadratic relationship explains that an exporter in a competitive market (with a small market share) operates where the price from each export country is very close (or the same theoretically) and, consequently, it cannot change its destination price significantly when the exchange rate fluctuates. Therefore, while exporters in oligopoly markets have the flexibility to adjust their destination prices, those who are in competitive markets or monopolistic markets cannot change or do not have incentives to change the destination prices.

The relationship between pass-through elasticities and market shares for the two exporters is examined in our case. While our results show that there does not exist a significant relationship between the two variables in both New Zealand and Australia, we hope that we can provide some insights regarding the debate about the relationship between them. Even though they appear insignificant in our paper, we include the results as it is one of the most important and interesting issues nowadays. It is not clear, however, at this stage whether we need more observations to examine accurately their relationship or there is virtually no relationship at all between them. This issue needs to be investigated further.

Figure 1 shows the linear relationship between New Zealand's market share and its pass-through elasticities in destination. As shown, the smallest market share New Zealand took in the eight destinations was, on average, about 30 per cent, which is too high to regard the market as competitive. Therefore, it may be improper to use a quadratic function to approximate the relationship. The straight line has a positive trend, implying that the change in the value of currency is transferred to the price of commodities to a larger extent, when the exporting country's market share is larger.

The same analysis is carried out for Australia, and the results are reported in Figures 2 and 3. As Australia has a relatively small market share, such as 4 per cent in the Netherlands and 7 per cent in Germany, Figure 2 uses a quadratic function to approximate the relationship between Australia's market share and its pass-through elasticities. The U-shaped curve explains that when the market is competitive or monopolistic, the fluctuation in exchange rates is passed through to the destination price to a lesser extent; in

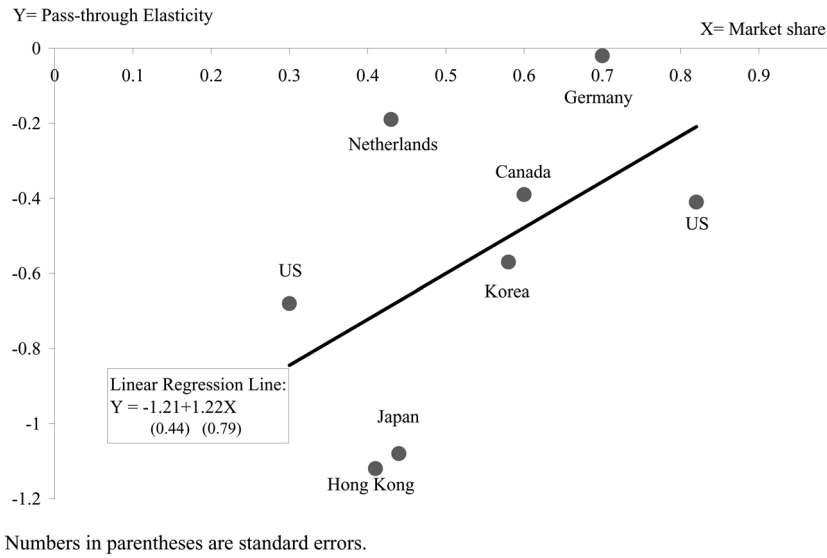

Figure 1. Pass-through elasticity and market share: linear regression line (New Zealand)

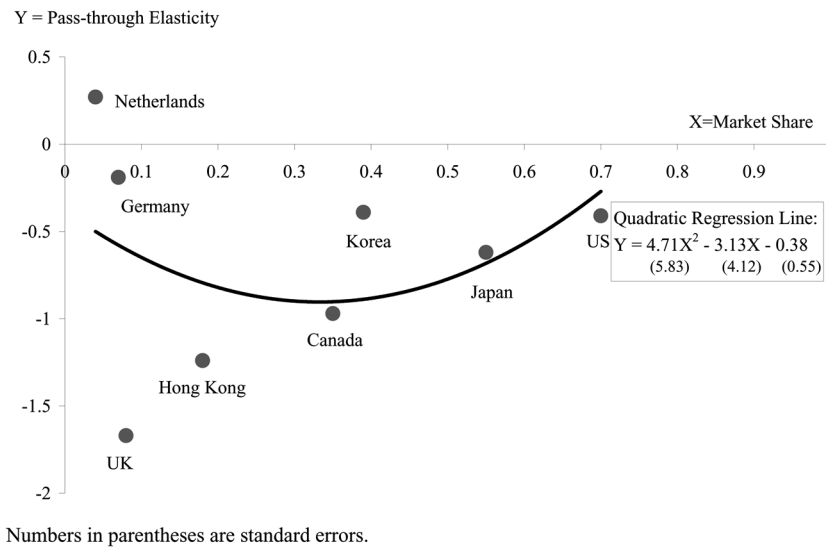

Figure 2. Pass-through elasticity and market share: quadratic regression line (Australia)

contrast, when the market is an oligopoly, it is passed through to the destination price to a larger extent. This result is consistent with

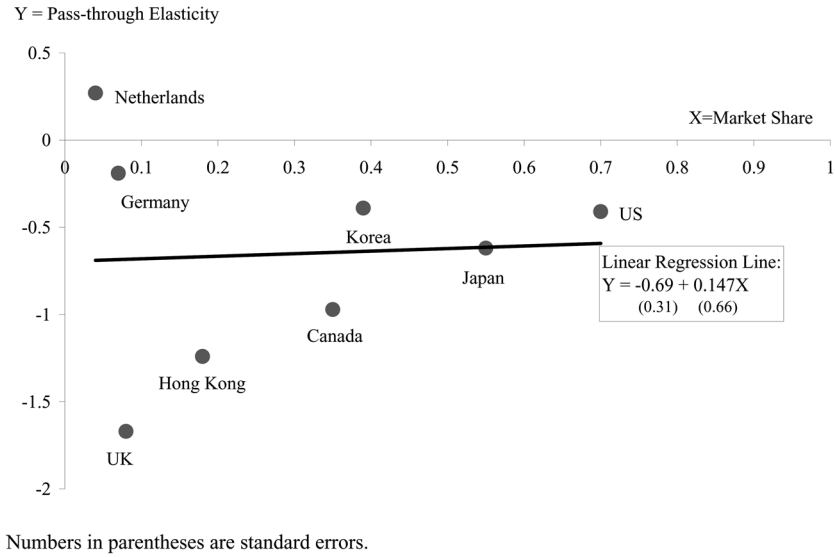

Figure 3. Pass-through elasticity and market share: linear regression line (Australia)

conventional wisdom. Figure 3 adopts a linear relationship to explain the same phenomena. It shows a positive trend, which is consistent with what is predicted from pass-through theories. It is noteworthy that the slope of the trend line for Australia (in Figure 3) is lower than that for New Zealand (in Figure 1). In other words, the relationship between market share and pass-through elasticity is higher in New Zealand. We consider that this might be related to the relative market share that the two exporting countries take; in general, New Zealand takes a larger market in most destinations, which may enable it to behave more actively in response to fluctuation in exchange rates. This finding will be further pursued with more data and information.

Conclusions

We empirically examined the exchange rate pass-through elasticity utilizing sheep meat export data from the two major sheep meat exporting countries in the world, Australia and New Zealand. Our results show the coexistence of incomplete and complete pass-through of exchange rate fluctuation to destination prices. The strong evidence of incomplete pass-through in an international sheep meat industry reveals that about 50 per cent of exchange rate changes are passed through to the import prices of sheep meat. However, a complete pass-through phenomenon in Hong Kong implies that both export producers from Australia and New Zealand do not stabilize the local currency prices with respect to the exchange rate fluctuations in that particular destination.

The results also indicate that, in the presence of its competitor, the Australian sheep meat exporters whose market shares are relatively smaller than those in New Zealand are not able to exercise their monopoly power so actively as New Zealand exporters do. The exporters in Australia tend to increase destination price by lower than those in New Zealand, which may be an effort to maintain or increase their relatively low market shares, while export producers in New Zealand find it profitable to increase their mark-ups in response to exchange rate fluctuation in the destination countries with large market shares.

Notes

[1] 'Hopes of lower car prices dashed.' *The Press*, 15 January, 2002.
[2] The marginal cost effects were omitted due to the degrees of freedom.
[3] Accurately speaking, transport cost should be added as well to be the destination price. However, this cost is ignored for simplicity. It is trusted that this ignorance does not change the results of analysis significantly.
[4] The test results are available upon requests.
[5] While our analysis found that the two coefficients are not significantly different from (− 1), Tivig (1996) showed that pass-through elasticity greater than (− 1) is possible in a dynamic situation. This 'perverse' relationship is observed for Australia's exports.
[6] The test results are not reported in the paper; however, they are available upon request.

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