The Impact of Domestic and Import Prices on U.S. Lamb Imports: A Production System Approach

Andrew Muhammad, Keithly G. Jones, and William F. Hahn

As U.S. lamb imports increased relative to domestic production, and the relative share of chilled to frozen lamb imports increased, importers of chilled lamb have become less responsive to domestic and import prices, while the direct opposite is the case for frozen lamb imports. From 1990 to 2003, chilled lamb imports from Australia and New Zealand became less and less responsive to U.S. prices, and frozen imports became more responsive. Unconditional own-price elasticities also show that, over time, imports of chilled lamb became less responsive to import prices while frozen imports became more responsive to import prices.

Key Words: lamb, demand, imports, trade, import demand, production

U.S. imports of lamb and mutton have significantly increased since the mid-1980s, with very sharp increases after 1994. In 2002, lamb imports were up 11 percent compared to the previous year and up 440 percent since 1975 (U.S. Department of Commerce 2004). Imports, which currently account for nearly half of U.S. lamb consumption, are primarily from Australia and New Zealand, accounting for more than 98 percent of all U.S. imports (Jones, Hahn, and Davis 2003).

The goal of this research is to estimate U.S. demand for imported lamb in order to obtain estimates of conditional and unconditional elasticities of demand. Imported lamb is differentiated by source country of production (Australia and New Zealand) and by quality (frozen and chilled). Source-/quality-specific import demand is estimated with respect to frozen and chilled prices in Australia and New Zealand, U.S. wholesale lamb price, U.S. wages in the wholesale trade sector, and the total quantity of lamb imported. Given that some product transformation and/or value-added takes place once imports reach the United States, a differential production approach is used to obtain output supply and import demand estimates. Unconditional output price and own/cross price elasticities, total import elasticities, and conditional own/cross price elasticities are estimated. Unconditional output price and own-price elasticities are also evaluated for the period 1990 to 2003 to assess changes in the responsiveness of U.S. importers to domestic and import prices.

As the consumption of lamb in the United States becomes increasingly dependent on foreign production, primarily from two sources only, the progression of importers' responsiveness to domestic and foreign prices gives insight into the behavior of importers in the presence of a declining domestic industry.

The next section presents an overview of the lamb industry. The section after that describes the differential production modeling approach used to estimate U.S. demand for imported lamb. Then follows a description of the data and estimation results. A summary and concluding remarks close the paper.

Lamb Industry Overview

Since 1975, total use of lamb and mutton in the United States has kept pace with the rise in population, enabling per capita consumption to remain fairly stable at just about 1.3 pounds on a carcass weight basis in recent years (U.S. Department of Commerce 2004). However, due to a depressed

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wool industry, of which lamb and mutton are joint products, sheep inventories have been declining, reducing the number of animals available for market each year.

The comparative advantage in production cost, trade, consumer preference, and advertising affords Australian and New Zealand lamb producers a competitive edge over other producers (Jones 2004). Unlike in the United States, where sheep producers rely on marginal lands/pastures for the first stage of production, then feed grains for the fattening and finishing stages, sheep producers in Australia and New Zealand for the most part use pastures for the entire production cycle, since the cost of production on strictly pasture-based operations is much lower than operations involved in feed grains in those countries (Meyer and Anderson 1998). In addition, pasture-fed lambs are generally marketed at a lighter weight. Whereas in Australia the average carcass weight at market ranges from around 44 to 47 pounds and in New Zealand from around 36 to 40 pounds, in the United States the average carcass weight ranges from 63 to 67 pounds (Jones 2004). Smaller, lighter-weight lambs produce smaller prime cuts, which are often more economical to consumers (Boal 2001). Also, these animals are less likely to suffer from the over-finished problem that occasionally occurs in grain-fed lamb (Jones 2004).

In 1989, a significant share of U.S. lamb imports was in frozen form. Chilled imports accounted for 25 percent of total lamb imports from Australia and New Zealand. Since that time, the trend in chilled imports has been steadily increasing. In 2003, chilled imports accounted for 45 percent of total imports. From 1989 to 1993, chilled imports from New Zealand and Australia averaged only 4.5 and 13.1 percent of all lamb imports, respectively. However, since 2000, chilled imports from these countries have averaged 12.4 and 31.2 percent respectively, nearly a threefold increase (Table 1). The growth in chilled imports is largely due to the improvement in distribution infrastructures and to consumers who are willing to pay a premium for freshness (Boal 2001). Overall, the data shows that U.S. imports (and hence consumption) have been shifting to chilled lamb, which is deemed to be of higher quality than frozen lamb (Smith et al. 1968 and Wheeler et al 1990).

Section 201 of the Trade Act of 1974 resulted in the imposition of a tariff rate quota (TRQ) on lamb imported from Australia and New Zealand between 1999 and 2001, but despite the TRQ, currency exchange rates made the U.S. market still profitable (U.S. International Trade Commission 1999). In 1998, the U.S. dollar appreciated against Australian and New Zealand currencies by more than 18 and 24 percent, respectively. Again in 1999 and 2000, when the TRQ was in effect, further appreciation of the U.S. dollar allowed Australia and New Zealand to effectively manage the TRQ, even at over-quota tariff rates of 40 percent in 1999 and 32 percent in 2000. As a result, Australia and New Zealand were able to competitively export lamb and mutton to the United States during this period.

Differential Production Model

Using the methodology of Laitinen and Theil (1978), Laitinen (1980), Theil (1980), Davis and Jensen (1994), and Washington and Kilmer (2002a, 2002b), the differential production model is used to estimate the output supply and import demand for lamb in the United States. The differential production model is derived from the differential approach to the theory of the firm where firms maximize profit in a two-step procedure. Although firms within the United States purchase lamb domestically and from abroad, to simplify the model we assume a firm that imports lamb from the possible sources and then wholesales the output "imported lamb" to domestic retailers. The output of these firms is the total amount of imported lamb sold domestically, and the inputs are the factors of production required in wholesale trade and the imported lamb. Assuming that lamb is differentiated by country of origin and quality, each import demand equation represents the demand for a type of lamb (chilled or frozen) from each exporting country.

In a two-step procedure, we get the output supply equation expressed in differential form (finite 12-month log changes),[1]

$$(1) \qquad \Delta X_t = \varphi \Delta p_t + \sum_{j=1}^{N} \pi_j \, \Delta w_{jt} + \varepsilon_t \ ,$$

[1] The 12th period difference is used to deseasonalize the data. See Kmenta (1986, pp. 325–326).

Table 1. Total U.S. Lamb Imports and Market Share: 1989–2003[a]

		Market Share in Percent			
Year	Total U.S. Imports	New Zealand Frozen	New Zealand Chilled	Australia Frozen	Australia Chilled
1989	43,325,088	22.60	6.04	52.79	18.57
1990	38,857,336	23.18	4.76	57.53	14.54
1991	38,123,032	24.81	2.87	62.40	9.92
1992	47,383,009	22.56	3.84	64.09	9.51
1993	49,816,588	29.07	4.75	52.99	13.19
1994	46,714,722	32.08	3.58	52.38	11.96
1995	59,845,856	29.64	5.67	52.89	11.80
1996	67,128,558	30.32	6.59	46.22	16.87
1997	75,343,858	25.06	9.24	47.03	18.66
1998	103,447,193	22.29	10.44	45.21	22.07
1999	102,849,429	18.39	12.58	42.21	26.82
2000	118,402,174	17.43	10.46	41.87	30.24
2001	133,717,076	16.00	11.47	37.86	34.68
2002	147,066,617	17.85	13.48	39.28	29.39
2003	107,408,853	25.37	14.09	30.10	30.44

[a] Total lamb imports are for New Zealand and Australia lamb only.

Source: U.S. Department of Commerce (2004).

where ΔX_t is the finite version of the Divisia volume import index (import index),

$$\Delta X_t = \sum_{i=1}^{n} \overline{f}_{it} \Delta x_{it} ,$$

which is an index of total imports,

$$\overline{f}_{it} = (f_{it} + f_{it-12}) / 2 ,$$

and $\Delta x_{it} = \log(x_{it} / x_{it-12})$; f_i is the share of the ith import in the total cost of all lamb imports

$$(w_i x_i \big/ \textstyle\sum_i w_i x_i) ,$$

and w_i and x_i are the price and quantity of imported lamb from source country i ;

$$\Delta w_{it} = \log(w_{it} / w_{it-12})$$

and

$$\Delta p_t = \log(p_t / p_{t-12}) ,$$

where p represents the output price; φ and π are the parameters to be estimated, where φ measures the impact of a percentage change in output price on the import index and the π_j's measure the impact of percentage changes in input prices on the import index; and ε_t is the disturbance term. Details on the derivation of the output supply equation are found in Theil (1980). For this research, the Divisia import input index is an index of the total lamb imports, p is the wholesale price at which firms sell imported lamb domestically, and the w_i's are the prices paid for lamb imports (frozen and chilled) from each of the exporting countries (Australia and New Zealand) and the price of labor.[2]

The differential derived demand model, which is used to estimate the system of import demand

[2] The output supply equation contains the price of all inputs value-added and imported. N denotes all inputs and n denotes imports only. Labor is the value-added input considered in this study. N is equal to the number of imported goods plus labor.

equations, is specified as follows (also expressed in finite 12-month log changes):

$$(2)\qquad \bar{f}_{it}\Delta x_{it} = \theta_i^*\Delta X_t + \sum_{j=1}^{n}\pi_{ij}^* \quad \Delta w_{jt} + u_{it}\ ,$$

where x_i and w_i represent the quantity and price of either frozen or chilled lamb imported from source country i; as before, ΔX_t is the import index; θ_i^* and π_{ij}^* are parameters to be estimated, where θ_i^* is the marginal import share coefficient and π_{ij}^* measures the source-specific price effects; and u_{it} is the disturbance term (Theil 1980, Laitinen 1980). The differential derived demand model requires that the following parameter restrictions be met in order for the model to conform to theoretical considerations:

$$\sum_j \pi_{ij}^* = 0 \ \text{(homogeneity)},$$

and

$$\pi_{ij}^* = \pi_{ji}^* \ \text{(symmetry)}.$$

Substituting the right-hand side of equation (1) for the import index term in equation (2), we get the demand for a source-specific import in terms of the changes in domestic prices and import/input prices:

$$(3)\qquad \bar{f}_{it}\Delta x_{it} \quad = \theta_i^*[\varphi\Delta p + \sum_{j=1}^{N}\pi_j \quad \Delta w_{jt}] + \sum_{j=1}^{n}\pi_{ij}^* \quad \Delta w_{jt}.$$

Equation (3) can be interpreted as the unconditional derived demand equation since changes in import demand are no longer conditional on output but a function of changes in input and output prices (Laitinen 1980). From equation (3) we get the unconditional elasticity of derived demand with respect to output price and the unconditional own/cross price elasticities.

Data and Estimation Results

Derived demand and supply equations are estimated using monthly data. The data set covers the time period January 1989 through September 2003. Monthly import quantities and expenditures on frozen and chilled lamb were obtained from the U.S. Department of Commerce (2004). All expenditures are on a cost, insurance, and freight (CIF) basis. CIF includes the total cost of buying imported lamb, plus any insurance costs incurred to ensure compensation in the event of loss or damage, and the freight paid to the shipping agent for transport to the United States. Using expenditures and quantities, per-unit values ($/pound) for New Zealand and Australia frozen and chilled lamb were calculated. Per-unit values are used as proxies for import prices. U.S. wholesale lamb prices were provided by the U.S. Department of Agriculture (2006). The price of labor, which is the average hourly earnings of all individuals in the wholesale trade sector, was obtained from the U.S. Department of Labor (2004). Imports from countries other than New Zealand and Australia are negligible.

Estimation of equations (1) and (2) were accomplished using TSP (Version 4.4). The output supply equation and the derived demand system were estimated separately using the multivariate Gauss-Newton method (Hall and Cummins 1998). According to Theil (1980) and Laitinen (1980), the error terms in equations (1) and (2) are statistically independent, allowing for separate estimation of the output supply equation and the derived demand system.[3] Likelihood ratio (LR) tests were used to test if the data satisfied the economic properties of homogeneity and symmetry. LR tests were also used to test for the presence of AR(1) using the maximum likelihood method from Berndt and Savin (1975). Test results are presented in Table 2. Results suggest that AR(1) could not be rejected at any reasonable significance level for the import demand system; therefore, all results have the AR(1) error structure imposed.[4] All results also have homogeneity and symmetry imposed, although Likelihood-Ratio (LR) tests rejected homogeneity. However, given homogeneity, LR tests indicated that symmetry could not be rejected. In addition to homogeneity and symmetry, the matrix of import price effects should be negative semi-definite (negativity). This property is satisfied if the eigenvalues of the price coefficient matrix are less than or equal to

[3] Theil (1980, pp. 92–94) shows that if the parameters in equation (1) and (2) are constant and the errors normally distributed, then cov(ε, u_i) = 0. Intuitively, this suggests that the output/total import decision is independent of the input allocation decision. This says that an output manager decides on a level of total imports, and that then an inputs manager decides on how that quantity is allocated across exporters.

[4] The AR(1) parameter for the output supply equation was 0.6055 and the significance level was less than 0.001. The LR test for AR(1) in Table 2 is for the import demand system only.

Table 2. Likelihood Ratio Test Results for AR(1) and Economic Constraints

Model	Log-Likelihood Value	LR Statistic	P-value
AR(1)	763.650		
No-AR(1)	708.963	109.3742	0.000(1) [a]
Unrestricted [b]	763.650		
Homogeneity	754.572	18.156	0.001(4)
Symmetry	753.813	1.518	0.958(6)

[a] The number of restrictions are in parentheses.
[b] The unrestricted model and the AR(1) model are the same model since No-AR(1) was rejected.

zero. Given that the eigenvalues were 0.0000, -.0946, -0.1761, and -0.3935, the negativity property was satisfied.

Estimation results for the output supply equation are presented in Table 3. Although the output price parameter estimate (0.241) is positive as expected, it is insignificant. Estimates of the impact of the price of frozen and chilled lamb from New Zealand on the total import index are 0.003 and -0.208 respectively, and estimates of the impact of the price of frozen and chilled lamb from Australia on the total import index are -0.237 and -0.460 respectively. With the exception of New Zealand frozen lamb prices, import prices and wages have a negative significant impact on total lamb imports (import index). Although positive, the parameter estimate for New Zealand frozen lamb prices (0.003) is insignificant. The parameter estimate for the impact of wages on the import index (-0.408) is also insignificant.

Table 4 presents the conditional parameter estimates of U.S. demand for imports of frozen and chilled lamb. As indicated in Table 4, all own-price coefficients are negative, as expected, and all are significant at the 0.01 significance level. The conditional marginal factor share estimates indicate a positive relationship between the total import index and source-/type-specific lamb imports. These indicate that as total lamb imports increase, both frozen and chilled lamb from Australia and New Zealand will also increase. Cross-price parameter estimates indicate that all cross relationships are substitutes. Substitute relationships occur between frozen and chilled lamb from the same source, frozen lamb from different sources, chilled lamb from different sources, and frozen lamb from one source and chilled lamb from the other. Lastly, estimates indicate that the relationship between frozen lamb from New Zealand and frozen lamb from Australia is insignificant.

Conditional Elasticities

From equation (2) we get the conditional own-price/cross-price elasticity,

$$\eta^{c}_{xw} = \pi^{*}_{ij} \Big/ \overline{f}_i \ , \tag{4}$$

and the total import index elasticity,

$$\eta_{xX} = \theta^{*}_{ij} \Big/ \overline{f}_i \ . \tag{5}$$

Table 5 presents the estimates of the conditional elasticities of derived demand for imported lamb (calculated at the mean). The import index elasticities that measure the responsiveness of a source-specific import to changes in total imports are 1.093, 0.804, 1.217, and 0.767 for New Zealand frozen, New Zealand chilled, Australia frozen, and Australia chilled, respectively. All import index elasticities are significant. These elasticities indicate that a percentage increase in the import index increases frozen and chilled imports by the elasticity values. The conditional own- and cross-price elasticities indicate the impact of import price changes on source-specific imports, holding total imports constant. As import prices change, particularly relative prices, firms change how the total imported is allocated across the exporting countries. The own-price elasticities are -0.240, -1.047, -0.725, and -0.884 for New Zealand frozen, New Zealand chilled, Australia frozen, and Australia chilled, respectively. All are significant at the 0.01 level. These indicate that the demand for chilled imports, particularly New Zealand chilled lamb, tends to be relatively more elastic than the demand for frozen imports—this is likely due to chilled imports being relatively more expensive and more perishable.

Conditional cross-price elasticities of derived demand for imported lamb in the United States indicate significant substitute relationships between frozen and chilled imports from both countries. A percentage increase in the price of frozen imports from New Zealand will significantly in-

Table 3. Parameter Estimates for the Supply of Imported Lamb in the United States

Input Price Coefficients, π_{ij}					
New Zealand Frozen	New Zealand Chilled	Australia Frozen	Australia Chilled	Wage	Output Price Coefficient φ
0.0025 (0.0752)[a]	-0.2078** (0.0835)	-0.2373** (0.0966)	-0.4600*** (0.1141)	-0.4082 (1.0337)	0.2413 (0.1831)
R^2 = .39					

[a] Asymptotic standard errors are in parentheses.

Notes: *** means significance level = 0.01. ** means significance level = 0.05.

Table 4. Conditional Derived Demand Parameter Estimates for U.S. Imports of Lamb

	Price Coefficients, π_{ij}^*				
Exporting Country/Good	New Zealand Frozen	New Zealand Chilled	Australia Frozen	Australia Chilled	Marginal Factor Shares, θ_i^*
New Zealand Frozen	-0.0721*** (0.0267)[a]	0.0265*** (0.0098)	0.0109 (0.0229)	0.0348*** (0.0212)	0.3287*** (0.0310)
New Zealand Chilled		-0.1285*** (0.0118)	0.0414*** (0.0119)	0.0606*** (0.0134)	0.0987*** (0.0114)
Australia Frozen			-0.2103*** (0.0332)	0.1579*** (0.0895)	0.3529*** (0.0317)
Australia Chilled				-0.2533*** (0.0322)	0.2197*** (0.0261)
System R^2 = .72					

[a] Asymptotic standard errors are in parentheses.

Note: *** means significance level = 0.01.

Table 5. Conditional Divisia and Price Elasticities of the Derived Demand for Imported Lamb

	Elasticities				
		Conditional Own- and Cross-Price			
Exporting Country/Good	Divisia Index	New Zealand Frozen	New Zealand Chilled	Australia Frozen	Australia Chilled
New Zealand Frozen	1.093*** (0.103)[a]	-0.240*** (0.089)	0.088*** (0.033)	0.036 (0.076)	0.116 (0.071)
New Zealand Chilled	0.804*** (0.092)	0.215*** (0.080)	-1.047*** (0.096)	0.337*** (.097)	0.494*** (0.109)
Australia Frozen	1.217*** (0.109)	0.037 (0.079)	0.143*** (.041)	-0.725*** (0.114)	0.545*** (0.090)
Australia Chilled	0.767*** (0.091)	0.121 (0.074)	0.212*** (0.047)	0.551*** (0.091)	-0.884*** (0.112)

[a] Asymptotic standard errors are in parentheses.

Note: *** means significance level = 0.01.

crease chilled imports from New Zealand by 0.215 percent, but results show no impact on imports from Australia. Percentage increases in the price of chilled imports from New Zealand will result in an increase in frozen imports from New Zealand by 0.088 percent, and frozen and chilled imports from Australia by 0.143 and 0.212 percent, respectively. Given a percentage increase in the price of frozen lamb from Australia, results suggest increases of chilled imports from New Zealand and Australia of 0.337 and 0.551 percent, respectively. Lastly, a percentage increase in the price of chilled imports from Australia will increase the demand for chilled imports from New Zealand by 0.494 percent and frozen imports from Australia by 0.545 percent.

Unconditional Elasticities

From equation (3) and using equations (4) and (5) to simplify notation, we get the unconditional derived demand elasticities. The unconditional elasticity of derived demand with respect to output price is

(6) $$\eta_{xp} = \eta_{xX}\varphi .$$

Equation (6) measures the responsiveness of source-specific lamb imports to U.S. wholesale lamb prices. The unconditional own-price/cross-price elasticity of derived demand is

(7) $$\eta_{xw} = \eta_{xX}\pi_j + \eta_{xw}^c .$$

Unconditional elasticities of derived demand are reported in Table 6. For every percentage increase in U.S. wholesale lamb prices (output price), frozen and chilled imports from New Zealand increase 0.264 and 0.194 percent, respectively, and frozen and chilled imports from Australia increase 0.294 and 0.185 percent, respectively. Chilled imports are relatively less responsive to U.S. prices than frozen imports, but the difference in elasticities is small.

Unconditional own-price elasticities all indicate a significant inverse relationship between the source-/type-specific import prices and quantities. Results indicate that the demand for New Zealand and Australia chilled lamb is elastic (-1.214 and -1.237, respectively). The demand for Australia frozen lamb is also elastic but close to unit elastic (-1.014), and the demand for New Zealand frozen lamb is the most inelastic of all the own-price elasticities (-0.237). Note that the conditional and unconditional own-price elasticities for New Zealand frozen lamb are very close. This is due to the insignificant relationship between the price of New Zealand frozen lamb and the Divisia import index.

Unlike the conditional cross-price elasticities, unconditional cross-price elasticities indicate that lamb imports can be either substitutes or complements. Chilled and frozen imports and imports from the two countries being substitutes conditionally and complements unconditionally is due to the unconditional own-/cross-price elasticities accounting for the impact of changes in source-specific import prices on total U.S. lamb imports. For example, if the price of Australia chilled lamb fell, then holding total imports fixed, imports from Australia will increase and imports from New Zealand will decrease. However, the unconditional elasticity incorporates the impact of the fall in price on total imports. The fall in Australia price could also increase total imports so much that the impact of total import increases could outweigh the impact of the fall in relative prices.

Given a percentage increase in the price of frozen lamb from New Zealand, imports of chilled lamb from New Zealand and frozen and chilled lamb from Australia will increase by 0.217, 0.040, and 0.123 percent, respectively. Given that the price of frozen lamb from New Zealand did not significantly impact the import index, both the conditional and unconditional elasticities indicate a substitute relationship between these imports. Given a percentage increase in the price of chilled lamb from New Zealand, imports of frozen lamb from New Zealand and frozen and chilled lamb from Australia will decrease by 0.139, 0.110, and 0.052 percent, respectively. Percentage increases in the price of frozen lamb from Australia will cause a decrease in imports of chilled lamb from New Zealand of 0.223 percent and an increase in imports of chilled lamb from Australia of 0.369 percent. The price of frozen lamb from Australia has an insignificant impact on chilled imports from New Zealand. Lastly, percentage increases in the price of chilled lamb from Australia will cause a decrease in frozen imports from New Zealand (-0.387) and an increase in chilled imports from New Zealand (0.124).

Unconditional output price elasticities are calculated from 1990 to 2003 and results are pre-

Table 6. Unconditional Elasticities of the Derived Demand for Imported Lamb

	Elasticities				
		Unconditional Own- and Cross-Price			
Exporting Country/Good	Output Price	New Zealand Frozen	New Zealand Chilled	Australia Frozen	Australia Chilled
New Zealand Frozen	0.264***	-0.237***	-0.139***	-0.223***	-0.387***
	(0.025)[a]	(0.089)	(0.038)	(0.078)	(0.047)
New Zealand Chilled	0.194***	0.217***	-1.214***	0.146	0.124***
	(0.022)	(0.002)	(0.097)	(0.100)	(0.043)
Australia Frozen	0.294***	0.040***	-0.110***	-1.014***	-0.015
	(0.026)	(0.000)	(0.023)	(0.116)	(0.050)
Australia Chilled	0.185***	0.123***	-0.052***	0.369***	-1.237***
	(0.022)	(0.000)	(0.019)	(0.022)	(0.042)

[a] Asymptotic standard errors are in parentheses.

Note: *** means significance level = 0.01.

sented in Figure 1. U.S. lamb imports increased significantly relative to U.S. production during this period. From 1990 to 1995 the responsiveness of source-specific imports to U.S. prices was relatively close. During that period, percentage increases in U.S. wholesale lamb prices increased all imports within a range of 0.20 to 0.32 percent. Since 1995, chilled lamb imports have become relatively less responsive to U.S. prices over time, and frozen imports have become relatively more responsive to U.S. prices. In 2003, a percentage increase in U.S. prices would have increased chilled imports from Australia and New Zealand by 0.181 and 0.133, respectively, and would have increased frozen imports by 0.58 and 0.60 percent, respectively. Although Australia frozen lamb was the least responsive to U.S. prices from 1991 to 1995, frozen lamb imports from Australia became the most responsive to U.S. prices from 1995 to 2003.

Unconditional own-price elasticities from 1990 to 2003 are presented in Figure 2. These indicate that imports of chilled lamb became less and less responsive to chilled lamb prices over time, while imports of frozen lamb became relatively more responsive. The demand for New Zealand frozen lamb remained inelastic at about -0.25 throughout most of the data period. Although from 2000 to 2003 the demand for frozen lamb from New Zealand was relatively more elastic, the decrease in the elasticity is quite small. This elasticity remained relatively unchanged due to the import share of New Zealand frozen lamb remaining relatively unchanged from 1989 to 2003, and due to the insignificant relationship between New Zealand frozen lamb prices and the import index. The demand for Australia frozen lamb went from being inelastic at the beginning of the period (approximately -0.75 from 1990 to 1994) to elastic at the end of the period (approximately -1.40 from 2000 to 2003). The opposite occurred for chilled lamb from both sources. At the beginning of the period the demand for chilled lamb was elastic and became relatively more elastic until 1993–1994. The unconditional own-price elasticity was as low as -2.11 for Australia in 1992 and -2.03 for New Zealand in 1994. After 1994 the demand for imported chilled lamb became relatively more inelastic each year. By 1998 the price elasticity of demand for chilled lamb imports was inelastic. From 2000 to 2003, the average own-price elasticity was -0.97 for New Zealand and -0.90 for Australia (Figure 2).

Summary and Conclusions

Unconditional own-price elasticities all indicate a significant inverse relationship between the source-/quality-specific import prices and quantities. The demand for New Zealand and Australia chilled lamb was elastic; the demand for Australia frozen lamb was also elastic, but close to unity; and the demand for New Zealand was the most

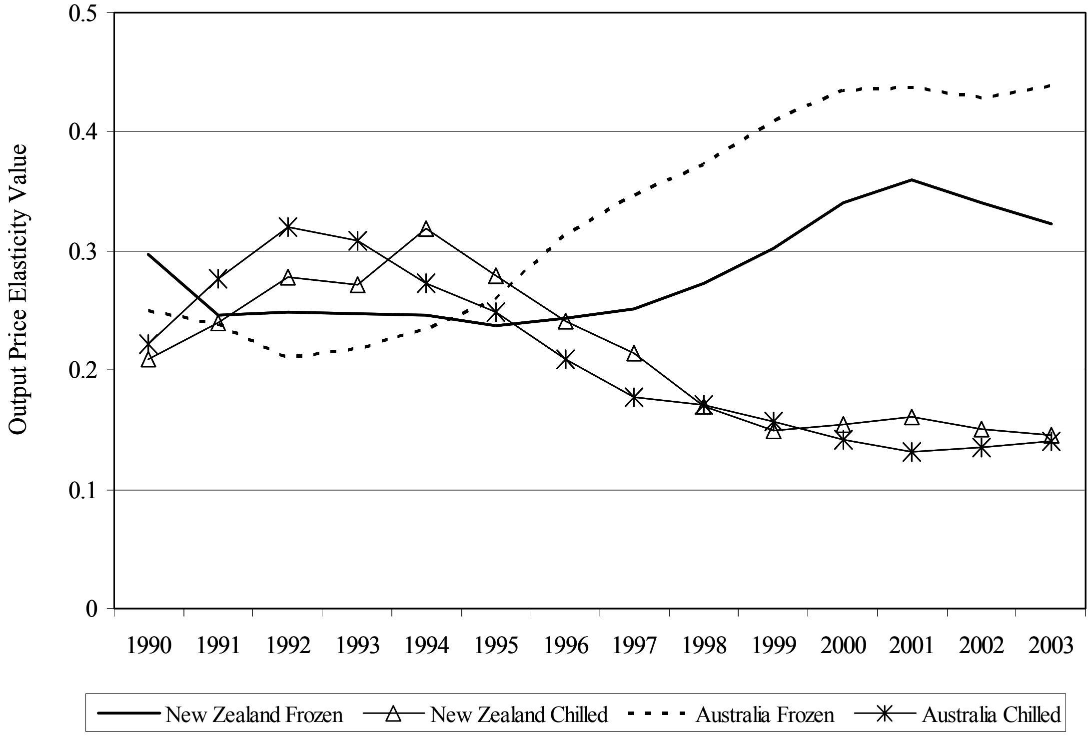

Figure 1. The Impact of U.S. Lamb Prices on Lamb Imports (Output Price Elasticities): 1990–2003

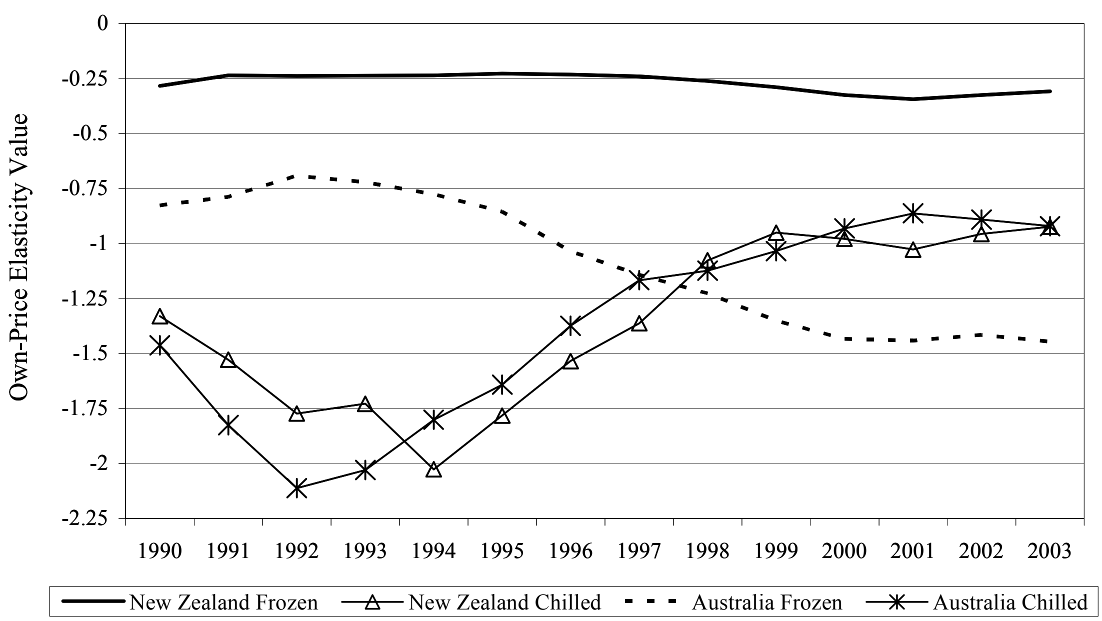

Figure 2. The Impact of Import Prices on Lamb Imports (Unconditional Own-Price Elasticities): 1990–2003

inelastic. Elastic own-price elasticities on chilled imports suggest that exporters (Australia and New Zealand) of chilled products have the ability to increase their revenues with price reductions. This will likely create additional competitive pressures on domestic producers of chilled/fresh lamb. With free trade of lamb, and the increased proportion of chilled imports, U.S. producers would therefore be challenged to increase their production efficiency and lower their costs in order to improve their competitive position in the domestic market.

Unconditional cross-price elasticities indicate that lamb imports from both countries can be either substitutes or complements, depending on the country's impact on total U.S. imports. However, the cross-price elasticities were relatively small, suggesting that increasing the price of one type/source of lamb had very little impact on the demand for the other types/sources of lamb. The results also show that when relative prices change, frozen lamb is more likely to be replaced with chilled lamb than the other way around. This underscores the preference of U.S. consumers for the chilled product.

Unconditional elasticities were calculated from 1990 to 2003. As U.S. lamb imports increased relative to domestic production, and as the relative share of chilled to frozen lamb imports increased, importers of chilled lamb became less responsive to domestic and import prices over time, while the direct opposite is the case for frozen lamb—confirming again that due to the preference for chilled lamb, the quantity imported will not vary as much with changes in domestic and import prices. Unconditional output price elasticities from 1990 to 1995 indicate that the responsiveness of source-/type-specific imports to U.S. prices was relatively close. From 1996 to 2003, chilled lamb imports have become less responsive to U.S. prices, and frozen imports have become more responsive. Unconditional own-price elasticities from 1990 to 2003 indicate that imports of chilled lamb became less and less responsive to chilled lamb import prices, while imports of frozen lamb have became relatively more responsive to frozen lamb import prices. Given that the unconditional own-price elasticities indicate that the demand for chilled products is becoming more and more inelastic, this suggests that in order to increase revenue, exporters now must increase prices, which will benefit the competitiveness position of U.S. firms.

Based on the results, it appears that lamb quality is an important issue for the U.S. market. Chilled imports were preferred to frozen imports. It can therefore be concluded that lamb exporters may be able to improve their market position and increase total revenues with proper marketing and management strategies, but that given inelastic demand in recent years, decreasing prices will actually decrease revenue. On the other side, U.S. lamb producers could capitalize on the fact that chilled lamb appears to be preferred to frozen because they are in a better position (transportation-wise) to provide chilled as well as fresh lamb to U.S. consumers. The challenge, however, will be to improve production efficiency and lower cost in order to compete effectively with imported lamb.

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