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AN ECONOMETRIC MODEL OF THE NORTH AMERICAN HOG AND PORK INDUSTRY: IMPLICATIONS OF A COUNTERVAILING DUTY ON PORK ENTERING THE USA FROM CANADA

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Abstract

During the late 1980's, the National Pork Producers Council lobbied the International Trade Commission for and received a countervailing duty on pork entering the U.S. from Canada. The intended effect was to offset Canadian subsidization of the pork industry. However, placing a tariff on pork does not necessarily protect hog producers. Since the tariff changes the pork price in both countries, the farm level demand curves shift in both countries. This causes the excess hog supply and excess hog demand curves to shift. The new equilibrium price will be higher only if the U.S. excess demand curve shifts farther right than the Canadian excess supply curve. This paper builds on the simultaneous equations model of the North American Hog/Pork market originally developed by Meilke and Scally and then shocks the model with a three percent price wedge between Canadian and American pork prices to simulate the effect of the countervailing duty. The results of the shock were a .37% decrease in American hog prices and a 0.21% decrease in U.S. hog supply as compared to a simulation run over the same time period. These two factors combine to form a 0.58% decrease in total revenue. Thus, U.S. hog producers actually hurt themselves in lobbying for the countervailing duty.

INTRODUCTION

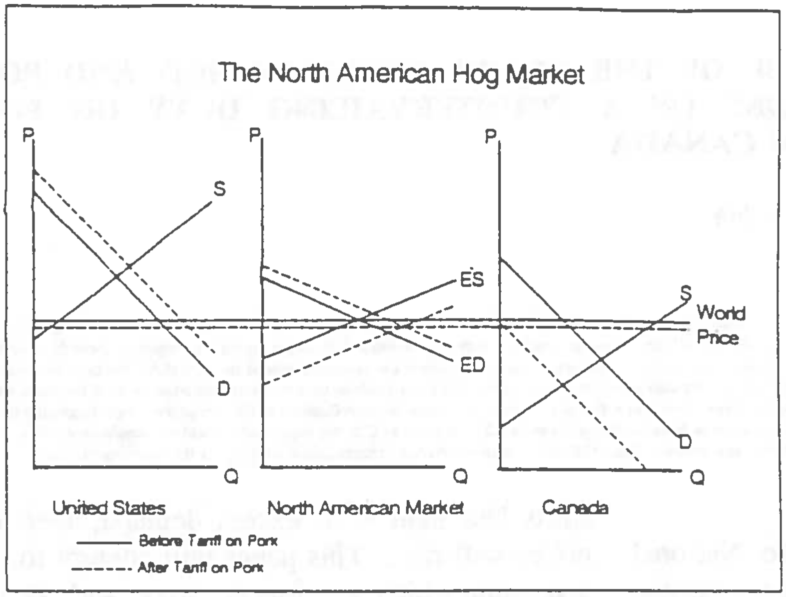
During the late 1980's, the National Pork Producers Council (NPPC) in the United States lobbied for and received a countervailing duty (CVD) on pork entering the United States from Canada. The justification for the NPPC's lobby efforts was that the subsidization of Canadian pork production led to more pork entering the U.S. market which in turn injures U.S. producers. Thus, the NPPC argued that the imposition of a CVD on pork entering the US would offset the subsidy and counter the damaging effects of the subsidy to the U.S. market. The thinking behind this assumes that a CVD on pork entering the U.S. would lead to higher hog prices in the U.S. and thus higher revenues for producers. However, the CVD on U.S. hogs causes a shift of the farm level demand curve in both Canada and the U.S. The shifts in farm level demand cause shifts of the excess hog demand and excess hog supply curves which intersect to establish the North American hog price. It is the relative magnitude of these shifts which determines whether hog price goes up or down. As can be seen in Diagram 1, if Canadian excess supply shifts less than U.S. excess demand, then hog prices will rise. This paper will attempt to determine which scenario is correct and whether or not U.S. producers gained from the imposition of the CVD on pork entering the U.S. from Canada.

Diagram 2 presents the theoretical framework for the model. This model is an adaptation of a simultaneous equations model originally estimated by Meilke and Scally (1988). Equations were estimated for farm level supply and demand; and retail demand for Canada and the U.S. As well, equations linking the Canadian and American prices of hogs and pork were estimated. The empirical observations for the supply and demand equations started with first quarter, 1969 and concluded with fourth quarter, 1987. Since exports of pork from Canada to the U.S. did not become significant until the late 1970's the price linkage equations were estimated over a sample period of 1980:1 to 1987:4.

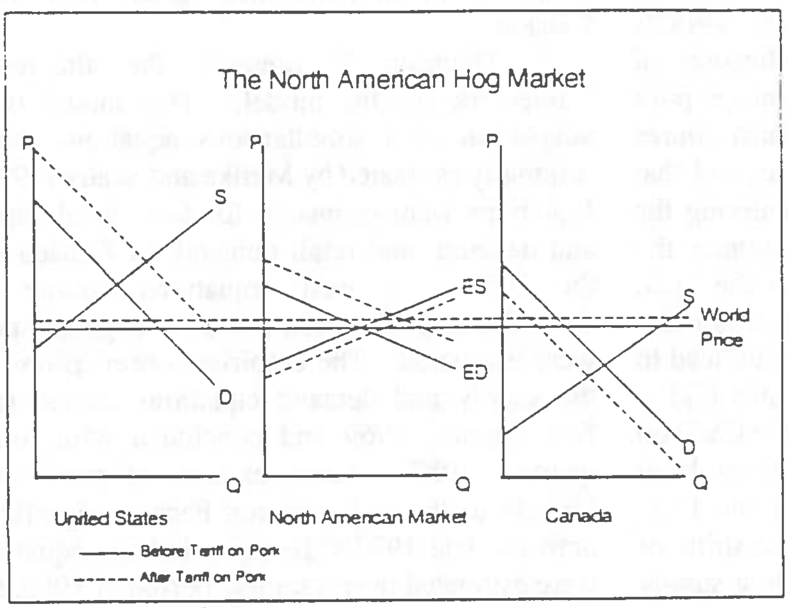
All prices in the model were deflated by the CPI for their respective country. The per capita demand variables were created by dividing the total demand for pork by the total population in the respective country. The natural logarithm of the deflated incomes was taken to impose the restriction of decreasing income elasticities as income increased.

Acknowledgement

This paper is the product of work done for a single semester course in Agricultural Price Analysis (Instructor: James Rude). The course covered the estimation, simulation and policy shocking of simultaneous equations models. The paper is a record of the work I completed over the course of the semester.



CASE 1: Price Decrease



CASE 2: Price Increase

Diagram 1: The Effect of a Tariff on Pork on Hog Price

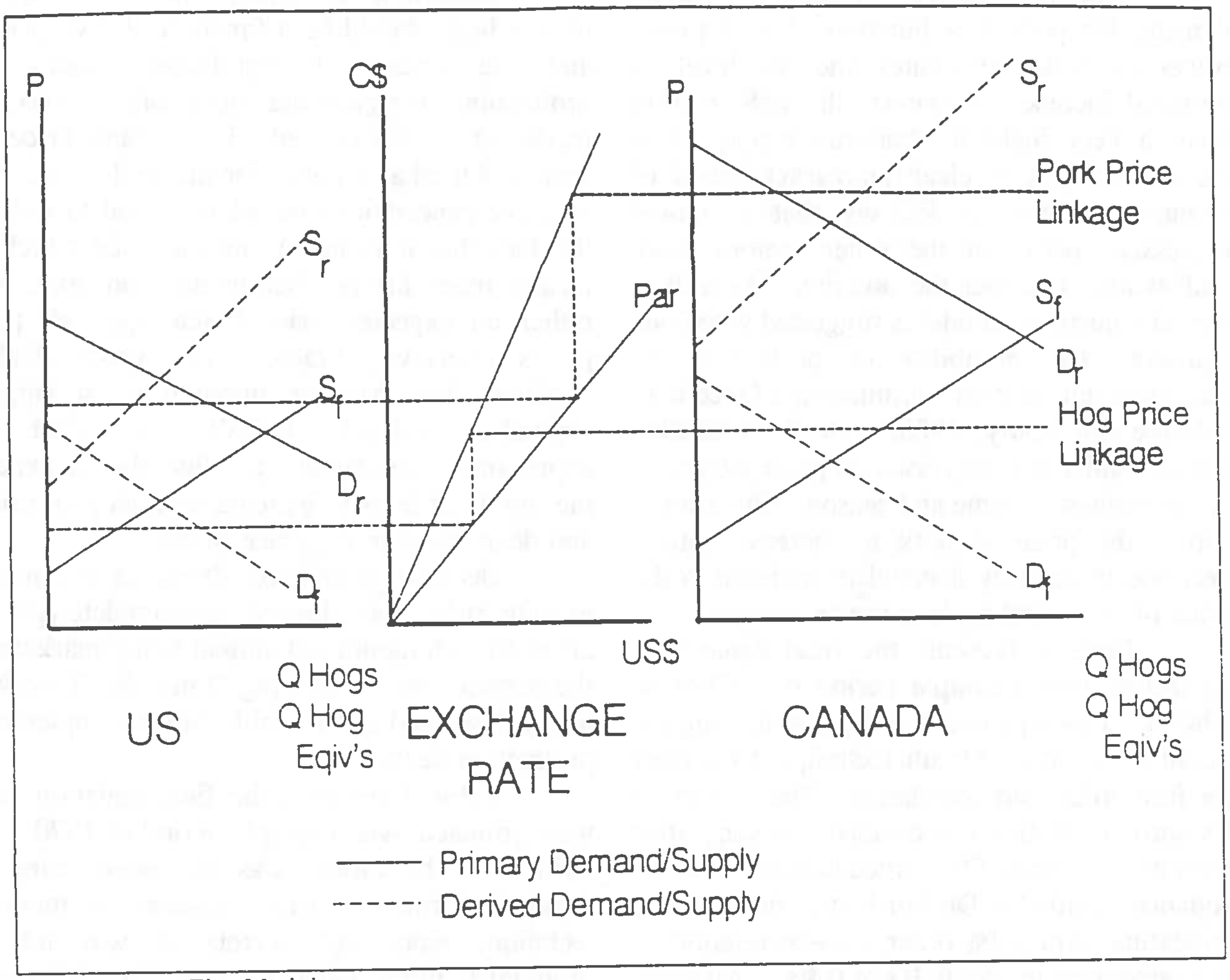


Diagram 2: The Model

RETAIL DEMAND EQUATIONS

Economic theory suggests per capita demand for pork is a function of own price, prices of close substitutes and the level of personal income. However, the U.S. market faces a very inelastic short-run supply, it is price that adjusts to clear the market instead of quantity. Thus it follows that a model regressing price on the other factors more realistically describes the situation. As well, a partial adjustment model is suggested when one considers the storability of pork and the imperfect information consumers are faced with (Meilke and Scally, 1988). On the Canadian side, quantity was regressed on price the prices of substitutes, income and season. One should expect the price of pork to increase with a decrease in quantity demanded, increase in the price of beef, and an increase in income.

Table 1 presents the final equation I estimated over a sample period of 1970:1 to 1987:4. This equation was regressed using the iterative Cochrane-Orcutt technique to correct for first order auto-correlation. The correction for auto-correlation was deemed necessary after running a standard OLS procedure on the same equation yielded a Durbin h-statistic of 5.16, indicating strong 1st order auto-correlation, a fact supported by the RHO of 0.93. All signs were as expected. The price of pork rises as the price of beef rices, normal behavior for close substitutes. The positive coefficient for the income variable suggests pork is a normal good. Although insignificant (t-stat = 0.934), income was left in the equation because micro-economic theory dictates that it should be and the omission of relevant variables biases the estimates of the other coefficients.

Table 2 presents the Canadian retail demand equation. It has good explanatory powers (adjusted R^2 = 0.85, F-stat = 71.16). The Cochrane-Orcutt technique was used to correct a problem with auto-correlation Otherwise, all variables reacted as expected.

FARM SUPPLY EQUATIONS

According to economic theory, the supply of live hogs should be a function of own price, and the prices of significant factors of production. A significant cost of raising a hog to market is the cost of feed. The deflated price of corn was used as a proxy for the feed costs. An adaptive expectations model was used to reflect the fact that it is not a current price which a farmer bases his production decision upon but rather an expected price based upon all past prices (Nerlove, 1956). The geometrically declining lag structure imposed by a lagged dependent variable (LDV) was used to approximate this situation. One should expect the supply of hogs to increase with its own price and decrease with the price of corn.

Because production decisions are made ex-ante, prices were lagged one complete year to allow for a 6 month old animal being marketed, the gestation period of a pig (3 months, 3 weeks, and 3 days) and a reasonable time to implement production decisions.

Table 3 presents the final equation that was estimated over a sample period of 1970:1 to 1987:4. The model was regressed using a standard ordinary least squares estimation technique since auto-correlation was not a problem (Durbin h-statistic = 0.37). All signs were as expected and all variables were significant. The supply of hogs was found to rise with an increase in the price of hogs and fall with an increase in the price of corn. This model has relatively good explanatory power since all variables are significant and behave as expected; and has a substantial adjusted R^2 of 0.85 and an F-statistic of $68.79_{[6,65]}$.

Table 4 presents the Canadian equation. An ordinary least squares technique was used since auto-correlation was not a problem. All variables reacted as expected. The explanatory power of this equation can be considered quite good (adjusted R^2 = 0.98, F-stat = 457.5).

Table 1: US Retail Demand Dependent Variable: P_{ret}

VARIABLE	ESTIMATED COEFFICIENT	T-STAT	FLEXIBILITY	
			Short Run	Long Run
Constant	0.677	7.668		
1st Qtr Dummy	-0.0336	-7.503		
2nd Qtr Dummy	-0.0568	-11.219		
3rd Qtr Dummy	-0.0387	-6.722		
Per Capita Demand	-75.02	-11.235	-12.565	-16.318
P_{beef}	0.447	8.223	8.751	11.365
Ln(Income)	0.00672	0.934	0.154	0.200
$P_{ret,t-1}$	0.230	4.251		
Dummy 1973:3	0.0295	2.218		
RHO	0.930	19.570		
Adj R^2	0.848			
$F\text{-STAT}_{9,65}$	52.000			
DURBIN-WATSON	2.419			

Table 2: Canadian Consumer Demand
Dependent Variable: Per Capita Demand_{ret}

VARIABLE	ESTIMATED COEFFICIENT	T-STAT	ELASTICITY
Constant	0.00477	5.518	
P_{ret}	-0.00706	-14.808	-0.977
P_{beef}	0.00249	6.809	0.362
Ln(Income)	0.00211	8.446	0.385
1st Qtr Dummy	-0.0000424	-0.604	
2nd Qtr Dummy	-0.000570	-7.478	
3rd Qtr Dummy	-0.000716	-10.136	
RHO	0.274	2.471	
Adj R^2	0.851		
DURBIN-WATSON	1.971		
$F\text{-stat}_{6,68}$	71.165		

Table 3: US Hog Supply
Dependent Variable: $Supply_{farm}$

VARIABLE	ESTIMATED COEFFICIENT	T-STAT	ELASTICITY	
			Short Run	Long Run
Constant	4676.4	3.772		
$P_{farm,t-4}$	10830.0	4.704	0.106	0.855
$P_{corn,t-4}$	-4075.0	-4.908	-0.092	-0.742
$Supply_{farm,t-1}$	0.876	16.713		
1st Qtr Dummy	-3428.4	-11.604		
2nd Qtr Dummy	-2457.9	-9.014		
3rd Qtr Dummy	-3374.0	-12.167		
Dummy 1973:3	-2290.2	-2.801		
Adj R^2	0.866			
$F\text{-}STAT_{7,64}$	66.292			
DURBIN H-STAT	0.371			

Table 4: Canadian Hog Supply
Dependent Variable: $Supply_{farm}$

VARIABLE	ESTIMATED COEFFICIENT	T-STAT	ELASTICITY	
			Short Run	Long Run
Constant	146.71	1.033		
$P_{corn,t-4}$	-157.97	-3.942	-0.074	-37.00
$P_{farm,t-4}$	124.54	2.871	5.774	2887.00
$Supply_{farm,t-1}$	0.998	36.289		
1st Qtr Dummy	-24.024	-0.690		
2nd Qtr Dummy	-188.12	-5.304		
3rd Qtr Dummy	-258.69	-7.250		
Adj R^2	0.975			
DURBIN H-STAT	-0.587			
$F\text{-}stat_{6,65}$	457.492			

PROCESSOR DEMAND FOR HOGS

This section of the paper develops and discusses an equation for processor demand for hogs. Theory tells us that processor input demand is a function of the price of the input in question, price of other inputs, and the price of the output(s). Thus, it follows that an equation which regresses hog slaughter on the price of hogs, the price of pork and wages in the U.S. meat packing sector should accurately describe the situation. Theory also allows for more elastic demand in the long run than the short run due to the inflexibility of wage contracts and capital investments. Thus, an equation allowing for differing long and short run elasticities such as the partial adjustment model should be used. If one considers the decision to build a plant and hire staff as the production decision, then a partial adjustment model is justified. However, if one considers the production decision as being made each morning based on current prices then the partial adjustment model is not justified. Meilke and Scally, (1988) chose the latter route in the development of their model, I the former. Regardless of which theory one subscribes to, processor demand should rise with an increase in the price of pork, a decrease in the price of hogs and a decrease in the wage rate.

Meilke and Scally, (1988) left out the partial adjustment process and turned the model around and estimated price based on quantity. Their justification for this model was the relative inelastic demand curve and the fact that there are very few channels for hogs to come through as well as little room for quantity to adjust, therefore they theorized that it was price that adjusted to clear the market.

The only lagged variable in the model is the lagged dependent variable needed to set up the partial adjustment model with a geometrically declining weight structure.

Table 5 presents the final equation I estimated over a sample period of 1970:1 to 1987:4. Since auto-correlation was not a problem (Durbin h-statistic equal to 1.66) an ordinary least squares regression technique was used. The adjusted R^2 of 0.921, F-statistic of $109.16_{[7,68]}$ and all variables being significant at the 95% level indicate a relatively high degree of explanatory power. This is a definite contrast to the regression results (not presented) when I attempted to duplicate Meilke and Scally's equation. While the R^2 and F-statistic were significant, only the coefficient on the price of pork and the price of hogs were significant. Thus, the possibility of multicollinearity was quite high. As well, auto-correlation became a problem that needed to be corrected for (Durbin h-statistic = 7.14) which raises questions about whether all relevant variables were included.

The equation presented in Table 5 has no serious contradictions with economic theory except the positive sign on the wage term. This may indicate a multicollinearity problem, however, it was left in the equation to avoid bias problems. All other signs were as expected. Demand rose with an increase in the price of pork and a decrease in the price of hogs.

Table 6 presents the Canadian processor demand equation. Its structure is identical to the U.S. and its results are similar. Once again the wage term has a positive coefficient. Although insignificant, it was left in to avoid bias problems associated with omitted relevant variables.

PRICE LINKAGE EQUATIONS

Tables 7 and 8 present the equations estimated to link Canadian prices to American prices. This estimation was performed since Canadian prices are set in the U.S. market. As can be seen from the results, these equations have high degrees of explanatory power (both R^2's > 0.80). The equations regress Canadian price on the U.S. price less any tariffs multiplied by the exchange rate and a lagged dependent variable. The LDV was included to allow for the fact that there is a lagged adjustment process (Meilke and Scally, 1988).

Table 5: US Hog Demand
Dependent Variable: $Demand_{farm}$

VARIABLE	ESTIMATED COEFFICIENT	T-STAT	ELASTICITY	
			Short Run	Long Run
Constant	8903.7	4.089		
P_{farm}	-35807.	-6.214	-0.348	-0.763
P_{ret}	8180.9	1.972	0.254	0.557
$Wage_{processor}$	3070.7	3.273	0.199	0.436
1st Qtr Dummy	-2221.4	-7.817		
2nd Qtr Dummy	-1868.5	-8.717		
3rd Qtr Dummy	-2332.9	-10.651		
$Demand_{farm,t-1}$	0.544	6.686		
Dummy 1973:3	878.72	1.273		
Adj R^2	0.921			
$F\text{-}STAT_{8,66}$	109.157			
DURBIN H-STAT	1.227			

Table 6: Canadian Hog Demand
Dependent Variable: $Demand_{farm}$

VARIABLE	ESTIMATED COEFFICIENT	T-STAT	ELASTICITY	
			Short Run	Long Run
Constant	118.65	0.506		
P_{farm}	-303.01	-4.423	-0.191	-1.447
P_{ret}	851.01	2.799	0.238	1.803
$Wage_{processor}$	75.360	1.110	0.095	0.720
$Demand_{farm,t-1}$	0.868	26.158		
1st Qtr Dummy	-56.889	-1.741		
2nd Qtr Dummy	-193.05	-5.805		
3rd Qtr Dummy	-242.61	-7.306		
Adj R^2	0.973			
DURBIN H-STAT	0.536			
$F\text{-}STAT_{7,67}$	393.475			

Table 7: Hog Price Linkage
Dependent Variable: CAN P_{farm}

VARIABLE	ESTIMATED COEFFICIENT	T-STAT	Flexibility	
			Short Run	Long Run
Constant	6.861	0.335		
(US P_{farm}-Tariff)* Exchange Rate	2.288	13.487	3.283	3.927
CAN $P_{farm,t-1}$	0.164	2.084		
RHO	0.809	6.319		
Adj R^2	0.863			
DURBIN-WATSON	1.870			
$F\text{-stat}_{2,28}$	95.557			

Table 8: Pork Price Linkage
Dependent Variable: CAN P_{ret}

VARIABLE	ESTIMATED COEFFICIENT	T-STAT	Flexibility
Constant	20.536	0.727	
US P_{ret} * Exchange rate	0.356	11.289	0.265
RHO	0.957	12.124	
Adj R^2	0.813		
DURBIN-WATSON	2.116		
$F\text{-stat}_{2,28}$	66.344		

THE SIMULATION

The eight estimated equations were combined with eight identities to form a closed model. Thus the equations and identities used were as follows:

Canadian Equations and Identities:

$Demand_{ret}$ = f($Price_{ret}$, $Price_{beef}$, Income, Season)

$Demand_{farm}$ = f($Price_{ret}$, $Price_{farm}$, LDV, Season)

$Supply_{farm}$ = f($Price_{farm}$, $Price_{corn}$, LDV, Season)

$Price_{ret}$ = f(US $Price_{ret}$ * exchange rate, LDV)

$Price_{farm}$ = f([US $Price_{farm}$ - Tariff] * exchange rate, LDV)

$Supply_{ret}$ ≡ $Demand_{farm}$ * hog carcass weight

$Supply_{farm}$ ≡ $Demand_{farm}$ + $Exports_{US}$

$Supply_{ret}$ ≡ $Demand_{ret}$ + $Exports_{US}$ + $Exports_{ROW}$ + ∆Inventory

Total $Demand_{ret}$ ≡ Per Capita $Demand_{ret}$* Population

American Equations and Identities:

$Demand_{ret}$ = f($Price_{ret}$, $Price_{beef}$, Income, LDV, Season)

$Demand_{farm}$ = f($Price_{ret}$, $Price_{farm}$, Wages, LDV, Season)

$Supply_{farm}$ = f($Price_{farm}$, $Price_{corn}$, LDV, Season)

$Supply_{ret}$ ≡ $Demand_{farm}$, *hog carcass weight

$Supply_{farm}$ ≡ $Demand_{farm}$ - $Imports_{CAN}$

$Supply_{ret}$ ≡ $Demand_{ret}$ - $Imports_{CAN}$ + $Exports_{ROW}$ + ∆Inventory

Total $Demand_{ret}$ ≡ Per Capita $Demand_{ret}$*Population

The endogenous variables are:

- US $Price_{ret}$
- US $Price_{farm}$
- US Per Capita Quantity $Demanded_{ret}$
- US Total Quantity $Demanded_{ret}$
- US Quantity $Supplied_{ret}$
- US Quantity $Demanded_{farm}$
- US Quantity $Supplied_{farm}$
- CAN $Price_{ret}$
- CAN $Price_{farm}$
- CAN Per Capita Quantity $Demanded_{ret}$
- CAN Total Quantity $Demanded_{ret}$
- CAN Quantity $Supplied_{ret}$
- CAN Quantity $Demanded_{farm}$
- CAN Quantity $Supplied_{farm}$
- CAN Hog Exports to US
- CAN Pork Exports to US

Statistics comparing the results of the simulation and the actual values are presented in table 9. Graphing the actual and simulated values revealed no major misses in terms of turning points. All variables except hog and pork exports from Canada to U.S. were simulated with reasonable accuracy.

THE COUNTERVAILING DUTY -- A 3% DUTY ON PORK ENTERING U.S.

The model was then shocked by creating a 3% price wedge between Canadian and American pork prices. This is an approximation of the actual countervailing duty placed on pork entering the United States from Canada. The tariff was incorporated into the pork price linkage equation as follows:

$$Price_{ret} = \beta_0 + \beta_1(\text{US } Price_{ret} * \text{exchange rate} * .97) + \beta_2 \, Price_{ret}(-1)$$

The simulation was then re-simulated from 1980:1 to 1987:4. Table 10 summarizes the changes relative to the original simulation over the period 1981:1 to 1987:4. 1980 was excluded from these results to allow for the four quarter lag in the primary supply equations.

DISCUSSION AND IMPLICATIONS

The results of the imposition of the CVD presented in table 10 indicate that the scenario of the Canadian excess supply curve shifting more than the U.S. excess demand curve is the correct description of this situation. Since U.S. farmers are shipping less hogs and receiving less for them with the CVD in place as compared to the same time period without it, their revenues have decreased. The imposition of a CVD doesn't alter the cost structure of the industry. Thus, producers revenues have decreased, and costs remained constant, implying their welfare decreased. Producer surplus would have been a better measure of the change in producer welfare. However, because of the lag structure employed in the model, a change in price for one period alters the intercept of the supply curve for all subsequent time periods. Therefore, to adequately describe the change in producer surplus I would have had to measure the area over the farm level supply curve and under the price line from the first time period until the end of time. This is impractical, thus, change in producer revenue is used as an approximation for the change in producer welfare.

LIMITATIONS

This model has two problems which limit the usefulness of its results. The first problem being its inability to accurately describe trade in hogs and pork. This problem should not bias the results and conclusions to any great degree since it is the behavior of the farm level supply and demand curves which determine the price levels; curves which simulated with a reasonable degree of consistency. The second problem is the time period over which the equations were estimated versus the time period over which the actual CVD was implemented. It is quite possible that there were structural changes in the North American Hog/Pork Industry between 1969 and 1988 (when the actual CVD was imposed). Thus, it is possible that the model does not accurately describe the situation in which the CVD was implemented.

Further research should be directed to updating this model with data from 1988 to 1991. Once the model is updated, it would be interesting to determine if the results presented hold for the actual time period that the CVD was implemented in.

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