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INTERNATIONAL MARKETS IN DISEQUILIBRIUM: A CASE STUDY OF BEEF

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I. Introduction

Beef is the most important item in the consumer food budget; hence, considerable controversy exists over U. S. beef import policies. 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 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 interests. This general atmosphere has been reflected in such consumer actions as the beef boycott of 1974.

Several studies (Rausser and Freebairn, 1974; Freebairn and Rausser, 1975; Schmitz and Nelson, 1977; Ehrich and Usman, 1974; Jackson, 1972; and Houck, 1974) have attempted to assess the effects of different import levels on domestic producers. All of these studies have assumed that the U. S. beef import market is continually in equilibrium and thus have used standard econometric techniques. Because of the distorting effects of the quota and the associated voluntary restraint program (explained below), however, it appears that the market for imported beef may be, in fact, in disequilibrium.[1] Hence, the results of the above studies are subject to some question. The purpose of the present paper is to analyze the U. S. beef import market with proper allowance for the presence of market disequilibrium. The results of the study indeed suggest the presence of disequilibrium, namely, excess supply. Furthermore,

the use of disequilibrium techniques for this case allows proper quantitative estimation of the net welfare effect of the quota and voluntary restraint agreements on domestic producers and consumers (jointly).

II. Background[2]

In 1964, after a 10-year period characterized by steadily rising imports and declining domestic cattle prices, the U. S. Congress in response to producer pressure passed Public Law 88-482 (commonly referred to as the Meat Import Law of 1964) to regulate the imports of fresh, chilled, or frozen meat which came primarily from Australia and New Zealand.[3] Imports of these commodities are allowed to expand from a base of 725 million pounds at the same rate that domestic production of these meats has expanded from the 1959-1963 base period to the most recent three-year average. If projected imports exceed the estimated quota level, as published in the Federal Register, by more than 10 percent (110 percent of the quota is referred to as the trigger level), the President is required by the provisions of Public Law 88-482 to invoke the meat quota. The President also has the power to suspend the quota level, however.

In the period 1965-1977, the provisions of Public Law 88-482 and Section 204 of the Agricultural Act of 1956, which provides the authority to negotiate and enforce voluntary agreements to restrict imports, have been used to keep the imports of meat products into the United States 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 imposed, the market for imported beef may well be in disequilibrium during certain periods of time.

III. Phenomena Underlying Disequilibrium

Before proceeding to the econometric analysis, it is useful to investigate more thoroughly the process underlying disequilibria. 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, however, 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 and, in particular, is not true when disequilibrium prevails.

Consider the effect of governmental pressure on Australian beef producers to restrain the amount supplied to the U. S. market. It can be shown under consumer utility and producer profit maximization, 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.[4] An interesting 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 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.

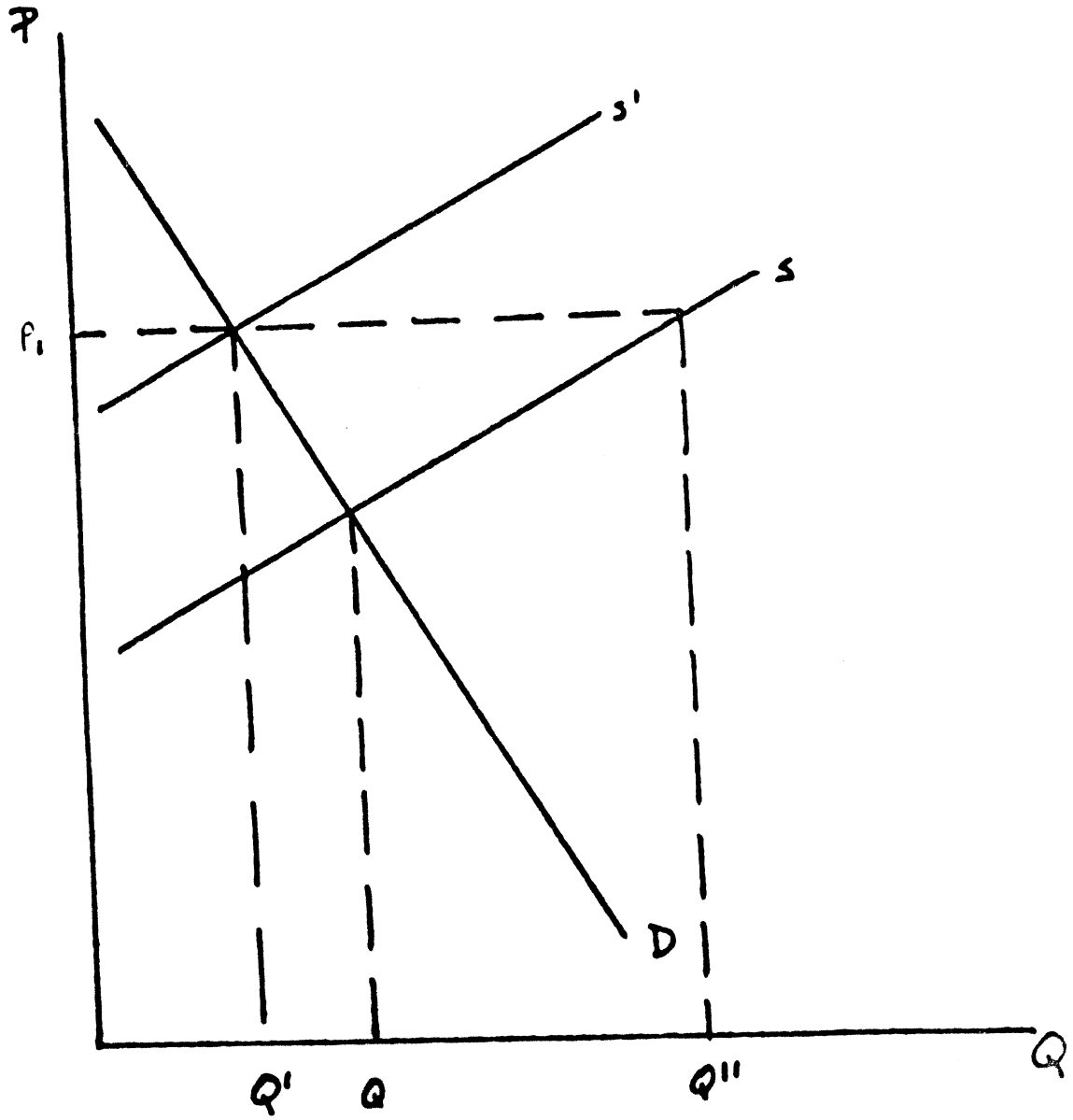

FIGURE 1.

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 *ex ante* equilibrium periods. Indeed, the opposite seems to be the more general assumption. To quote from Hicks:

> "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" (1972, p. 53).

It seems probable, therefore, that the quota and the associated voluntary restraint agreements negotiated between the United States and the major beef exporters may drive a wedge between the *ex ante* and *ex post* import functions. To appropriately analyze 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 on *ex post* quantities only. Clearly, standard econometric techniques are not applicable. However, under the reasonable assumption that the short side of the market dominates, estimates of *ex ante*, exact demand and supply for beef can be obtained by disequilibrium econometrics.[5]

IV. Welfare Effects in a Disequilibrium Market

From a welfare standpoint, it is well known that under equilibrium 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, as the disequilibrium framework shows, there is a possibility of a net welfare gain. In figure 2, SE is supply in the exporting country and SM is supply in the importing country; DM is demand in the importing country. Under free trade, price is P_f while $0Q^*$ is the amount imported [determined where excess supply (ES) intersects excess demand (ED)]. Suppose now that the importing country imposes a quota which restricts trade to $0Q_1$. Under equilibrium conditions, producers gain $P_f abP_1$, and consumers lose $P_2 egP_f$ as a result of the quota.

In a disequilibrium situation 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 after the imposition of the quota is $echP_0$. Since P_fP_0dh is greater than cdf, there is a net gain from the quota. Therefore, 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 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 whether or not the market price under quotas is above or below the free-market price P_f 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 in a disequilibrium market.[6] Furthermore, since these welfare ambiguities arise only in a disequilibrium framework, appropriate welfare analysis of the effects of the beef import quotas cannot, in fact, be carried out in a satisfactory manner using ordinary equilibrium techniques; such an approach determines the qualitative results by *a priori* specification.

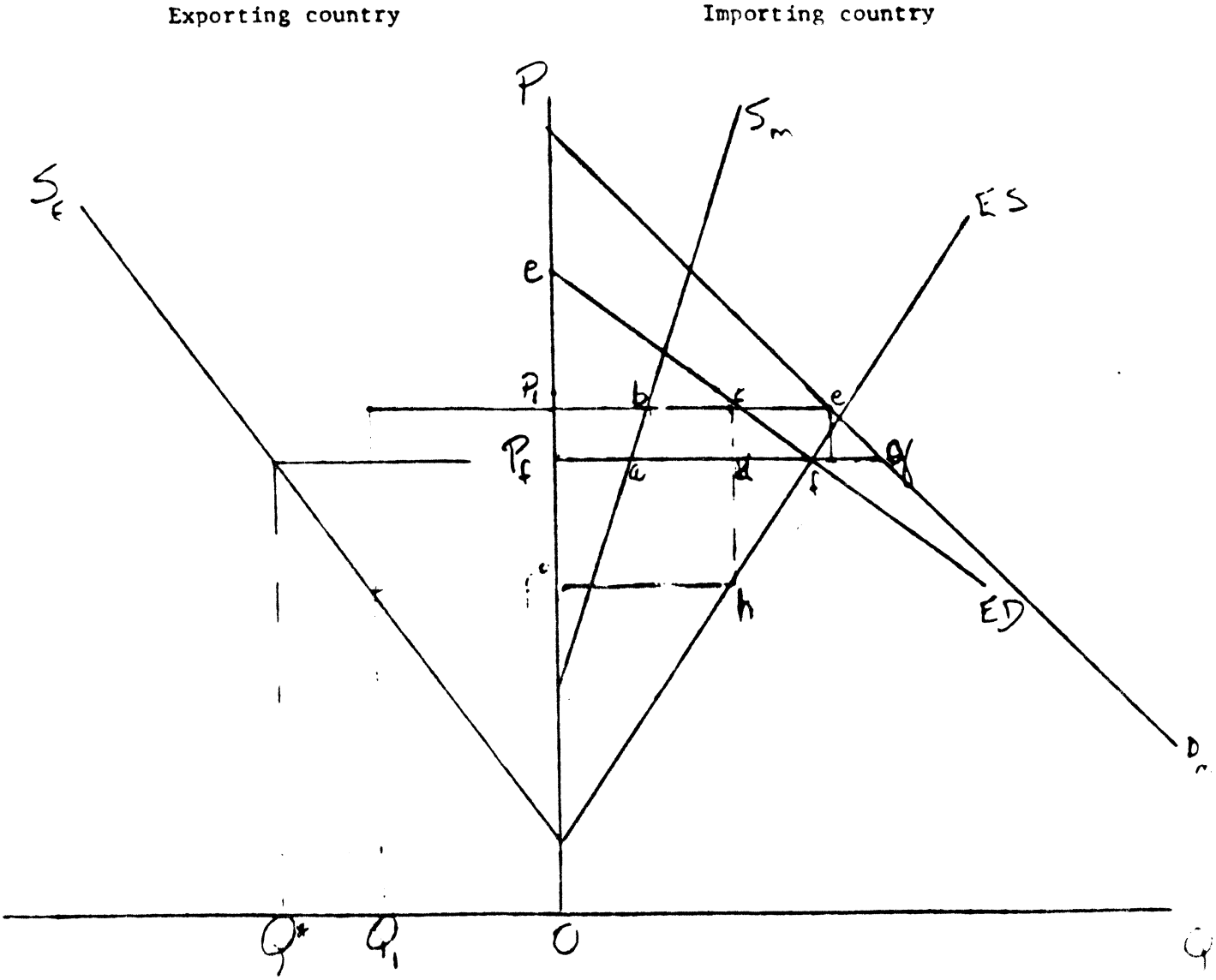

FIGURE 2. Welfare Measures in a Disequilibrium Framework

V. A Model of Import Demand and Supply

To examine these issues empirically, this section outlines a simple model of the *ex ante* excess demand and excess supply for beef in a two-country U. S. and rest-of-the-world model. The demand and supply functions in the importing country are represented by

$$\begin{aligned} D &= D\ (p,\ M) \\ S &= S(p) \end{aligned} \tag{1}$$

where D is demand, S is supply, p is vector of prices, and M is income. The corresponding excess demand function is

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

Similarly, the excess supply function of the exporting nation is written as

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

where (*) denotes the exporting nation. Both ED and ES will not generally be observable. Only the quantity imported, QM, is observable. This quantity is linked to ES and ED using the assumption that the short side of the market dominates:

$$QM = \min\ (ES,\ ED). \tag{4}$$

Since the prevailing market price is not determined by equilibrium in the *ex ante* market, it is treated as predetermined.

To allow simple application of recent econometric work relating to estimation in disequilibrium, the functions above can be specified linearly,

$$ED_t = X_t a + U_t$$
$$ES_t = X_t b + V_t \tag{5}$$

where X_t is the row vector of observations on the predetermined variables of the system at time t; a and b are appropriately defined parameter column vectors; and U_t and V_t are independent, normally distributed random disturbances with zero means with variances σ_1^2 and σ_2^2, respectively. Maddala and Nelson (1974) have demonstrated that the unconditional density of QM_t can be written as

$$h_t\ (QM_t) = \int_{QM_t}^{\infty} g_t\ (QM_t,\ ES_t)\ dES_t + \int_{QM_t}^{\infty} g_t\ (ED_t,\ QM_t)\ dED_t \tag{6}$$

where $g_t\ (\cdot,\ \cdot)$ denotes a joint density. The corresponding likelihood function is, therefore,

$$L(\theta) = \prod_{t=1}^{T} h_t\ (QM_t). \tag{7}$$

Maximum-likelihood estimators of the vector of parameters $\theta = (a, b, \sigma_1, \sigma_2)$ are obtained by choosing $\hat{\theta}$ such that $\partial \ln L(\theta)/\partial\theta \Big|_{\hat{\theta}} = 0$. Sen (1976) has recently demonstrated that such a solution corresponding to a <u>local</u> maximum is consistent and asymptotically normal. More specifically, it has been shown that

$$\sqrt{T}\ (\hat{\theta} - \theta) \to N\left\{0, -\text{plim}\ T\left[\frac{\partial^2 \ln L}{\partial\theta\partial\theta'}\right]^{-1}\right\} \tag{8}$$

where $\hat{\theta}$ is the corresponding solution to the likelihood equations.

Maddala and Nelson (1974) have further obtained expressions for the first and second derivatives of the likelihood function. It is thus possible in principle to use a Newton-Raphson iterative procedure to numerically maximize the likelihood function. Nevertheless, various authors have reported problems in obtaining convergence of their estimates. Quite recently, however, Hartley (1977) has extended the Dempster, Laird, and Rubin (1976) E-M algorithm for calculating maximum-likelihood estimators in the face of incomplete data to the likelihood function described by (7). Hartley's algorithm is based on the recognition that, if both *ex ante* demand and supply are always observable, then the maximum-likelihood estimators for unobservable excess demand (supply) are replaced by a pseudo dependent variable that is a convex combination of the observed quantity, QM_t, and the expectation of excess demand (supply), given $QM_t = ES_t$ ($QM_t = ED_t$). The maximum-likelihood estimator is then calculated as the limit of a sequence of OLS regressions where the pseudo dependent variables are used in place of ED_t and ES_t.

VI. The Estimated Model

Using the above E-M algorithm, a model was estimated using monthly data on the U. S. beef import market for the period January, 1974, through October, 1976. The resulting estimates are

$$\begin{aligned} \ln ED_t &= \underset{}{-3.238} - \underset{(.177)}{.401} \ln\left(\frac{HP}{CPI}\right)_t + \underset{(.207)}{.484} \ln\left(\frac{PP}{CPI}\right)_t + \underset{(.264)}{3.999} \ln\left(\frac{M}{CPI}\right)_t + \underset{(.042)}{} \\ \ln ES_t &= \underset{}{10.723} + \underset{(1.011)}{.767} \ln\left(\frac{HP}{CPI}\right)_t + \underset{(1.091)}{4.928} \ln e_t - \underset{(.738)}{1.362} \ln M_t^* \quad \underset{(.511)}{} \end{aligned} \tag{9}$$

where

HP = retail hamburger price in cents per pound [U. S. Department of Agriculture (1974-1976)]

PP = retail pork price in cents per pound [U. S. Department of Agriculture (1974-1976)]

M = U. S. personal income in millions of dollars [U. S. Department of Commerce (1974-1976)]

CPI = U. S. consumer price index [U. S. Department of Commerce (1974-1976)]

e = Australian/U. S. dollar exchange rate [International Monetary Fund (1974-1976)]

M_t^* = Australian national income in millions of dollars [International Monetary Fund (1974-1976)].[7]

Standard errors derived from the inverted Hessian of the likelihood function and based on expression (8) are reported in parentheses. Based on these results, one may note that estimated own-price elasticities for import demand and supply are strikingly different from those estimated previously in equilibrium models. For example, both the import demand and supply functions estimated by Ehrich and Usman (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 in itself that disequilibrium prevails in the beef import market and that considerably different welfare effects would be suggested by the disequilibrium approach.

VII. Implied Effects of Beef Import Quota

The estimated demand and supply equations can be used to approximate the level of *ex ante* import 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 characterized by excess supply. In the context of figure 2, this implies that the United States 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 further estimate 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 quantity and price generated by the reduced form of the *ex ante* model are reported in table 2 along with observed imports and price. 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), in the absence of quotas the price would have been approximately 9 cents per pound (or 10%) lower and imports would have been 19 million pounds per month (or 12%) higher on the average. To obtain an idea as to the welfare implications of this result, the import demand equation can be inverted obtaining $HP_t = HP\ (ED_t, Z_t)$ where $Z_t = (PP_t, M_t, CPI_t)$. The following surplus measure can then be calculated for both the *ex ante* equilibrium level of imports and the observed level of imports:

$$S_t = \int_0^{QM_t} HP\ (ED_t, Z_t)\ dED_t - HP_t \cdot QM_t. \qquad (10)$$

TABLE 1

Ex ante Demand and Supply for Beef Imports
United States, January, 1974, to October, 1976

Year	*Ex ante*		Quantity imported
	Demand	Supply	
	million pounds		
1974			
Jan.	.160	.182	.178
Feb.	.151	.190	.127
Mar.	.144	.186	.164
Apr.	.144	.170	.137
May	.141	.163	.125
June	.137	.160	.129
July	.151	.137	.990
Aug.	.148	.141	.161
Sep.	.146	.265	.135
Oct.	.145	.196	.108
Nov.	.144	.185	.134
Dec.	.144	.173	.149
1975			
Jan.	.145	.202	.192
Feb.	.144	.176	.139
Mar.	.144	.180	.151
Apr.	.146	.171	.124
May	.148	.179	.110
June	.160	.196	.146
July	.158	.208	.154
Aug.	.170	.221	.167
Sep.	.179	.236	.171
Oct.	.182	.170	.137
Nov.	.180	.177	.182
Dec.	.177	.175	.109
1976			
Jan.	.180	.212	.182
Feb.	.185	.206	.121
Mar.	.188	.212	.189
Apr.	.191	.199	.171
May	.192	.218	.186
June	.193	.208	.202
July	.196	.182	.165
Aug.	.193	.177	.167
Sep.	.191	.180	.203
Oct.	.190	.156	.190

TABLE 2

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

Year	*Ex ante* equilibrium imports	Observed imports	*Ex ante* equilibrium price	Observed price
	million pounds		cents per pound	
1974				
Jan.	.167	.178	.916	.102
Feb.	.163	.127	.903	.109
Mar.	.157	.164	.867	.108
Apr.	.152	.137	.878	.101
May	.149	.125	.858	.971
June	.144	.129	.835	.952
July	.146	.990	.981	.905
Aug.	.145	.161	.987	.948
Sep.	.179	.135	.578	.964
Oct.	.161	.108	.721	.930
Nov.	.157	.134	.723	.897
Dec.	.154	.149	.749	.875
1975				
Jan.	.163	.192	.644	.854
Feb.	.154	.139	.696	.828
Mar.	.155	.151	.663	.805
Apr.	.154	.124	.701	.805
May	.158	.110	.738	.867
June	.171	.146	.761	.906
July	.174	.154	.743	.938
Aug.	.186	.167	.741	.927
Sep.	.197	.171	.713	.901
Oct.	.178	.137	.962	.908
Nov.	.179	.182	.917	.904
Dec.	.176	.109	.894	.888
1976				
Jan.	.192	.182	.776	.893
Feb.	.192	.121	.798	.874
Mar.	.196	.189	.780	.864
Apr.	.194	.171	.824	.856
May	.200	.186	.811	.904
June	.198	.202	.844	.900
July	.191	.165	.949	.889
Aug.	.187	.167	.952	.888
Sep.	.187	.203	.913	.869
Oct.	.177	.190	.101	.857
Average	172.08	153.06	81.89	91.129

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 United States of approximately $40 million 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 consumers after accounting for the loss to producers due to increased imports and lower prices. Thus, the net welfare loss due to imposition of U. S. beef import quotas appears to be substantial; a domestic lump-sum transfer from consumers to producers would apparently offer a better alternative for supporting the incomes of cattle producers since the United States is not successful in obtaining lower import prices when import purchases are limited. Alternatively, a tariff could possibly be imposed to improve the U. S. balance of payments at various import levels.

VIII. Conclusions

In this paper a beef import model has been specified and estimated using disequilibrium econometrics. The statistical significance of the model suggests that disequilibrium has existed in the U. S. 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 the associated restraint program. The estimated model implies that a removal of the quota program would hold the total expenditure on beef imports relatively stable while reducing price by about 10% and increasing the imported quantity by about 12%.

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* excess supply or *ex ante* excess 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 United States 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.

FOOTNOTES

[†]Giannini Foundation Paper No.

[*]Chambers, The Ohio State University; Just, Moffitt, and Schmitz, all at the University of California, Berkeley.

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

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

[3]Imports of goat meat and mutton are also regulated, but imports other than beef are of no practical importance.

[4]The interested reader can solve the two constrained maximization problems, $\max_{Q} PQ - C(Q)$ subject to $Q \leq Q^0$ and $\max_{Q} U(Q)$ subject to $(M - PQ) \geq 0$ and $Q \leq Q^0$, where Q^0 is the quota amount, to confirm that the *ex post* demand and supply curves will lie inside the *ex ante* curves, given diminishing marginal utility and increasing marginal costs.

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

[6]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, however, is discussed further in the conclusions.

[7]Since Australia is the single largest exporter of meat to the United States, 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. This particular specification recognizes

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 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.

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