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Economic Effects of a Countervailing Duty Order on the U.S. Lamb Meat Industry

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This paper provides the model, analysis, and results of the investigative research by the U.S. International Trade Commission (USITC) staff on the U.S. lamb market impacts from the countervailing duty (CVD) order imposed on certain U.S. imports of New Zealand lamb meat during 1985–90. Presented here are the monthly three-stage least squares model of the U.S. lamb meat industry at the wholesale or meat-packing level, along with the econometric results and analyses obtained from the USITC investigation. Analysis of model results quantifies average estimated CVD-attributed effects on U.S. lamb price, demand and supply of domestically produced lamb, and U.S. lamb import levels. A number of economic parameter estimates and inference results concerning U.S. wholesale lamb market relationships are reported and are of interest, given the scarce published research on the U.S. lamb industry.

Recently, the U.S. International Trade Commission (USITC) conducted an investigation of the impacts that certain antidumping (AD) and countervailing duty (CVD) orders have had on the U.S. economy, as well as on selected U.S. industrial markets that include, among others, lamb meat (hereafter, lamb) at the wholesale or meat-packing level (USITC 1995a, and hereafter denoted as Investigation 332–344). In addition to USITC Investigation 332–344, there have been other USITC investigations on a wide array of lamb-related competitive issues, including the issue of CVD impacts. Among these are USITC Investigation 332–264 on lamb meat imports (USITC 1990), and more recently USITC Investigation 332–357 on general competitive conditions of the U.S. and foreign lamb industries (USITC 1995b).

A CVD is a duty imposed on selected U.S. imports deemed by the U.S. Department of Com-

merce (hereafter Commerce) as benefiting from subsidies (bounties or grants) generated by a foreign government, or by a firm or person in that foreign country (USITC 1993, pp. 8–9). Under the U.S. Code (USC), industries may petition the U.S. government for relief from such “subject” imports. Commerce determines if such subsidies exist, and to what specific degree, while the USITC determines whether the subsidized imports materially injure or threaten to materially injure the U.S. industry. If, after a series of preliminary and final investigations detailed and summarized in USITC (1993), the USITC determines that the subject imports are injuring or threatening to injure a U.S. industry, and/or are interfering with, or threatening to interfere with, the establishment of a U.S. industry, the Secretary of Commerce issues a CVD order, which is enforced by the U.S. Customs Service (USITC 1993). A CVD is imposed only on U.S. “subject imports,” and not necessarily on all U.S. imports of the relevant good or commodity from a country (USITC 1990; 1995a, b; 1993, pp. 8–9). Furthermore, a CVD order does not necessarily impose one CVD on all the subject U.S. imports, insofar as different imported consignments from a country may be determined by Commerce as benefiting from different levels of subsidies (USITC 1995a, b; 1993, pp. 8–9). That is, U.S. imports from the subject foreign firms are countervailed in accordance with the amount of subsidies (bounties and grants) benefiting such imports according to Commerce’s determinations (USITC

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1995a, b). Thus the CVD order's imposed duties can actually vary firm by firm. And finally, the firm-specific duties vary annually, as Commerce reviews the levels of subsidy still characterizing the subject imports, and adjusts the CVD order's firm-specific duties accordingly (USITC 1990; 1993; 1995a, b). Therefore a CVD order does not necessarily apply to all U.S. imports of the relevant commodity from the country; the order's levels of imposed duties vary by exporter/firm depending on the Commerce-determined firm-specific subsidy levels characterizing such imports; and such firm-specific duties vary year by year in accordance with Commerce's annual reviews of the subsidy levels characterizing U.S. imports through such firms (USITC 1993; 1995a, b). Imposition of a CVD order is thus far more complex than that of a constant and universally applied tariff rate or duty, which is often imposed on textbook trade models.

The USITC (1990; 1995a, b) reports that, during the period June 25, 1985–March 31, 1990, Commerce determined that certain volumes of New Zealand lamb benefited from bounties and grants, and then imposed countervailing duties on these imports. This paper has a twofold goal. The first is to provide a summary of Investigation 332–344's lamb-related analyses and results. Included are the econometric model and estimates of the CVD-induced market impacts on U.S. lamb price, demand and supply of domestically produced lamb (hereafter, domestic lamb), and U.S. lamb imports.

Capps, Byrne, and Williams (1995, p. 232) and Van Tassel and Whipple (1994) note the dearth of published work on the U.S. lamb industry. Consequently, this paper's second aim is to provide empirical estimates and evidence concerning the nature of U.S. lamb market parameters and relationships at the U.S. wholesale or meat-packing level. As explained by the USITC (1990; 1995a,b), the CVD investigation was requested by U.S. wholesalers, and not by farmers, and the CVD order applied to lamb imports at the wholesale (meat-packing) level. Consequently, Investigation 332–344's lamb-related analyses, and hence this article, focus on the lamb meat-packing industry (i.e., at the wholesale marketing level), and not the farm production level. Relationships and parameters include, among others, own-price elasticities of demand (for domestic and imported lamb) and supply, the income elasticity of U.S. demand for lamb (domestic and imported), and the statistical significance of declining trends in the demand and supply of U.S.-produced lamb. Also included are findings concerning the degrees to which U.S. consumers consider the following product groups as substitutes or complements: primarily fresh and larger-

cut U.S.-produced lamb and primarily frozen and smaller-cut lamb imports; New Zealand and Australian lamb imports; and lamb generally and other nonlamb meat alternatives (chicken, beef, pork).

Model Specification

The USITC staff (USITC 1995a, ch. 8) formulated and estimated the following monthly econometric model over the period January 1981–May 1994.

(1)

$$USPRICE(t) = a_0 * CONSTANT + a_1 * USLAMB(t) + a_2 * WAGE(t) + a_3 * PELEC(t) + a_4 * REMEDY + a_5 * TREND + R1(t)$$

(2)

$$USLAMB(t) = b_0 * CONSTANT + b_1 * USPRICE(t) + b_2 * PERSINC(t) + b_3 * PCHICKEN(t) + b_4 * PBEEF(t) + b_5 * PPORK(t) + b_6 * PNZ(t) + b_7 * PAUS(t) + b_8 * REMEDY(t) + b_9 * TREND + R2(t)$$

(3)

$$NZLAMB(t) = c_0 * CONSTANT + c_1 * USPRICE(t) + c_2 * PERSINC(t) + c_3 * PCHICKEN(t) + c_4 * PBEEF(t) + c_5 * PPORK(t) + c_6 * PNZ(t) + c_7 * PAUS(t) + c_8 * REMEDY + R3(t)$$

(4)

$$AUSLAMB(t) = d_0 * CONSTANT + d_1 * USPRICE(t) + d_2 * PERSINC(t) + d_3 * PCHICKEN(t) + d_4 * PBEEF(t) + d_5 * PPORK(t) + d_6 * PNZ(t) + d_7 * PAUS(t) + d_8 * REMEDY + R4(t)$$

Above, a, b, c, and d denote regression coefficient estimates for equations (1), (2), (3), and (4), respectively. Note that an intercept (*CONSTANT*) is included in each equation. The parenthetical *ts* refer to a variable's current (*t*th period) value; the nought-subscripted coefficients reflect intercepts; and the *R1(t)*, *R2(t)*, *R3(t)*, and *R4(t)* reflect the white-noise residuals on equations (1), (2), (3), and (4), respectively.

The supply and demand for domestic lamb (equations [1] and [2]) are simultaneous (see Harvey 1990, p. 66). Equation (1), the price-dependent U.S. supply of domestic lamb, has the U.S. wholesale lamb price or *USPRICE* as the dependent variable, and is a function of the quantity of domestic lamb produced and consumed (*USLAMB*); the wage for meat-packing house workers (*WAGE*); the price of electric power (*PELEC*); a time trend (*TREND*); and a binary variable (*REMEDY*) defined as unity over the "CVD period" of 1985:6–1990:3.¹ As stated, this period is when Commerce determined that certain U.S. imports of New Zealand lamb benefited from bounties and grants and imposed a CVD order on these imports (USITC 1990; 1995a, b). Equation (2), the U.S. demand for domestically produced lamb (hereafter, domestic lamb demand), has the quantity of domestic lamb or *USLAMB* as the dependent variable, and is a function of the U.S. lamb price (*USPRICE*); U.S. personal income (*PERSINC*); the U.S. prices of chicken, beef, and pork (*PCHICKEN*, *PBEEF*, and *PPORK*, respectively); the import prices of New Zealand and Australian lamb (*PNZ*, *PAUS*); and *REMEDY* and *TREND*.

Equations (3) and (4) are, respectively, the U.S. demands for imported New Zealand and Australian lamb, and have the quantities of U.S. lamb imports from these two nations, *NZLAMB* and *AUSLAMB*, respectively, as the dependent variables. These equations are both functions of *PERSINC*, *PCHICKEN*, *PBEEF*, *PPORK*, *PNZ*, *PAUS*, *USPRICE*, and *REMEDY*.

Beginning stock levels were not included in the two import demand equations. This is because the model was estimated at the industry's wholesale (meat-packing) level, at which beginning stocks have historically been small or negligible. According to the U.S. Department of Agriculture's Economic Research Service (USDA, ERS), beginning lamb and mutton stocks have constituted from 2 to 3% of U.S. annual production during the period 1990–94 (see USDA, ERS, 1981–94, 1994, pp. 32 and 39).

The above model was formulated under the USITC staff's assumptions (1995a) that the export supplies of New Zealand lamb and of Australian lamb to the United States have infinite own-price elasticities of supply. Evidence in Investigation 332–344, as well as in the more recent USITC Investigation 332–357 (USITC 1995b), supports

the validity of these assumptions. The evidence and testimony suggest that both countries would be able to supply substantially more lamb meat at U.S. market prices. For New Zealand, the U.S. market accounts for only about 3% of its exports (USITC 1995a, b, c). While about 23% of Australia's lamb exports are purchased in the United States, testimony presented at Investigation 332–357's public hearing by both U.S. and Australian producer interests suggests that Australia is able to supply substantially more lamb than it currently supplies to the U.S. market at competitive prices (USITC 1995c). U.S. lamb producer interests testified that Australia was actively promoting increased volumes within the United States (USITC 1995c, pp. 22–25). Officials of the Australian Meat and Livestock Corporation (AMLC) testified that more Australian product could be marketed at prevailing prices; that the AMLC is willing and able to supply more lamb competitively to the U.S. market; and that the AMLC not only desires to promote increased "generic" lamb consumption within the United States but has actually approached U.S. producer groups to cooperate to this end (USITC 1995c, pp. 163–76). New Zealand and Australia thus both seem able to supply whatever is needed at prevailing U.S. prices, lending validity to the assumptions of infinitely elastic lamb export supplies to the U.S. market.

USITC staff (1995a) specified the U.S. import demands for lamb from New Zealand and Australia as two Marshallian demands for otherwise homogeneous imports. USITC staff did not resort to such approaches as the Armington (1969a, b) model, wherein the U.S. market would have differentiated imported lamb supplies on the basis of New Zealand or Australian origin. USITC staff (1995a, ch. 8) opted for this straightforward Marshallian treatment because findings from three recent USITC investigations (USITC 1990; 1995a, b) and certain hearing testimony (USITC 1995c) suggested that (1) the U.S. market differentiates between the smaller-cut, primarily frozen imported products and the larger-cut, primarily fresh domestic products, (2) the U.S. market treats New Zealand and Australian imports as highly substitutable (i.e., homogeneous) products, and (3) virtually all U.S. lamb imports are, and have been historically, from Australia and New Zealand. Such considerations, together with assumptions of perfectly elastic export supplies to the United States (explained above), simplified the modeling of the U.S. lamb import market into one of specifying the two Marshallian U.S. import demands for the two nations' products that are considered homogeneous.

A time trend was included in the U.S. domestic lamb supply and demand relations to account for

¹ Throughout, monthly dates are denoted numerically with the year to the left, and the month to the right, of the colon. So 1990:1 and 1990:12 denote January and December of 1990, respectively.

post-World War II declining trends in production and consumption of domestic lamb noted in the last three USITC lamb investigations (USITC 1995a, ch. 8; 1995b; 1990), and in recently published research by Capps, Byrne, and Williams (1995) and Van Tassel and Whipple (1994). Following previous empirical work, a series of eleven binary (or dummy) variables was included to account for seasonal influences in each of the model's four equations (see Capps, Byrne, and Williams 1995, p. 236; TAMRC Lamb Study Team 1991, pp. B5-B6).

Data are in natural logarithms rendering regression coefficient estimates in elasticity form for nonbinary variables. Since the model's nonbinary variables are in natural logarithms, coefficient estimates on the binary REMEDY variable may be used to determine the percentage changes in each equation's dependent variable because of all events (including the CVD) that occurred during the CVD period. These REMEDY coefficients are translated into such percentage effects using Halvorsen and Palmquist's established procedure (1980) of raising e , the base of the natural logarithm, to the power of the coefficient estimate on REMEDY, subtracting 1.0, and then multiplying by 100. What results is a REMEDY coefficient estimate that reflects the approximate percentage change in the equation's dependent variable from the events of the CVD period. REMEDY coefficient estimates are used to discern the degree to which U.S. lamb price, U.S. domestic lamb quantity, and U.S. import levels of New Zealand and Australian lamb were above or below average historical levels because of events (including the CVD order) that occurred during the CVD period.

In a massive study on the economic effects of antidumping and CVD orders on the U.S. economy, and more specifically on eight U.S. industries (lamb included), USITC staff (1995a) established the binary variable method as an econometrically acceptable, though somewhat imprecise, method with which to model the impacts of such orders. The study established the binary variable method as an effective (perhaps the most effective) econometric method for assessing industry impacts of antidumping and CVD orders, given data limitations and the orders' complexity. This paper presents a modeling analysis for the CVD order placed on certain U.S. imports of New Zealand lamb during the CVD period of June 25, 1985-March 31, 1990. Modeling this CVD order was not a straightforward matter given the complex manner in which the CVD order was imposed and maintained, and given limitations of available economic data. As with the previous description of CVD

orders generally, this CVD order imposed on certain U.S. imports of New Zealand lamb was actually a series of firm-specific and annually varying duties placed on a series of firm-specific consignments (of more than five New Zealand firms during some years) of U.S. imports of New Zealand lamb (USITC 1995a, p. 8.2). Existing data limitations and the complexity of the CVD order's imposition and maintenance rendered modeling the order's firm-by-firm and year-by-year nature as econometrically impractical.

Consequently, the USITC staff's binary method (using *REMEDY* above) was chosen. Binary variable analysis generally has a limitation of imprecision in not being able to ferret out the specific effects of that event for which the variable was defined when other events with effects occurred during the relevant period. In such cases of multiple concurrent events, the binary variable captures the combined or collective effects of the multiple events. The coefficient estimates on *REMEDY* are imprecise because they reflect the collective effects on each equation's dependent variable not only of the CVD order, but of all other events that occurred during the CVD period as well. Therefore each equation's coefficient estimate on *REMEDY* is unable to ferret out the effects of the CVD order specifically. Yet given data limitations and the CVD order's complexity, no other econometric method of capturing firm-specific and annually varying CVD-related effects was obvious, either here for lamb, or for those other orders imposed on seven other U.S. industries (see USITC 1995a).

Data Sources

The U.S. domestic lamb price (*USPRICE*) is the U.S. wholesale lamb price for Choice/Prime, East Coast carcasses of 55-65 pounds published by the U.S. Department of Agriculture, Economic Research Service (USDA, ERS 1981-94, 1994). Quantities of domestic lamb meat are reflected by commercial lamb and yearling slaughter levels. These slaughter levels (in pounds) were constructed for each month by multiplying the commercial yearling slaughter (number of animals) published by USDA, ERS (1981-94, 1994) and the USDA's National Agricultural Statistical Service (USDA, NASS) by the average dressed weight per head (in pounds) published by USDA, NASS.

The Bureau of Labor Statistics of the U.S. Department of Labor (hereafter, Labor, BLS) provided monthly data on the following (which were then deflated as explained below): the producer price index (or PPI) for commercial electric power

as *PELEC*, the PPI for beef and veal as *PBEEF*, the PPI for fresh whole chicken as *PCHICKEN*, and the PPI for pork as *PPORK*. Average hourly earnings in meat-packing plants served as *WAGE* and were obtained from the U.S. Department of Labor's LABSTAT Data Base. Personal income, published by the Department of Commerce, Bureau of Economic Analysis (1988, 1995), served as the income variable (*PERSINC*) in the U.S. demand functions for domestic lamb and for New Zealand and Australian imports.

As confirmed by the TAMRC Lamb Study Team (1991), monthly prices of U.S. imports of New Zealand and Australian lamb meat were not available with enough observations to do an econometric investigation. Unit values of New Zealand and Australian lamb meat imports (denoted *PNZ* and *PAUS*, respectively) were consequently used as proxies for these prices of U.S. lamb meat imports. Unit values for each country were calculated by dividing the value of lamb meat imports from a country by the quantity imported from that country, where value and quantity import data were official Department of Commerce statistics. Despite limitations, these unit values were the best, and in fact the only, monthly import price proxies available with enough historical observations with which to do this econometric analysis.²

Given the well-known homogeneity properties of the three Marshallian demands (equations [2], [3], and [4]) and the supply (equation [1]), the price and income arguments in the demands and the input prices in the supply were deflated. Given the wholesale nature of this analysis, these price and income variables were deflated by the producer price index (PPI) for all items published by Labor, BLS (1981–1994).

Estimated Model

As demonstrated in the ensuing subsections, equations (1)–(4) were appropriately estimated as a simultaneous system with three-stage least squares (3SLS), a method that combines two-stage least squares (2SLS) to account for simultaneous equations, with information inherent in contemporane-

ously correlated residuals among equations (Hamilton 1994; Harvey 1990; Kennedy 1986; Judge et al. 1980). Ensuing discussion also justifies application of Cochrane-Orcutt and Prais-Winsten methods to account for serially correlated errors (Granger and Newbold 1986; Harvey 1990; Kennedy 1985).

Equations (1) (U.S. domestic lamb supply) and (2) (U.S. demand for domestically produced lamb) are simultaneous. Estimated by themselves and accounting only for simultaneous regressors, these two equations would be appropriately estimated with two-stage least squares (2SLS) in order to avoid parameter estimate bias from regressor simultaneity (see Hamilton 1994, ch. 9).

Correlations among Residuals

Two kinds of residual correlations are common to economic time series: (1) contemporaneously correlated current errors, where disturbances of different equations are correlated at a point in time (i.e., correlated "contemporaneously"); and (2) serially correlated errors, where a single equation's residuals are correlated across two points in time (Harvey 1990; Granger and Newbold 1986). Harvey (1990, pp. 65–69) and Hamilton (1994, pp. 224–26) note that failure to utilize information inherent in such contemporaneous and serial correlations may result in nonminimal variances, such that inference on coefficient estimates (e.g., with Student *t*-values) may not be valid.

Evidence suggests that residuals on each of the four equations are serially correlated,³ while re-

³ Granger and Newbold (1986, pp. 99–101) suggest that the Ljung-Box portmanteau ("Q") test validly tests the null hypothesis that an equation's residuals are not serially correlated. Q-values calculated for the residuals of the U.S. domestic lamb supply, U.S. domestic lamb demand, and U.S. import demand for New Zealand lamb were 86.4 or higher, and exceeded the critical chi-square values of 51 (5% significance level and 36 degrees of freedom). Evidence at the 5% significance level was sufficient to reject the null hypothesis that residuals for each of these three equations are not serially correlated.

Evidence was less clear on whether residuals on the U.S. import equation for Australian imports (i.e., the "Australian" equation) were serially correlated. This equation's Q-value of about 35 was less than the critical chi-square value, suggesting that evidence at the 5% level was insufficient to reject the null hypothesis of no serial correlation. Further tests using the Durbin-Watson (DW) statistic on the ordinary least squares (OLS) estimation of the Australian equation were performed. The DW of 1.86, given the equation's 20 regressors and 144 degrees of freedom, suggests that evidence of serial correlation falls within the inconclusive range at the 5% significance level. Despite this ambiguous evidence, I concluded that Australian equation residuals were probably serially correlated because the equation's estimation corrected for serial correlation generated theoretically more plausible results. Compared with the equation's estimation without corrections, the Australian equation corrected with Cochrane-Orcutt and Prais-Winsten methods generated more statistically significant own-price and income elasticities, and provided inferentially clearer results for *REMEDY*'s coefficient estimates.

² These unit values may vary from month to month in the mixes of differently valued cuts. For example, one month's shipments may generate a high unit value because of a high proportion of high-valued racks, while another month's unit value may be lower because of high percentages of lower-valued cuts (e.g., shoulders). However, any such monthly variation that is systematically recurring over time may be captured in the monthly binary seasonal variables. Furthermore, these unit values fail to reflect values added from the processing of carcasses into primal cuts, transportation costs within the United States, and importer profits.

residuals of equations (1)–(4) are most probably contemporaneously correlated. The Cochrane-Orcutt and Prais-Winsten methods described in Hamilton (1994), Harvey (1990), and Kennedy (1985) were used to correct for first-order serial correlation. Such methods entail estimating the correlation coefficient estimate (i.e., ρ -estimate) with OLS by regressing the equation's residuals against its one-period lag without an intercept. Yet a systemwide coefficient was deemed desirable for two reasons. First, the four-equation model was estimated as a system. Second, the first two equations (domestic demand and supply relations) are simultaneous and require a common ρ -estimate if the same identically valued price and quantities are to be exchanged among the two equations. To obtain a systemwide ρ -estimate, each equation's residuals were posited as a function of one-lag of itself; the four regressions were stacked into a seemingly unrelated regression (SUR) system; and the SUR system was estimated with the imposed condition that the ρ -estimate be equal across the four equations. The ρ -estimate that emerged was -0.2501 , which was then used to implement the noted Cochrane-Orcutt and Prais-Winsten corrections for serial correlation.

The model was 3SLS-estimated with monthly 1981:1–1994:5 data. As Judge et al. (1980) pointed out, it is well known that coefficients of determination (R-square values) are not well defined when generated with systems estimation methods, and therefore they are not considered here. Stationarity of each equation provides an accepted indication of adequate specification (Granger and Newbold 1986). Stationary equations should generate residuals that behave approximately as white noise at the chosen significance level (Granger and Newbold 1986, pp. 188–89). More specifically, a stationary series of residuals should not be characterized by a unit root. Tests developed by Fuller (1976) and Dickey and Fuller (1979), and augmented by Engle and Granger (1987) (hereafter, augmented Dickey-Fuller or ADF tests), were applied to the four equations' residuals. Evidence at the 5% significance level was sufficient in each equation's case to reject the null hypothesis of non-stationarity using both the τ_μ and τ_τ tests. That is, pseudo-t values on the lagged, nondifferenced residual regressors (i.e., the test values) were negative and had absolute values above those of the critical values of -2.89 (τ_μ test) and -3.45 (τ_τ test) published in Hamilton (1994).

Results

Econometric results are presented in table 1 and are discussed below in four subsections (within the

context of statistical significance levels of 5%). The first subsection is an analysis of the four equations' coefficient estimates on *REMEDY* to discern the effects, coinciding with CVD period events, on domestic lamb supply and demand, U.S. lamb price, and U.S. lamb import volumes. The second subsection provides evidence that the market effects attributed to CVD period events were either not substantial enough, or perhaps mutually offsetting, so as not to have generated fundamental changes in the modeled relationships (i.e., "structural change") over the 1981:1–1994:5 sample. The third subsection presents econometric parameter estimates and analyses concerning U.S. lamb market relationships. The final subsection provides concluding remarks.

Analysis of the Effects of the CVD Period Events

Four effects of the events of the CVD period emerge from the econometric results in table 1. The econometric estimates in table 1 reflect the gross effects that the predetermined variables have on the dependent variables. For the model's simultaneous equations (equations [1] and [2]), the net effects of the predetermined variables may be calculated using the analytical reduced forms (derived below). Given this paper's focus on discerning total effects attributed to CVD period events, the discussion emphasizes the gross effects below. Furthermore, discussion of the net effects from the two simultaneous equations is limited to the implications of the *REMEDY* coefficient estimates.

Gross Effects of CVD Period Events. Four gross effects emerge from analysis of table 1's coefficient estimates on *REMEDY*. First, the CVD period events appeared successful, to a degree, in elevating the price received by U.S. lamb producers. The price-dependent supply equation's negative and statistically significant coefficient estimate on *REMEDY* indicates that U.S. domestic lamb price during the CVD period was, on average, 10% higher than levels during other sample subperiods. This result of a generally higher U.S. lamb price during the CVD period is supported by monthly U.S. lamb carcass prices published and analyzed by the USITC staff (1995a, pp. 8.15–8.21), who reported that on average, U.S. lamb prices were from 7.0 to 10% higher during the CVD period than during other sample subperiods.

Second, the negative coefficient estimate on *REMEDY* in equation (2) indicates that U.S. domestic lamb demand was 3.5% below average levels during other sample subperiods.

Third, the estimated coefficient on the New Zealand equation's *REMEDY* variable suggests that U.S. imports of New Zealand lamb were about

Table 1. Econometric Coefficient Estimates with Related Student t-Values (in parentheses)

Independent variable	U.S. domes. lamb supply	U.S. domes. lamb demand	U.S. imports, N.Z. lamb	U.S. imports, Aus. lamb
Remedy variable (<i>REMEDY</i>)	0.099* (7.6)	-0.036* (-1.97)	-0.12 (-0.9)	0.65* (7.5)
Domestic quantity (<i>USLAMB</i>)	0.352* (6.7)	N/A	N/A	N/A
Wages (<i>WAGE</i>)	0.479* (3.1)	N/A	N/A	N/A
Electricity price (<i>PELEC</i>)	1.06* (5.65)	N/A	N/A	N/A
U.S. price, domestic lamb (<i>USPRICE</i>)	N/A	-0.78* (-3.4)	2.20* (3.4)	-1.69* (-4.0)
U.S. personal income (<i>PERSINC</i>)	N/A	1.76* (11.9)	0.80* (2.5)	2.87* (13.5)
U.S. chicken price (<i>PCHICKEN</i>)	N/A	-0.06* (-1.1)	-0.09 (-0.18)	-0.05 (-0.17)
U.S. beef price (<i>PBEEF</i>)	N/A	-0.15 (-0.8)	3.97* (3.0)	0.48 (0.56)
U.S. pork price (<i>PPORK</i>)	N/A	-0.065 (-0.8)	-2.29* (-3.0)	0.74 (1.56)
Price, New Zealand imports (<i>PNZ</i>)	N/A	0.017 (0.68)	-0.08 (-0.33)	0.49* (3.4)
Price, Australian imports (<i>PAUS</i>)	N/A	-0.016 (-0.3)	-0.63 (-1.5)	-1.14* (-4.3)
Time trend (<i>TREND</i>)	-0.0008* (-4.7)	-0.006* (-9.5)	N/A	N/A
<i>CONSTANT</i>	0.278 (0.8)	1.02* (3.1)	-2.65 (-0.9)	-1.77 (-0.9)

NOTE: Asterisks denote significant coefficients (5% significance level or less). N/A denotes coefficients that are not applicable to the equation. Domes. denotes domestic.

11% less during the CVD period than during other sample subperiods. Although this coefficient estimate was not statistically significant (at the 5% level),⁴ Commerce's data, plotted in figure 1, on U.S. imports of lamb seem to support the validity of *REMEDY*'s suggestion of lower U.S. imports of the New Zealand product during the CVD period. Figure 1 clearly shows a marked decline in U.S. imports of New Zealand lamb soon after imposition of the CVD order and for much of the (shaded) CVD period.

Fourth, the Australian equation's statistically significant and positive *REMEDY* coefficient estimate suggests that U.S. imports of Australian lamb during the CVD period were, on average, 92% higher than levels during other sample subperiods. The large percentage increases in CVD period import levels are explained by the low pre-CVD levels (of less than a million pounds) from which the

CVD period levels increased (USITC 1995b). These results are supported by evidence in figure 1, where U.S. imports of Australian lamb rose sharply after imposition of the CVD order and sustained noticeably higher levels for much of the CVD period.

The readiness and strength with which U.S. imports of noncountervailed Australian lamb offset declines in the countervailed U.S. imports of the New Zealand product suggest a high degree of substitutability between Australian and New Zealand lamb by U.S. demanders. The industry and market analyses of USITC Investigations 332-264, 332-344, and 332-357 provided findings in support of this substitutability (USITC 1990; 1995a, b, c). The industry analyses and findings in these investigations establish that the smaller-cut, primarily frozen, and range-fed New Zealand and Australian lamb imports are more similar to each other than to the larger-cut, primarily fresh, and grain-fed American product (USITC 1990; USITC 1995a, pp. 8.4-8.5; 1995b, ch. 1). Furthermore, U.S. marketers of imported lamb from both New Zealand and Australia testified at the USITC Investigation 332-357 hearing that they "trade off" purchases of Australian and New Zealand lamb depending on

⁴ The insignificance may arise from the New Zealand equation's *REMEDY* coefficient estimate having picked up effects of other CVD period events that conflicted with the presumably decreasing effects of the CVD order. For example, the New Zealand government was taking measures to deregulate the nation's agricultural markets during the CVD period. The reflection of multiple concurrent effects was previously noted as a limitation of the binary variable method.

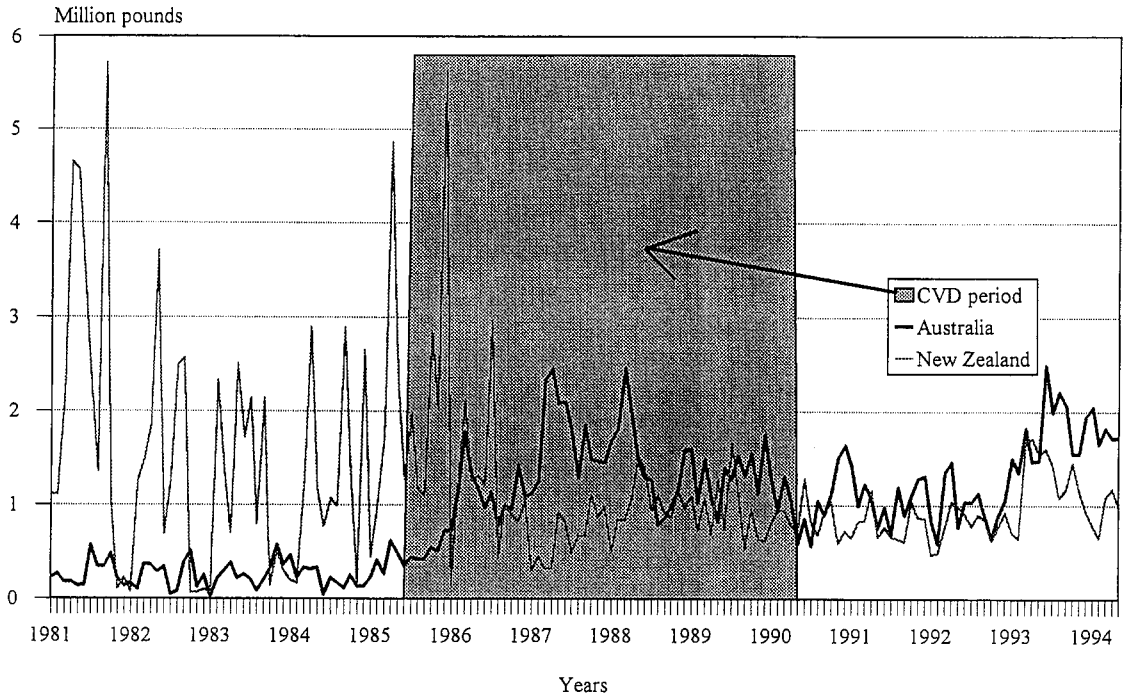


Figure 1. U.S. Lamb Meat Imports from New Zealand and Australia by month January 1981–May 1994. SOURCE: Compiled from official statistics of the U.S. Department of Commerce.

relative prices, suggesting their interchangeability or substitutability within the U.S. market (USITC 1995c, pp. 120–22). Aside from Australian carcasses being somewhat larger than New Zealand carcasses, lamb imports from both countries are very similar: they are range-fed; primarily frozen in nature; and far smaller in cut than the primarily fresh U.S. product. Clearly, imported lamb products from the two countries are far more similar to each other than each country's imports are to U.S. lamb (see USITC 1995b, pp. 5.20–5.22).

Econometric evidence in table 1 is ambiguous on whether New Zealand and Australian products are substitutes. The New Zealand price coefficient in the Australian equation is positive and significant, suggesting substitutability among imports from both countries. Yet the Australian lamb price in the New Zealand equation is not significant, perhaps owing to collinearity and other problems noted more fully below. Nonetheless, with the total evidence taken from the Australian equation, figure 1, and expert testimony from the USITC hearing (USITC 1995c), it is concluded that the U.S. market probably does treat New Zealand and Australian lamb as rather close substitutes.

In summary, then, CVD period events generated four gross econometric effects. The 10% higher domestic supply price coincided with 3.5% lower

levels of consumption of domestically produced lamb. The apparently CVD-induced drops of 11% in countervailed U.S. imports of New Zealand product coincided with large (92%) increases in U.S. imports of noncountervailed Australian product. Overall U.S. lamb imports were apparently not much affected by the CVD imposed on certain New Zealand quantities, because imports of noncountervailed Australian lamb rose to compensate for the decline in imports of the countervailed New Zealand product. Furthermore, U.S. imports of Australian lamb rose not only to levels offsetting the import reductions of New Zealand product, but to sustained levels that increased total imports' share of U.S. consumption from 5 to 8% over the period 1984–86 (see USITC 1995b, p. 6.6).

Comparing Gross Effects with Net Effects of the Analytical Reduced Forms. Equations (1) and (2), the U.S. price-dependent supply and demand equations of domestically produced lamb, are a simultaneous system of equations, the coefficients of which were estimated with three-stage least squares. Therefore, the coefficient estimates analyzed above for these two simultaneous equations are clearly gross effects of the predetermined variables on the dependent variables, and the net effects of predetermined variables in contemporaneous time are available through derivation of the

analytical reduced forms. The reduced forms for the model's first two simultaneous equations were therefore calculated, and the net impacts of the CVD period events, as suggested by *REMEDY* coefficients, on *USPRICE* and *USLAMB* variables were calculated and compared with the gross effects provided above.⁵ According to the *REMEDY* coefficient estimate for the supply equation (equation [1]), the CVD period events had gross effects of 10.4% on *USPRICE*, as previously shown, as well as net impacts of 12.4%.

According to the *REMEDY* coefficient estimate for the U.S. demand for domestically produced lamb (equation [2]), the CVD period events had, as already shown, a gross -3.5% effect on *USLAMB*. The net effect was calculated from the reduced form as 3.3%. The negative gross impact of CVD period events on quantity of domestically produced lamb seems plausible and appears the most relevant in terms of discerning the total impacts of the CVD period events ferreted out by the binary variable methods. However, the CVD period events' net effect, which emerged from applying the analytical reduced forms to the equation 2's *REMEDY* coefficient, were positive. This may suggest that the higher price had some upward *net* influence in contemporaneous time on the quantity of domestic lamb produced and consumed, through the supply side of the simultaneous system. That is, while the domestic lamb demand equation's *REMEDY* coefficient suggests that CVD period events had gross effects that resulted in a decline in the quantity of domestic lamb produced and consumed, there was a positive net effect in contemporaneous time on domestic lamb quantity—perhaps from a positive supply response from the higher price.

Tests for Market Structural Change

For an econometric (linear regression) model of a market, "structural change" or "time-variance of parameters" occurs when events act to fundamentally change modeled market relationships over the sample period. Given structural change, the econometric parameter estimates are not constant and hence do not validly characterize the modeled market relationships over the sample. Existence of

structural change usually requires division of the sample into subsamples at the juncture(s) of the change's occurrence, and the reestimation of the model separately for the subperiods (Harvey 1990, pp. 163–64). A set of structural change tests was conducted to discern whether the CVD period events coincided with fundamental changes in the modeled lamb market relationships before the imposition of the CVD order (during the pre-CVD period, or 1981:1–1985:5) and after (during the post-CVD period, or 1990:4–1994:5).

Given that the four equations were estimated using a systems estimator, Chow tests for structural change based on equation-specific F-tests were not used. Instead, the four equations were treated as a system, and likelihood ratio test statistics were used to test the null hypothesis of no structural change in two separate tests: between the pre-CVD and CVD periods of the sample, and between the CVD and post-CVD periods. The calculated likelihood ratio test values of 20.8 and 23.6 for these two tests fall below the critical chi-square value of 95.1. Evidence at the 5% significance level in both tests was thus insufficient to reject each test's null hypothesis of no structural change.

Recall that the CVD period events coincided with four (gross) effects—10% higher levels of domestic price, 3.5% lower levels of domestic lamb quantity, 11% lower levels of imports from New Zealand, and 92% higher levels of imports from Australia. Yet evidence generated from the likelihood ratio tests for market structural change suggests that the CVD period events and the noted four effects were either not substantial enough or perhaps mutually offsetting, so that structural change did not arise during the sample between the pre-CVD and CVD periods or between the CVD and post-CVD periods.

The reasons for the effects' apparent failure to induce such structural change may have arisen from two events emerging from evidence reflected in table 1 and figure 1. First, overall imports of the closely substitutable New Zealand and Australian products, which have constituted virtually all U.S. lamb imports historically, seemed little affected by the CVD period events. This may be so because the apparently CVD-induced drop in the countervailed U.S. imports from New Zealand were concurrently compensated for by a rise in the noncountervailed U.S. imports from Australia. Second, U.S. imports from Australia rose more than proportionally to the drop in imports from New Zealand, such that imports increased U.S. market share during the CVD period. This rise in import penetration may have offset or lessened the effects of higher prices and

⁵ In matrix notation, this two-equation simultaneous component of the four-equation model can be written as $\mathbf{BY} = \mathbf{GZ} + \mathbf{E}$, where \mathbf{B} is a matrix of the coefficient estimates on the endogenous variables; \mathbf{Y} is a vector of endogenous variables (two such variables, *USPRICE*, *USLAMB*); \mathbf{G} is a matrix of coefficient estimates on the predetermined variables; \mathbf{Z} is a matrix of the predetermined variables; and \mathbf{E} is a matrix of residuals. The analytical reduced forms for the model's two-equation simultaneous equation subcomponent are $\mathbf{Y} = -(\text{inv}\mathbf{B}) * (\mathbf{G} * \mathbf{Z} + \mathbf{E})$, where $\text{inv}\mathbf{B}$ reflects the inverse of \mathbf{B} .

lower quantities of domestically produced U.S. lamb, which appear imperfectly import-substitutable.

Analysis of Other Econometric Results

Before examination of other results in each equation (table 1), a number of comments are made concerning the coefficient estimates generated by U.S. lamb price, chicken price, beef price, pork price, and the prices of New Zealand and Australian lamb imports (hereafter, the six meat prices). Not surprisingly, many (from three to five) of each equation's meat price coefficients appear statistically insignificant. A likely reason for the apparent insignificance may be that some of the meat prices are collinear and do not vary independently of each other. Such collinearity precludes valid interpretation of the meat price coefficients individually and can result in unreliable *t*-values on the coefficient estimates, so as to render their significance levels unclear (see Kennedy 1985, pp. 146–56). Because theory suggests the relevance and importance of these six meat prices, and because inclusion of relevant, though collinear, variables does not necessarily compromise fit, these six meat prices were included to avoid estimate bias from omitted relevant variables (Kennedy 1985, pp. 146–56). Furthermore, a meat price index was not chosen to replace the separate collinear prices, because the specific exogenous meat price variables were useful for identification of relations in the 3SLS system.

Parameter estimates for the U.S. domestic lamb supply equation are provided in table 1. The own-price elasticity of supply of 2.8 is statistically significant, is of the expected positive sign, and falls within, although toward the higher end of, the 0.01–2.8 range of literature estimates of Whipple and Menkhaus (1989a, 1990) for horizons of ten years or less.⁶ As anticipated, wages and electricity price serve as important and statistically significant explanators of domestic lamb supply at the meat packing level.

Parameter estimates for U.S. demand for domestically produced lamb provide a number of insights. The own-price elasticity of -0.78 is statistically significant, is negative (as anticipated), and falls within the literature's range of estimates formed by -0.62 of the TAMRC Lamb Study Team (1991) and the -3.96 estimate of Whipple

and Menkhaus (1989b). The income elasticity estimate of 1.76 is statistically significant and of the expected positive sign; suggests that domestic lamb consumption is income-elastic; and falls to the "right of center" of the literature's rather wide, and consequently not very informative, estimate range formed by the 0.13 estimate of Peterson and Jones (1995) and the 2.2 estimate of Anderson (1994). The statistically significant, and, as expected, negative, coefficient on the time trend reinforces findings by Van Tassel and Whipple (1994) and the USITC (1990, 1995a, b) of historically declining trends in U.S. consumption of domestically produced lamb. For reasons mentioned above, collinearity among the domestic demand's meat price regressors has provided unclear inferential evidence concerning whether the U.S. domestic lamb consumers treat, as complements or substitutes, (1) domestic and imported lamb, or (2) lamb generally and other meats.

Several econometric estimates concerning the U.S. demands for New Zealand and Australian imports are of interest. Income elasticities of lamb import demand are statistically significant, are of the expected positive sign, and range from 0.8 to 2.87, a range that substantially overlaps with the 0.13–2.22 range for lamb demand generally cited above (see Anderson 1994; Peterson and Jones 1995). Estimates of income elasticities of U.S. demand for *imported* lamb were not located in the literature. As with domestically produced lamb, U.S. consumers' demand for frozen lamb meat appears responsive to income changes.

Evidence is mixed on the role of own-price in U.S. demand for lamb imports. The own-price elasticity for the New Zealand equation is -0.08 , and although negative as expected, is not statistically significant. The own-price elasticity for the Australian equation, estimated at -1.14 , is much larger and more statistically significant than the New Zealand equation's own-price elasticity estimate. U.S. imports of Australian lamb seem more responsive to own-price than do U.S. imports of New Zealand lamb. The insignificance of the New Zealand equation's own-price elasticity estimate may arise from the price (*PNZ*) not including the CVDs imposed on subject U.S. imports from targeted New Zealand firms, and hence does not constitute the "full" price paid for the countervailed imports during the 1985:6–1990:3 portion of the sample. Therefore the New Zealand equation's insignificant own-price coefficient may arise from the CVD order having accomplished its intended task of neutralizing the subsidy-induced price advantages of the subject U.S. imports.

⁶ The price elasticity of supply follows Whipple and Menkhaus (1989b, 1990) and is approximated as the inverse of the price flexibility coefficient on the quantity regressor of the price-dependent supply.

Concluding Remarks

The USITC (1995a) recently conducted an investigation to econometrically estimate, among other things, the effects of the 1985–90 countervailing duties imposed on certain U.S. imports of New Zealand lamb. One methods-related point of interest emerges for trade researchers: the difficulty in modeling the complex process of imposing and maintaining a CVD order such as that imposed on certain U.S. imports of New Zealand lamb. Rather than one universally applied and constant rate of duty, the CVD order was actually a series of firm-specific and annually varying duties placed on only part of U.S. imports of New Zealand lamb. USITC staff, in their investigative research of the effects of antidumping and countervailing duty orders on the U.S. economy (USITC 1995a), demonstrated how the binary variable method was an econometrically effective, although somewhat imprecise, method for capturing industry-specific effects of such remedial trade measures for eight U.S. industries (lamb included). This paper demonstrates how the method's application to the U.S. lamb industry generated estimates of the market effects of the CVD period events (the CVD order included among others) on the U.S. lamb industry at the wholesaler/meat-packer level.

A number of empirical results emerged. Results suggest that the CVD period events coincided with four (gross) effects on the U.S. wholesale lamb market: a 10% higher domestic price; 3.5% lower levels of domestic lamb demand; 11% lower levels of imports from New Zealand; and 92% higher levels of imports from Australia. Yet evidence from likelihood ratio tests for structural change suggests that these elicited changes combined so as not to induce fundamental change in the modeled market relationships. The CVD period events appeared to have little influenced total U.S. lamb imports—virtually all from New Zealand and Australia historically—because during the CVD period, the apparently CVD-induced declines in countervailed imports of New Zealand lamb were offset by a concurrent rise in noncountervailed U.S. imports of the Australian product. Furthermore, USITC Investigation 332–344's market and industry analyses suggest that despite the June 1985 imposition of CVDs on certain imports of New Zealand lamb, U.S. imports of Australian lamb rose to such an extent that total import shares of the 1984–86 U.S. market actually rose from 5 to 8% (USITC 1995b, p. 6.6). These gains in import shares may have, in turn, at least partially compensated the market for increases in producer prices for, and decreased quantities of, domestically pro-

duced lamb during the CVD period, so that these combined effects did not “register” or generate structural change from pre-CVD and post-CVD market relationships in the model.

This paper also reports a number of parameter estimates for the U.S. domestic and import markets at the wholesale level, for which few estimates are provided in the literature. At the wholesale or meat-packing level, U.S. own-price elasticity of domestic demand is less than unity, while the own-price elasticity of domestic supply appears to be near 3.0. Income apparently plays an important role in U.S. demand for lamb, whether domestically produced or imported. Yet this paper's econometric results suggest that the U.S. income elasticities of demand for lamb meat (whether imported or domestically produced) fall toward the upper end on the wide range of income elasticity estimates in the literature. Because of apparently collinear meat prices, evidence in Investigation 332–344 was not definitive concerning the degrees to which U.S. consumers differentiate between U.S.-produced and imported lamb meat, or between lamb generally and nonlamb meat alternatives. There is some evidence from the econometric results, supported with figure 1's trends and hearing testimony, that the U.S. market considers imports from New Zealand and Australia as rather close substitutes. Evidence of declining U.S. domestic consumption and production reported by Van Tassel and Whipple (1994), by Whipple and Menkhaus (1989a, b; 1990), and by the USITC (1990; 1995a, b) seem to be verified by this paper's strongly significant and negative coefficient estimates on the time trend in the domestic demand and supply equations.

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