Australian Journal of Agricultural Economics, Vol. 25, No. 2 (August 1981), pp. 123-133.

ESTIMATING THE IMPACT OF BEEF IMPORT RESTRICTIONS IN THE US IMPORT MARKET

R. G. CHAMBERS, R. E. JUST, L. J. MOFFITT and A. SCHMITZ

*University of Maryland, College Park, 20742, U.S.A.**

A beef import model is specified and estimated using disequilibrium econometrics. The statistical significance of the model suggests that disequilibrium has historically existed in the US beef import market. Surplus analysis based on the disequilibrium framework indicates that a welfare loss has been incurred as a result of the quota and associated voluntary restraint programmes that have existed in that market.

In terms of food expenditures, beef represents the single most important item in the US consumer food budget. Hence, the restrictive beef import policies of the US are controversial. Consumer groups contend that maintenance of the quota on meat imports has led to excessively high prices; producers, on the other hand, argue that unlimited imports would seriously depress the domestic cattle market. The problem takes on added significance in the light of the growing awareness on the part of consumers and consumer groups that agricultural policies designed to guarantee a market for domestic producers may seriously harm consumer interest. This general atmosphere has been reflected in such consumer actions in the US as the beef boycott of 1974.[1]

Several studies (Jackson 1972; Ehrich and Usman 1974; Houck 1974; Rausser and Freebairn 1974; Freebairn and Rausser 1975; Schmitz and Nelson 1977) have been undertaken to assess the effects of different import levels on domestic US producers. None of these studies, however, have attempted to analyse empirically the US beef import market in the absence of both quota and voluntary restraint regulations. In other words, the question of total deregulation of the market has not been addressed in these studies. An attempt to outline and implement a general procedure for doing that is the subject of this paper. Hopefully, the procedure is sufficiently general to allow application to other regulated markets.

The recent history of the US beef import market is reviewed initially, followed by discussion of reasons why standard competitive assumptions may be inappropriate for the market under consideration. A discussion of the possible welfare effects in such a market, the empirical estimation and comments on the results complete the paper.

Background[2]

In 1964, after a 10-year period characterised by steadily rising imports

* R. E. Just and A. Schmitz are at the University of California at Berkeley.

[1] For example, see the report issued by the US International Trade Commission (1977).

[2] A more detailed description is presented by the US International Trade Commission (1977).

and declining domestic cattle prices, the US Congress passed Public Law 88-482 (commonly referred to as the Meat Import Law of 1964) in response to producer pressure to regulate the imports of fresh, chilled, or frozen meat which originate primarily in Australia and New Zealand.[3] Imports of these commodities were allowed to expand from a base of 725 million lbs at the same rate that domestic production of these meats had expanded from the 1959 to 1963 base period to the most recent three-year average. If projected imports exceeded the estimated quota level, as published in the US *Federal Register*, by more than 10 per cent (110 per cent of the quota is referred to as the trigger level), the President was required by the provisions of Public Law 88-482 to invoke the meat quota. However, the President also had the power to suspend the quota level if he deemed that to be in the national interest.

In the period 1965 to 1977, the provisions of Public Law 88-482 and Section 204 of the *Agricultural Act of 1956*, which provided the authority to negotiate and, if necessary, enforce voluntary agreements to restrict imports, had been used to keep the imports of meat products into the US at a level lower than they would have been in the absence of these barriers to trade. Because of the combination of voluntary and strict controls, however, the market for imported beef may well not have cleared (e.g. import demand exceeding import supply) during certain periods of time in an *ex ante* sense.

In 1979 the Meat Import Law was passed. It allows imports to run counter-cyclical to domestic production. Imports are voluntarily restricted but the negotiated levels are adjusted by both growth and counter-cyclical factors. These factors increase imports when domestic cow beef supplies are tight without compelling the suspension of quotas.

Disequilibrium in Restricted Markets

For an individual consumer, the *ex ante* demand for a commodity represents a schedule of *desired* consumption at various prices. Similarly, the *ex ante* supply for an entrepreneur is given by a schedule of *desired* quantities supplied at various prices. *Ex ante* supply and demand, however, may not be equal at prevailing prices. *Ex post* demand and supply, correspond to what is actually traded in the market and are, therefore, always equal. Although *ex ante* demand (supply) may equal *ex post* demand (supply), this is not true in general.

Consider the effect of US governmental pressure on Australian and other foreign beef producers to restrain the amount supplied to the US market. It can be shown under consumer utility and producer profit maximisation, for example, that the effective or *ex post* supply and demand curves lie everywhere to the inside of the *ex ante* supply and demand curves, respectively. A problem, therefore, is how to isolate the *ex ante* demand and supply curves from the *ex post* relationships. Once it is established that consumers (producers) may not be operating on their *ex ante* demand (supply) curve, there is no reason to suspect that the market will clear in an *ex ante* sense.

Suppose, for example, that consumers operate on their *ex ante* curve

[3] Imports of goat meat and mutton are also regulated, but imports other than beef are of no practical importance and thus will not be directly considered in the ensuing analysis.

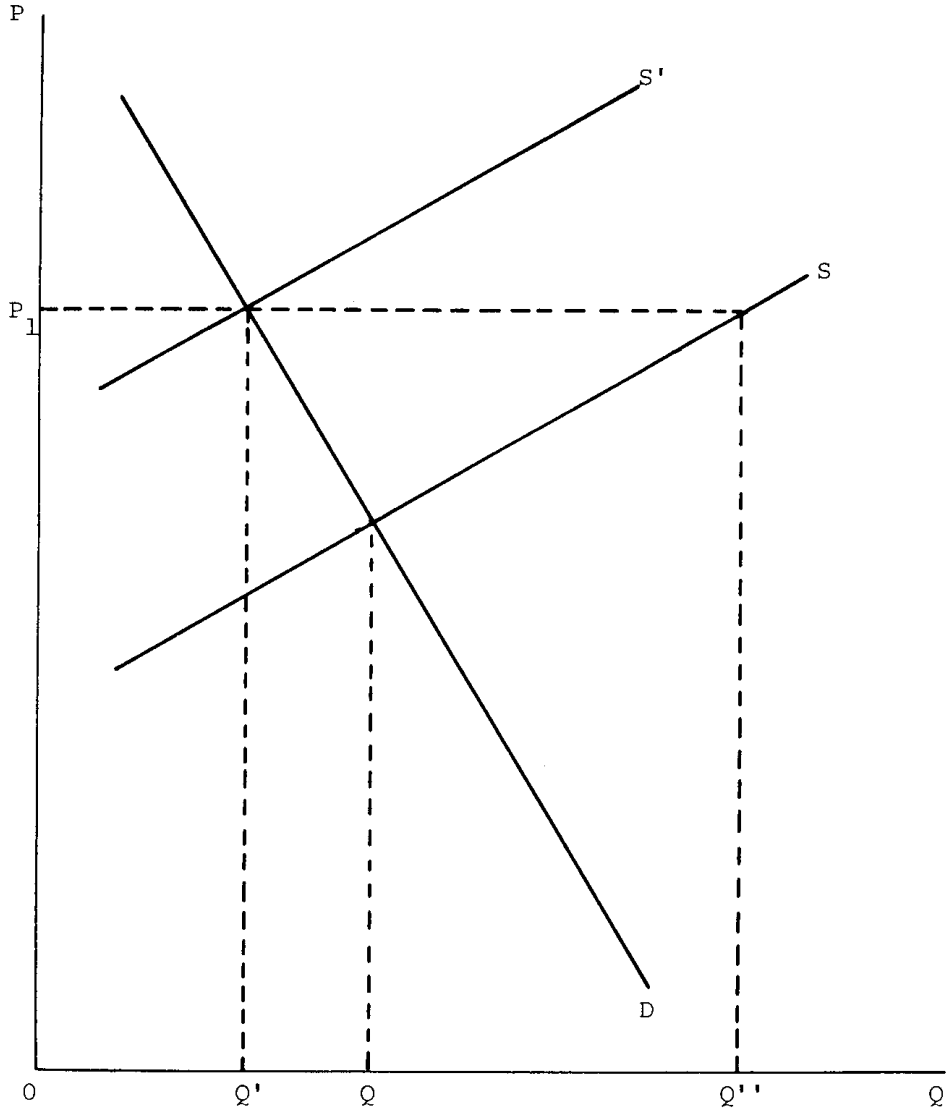

FIGURE 1—*Ex ante* and *ex post* equilibria.

but producers for some reason are forced off their *ex ante* curve. This is illustrated in Figure 1 where D and S represent the *ex ante* demand and supply curves and S' is the *ex post* supply curve. The amount traded in the market is Q' as opposed to the *ex ante* equilibrium amount Q; and at the observed market price P_1, there is excess supply, $Q'Q''$, in the *ex ante* market. Failure to account for such phenomena could lead to inconsistent parameter estimates in empirical work.

Since demand and supply curves are best typified as 'snapshots' of a market at any point in time, there appears to be no reason to assume that the periods of time in which observations are made happen to be periods where the market clears in an *ex ante* sense. Indeed, the opposite seems to be the more general assumption. To quote from Hicks (1972, p. 53):

> Equality between demand and supply, in the sense of the amount bought and sold, is an identity which has nothing to do with the equilibrium assumption. Equality between amount sold and the amount which in the given circumstances sellers will want to sell is quite a different matter.

It seems probable, therefore, that the quota and the associated voluntary restraint agreements negotiated between the US and the major beef exporters may drive a wedge between the *ex ante* and *ex post* import functions. To analyse the impact of the quota as opposed to the free-trade case, it is, therefore, necessary to identify the *ex ante* demand and supply relationships. The problem at hand then becomes one of identifying *ex ante* relationships having information only on *ex post* quantities. Clearly, standard econometric techniques are not applicable.

To see the empirical problem more clearly, recall that standard econometric estimation techniques assume that observed price-quantity couples (such as P_1,Q') correspond to the intersection of the *ex ante* demand and supply curves. Under appropriate identifying restrictions, these observations are then used to generate estimates of the parameters of the *ex ante* demand and supply functions. In the case described above, however, the observed price and quantity correspond to the intersection of the *ex post* demand and supply curves. Standard econometric techniques, therefore , will only yield estimates of the *ex post* demand and supply curves. Welfare analysis of the effects of the restrictive import policies of the US requires a knowledge of *both* the *ex ante* and the *ex post* relationships. Under the reasonable assumption that the short side of the market dominates, however, estimates of *ex ante* demand and supply for beef can be obtained by 'disequilibrium econometrics' as explained below.[4]

Welfare Effects in a Restricted Market

From a welfare standpoint, it is well known that under usual competitive conditions a quota results in a welfare gain to producers and a welfare loss to consumers. Ignoring any quota licensing fee, there is a net welfare loss to the country imposing the quota. However, when price setting occurs by a different mechanism, there is a possibility of a net welfare gain. In Figure 2, S_e is supply in the exporting country and S_m is supply in the importing country; D_m is demand in the importing country. Under free trade, price is P_f while OQ^* is the amount imported, determined where import supply (ES) intersects import demand (ED). Suppose now that the importing country imposes a quota which restricts trade to OQ_1. Under usual competitive market clearing assumptions, producers gain P_fabP_1, and consumers lose P_1egP_f as a result of the quota for a net loss in the importing country of P_1cfP_f.

In a situation where *ex ante* import demand is not assumed to equal *ex ante* import supply, however, the quota may lead to an opposite result. Suppose that the price charged to the importing country is P_0 which is also the price paid to the exporting country. The net gain for the importing country from imposition of the quota is $P_1cfP_f - P_1chP_0$. Since P_fP_0dh is greater than cdf, there is a net gain from the quota. Therefore,

[4] This corresponds to the case where the constraint binds only one side of the market.

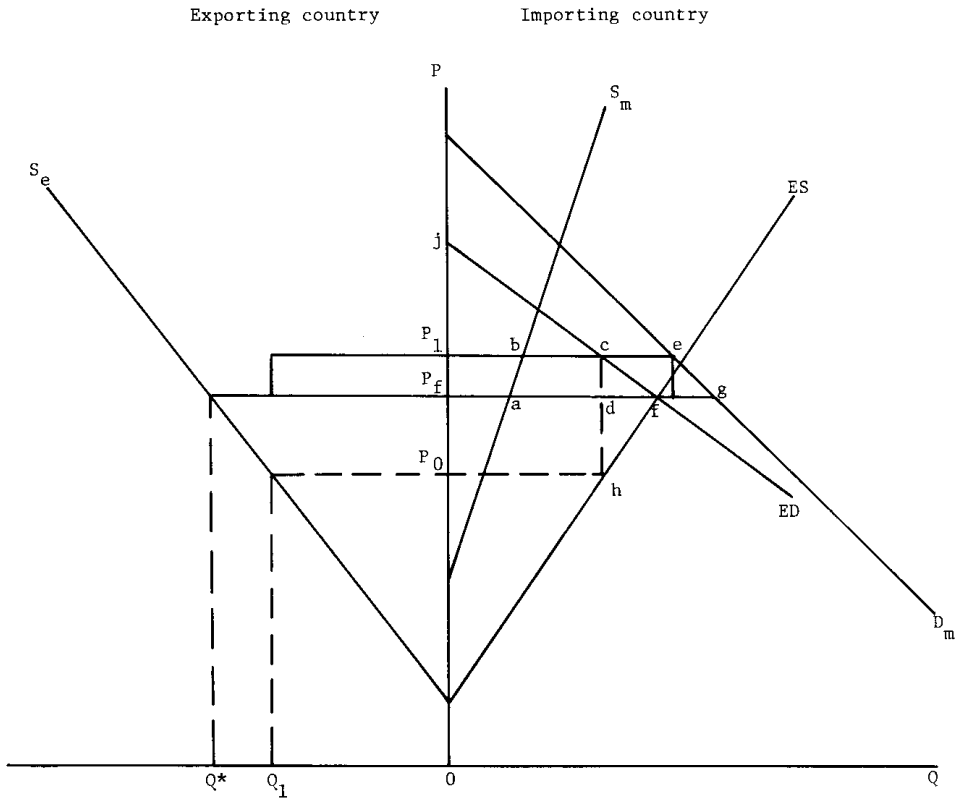

FIGURE 2—Welfare measures in a disequilibrium framework.

it is to the advantage of the importing country to impose a quota in this case if it is able to purchase the quota amount at a price P_0. On the other hand, the quota could work to the disadvantage of the importing country if market price P_1 occurs. Obviously, a determination of which market price occurs under quotas is necessary before one can determine whether or not the imposition of a quota results in a net welfare loss or gain. Disequilibrium econometrics provides a mechanism for determining whether or not one is observing P_0 or P_1.[5] Furthermore, since these welfare ambiguities only arise when *ex ante* import demand does not equal *ex ante* import supply, appropriate welfare analysis of the effects of the beef import quotas cannot, in fact, be carried out in a satisfactory manner with usual techniques; such an approach determines the qualitative results by *a priori* specification. That is, if supply and demand are estimated under competitive free market assumptions, then the welfare effects follow the former case above and necessarily imply a welfare loss for the importing country from imposing quotas.

A Model of Import Demand and Supply

To examine these issues empirically, a simple model of the *ex ante*

[5]Estimation, even in a disequilibrium framework, is not feasible unless observations pertain to either *ex ante* excess demand or *ex ante* excess supply. This problem is discussed further in the conclusions.

import demand and import supply for beef in a two-country US and rest-of-the-world model is developed. The *ex ante* demand and supply functions in the importing country are represented by:

$$D = D(p,M,Z), \text{ and} \quad S = S(p,H), \tag{1}$$

where D is demand,
S is supply,
p is vector of prices,
M is income,
Z and H are vectors of shift parameters.

The corresponding *ex ante* import demand function is:

$$ED = D(p,M,Z) - S(p,H) = ED(p,M,Z,H). \tag{2}$$

Similarly, the *ex ante* export supply function of the exporting nation is written as:

$$ES = ES(p^*,M^*,Z^*,H^*), \tag{3}$$

where * denotes the exporting nation. Since the prevailing market price is not determined by equilibrium in the *ex ante* market but is likely to be affected by the level of import demand and import supply, assume that:

$$\Delta P_t = \gamma(ED_t - ES_t). \tag{4}$$

Both ED_t and ES_t will not generally be observable. Only the actual quantity imported (QM_t) is observed. This quantity is linked to ES_t and ED_t by the assumption:

$$QM_t = ES_t, \ \Delta P_t > 0, \text{ and} \quad QM_t = ED_t, \text{ otherwise.} \tag{5}$$

To implement this model empirically, a linear form is assumed for both ED_t and ES_t.

$$ED_t = \alpha_1 P_t + \alpha' X_t + U_t \quad ES_t = \beta_1 P_t + \beta' Z_t + V_t, \tag{6}$$

where X_t and Z_t are vectors of observations on the predetermined variables of the system at time t;
α and β are appropriately defined parameter column vectors; and
U_t and V_t are independent, normally distributed random disturbances with zero means and variances σ_1^2 and σ_2^2, respectively.

It now remains to derive the joint density for Q_t and P_t. To proceed, let Ψ_1 represent those sample observations corresponding to $\Delta P_t \leq 0$ and Ψ_2 represent Ψ_1's complement among the sample observations. If the tth observation belongs to Ψ_1, note that equation (4) can be rewritten as:

$$\Delta P_t = \gamma(QM_t - \beta_1 P_t - \beta' Z_t - V_t). \tag{7}$$

This implies that the joint density for QM_t and P_t can be written as:

$$f_{QM,P}(QM,P) = |J| f_{U,V}(U,V) \tag{8}$$

where $f_{i,j}(\cdot)$ is the joint density between i and j,
J is the Jacobian of the transformation from U,V to QM,P (time subscripts are implicit for QM, P, J, U, and V):

$$J = \begin{vmatrix} 1 & -\alpha_1 \\ 1 & -(1+\beta_1\gamma)/\gamma \end{vmatrix}$$

A similar argument will establish that the joint density between QM and P for observations belonging to Ψ_2 can be written as:[6]

$$f_{QM,P}(QM,P) = |J^*| f_{U,V}(U,V), \tag{9}$$

where

$$J^* = \begin{vmatrix} 1 & -\beta_1 \\ 1 & (1/\gamma)-\alpha_1 \end{vmatrix}.$$

The corresponding log-likelihood function for the parameters is, therefore,

$$L(\theta) = \sum_{t\epsilon\Psi_1} ln[|J|\cdot f_{U,V}(U,V)] + \sum_{t\epsilon\Psi_2} ln[|J^*|\cdot f_{U,V}(U,V)]. \tag{10}$$

Maximum likelihood estimators can be obtained by numerically maximising $L(\theta)$ with respect to θ.

The Estimated Model

The above log-likelihood function was maximised under the assumption of normality using monthly data on the US beef import market for the period January 1974 to October 1976. The resulting estimates are:

$$\begin{aligned} ln\,ED_t = {} & -4.210 - \underset{(0.066)}{0.9737}\, ln\,(HP/CPI)_t + \underset{(0.067)}{0.1974}\, ln\,(PP/CPI)_t + \underset{(0.195)}{4.415}\, ln\,(M/CPI)_t \\ & - \underset{(0.051)}{0.049}\, ln\,PLONF_t, \\ \sigma_1 = {} & \underset{(0.0128)}{0.1630} \end{aligned}$$

$$\begin{aligned} ln\,ES_t = {} & \underset{(0.0627)}{4.126} + \underset{(0.232)}{2.817}\, ln\,[HP.e/CPI]_t - \underset{(0.064)}{3.978}\, ln\,e_t - \underset{(0.059)}{0.6171}\, ln\,[M^*/AUSCPI]_t \\ & - \underset{(0.1083)}{0.4418}\, ln\,[ABP/AUSCPI]_t, \\ \sigma_2 = {} & \underset{(0.047)}{1.071} \end{aligned}$$

$$\Delta[HP/CPI]_t = \underset{(0.071)}{2.622}\,[ln\,ED_t - ln\,ES_t],$$

where HP = retail hamburger price in cents per lb. (US Department of Agriculture (1974-1976));
PP = retail pork price in cents per lb. (US Department of Agriculture (1974-1976));
M = US personal income in millions of dollars (US Department of Commerce (1974-1976));

[6]Note that in expression (8) the density is evaluated at:
$$V = QM_t - \beta_1 P_t - \beta' Z_t - (1/\gamma)\Delta P_t,$$
while in expression (9) the density is evaluated at:
$$U = (1/\gamma)P_t - \alpha_1 P_t - \gamma' X_t + QM_t.$$

CPI = US consumer price index (US Department of Commerce (1974-1976));
e = Australian/US dollar exchange rate (International Monetary Fund (1974-1976));
$PLONF$ = cattle placed on feed;
ABP = Australian beef price; and
M^*_t = Australian national income in millions of dollars (International Monetary Fund (1974-1976)).[7]

Standard errors derived from an estimate of the Fisher information matrix are reported in parentheses. Based on the results, one may note that estimated own-price elasticities for *ex ante* import demand and supply are strikingly different from those estimated previously. For example, both the import demand and supply functions estimated by Ehrich and Usman (1974) (who investigate a structure more closely resembling the present model than other studies) are highly elastic (-2.4 and 1.5, respectively).[8] This large difference in elasticities suggests that considerably different welfare effects would be suggested by allowing for the possibility that *ex ante* import demand might not be equal to *ex ante* import supply.

Implied Effects of Beef Import Quota

The estimated *ex ante* import demand and supply equations can be used to approximate the level of *ex ante* excess demand and supply over the sample period. These results (reported in Table 1) suggest that, for the major part of the period from January 1974 to October 1976, the import market was characterised by excess supply. In the context of Figure 2, this implies that the US suffers a welfare loss due to beef import quotas, since the price in the importing country with quotas is above the free-trade price.

To estimate further the magnitude of the welfare impacts of the quota, the estimated *ex ante* import demand and supply equations can be used to solve for the price and import level that would clear the *ex ante* market. The *ex ante* equilibrium import quantities and prices generated by the reduced form of the *ex ante* model are reported in Table 2, along with observed imports and prices. The results indicate that, if both suppliers and demanders had been permitted to operate on their *ex ante* curves (i.e. the free-trade solution), the price would have been slightly (about 2 cents per lb) lower and imports would have been slightly (about 3 million lb per month) higher on the average.

To obtain an idea of the welfare implications of this result, the import demand equation can be inverted obtaining $HP_t = HP(ED_t, Z_t)$ where

[7] Since Australia is the single largest exporter of meat to the US, its income and exchange rate are used to represent those variables. Also, the specification of the exchange rate as a separate independent variable is discussed at length in Chambers and Just (1979). This particular specification recognises that the responsiveness of trade flows to movements in the exchange rate need not be restricted to be identical in elasticity terms to own-price movements. The associated asymptotic t-statistic supports the specification.

[8] It may be noted that the elasticities reported by Ehrich and Usman (1974) are based on undeflated prices, while the elasticities computed in this study are based on prices deflated by the consumer price index (to allow for substitution possibilities). Nevertheless, an examination of other than nominal elasticities should presumably not lead to such remarkable differences.

TABLE 1

Ex ante Demand and Supply for Beef Imports at Disequilibrium Prices, United States, February 1974 to October 1976 (million lb)

Year	*Ex ante* Demand	*Ex ante* Supply	Quantity imported
1974			
February	144.3	154.2	127
March	143.2	145.4	164
April	142.8	144.0	137
May	142.7	143.2	125
June	144.5	146.1	129
July	149.4	149.6	99
August	152.4	153.0	161
September	147.6	146.9	135
October	144.1	143.7	108
November	142.8	144.3	134
December	146.1	147.2	149
1975			
January	149.6	152.5	192
February	149.5	150.7	139
March	148.5	148.6	151
April	145.5	145.3	124
May	151.9	151.6	110
June	163.9	163.3	146
July	157.8	157.1	154
August	164.1	161.7	167
September	158.4	155.8	171
October	154.8	152.6	137
November	153.3	153.3	182
December	152.3	152.4	109
1976			
January	159.2	159.7	182
February	162.6	162.6	121
March	164.1	164.9	189
April	164.8	164.6	171
May	170.3	170.2	186
June	174.9	175.9	202
July	170.3	167.6	165
August	160.1	168.1	167
September	165.9	165.4	203
October	162.3	161.1	190

$Z_t = (PP_t, M_t, CPI_t)$. The following surplus measure can then be calculated for both the *ex ante* equilibrium level of imports and the observed level of imports:

$$S_t = \int_0^{QM_t} HP(ED_t, Z_t)\, dED_t - HP_t \cdot QM_t. \tag{11}$$

Following this procedure, one finds that removal of quotas and restraints over the sample period (i.e. allowing both suppliers and demanders to operate on their *ex ante* schedules) would have resulted in a total surplus gain to the US of approximately \$1.72m per month on the average. Furthermore, since these calculations are based on the excess demand curve, this welfare effect is a net figure and measures the gain to con-

TABLE 2

Ex ante Equilibrium Imports and Prices of Beef Imports Compared with Observed Imports and Prices, United States, February 1974 to October 1976

Year	*Ex ante* equilibrium imports	Observed imports	*Ex ante* equilibrium price	Observed price
	million pounds		cents per pound	
1974				
February	146.8	127	85.9	109.0
March	143.8	164	84.7	108.0
April	143.1	137	83.3	101.0
May	142.8	125	83.6	97.1
June	144.9	129	81.8	95.2
July	149.5	99	83.4	90.5
August	152.6	161	82.5	94.8
September	147.5	135	84.6	96.4
October	144.0	108	85.9	93.0
November	143.2	134	84.1	89.7
December	146.4	149	83.2	87.5
1975				
January	150.4	192	79.1	85.4
February	149.8	139	78.2	82.8
March	148.6	151	78.7	80.5
April	145.4	124	79.3	80.5
May	151.8	110	80.2	86.7
June	163.8	146	81.6	90.6
July	157.6	154	83.4	93.8
August	163.5	167	87.2	92.7
September	157.7	171	91.5	90.1
October	154.3	137	95.6	90.8
November	153.2	182	95.8	90.4
December	152.3	109	96.0	88.8
1976				
January	159.4	182	95.6	89.3
February	162.7	121	95.9	87.4
March	164.3	189	94.7	86.4
April	164.8	171	95.8	85.6
May	170.3	186	96.4	90.4
June	175.2	202	95.3	90.0
July	169.6	165	100.5	88.9
August	168.1	167	100.7	88.8
September	165.8	203	102.0	86.9
October	162.0	190	104.6	85.7
Average	155.0	152.30	88.8	90.08

sumers after accounting for the loss to producers due to increased imports and lower prices. A domestic lump-sum transfer from consumers to producers would apparently offer a better alternative for supporting the incomes of cattle producers since the US is not successful in obtaining lower import prices when import purchases are limited. Alternatively, a tariff could possibly be imposed to improve the US balance of payments at various import levels.

Conclusions

In this paper a beef import model has been specified and estimated using disequilibrium econometrics. Surplus analysis, based on the disequilibrium framework, indicates that a welfare loss has been incurred as a result of the quota and the associated restraint program. The estimated model implies that a removal of the quota program would slightly reduce the total expenditure on beef imports while reducing price by about 2 per cent and increasing the imported quantity by about 1.9 per cent.

A possible shortcoming of this paper, which the reader should bear in mind, however, is that the econometric analysis assumes price-quantity observations lie either on the *ex ante* import supply or *ex ante* import demand curve. The possibility exists, of course, that the observed prices fall between the two curves at the import quota level, due to some kind of gamesmanship between the US and other countries in price determination. Standard equilibrium models, however, assume that price-quantity observations lie on both curves; thus, the present analysis is at least less restrictive than previous work.

References

Chambers, R. G. and Just, R. E. (1979), 'A critique of exchange rate treatment in agricultural trade models', *American Journal of Agricultural Economics* 61(2), 249-51.

Ehrich, R. and Usman, M. (1974), Demand and Supply Functions for Beef Imports, Wyoming Agricultural Experiment Station Bulletin 604, Laramie, Wyoming.

Freebairn, J. W. and Rausser, G. C. (1975), 'Effects of changes in the level of U.S. beef imports', *American Journal of Agricultural Economics* 57(4), 676-88.

Hicks, J. R. (1972), *Capital and Growth*, Oxford University Press, Oxford.

Houck, J. P. (1974), 'The short-run impact of beef imports on U.S. meat prices', *Australian Journal of Agricultural Economics* 18(1), 60-72.

International Monetary Fund (1974-1976), *International Financial Statistics*, Washington, D.C.

Jackson, G. H. (1972), The Impact of Eliminating the Quota on U.S. Imports of Beef, Agricultural Economics Research Paper 338, Cornell University, Ithaca, New York.

Rausser, G. C. and Freebairn, J. W. (1974), 'Estimation of policy preference functions: an application to U.S. beef import policy', *Review of Economics and Statistics* 56(4), 437-49.

Schmitz, A. and Nelson, R. D. (1977), The Impact of United States Beef Imports, *in Conditions of Competition in U.S. Markets Between Domestic and Foreign Live Cattle and Cattle Meat Fit for Human Consumption*, United States International Trade Commission, Publication 482, Washington, D.C.

U.S Department of Agriculture, (1974-1976), *Livestock and Meat Situation*, Economic Research Service, Washington, D.C.

U.S. Department of Commerce (1974-1976), *Survey of Current Business*, Washington, D.C.

U.S. International Trade Commission (1977), *Conditions of Competition in U.S. Markets Between Domestic and Foreign Live Cattle and Cattle Meat Fit for Human Consumption*, Publication 482, Washington, D.C.