TRADE IN VERTICALLY RELATED MARKETS: THE CASE OF HOGS AND PORK

by

K. D. Meilke
and
M. Scally

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Department of Agricultural Economics and Business
University of Guelph
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PREFACE

This reports contains the results of a preliminary attempt to model Canada-United States trade in hogs and pork. A model that allows for the differentiation of trade between raw and further processed products is essential in evaluating the trade and welfare effects of tariffs (duties) placed on raw and/or processed products.

While the approach taken in this study appears promising further work is needed to refine the model and to extend it so that precise welfare calculations for various market participants can be made.

Trade in Vertically Related Markets: The Case of Hogs and Pork

1.0 INTRODUCTION

The rapid growth of the hog industry in Canada since 1978 and the resultant increase in exports to the U.S. demonstrates the increasing importance of export markets to Canadian hog producers. However, access to foreign markets for Canada's agricultural products is increasingly being determined by the domestic and trade policies of Canada's trading partners. U.S. hog producers, motivated by Canada's increased exports of hogs and pork, mounted a countervailing duty action under U.S. trade law in 1984 (Meilke and van Duren; Martin and Goddard). A preliminary determination that Canadian exports of hogs and pork had caused economic injury to the U.S. industry was made by the U.S. International Trade Commission. Following formal hearings a countervailing duty of $4.39/cwt. was placed on live hogs, taking effect in April 1985, while the preliminary duty placed on pork was rescinded.

This case highlights a shortfall in traditional agricultural trade policy analysis which has typically focused on problems related to trade in primary products. Trade in semi-processed and processed product forms tends to be ignored when trade flows at the primary level are impeded, even though trade in these products influences the distribution of welfare gains and losses throughout the industry. Thus there is a need for an expanded framework that can explain how trade barriers that are imposed at one market level influence trade flows at other levels.

The objective of this paper is to use the example of Canada/U.S. hog and pork trade to provide a framework within which trade in raw and processed agricultural products can be analyzed.

The specific objectives are:

a) to specify a theoretical and empirical model of trade in hogs and pork between the United States and Canada with a focus on factors that determine whether trade is in primary or final form;

b) to determine the effect of the U.S. countervailing duty on the economic welfare of market participants as well as Canada's exports of live hogs and fresh and frozen pork; and

c) to determine what the effect on Canada's exports of hogs and pork would have been if a duty was also applied to pork.

2.0 BACKGROUND

Pork and hog prices in Canada are determined to a large degree by supply and demand conditions in the U.S. market. The size and proximity of the U.S. market, as well as the absence of significant trade barriers, contributes to the strong connections between the U.S. and Canadian markets. Canadian exports of pork to the U.S. account for a significant proportion of total exports (Table 1). At various times the Japanese market has also been important, particularly during the period 1975 to 1979, but recently the U.S. has once again become Canada's predominant trading partner. The importance of exports to the Canadian industry is also illustrated in Table 1 which shows that trade in pork accounted for 23.4% of Canada's commercial pork production in 1987.

Virtually all of the hogs exported by Canada go to the U.S. market. Exports of hogs have increased sharply since 1981 so that by 1984 they represented 9.2% of total marketings.

The balance of trade in pork with the U.S. illustrates the source of the current trade conflict with the United States (Figure 1). Reciprocal trade flows in pork between Canada and the U.S. resulted in a small net trade surplus for Canada in most years prior to 1974. Between 1974 and 1978 Canada was a net importer of pork from the U.S. but since then the trade balance has been overwhelmingly in Canada's favour.

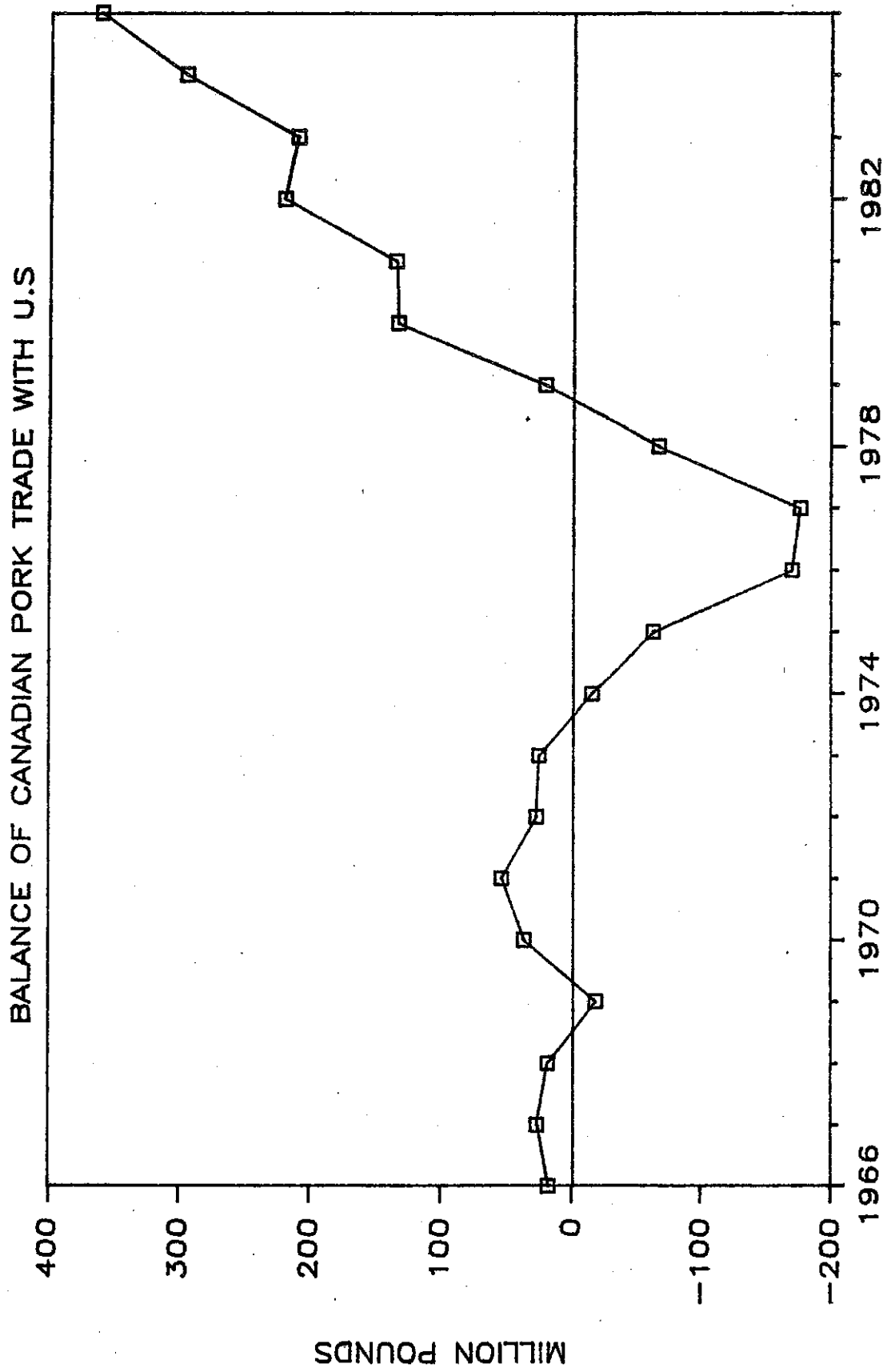
Table 1: Pork Production and Exports

Year	Canadian Production	Exports to U.S.	Percent of Total Exports	Percent of Domestic Production
	(mil. lbs.)		%	%
1970	1160.6	60.9	83.2	5.2
1971	1346.5	68.9	69.1	5.1
1972	1248.0	62.3	53.7	5.0
1973	1196.3	68.5	54.4	5.7
1974	1227.4	48.6	52.1	4.0
1975	1013.7	30.8	33.7	3.0
1976	1017.3	22.6	25.7	2.2
1977	1081.1	22.8	22.4	2.1
1978	1251.3	47.5	38.1	3.8
1979	1540.0	89.7	51.0	5.8
1980	1799.8	170.2	65.4	9.4
1981	1786.2	174.5	61.3	9.8
1982	1776.8	249.2	69.1	14.0
1983	1819.8	243.5	70.0	13.4
1984	1838.4	314.3	81.2	17.1
1985	1922.1	374.7	86.4	19.5
1986	1937.9	415.4	87.6	21.4
1987	1998.8	467.4	89.2	23.4

Table 2: Hog Production and Exports

Year	Canadian Production	Exports to U.S.	Exports as Percent of Production
	('000 head)		%
1970	8813.2	88.2	1.0
1971	10264.9	88.7	0.9
1972	9524.9	88.7	0.9
1973	9131.4	90.2	1.0
1974	9467.2	197.1	2.1
1975	7702.2	30.7	0.4
1976	7729.1	45.0	0.6
1977	8209.9	43.3	0.5
1978	9272.9	188.0	2.0
1979	11367.3	131.2	1.1
1980	13388.7	237.6	1.8
1981	13193.1	147.3	1.1
1982	13191.6	305.5	2.3
1983	13575.8	459.3	3.4
1984	14600.6	1346.5	9.2
1985	14974.4	1152.4	7.7
1986	14319.3	502.2	3.5
1987	14648.3	427.6	2.9

FIGURE 1


BALANCE OF CANADIAN PORK TRADE WITH U.S
MILLION POUNDS
400
300
200
100
0
−100
−200
1966
1970
1974
1978
1982

3.0 THE MODEL

The model used to describe trade in a primary and a further processed product involves a simple extension of the one product trade flow model. The equilibrium condition, described by the law of one price, remains unchanged except that it operates in two markets simultaneously. As Moschini and Meilke (1987) point out, the spatial configuration of prices in a single market obeys the same linkage conditions regardless of the presence of related markets. That is, the exhaustion of spatial arbitrage possibilities. Thus a market equilibrium model with appropriately specified demand and supply regions and associated price linkages provides information on net trade flows and prices. In addition, trade policies (tariffs) and macroeconomic variables (exchange rates) can be incorporated into the price linkage equations. Once constructed, this type of model can be used to provide information on the adjustment of trade flows and prices resulting from changes in trade policy.

Before proceeding to a discussion of the empirical model a simplified theoretical model is developed in order to assess, using comparative statics, the effects of a countervailing duty on the Canadian and United States hog/pork sector.

The theoretical model is simplified by making the following assumptions (a) hog supply is fixed; (b) price transmission from the U.S. to Canada is perfect for both hogs and pork; (c) zero transportation costs; (d) a common currency; (e) no trade with third country markets; (f) Canada is a net exporter of both hogs and pork; and (g) homogeneous products.

With these assumptions a model of the Canada/United States hog/pork

market can be represented using eight equations.

(1) $D_p^c = a - bP_p^c$ (5) $D_p^u = m - nP_p^u$

(2) $D_h^c = c + dP_p^c - eP_h^c$ (6) $D_h^u = o + qP_p^u - rP_h^u$

(3) $P_h^c = P_h^u - T_h$ (7) $D_p^c + D_p^u = K_c\bar{Q}_h^c + K_u\bar{Q}_h^u$

(4) $P_p^c = P_p^u - T_p$ (8) $D_h^c + D_h^u = \bar{Q}_h^c + \bar{Q}_h^u$

where, equations (1) and (5) are pork demand in Canada (D_p^c) and the United States (D_p^u); equations (2) and (6) are hog demand in Canada (D_h^c) and the United States (D_h^u); equations (3) and (4) link Canadian hog (P_h^c) and pork (P_p^c) prices to their United States counterparts (P_h^u and P_p^u); and equations (7) and (8) are the market clearing identities for pork and hogs. Variables not previously defined are: T_h = countervailing duty for hogs, T_p = countervailing duty for pork, K_c and K_u = carcass weight for Canadian and U.S. hogs, and $\bar{Q}_h^c$ and $\bar{Q}_h^u$ = fixed production of Canadian and U.S. hogs. The letters a through r represent parameters to be estimated.

Substituting equations (1) and (5) into (7) gives

$$(9)\quad P_p^u = (a + m + bT_p - K_c\bar{Q}_h^c - K_u\bar{Q}_h^u)/(b+n)\ ,$$

and substituting (2) and (6) into (8) gives

$$(10)\quad P_h^u = (c + o + (d+q)P_p^u - dT_p + eT_h - \bar{Q}_h^c - \bar{Q}_n^u)/(e+r)\ .$$

Finally, substituting (9) into (10) gives

$$(11)\quad P_h^u = [1/(e+r)]\,[c + o + (d+q)/(b+n)\,(a + m + bT_p - k_c\bar{Q}_h^c - k_u\bar{Q}_h^u) - dT_p + eT_h - \bar{Q}_h^c - \bar{Q}_h^u\,].$$

Equations (9) and (11) can be differentiated with respect to T_h and

T_p to derive the effects of a countervailing duty on U.S. hog and pork prices. The values of these derivatives are shown below.

From (9)

$$(12)\quad \frac{\partial P_p^u}{\partial T_p} = b/(b+n) > 0 \text{ , and}$$

$$(13)\quad \frac{\partial P_p^u}{\partial T_h} = 0 \text{ .}$$

From (11) ,

$$(14)\quad \frac{\partial P_h^u}{\partial T_h} = \frac{e}{e+r} > 0 \text{ , and}$$

$$(15)\quad \frac{\partial P_h^u}{\partial T_p} = (1/e+r)\,[(d+q)b/(b+n) - d]$$

$$= (bq-dn)/[(e+r)(b+n)] \gtrless 0$$

The effect of a countervailing duty on hogs has no effect on pork prices because of the fixed hog supply assumption. A countervailing duty on pork raises U.S. pork prices but has an ambiguous effect on U.S. hog prices. Since the denominator in equation (15) is positive the sign of the derivative is determined by the sign of the numerator. A countervailing duty on pork will raise U.S. hog prices if $bq > dn$ and lower them if $bq < dn$. The sign of this derivative is an empirical question resting on the relative price responsiveness of U.S. and Canadian consumers and hog processors.

If a countervailing duty is applied to both Canadian hogs and pork the expected effects can be determined by adding together the appropriate derivatives from above. The effect of a duty on both hogs and pork has an unambiguously positive effect on U.S. pork prices but an indeterminate

effect on U.S. hog prices. However, this effect is much more likely to be positive than if the duty is on pork only.

A pictorial representation of the empirical model is presented in Figure 2. The model consists of three supply regions, two demand regions, two processing regions and two inventory regions. The full model (excluding accounting relationships) contains 19 equations, 30 exogenous variables, and 19 endogenous variables (Table 3).

Both the pork and the hog markets are linked horizontally by price between the Canadian regions and the U.S. The price links were estimated over a time period when Canada was a significant net exporter of both hogs and pork to the U.S. The markets are linked vertically by the processing sector in each country which determines the price spread between hogs and pork. The model represents the North American market only and imports and exports involving other regions, most notably Japan, are treated exogenously.

3.1 Model Estimation

The size and the simultaneous nature of the model pose several estimation difficulties. For the demand side of the model the use of ordinary least squares (O.L.S.) is inappropriate since the parameter values that result are biased and inconsistent because of the presence of endogenous variables on the right hand side of the equations (Pindyck and Rubinfeld, p. 321).

There are two approaches to resolving this problem; systems estimation techniques and single equation techniques. Systems techniques can not be used with undersized samples, such as we have in this situation, consequently, only single equation methods are considered. Among single

Figure 2. The Pork - Hog Model Outline

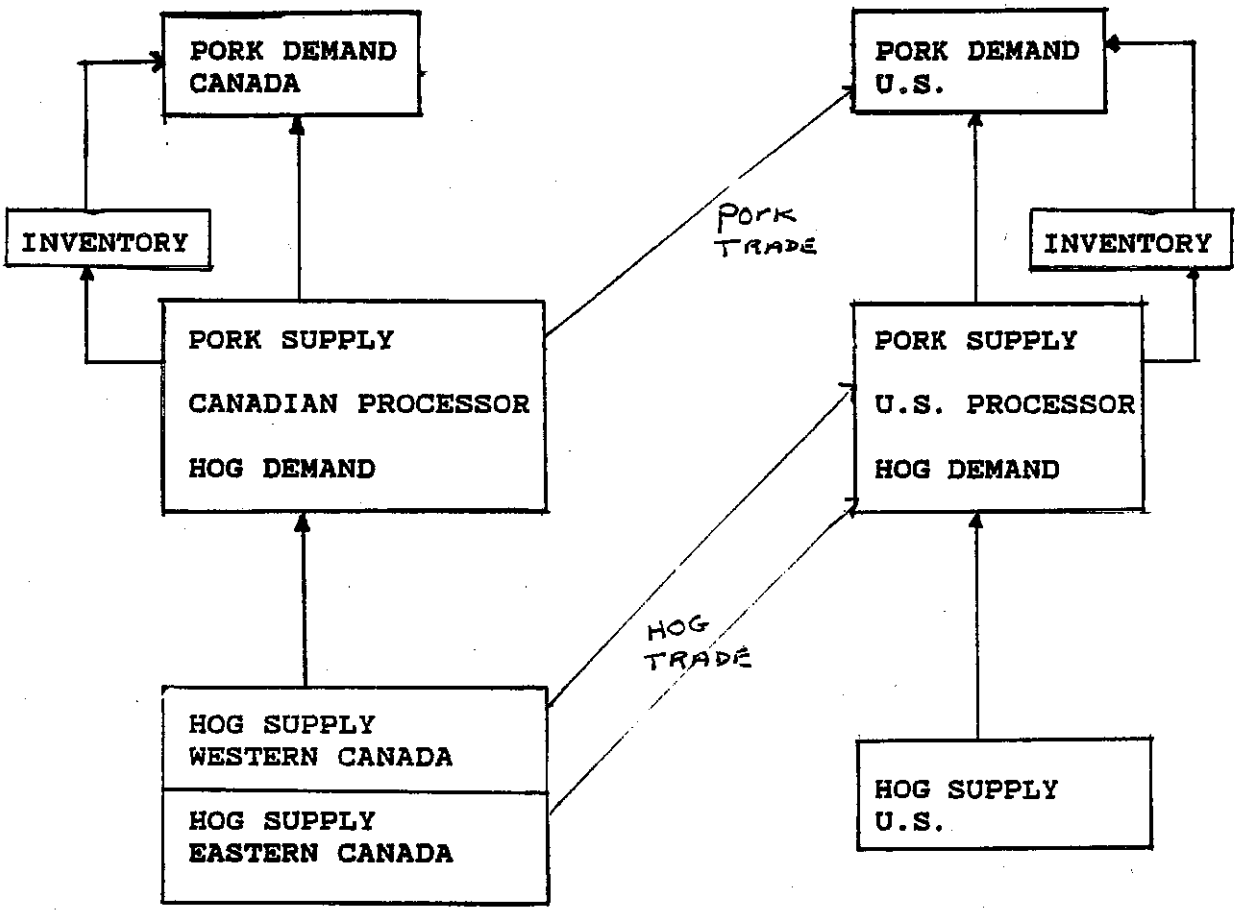


Table 3: The Model Equations

RETAIL PORK DEMAND

Per Capita Demand for Pork (Canada) = f(Deflated Price of Pork, Deflated Price of Beef, Log of Income)
Deflated Retail Price of Pork (U.S.) = f(Per Capita Demand for Pork, Deflated Price of Beef, Log of Income, Deflated Price of Chicken, LDV)

HOG SUPPLY

Supply of Hogs (West Can.) = f(Deflated Price of Hogs (t-4), Deflated Price of Barley (t-4), Time Trend, LDV)
Supply of Hogs (East Can.) = f(Deflated Price of Hogs (t-4), Deflated Price of Corn (t-4), Time Trend, LDV)
Supply of Hogs (U.S.) = f(Deflated Price of Hogs (t-4), Deflated Price of Corn (t-4), LDV)

INVENTORY DEMAND

Pork Stocks (Canada) = f(Change in the Deflated Price of Pork, LDV)
Pork Stocks (U.S.) = f(Change in the Deflated Price of Pork, LDV)

PACKER HOG DEMAND/SUPPLY OF PORK

Deflated Price of Hogs (Canada) = f(Deflated Price of Pork, Meat Packing Real Wage Index, Domestic Demand for Hogs)
Deflated Price of Hogs (U.S.) = f(Deflated Price of Pork, Meat Packing Real Wage Index, Demand for Domestic Hogs plus Imports, Time Trend)

LINKAGE EQUATIONS

Retail Price of Pork (Canada) = f(Time Trend, U.S. Price of Pork in Canadian Dollars minus Duty, LDV)
Price of Hogs (West Canada) = f(U.S. Price of Hogs in Canadian Dollars minus Duty, Log of Export Volume, LDV)
Price of Hogs (East Canada) = f(U.S. Price of Hogs in Canadian Dollars minus Duty, Log of Export Volume, LDV)

IDENTITIES

Canadian Hog Price = .345 * Eastern Canada Price + .655 * Western Canada Price
Canadian Domestic Pork Supply = Canadian Hog Demand * Canadian Carcass Weight
U.S. Domestic Pork Supply = U.S. Hog Demand * U.S. Carcass Weight + U.S. Hog Imports * Canadian Carcass Weights
Canadian Supply of Pork + Net Inventory Change - Demand for Pork = Net Exports to U.S. + Net Exports to ROW
U.S. Supply of Pork + Net Inventory Change - Demand for Pork = Net Imports from Canada + Net Imports from ROW
Supply of Hogs in Eastern Canada + Supply of Hogs in Western Canada - Demand for Hogs in Canada = Net Exports to U.S.
Supply of Hogs in U.S. - Demand for Hogs in U.S. = Net Imports from Canada

equation estimators two-stage least squares - (T.S.L.S.) has a number of attractive features. In our model the number of exogenous variables exceeds the number of observations which are available for some equations. Consequently, the conventional T.S.L.S. approach of creating instruments by regressing all of the RHS endogenous variables against all of the exogenous and predetermined variables in the system is impossible. McCarthy discusses this problem and shows that to maintain consistency in the estimates, the exogenous regressors for all of the endogenous variables in a given structural equation must be the same, and they must include explicitly the exogenous variables included in that structural equation. Other exogenous variables or principle components of them may be added in order to reduce the variance and improve the efficiency of the estimates while maintaining consistency.

This was the procedure used to estimate the model. Current endogenous variables in each equation were replaced by an instrument created by regressing them against all of the exogenous variables in that equation and enough principle components to explain 95% of the variance in the remaining exogenous variables. The presence of autocorrelation and lagged dependent variables in several equations resulted in a modified set of instruments being used (Fair).

The estimation range for the various equations differ by the type of variable being estimated. Hog supply equations and pork inventory equations are estimated from 1970 first quarter to 1986 second quarter, except when an autocorrelation correction is needed in which case one observation is added at the beginning of the period to account for the Cochrane-Orcutt transformation which drops the first observation. Demand equations are estimated from 1975 first quarter to 1986 second quarter.

This estimation period is shorter because of the possibility of a structural change in the demand for meat in the early 1970's (Moschini and Meilke, 1988). The price linkage equation for pork is estimated from the first quarter of 1980 to the second quarter of 1986. During this period Canada was a consistent net exporter of pork to the U.S. and hence this sample period avoids the problem of how to handle changes in the direction of trade flows. The price linkage equations for hogs are treated differently because of the estimation problems that were encountered. This is discussed later.

3.2 The Demand Block

Pork demand equations are estimated for Canada and the United States. Per capita demand is a function of own price, prices of substitutes and the level of income. Prices are expressed in real terms to impose the homogeneity condition using the consumer price index as a deflator.

The estimation results are shown in Table 4. In the Canadian demand equation the parameter estimates for own price, and for the price of beef have large t-values associated with them. The log of income was included to ensure that the income elasticity of demand diminishes as income rises. Contrary to expectations, the income variable has a negative although insignificant coefficient. The equation is corrected for serial correlation using the Cochrane-Orcutt procedure. Seasonal intercept dummies are included and as a group are statistically significant at the 5% level as measured by the F-test. The estimates of own price and cross price elasticities are broadly consistent with those found in previous studies (Meilke and Coleman).

The U.S. demand for pork is estimated renormalized on price. This

Table 4: Estimated Demand Equations

LHS VAR DPK3/POPN3 R-SQR .937 D.W. 1.93
RANGE 1974 4 to 1986 2

Region	Qtr.	Intercept		RPPK3/ CPI3	RPBF3/ CPI3	LOG (PCDY3/ CPI3)	RHO
Canada		23.34	Beta	-11.18	4.95	-0.267	0.379
	1	-0.523	T-Stat	-8.58	6.11	-0.085	2.73
	2	-1.196	Elasticity	-0.84	0.31	-0.02	
	3	-0.979					

LHS VAR RPPK4/CPI4 R-SQR .991 D.W. 1.89
RANGE 1975 1 to 1986 2

Region	Qtr.	Intercept		DPK4/ POPN4	RPBF4/ CPI4	LOG (PCDY4/ CPI4)	RPCK4/ CPI4	RPPK4(-1)/ CPI4(-1)
U.S.		2.22	Beta	-0.0337	0.222	-0.235	0.4887	0.369
	1	-0.0364	T-Stat	-14.2	8.13	-4.17	6.478	10.25
	2	-0.0489	Flexibility	-0.84	0.3	-0.37	0.23	
	3	-0.0346						

specification is consistent with a market that faces a relatively inelastic short-run supply curve so that price must adjust to equate supply and demand. This specification was not used for Canada since Canada is a small country that faces prices determined largely in the United States.

In the U.S. demand equation, two additional variables are included, the price of chicken -- which was insignificant in the Canadian equation -- and the lagged price of pork. The lagged price of pork allows for a partial adjustment process.

3.3 Supply Block

The hog supply section of the model is represented by three equations, two for Canada--West and East--and one for the United States. Western Canadian hog production tends to be regarded by a majority of producers as a residual market for feed grains during times of depressed feed grain prices, while Eastern Canada contains more specialized hog operations. Nonetheless, the specifications of the equations are similar. Supply function estimation requires information on input prices and product prices. The nature of biological supply functions creates time lags between price changes and production responses. Hence, a four quarter lag is used to reflect decision, gestation and growth lags. A lagged endogenous variable is included in each equation to capture the partial adjustment process first suggested by Nerlove.

The results for the supply block are shown in Table 5. All equations were estimated using O.L.S. since these equations are recursive. In the Western Canada equation, the lagged deflated price of feed barley, is used as an input price. A time variable is inserted to account for

Table 5: Estimated Supply Equations

LHS VAR SHG1 R-SQR .938 D.W. 1.89 h = 0.48
RANGE 1970 1 to 1986 2

Region	Qtr.	Intercept		PHG1(-4)/ WPI3(-4)	OPBA3X(-4)/ WPI3(-4)	SHG1(-1)	TIME
Western Canada		185.27	Beta	0.791	-1.186	0.856	0.422
	1	59.72	T-Stat	1.69	-5.9	19.11	1.08
	2	2.71	Elasticity	0.07	-0.15		
	3	-85.12					

LHS VAR SHG2 R-SQR .987 D.W. 2.09 h = 0.38
RANGE 1969 4 to 1986 2

Region	Qtr.	Intercept		PHG2(-4)/ WPI3(-4)	FPCO2(-4)/ WPI3(-4)	SHG2(-1)	DQUEX	RHO
Eastern Canada		196.59	Beta	1.27	-0.584	0.913	10.66	-0.303
	1	-73.79	T-Stat	2.96	-2.93	27.22	3.49	-2.38
	2	-156.31	Elasticity	0.06	-0.05			
	3	-174.94						

LHS VAR SHG4 R-SQR .884 D.W. 1.83 h = 0.78
RANGE 1970 1 to 1986 2

Region	Qtr.	Intercept		PHG4(-4)/ WPI4(-4)	PCO4(-4)/ WPI4(-4)	SHG4(-1)	D19733
U.S.		5425.3	Beta	106.6	-47.7	0.858	-2416.2
	1	-3456.7	T-Stat	4.16	-4.24	14.97	-2.92
	2	-2400.9	Elasticity	0.10	-0.11		
	3	-3332.9					

technological change. The Eastern Canadian equation contains the lagged deflated price of corn and a modified time trend variable to account, not only for technological change, but also for changes in the institutional framework and lending policies which occurred between 1977 and 1979. This equation was corrected for autocorrelation using the Cochrane-Orcutt procedure.

The U.S. supply equation contains lagged deflated corn prices and a dummy variable for the third quarter of 1973 to account for the removal of price controls in the U.S.. All three supply equations show a high degree of explanatory power as evidenced by the high value of the multiple correlation coefficient. All signs are consistent with theory and all variables except the time variable in the Western Canada equation are statistically significant at the 5% level. Short and long-run elasticities are quite consistent between equations. It should be noted that the Durbin-Watson statistic is biased when lagged endogenous variables are included in the specification so Durbin's h-test is also reported.

3.4 Inventory Block

Pork inventory demand functions are estimated for Canada and the United States. Following previous studies the demand for inventories is assumed to be explained by speculative and transactions demand motives. Transactions demand is the processors response to the possibility of unanticipated changes in consumer demand. Speculative demand arises from the belief that prices will rise in the future such that the gain from selling current stocks at future prices outweighs the cost of storing the stocks until that time.

The results from these equations are shown in Table 6. The price change variable is used to capture the speculative demand while current supply was included to capture transactions demand. Interest rates which influence the cost of holding stocks were also included as an explanatory variable in the early estimates of these equations. However, neither current supplies nor interest rates were found to add to the explanatory power of the equations. The lack of significance of interest rates could occur because the interest cost is small compared to the cost incurred from an inventory shortfall. The dummy variable for the second quarter of 1972 is used to explain an outlying observation.

All coefficient signs are as expected. A positive change in pork prices causes stocks to be reduced since speculative demand is diminished as prices rise. The r-squared in both equations is low and there is a risk that the equations are misspecified by the exclusion of relevant variables. However, there is little variation in the inventory data and potential errors in these equations are unlikely to cause problems in policy analysis. The U.S. equation is corrected for autocorrelation using the Cochrane-Orcutt procedure.

3.5 Hog Demand/Supply of Pork Block

A hog processing equation is estimated for Canada and the United States. These equations represent the demand for hogs and the supply of pork. They act to link the two product markets together. The demand for hogs exhibited by packers will depend upon input prices and output prices. Inputs in the packing sector are primarily hogs and labour. Output is pork.

The results of estimating these equations are shown in Table 7. Both

Table 6: Estimated Inventory Equations

LHS VAR IPK3 R-SQR 0.698 D.W. 2.07 h = 0.59
RANGE 1970 1 to 1986 2

Region	Qtr.	Intercept		Change in (RPPK3/WPI3)	IPK3(-1)	D19712
Canada		15.44	Beta	-0.165	0.418	46.17
	1	3.63	T-Stat	-1.36	3.86	3.34
	2	-2.29				
	3	-4.77				

LHS VAR IPK4 R-SQR .789 D.W. 1.91 h = 0.73
RANGE 1969 4 to 1986 2

Region	Qtr.	Intercept		Change in (RPPK4/WPI4)	IPK4(-1)	D19712	RHO
U.S.		131.78	Beta	-279.73	0.627	155.47	0.22
	1	-11.78	T-Stat	-1.91	6.84	2.4	1.72
	2	-18.1					
	3	-107.59					

Table 7: Estimated Packer Demand Equations

LHS VAR PHG3/WPI3 R-SQR 0.964 D.W. 2.04
RANGE 1969 4 to 1986 2

Region	Qtr.	Intercept		RPPK3/ WPI3	WAPK3/ WPI3	DHG3	RHO
Canada		86.63	Beta	1.26	-0.292	-0.014	0.728
	1	1.44	T-Stat	10.12	-3.71	-3.79	9.3
	2	3.31	Flexibility	1.68	-1.28	-0.45	
	3	2.39					

LHS VAR PHG4/WPI4 R-SQR 0.954 D.W. 1.99
RANGE 1969 4 to 1986 2

Region	Qtr.	Intercept		RPPK4/ WPI4	WAPK4/ WPI4	DHG4+ EXHG3	TIME	RHO
U.S.		27.84	Beta	35.56	-0.076	-0.0007	-0.056	0.647
	1	-0.649	T-Stat	5.52	-2.35	-3.14	-1.92	6.39
	2	-0.873	Flexibility	1.14	-0.51	-0.79		
	3	-0.752						

equations are normalized on the deflated hog price. Given the concentrated nature of the marketing channels and the rigidities that exist in the processing sector, the derived demand--the most inelastic--will do the adjusting. Thus, the hog price will adjust to other conditions to equate supply and demand.

Time variables were included in both equations to act as a proxy for technological change but gave satisfactory results only in the U.S. equation. The negative sign indicates that the farm-retail price spread is widening over time, possibly as a result of demand changes at the retail level that are changing the product mix and the markup behaviour.

Both equations are adjusted for first-order autocorrelation. This raises the spectre of omission of relevant variables. Since these are input demand equations a more complete accounting for other input costs would be desirable. The results are, however, roughly consistent with those of Holloway and Goddard.

All signs in the input demand equations are correct and the coefficients are all significant at the 5% level. The degree of explanatory power is high for both equations.

3.6 The Price Link Block

There are three price linkage equations in the model, two for hogs and one for pork. The estimation of these equations created some difficulties. According to theory, spatial price differences should be equal to transfer costs adjusted for exchange rates. Unfortunately, no historical data exists on transfer costs and these expenses must be proxied using aggregate indicies of transportation costs and tariffs (Moschini and Meilke, 1987). Furthermore there is more variation in the

U.S.-Canada hog price spreads than seems likely to originate from short-run variations in transfer costs (Figure 3), and at the pork level the prices being compared may not be equivalent. The Canadian pork price index is an average of selected cuts while in the U.S. it is based on the entire carcass. There may also be differences in hog quality between the two regions which would affect the price linkage.

In initial estimation the Canadian prices were specified as a function of tariffs, transportation costs (as represented by the personal transportation component of the CPI), the U.S. price (converted to Canadian dollars), and the volume of exports to provide for an upward slope on the supply of transportation services (Moschini and Meilke, 1987). These results were not entirely satisfactory and as a result some adjustments were made. The pork price linkage (Table 8) contains the exchange rate adjusted U.S. price, a trend variable to account for differing movements in the pork price variables in each region due to their slightly different commodity specifications, and a lagged endogenous variable to account for lagged adjustments in the arbitrage markets. Inclusion of transportation costs in this equation gave unsatisfactory results and it was omitted. The included variables are all significant at the 5% level and the explanatory power of the equation is high.

The hog price linkages (Table 8) were estimated starting in 1982(1) when Canadian exports of hogs began to reach significant levels. In order to increase the degrees of freedom, and to include more observations after the countervailing duty was imposed the sample size was extended to the second quarter of 1987. Since recent data could not be obtained for every variable, the application of two stage least squares became impossible. Thus, some bias in the estimates was accepted as a

FIGURE 3: United States-Canada Price Spread for Hogs

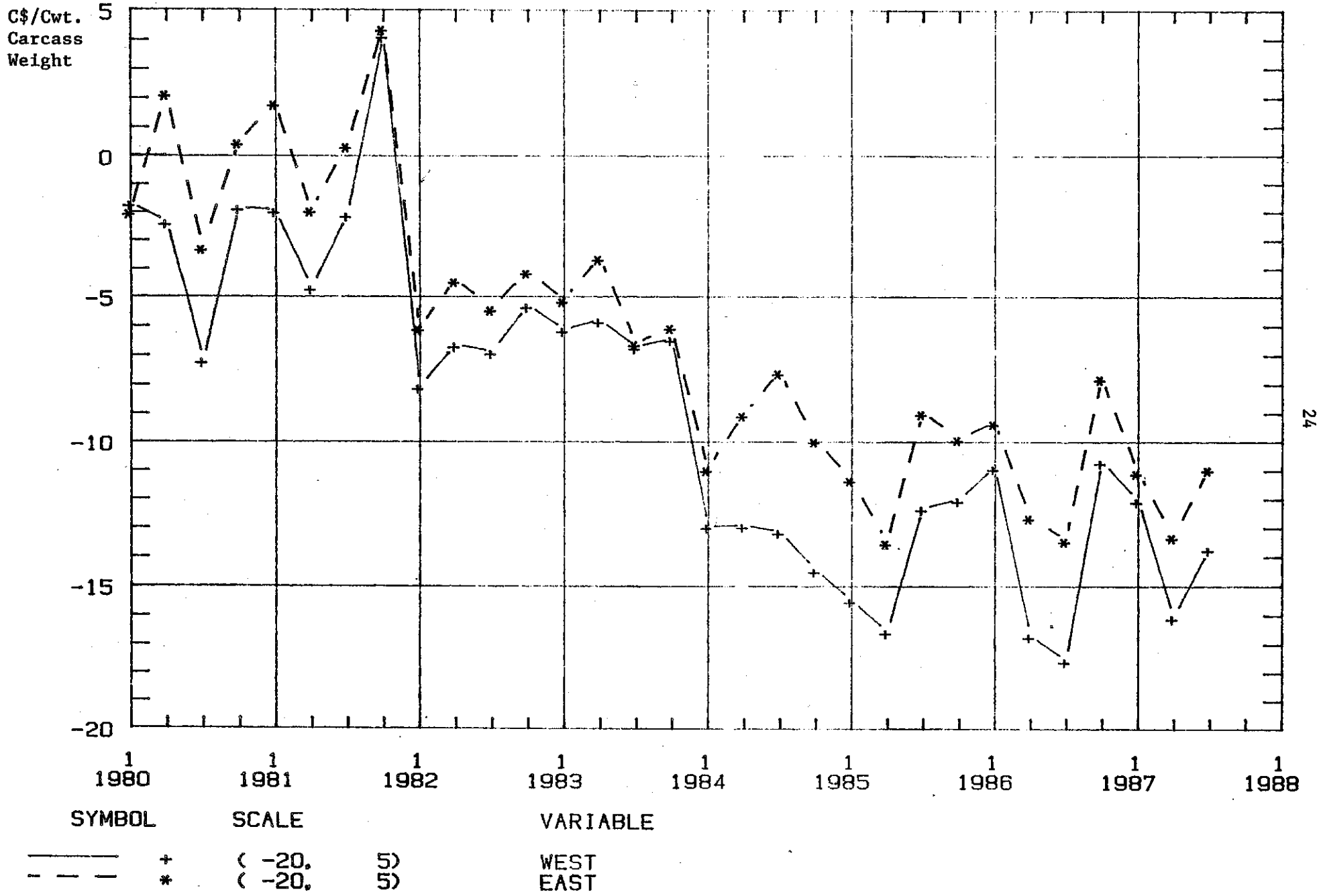


Table 8: Estimated Price Linkage Equations

LHS VAR RPPK3 R-SQR 0.99 D.W. 1.67
RANGE 1980 1 to 1986 2

Region	Qtr.	Intercept		Time	RPPK4* ER34	RPPK3(-1)
Pork		-22.54	Beta	0.31	0.73	0.19
Canada-U.S.	1	-0.85	T-Stat	3.5	11.67	2.78
	2	-0.9	Flexibility		0.73	
	3	1.65				

OLS ESTIMATES
LHS VAR PHG1 R-SQR 0.98 D. W. 1.79
RANGE 1982 1 to 1984 3, 1985 1 to 1987 2

Region	Qtr.	Intercept		(PHG4-TAR4HG3)* ER34	LOG (EXHG3)	PHG1(-1)
Hogs Western Canada-U.S.		14.61	Beta	0.85	-3.66	0.11
	1	-0.97	T-Stat	18.73	-5.38	2.33
	2	-1.79	Flexibility	0.95	0.05	
	3	0.046				

OLS ESTIMATES
LHS VAR PHG2 R-SQR 0.980 D.W. 1.52
RANGE 1982 1 to 1984 3, 1985 1 to 1987 2

Region	Qtr.	Intercept		(PHG4-TAR4HG3)* ER34	LOG (EXHG3)	PHG1(-1)
Hogs Eastern Canada-U.S.		7.25	Beta	0.9	-2.27	0.09
	1	-1.31	T-Stat	18.99	-3.46	1.88
	2	-0.98	Flexibility	0.97	-0.03	
	3	0.23				

tradeoff for a larger sample. In each equation the U.S. price, the log of exports, and a lagged dependent variable is included. The log of exports is included to account for any increase in transfer costs resulting from rising exports. The lagged price variable is included in each equation to account for any lagged adjustment factors.

Both equations have a high degree of explanatory power. The U.S. price variable is highly significant in both equations and indicates that a $1 Canadian change in the U.S. price results in a $0.85 change in the first quarter in Western Canada, and a $0.90 change in Eastern Canada.

3.7 The Identities

There are seven identities used to close the model. A Canadian price link equation combines the Eastern and Western hog price into a Canadian price which is the average price faced by Canadian processors. Two identities convert the number of hogs slaughtered into pounds of pork and four equations, two for pork and two for hogs, define and equate net trade in pork and hogs between Canada and the United States.

4.0 VALIDATING THE MODEL

The decision to accept or reject the specification of an individual equation is generally quite straightforward. Theory provides strong priors on the signs of coefficients and statistics representing the goodness of fit, multicollinearity, serial correlation and significance of variables are available to help judge the appropriateness of the specification. Nonetheless, although individual equations may be satisfactory their ability to "behave" with other equations becomes paramount when a model is constructed. Theory is less clear on these matters and the decision to accept a model as satisfactory is far more subjective.

Two methods used to evaluate the model will be discussed. The first is the Root Mean Squared Percentage Error (RMSPE) and the second is the regression of actual data on the simulated data from the model. In both cases the base simulation is obtained dynamically by simulating the model from 1982(1) to 1986(2).

The RMSPE is a measure of how well the simulated values correspond to the actual values. The formula for this statistic is

$$\text{RMSPE} = \frac{1}{n} \sum_{t=1}^{n} \left(\frac{A_t - P_t}{A_t} \right)^2$$

where, A_t = the actual value of the endogenous variable;

P_t = the simulated value of an endogenous variable;

n = the number of periods in the simulation.

The closer the simulated values are to the actual values over the course of the simulation, the lower the statistic. Table 9 shows the RMSPE for the endogenous variables. The supply and demand variables for both hogs

Table 9: Root Mean Square Percentage Errors for a Dynamic Simulation from 1982 1 to 1986 2

VARIABLE	RMSPE
Demand for hogs in Canada	3.7
Demand for hogs in U.S.	4.3
Demand for pork in Canada	3.4
Demand for pork in U.S.	3.8
Exports of hogs from Canada	72.1
Exports of pork from Canada	28.7
Pork inventories in Canada	16.7
Pork inventories in U.S.	16.2
Price of hogs in Western Canada	11.3
Price of hogs in Eastern Canada	11.0
Price of hogs Canada-wide	11.0
Price of hogs in the U.S.	10.5
Pork supply in Canada	3.7
Pork supply in U.S.	4.3
Retail pork price in Canada	3.8
Retail pork price in U.S.	4.2
Supply of hogs in Western Canada	7.4
Supply of hogs in Eastern Canada	2.8
Supply of hogs in the U.S.	4.3

and pork behave extremely well with only the supply of hogs in Western Canada having a RMSPE above 5%. The price variables are also quite well behaved. The pork price variables RMSPEs are both under 5% and all the price variables are under 15%.

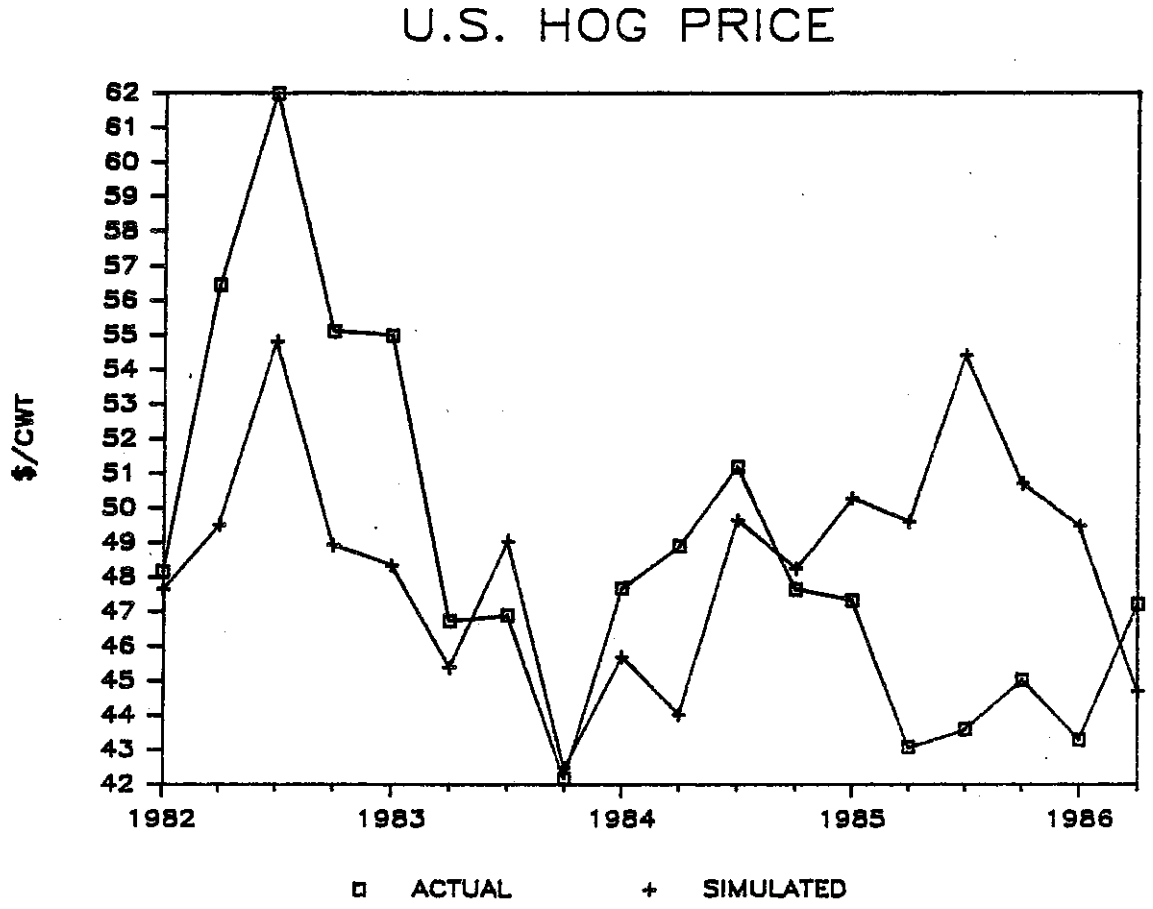
The RMSPEs for the net trade variables are large even though the simulation generally tracks well. This illustrates a short coming of the RMSPE measure since it is often very large for variables whose actual values are close to zero, even when the actual error is small.

A second test of the model is accomplished by regressing the actual values of the endogenous variables against their predicted values. Thus an equation of the form $AV = \alpha + \beta * PV$ is estimated where AV = actual value, PV = predicted values, α is an intercept and β is a slope parameter. A perfect fit would generate a zero intercept, a slope parameter of 1 and an R-squared of 1. Thus a test of the tracking ability of the model can be done by testing whether $\alpha = 0$, $\beta = 1$. A further F test can be done to test the joint hypothesis that $\alpha = 0$ and $\beta = 1$. These results are presented in Table 10.

The values of the squared correlation coefficients are smaller than desirable. Nine of the 19 variables have R-squared above 0.5 while one variable, the price of hogs in the U.S. has an R-squared of only 0.1. The results from the t and F tests are better. The null hypothesis that $\beta = 1$ is rejected for 8 of the 19 variables and that of $\alpha = 0$ is rejected for 4 of 19. The joint hypothesis that $\alpha = 0$ and $\beta = 1$ is rejected for 7 of the 19 variables.

A visual inspection of selected graphs helps give insight into the validity of these statistics. For example, the graph of the U.S. hog price (Figure 4) indicates that despite an R-squared of only 0.11, the

Figure 4: Actual and Simulated Values of U.S. Hog Price and Eastern Canada Hog Supply



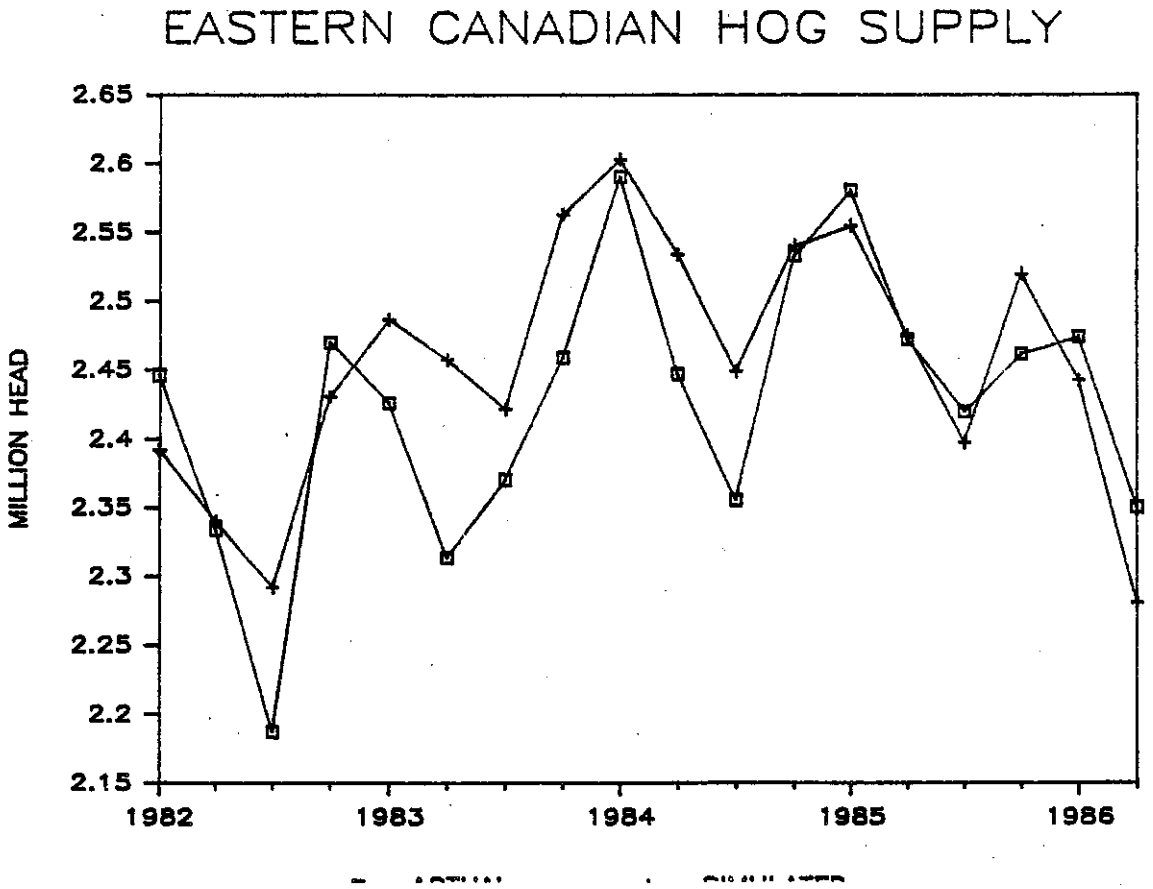


Table 10: Regression of Actual Values on Simulated Values from 1982 1 to 1986 2

Variable Name	R^2	t-Values B=1	t-Values a=0	F-Value a=0 and B=1
DHG3	0.48	0.11	0.43	5.70
DHG4	0.59	0.68	0.71	3.26
DPK3	0.52	0.33	0.51	1.53
DPK4	0.51	0.01	0.06	1.64
EXHG3	0.76	6.94	0.74	7.32
IPK3	0.44	6.99	2.04	13.67
IPK4	0.28	0.19	0.55	0.48
NT3PK4	0.39	3.99	3.37	13.49
PHG1	0.21	1.99	1.43	1.05
PHG2	0.18	2.13	1.47	1.09
PHG3	0.19	2.07	1.46	1.07
PHG4	0.11	1.36	1.18	0.70
QPK3	0.58	0.00	0.11	5.60
QPK4	0.61	0.60	0.66	3.08
RPPK3	0.66	4.28	2.18	3.75
RPPK4	0.36	0.00	0.01	1.30
SHG1	0.82	6.19	2.11	13.76
SHG2	0.61	0.91	0.89	2.13
SHG4	0.58	0.92	0.66	2.61

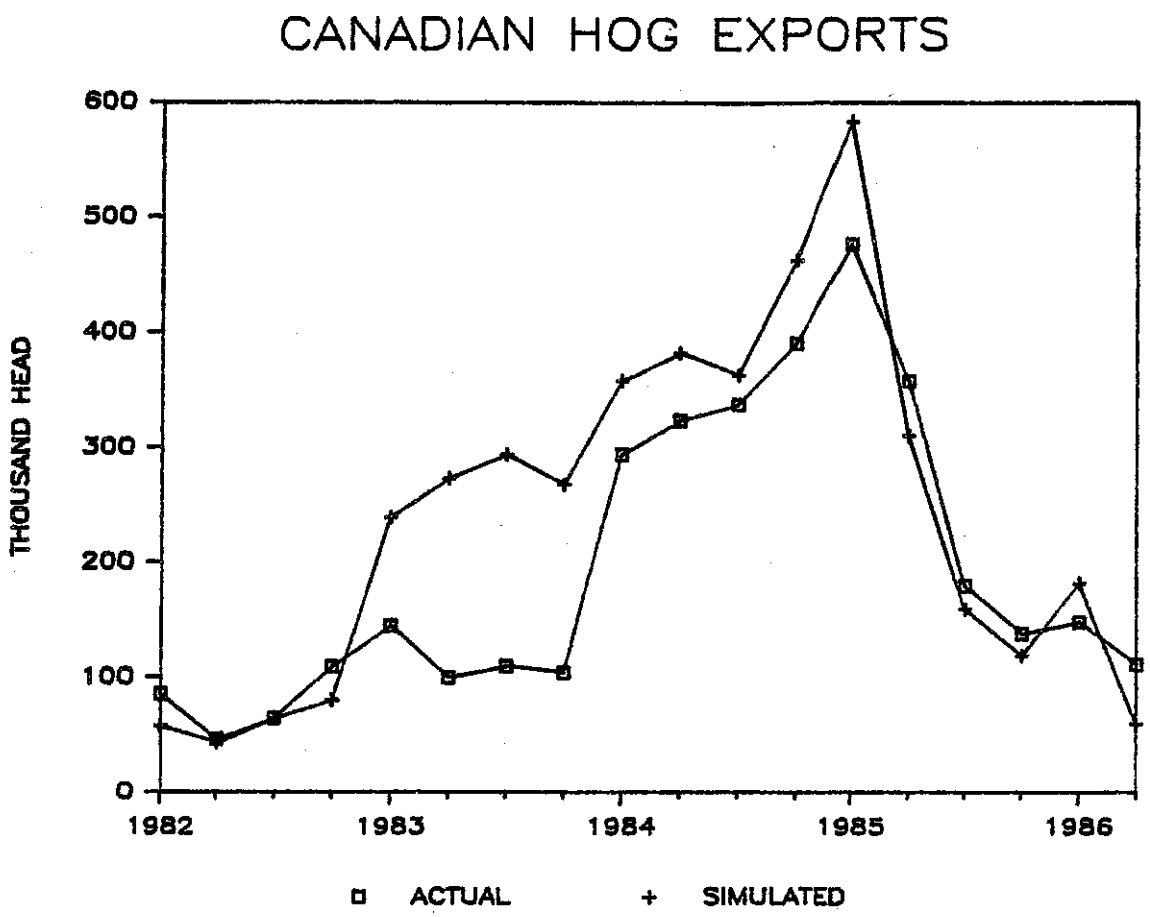
t-statistic at 5% level of significance and 16 d.f. = 1.746
F-statistic at 5% level of significance and 2/16 d.f. = 3.63

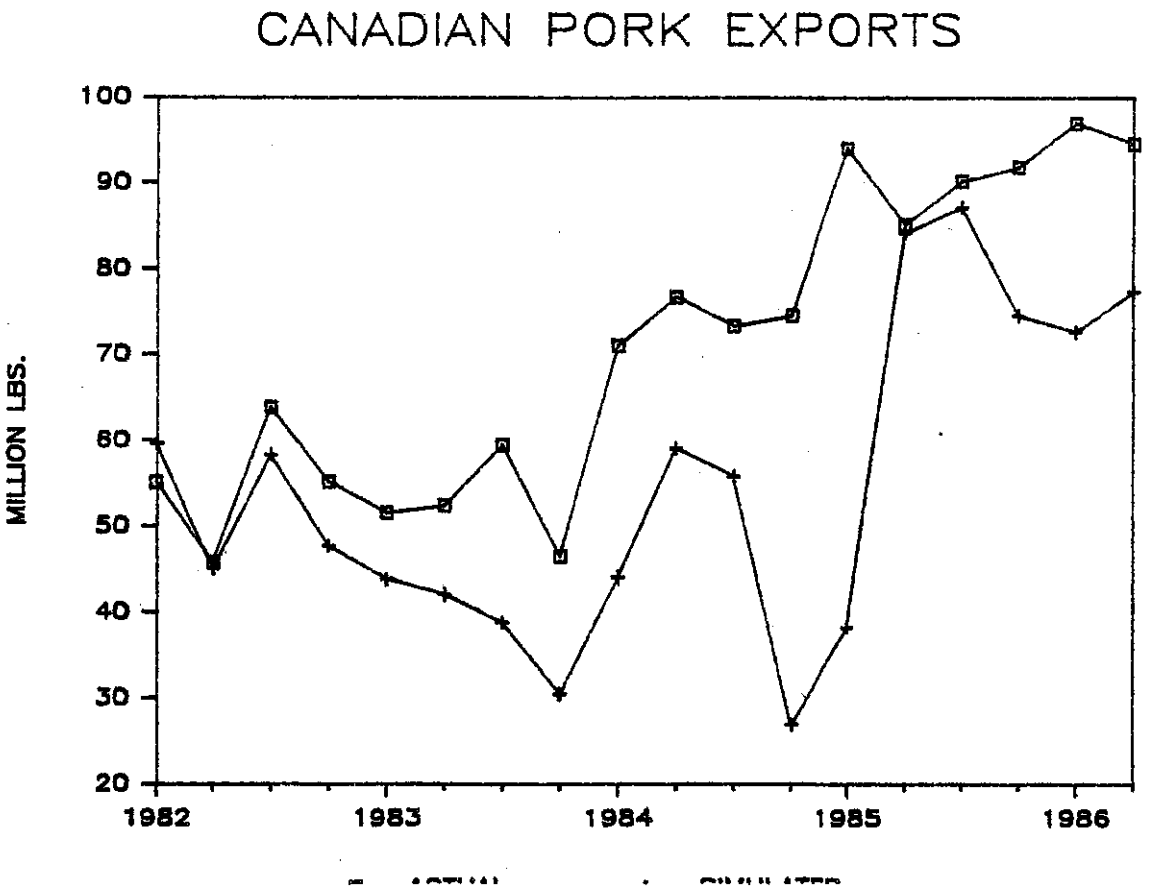
DHG3	Demand for hogs in Canada
DHG4	Demand for hogs in U.S.
DPK3	Demand for pork in Canada
DPK4	Demand for pork in U.S.
EXHG3	Exports of hogs from Canada
IPK3	Pork inventories in Canada
IPK4	Pork inventories in the U.S.
NT3PK4	Exports of pork from Canada to the U.S.
PHG1	Price of hogs in Western Canada
PHG2	Price of hogs in Eastern Canada
PHG3	Price of hogs Canada-wide
PHG4	Price of hogs in the U.S.
QPK3	Pork supply in Canada
QPK4	Pork supply in U.S.
RPPK3	Retail pork price in Canada
RPPK4	Retail pork price in U.S.
SHG1	Supply of hogs in Western Canada
SHG2	Supply of hogs in Eastern Canada
SHG4	Supply of hogs in the U.S.

simulated value tracks reasonably well until 1984(3) where it misses a turning point. The graph of the Eastern Canadian hog supply also shows how well the simulated values catch the turning points in the actual data despite an R-squared of 0.60. The two export variables are shown in Figure 5. These graphs emphasize how a few data values with large errors result in a high value for the RMSPE even though the overall tracking ability is adequate.

Thus, given these results, there is no a priori reason to say that the model does not behave as it should. Consequently, the model is used to evaluate policy changes.

Figure 5: Actual and Simulated Values of Canadian Hog and Pork Exports





5.0 POLICY ANALYSIS

A model describing the trade in hogs and pork between Canada and the U.S. has now been constructed and validated. The questions posed in the first section of the paper; what is the effect of a U.S. countervail duty on hog and pork trade, and what are the effects on consumers, processors and producers, can now be addressed through simulation experiments. The simulation experiments compare values obtained after a policy shock with a control or base simulation. For presentation purposes the base simulation represents the free trade situation i.e. no tariffs on hogs or pork.

Three policy simulations are carried out. The first is the imposition of a $4.39 Canadian per live cwt. duty on hog exports. This is the actual duty that was imposed in the second quarter of 1985. Because of the lagged supply response in the model it was decided to simulate the model as if the duty was imposed in the first quarter of 1983. This allows a longer period for adjustments to occur and the full effects of the tariff to be seen.

The second simulation is the imposition of a 5.3 cents per pound duty on fresh and frozen pork exports. This corresponds to the duty that was proposed at the same time as the hog duty. The final simulation is the imposition of both duties simultaneously. This allows for feedback effects and adjustments at both market levels. Like the first simulation these two are started in the first quarter of 1983 and run through the second quarter of 1986.

The comparison of the endogenous variables before and after the policy shock are made in both absolute and percentage terms. Space limitations prohibit the presentation of graphs for all variables but the

most relevant ones are included.

5.1 Hog Tariff Only

The initial impact of the imposition of the tariff of $4.39 Can./live cwt. on hogs (approximately equal to a 7% tariff relative to the Canadian price) is to lower the hog price in Toronto by $2.4 Can./carcass cwt. and to raise the price in the U.S. by $0.4 U.S./live cwt. (Table 11).

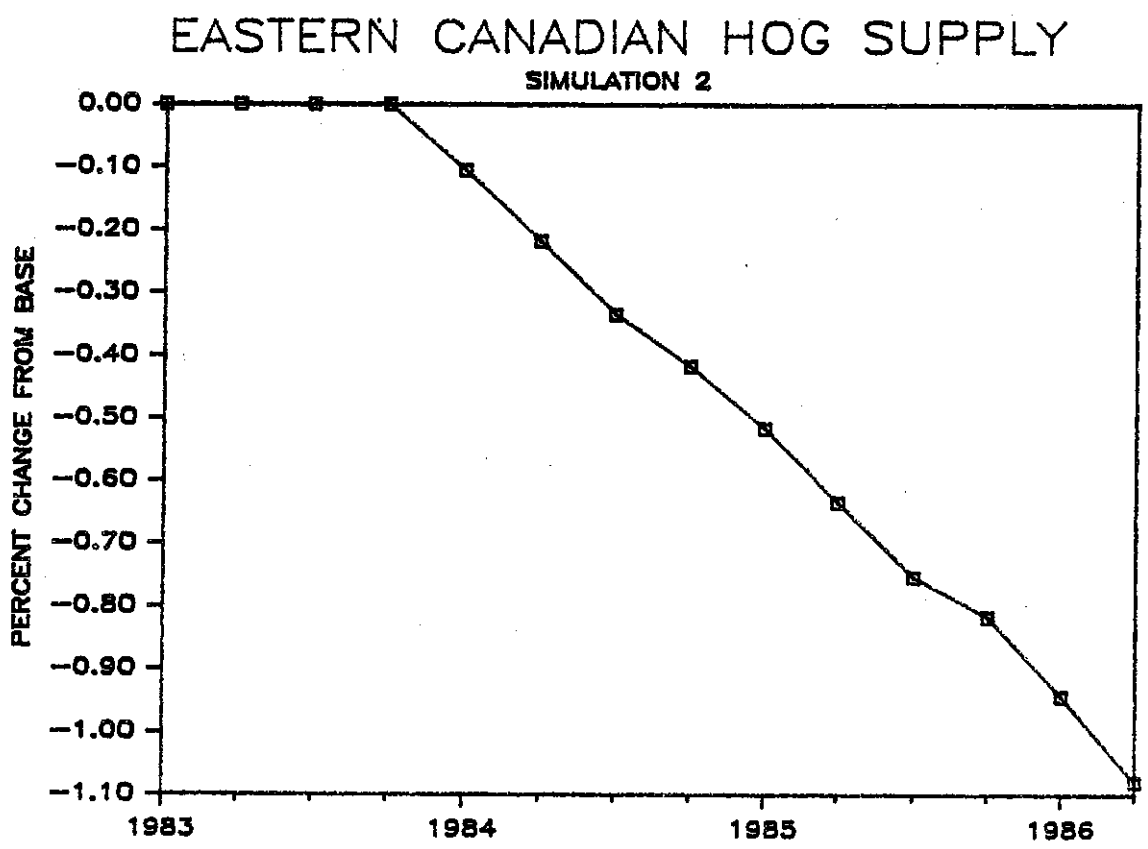
This simulation illustrates the importance of the hog trade variable in the Canada-U.S. price linkage equations. Normally, when one country places a tariff on another country's exports it drives a wedge between the prices in the two countries equal in size to the tariff (Houck). In this case, however, the increase in the price spread between Toronto and the U.S. is only $2.26 Can./live cwt. - implying that transfer costs decline by $2.13 Can./live cwt., in Eastern Canada, as a result of the decline in hog exports. The price decline in Western Canada is even smaller than the East because of the larger estimated impact of the trade variable in the price link equation. On average, over the simulation period Eastern Canadian hog prices decline by $3.2/carcass cwt. and U.S. prices increase by $0.30 /live cwt.

The change in hog prices influences the demand for hogs in both countries. In Canada the demand is increased, on average, by 4.7% and in the U.S. it is lowered by 0.6%. Because Canada is a net exporter of both hogs and pork, an increase in domestic hog demand is translated directly into an increase in domestic pork supply. Thus pork supply in Canada increases by 4.7% and U.S. pork supply falls by 0.4%. This results both from a lower demand for domestic hogs and a lower demand for imported hogs. Canadian exports of hogs decline by 61.3% in the first quarter of

Table 11: Simulated Effects of a Countervailing Duty on Canadian Hogs Only, 1983(1) to 1986(2)

	Units	First Quarter		Last Quarter		Average	
		unit Δ	percent Δ	unit Δ	percent Δ	unit Δ	percent Δ
CANADA							
Hog Demand	'000 head	119.6	3.6	97.0	3.0	152.2	4.7
Hog Supply, East	'000 head	0.0	0.0	-24.8	-1.1	-10.3	-0.4
Hog Supply, West	'000 head	0.0	0.0	-8.3	-0.7	-3.1	-0.3
Hog Exports	'000 head	-119.6	-61.3	-130.2	-67.4	-165.6	-50.2
Hog Price, East	C$/car.cwt.	-2.4	-2.9	-2.7	-3.7	-3.2	-4.3
Hog Price, West	C$/car.cwt.	-0.9	-1.1	-0.9	-1.3	-1.9	-2.7
Net Revenue, East	mil. C$	-8.2	-4.7	-10.3	-7.5	-11.7	-10.4
Net Revenue, West	mil. C$	-1.2	-1.6	-2.0	-2.7	-3.2	-5.3
Pork Demand	mil. lbs.	0.0	0.0	0.8	0.2	0.4	0.1
Pork Supply	mil. lbs.	16.8	3.6	13.6	3.0	21.2	4.7
Pork Net Exports	mil. lbs.	16.8	24.6	6.4	20.1	20.7	38.7
Pork Price	index	0.0	0.0	-0.4	-0.3	-0.2	-0.2
Processors Prod. Sur.	index	691.7	7.4	601.5	6.1	924.6	9.5
Consumer Surplus	index	0.0	0.0	229.6	0.4	112.6	0.2
UNITED STATES							
Hog Demand	'000 head	-119.6	-0.6	-59.1	-0.3	-127.7	-0.6
Hog Supply	'000 head	0.0	0.0	71.0	0.3	37.9	0.2
Hog Price	US$/live cwt.	0.4	0.6	0.0	0.1	0.3	0.7
Net Revenue	mil. US$	16.0	1.0	6.4	0.5	17.6	1.4
Pork Demand	mil. lbs.	0.0	0.0	7.1	0.2	4.3	0.1
Pork Supply	mil. lbs.	-16.8	0.0	-5.8	-0.2	-16.4	-0.4
Pork Price	US ¢/lb.	0.0	0.0	0.0	-0.3	-0.0	-0.2
Processors Prod. Sur.	mil. US$	-33.4	-0.9	-18.2	-0.5	-34.1	-0.7
Consumer Surplus	mil. US$	0.0	0.0	12.4	0.4	7.6	0.2

Figure 6: Simulated Effect of a Hog Tariff on U.S. and Eastern Canada Hog Supply



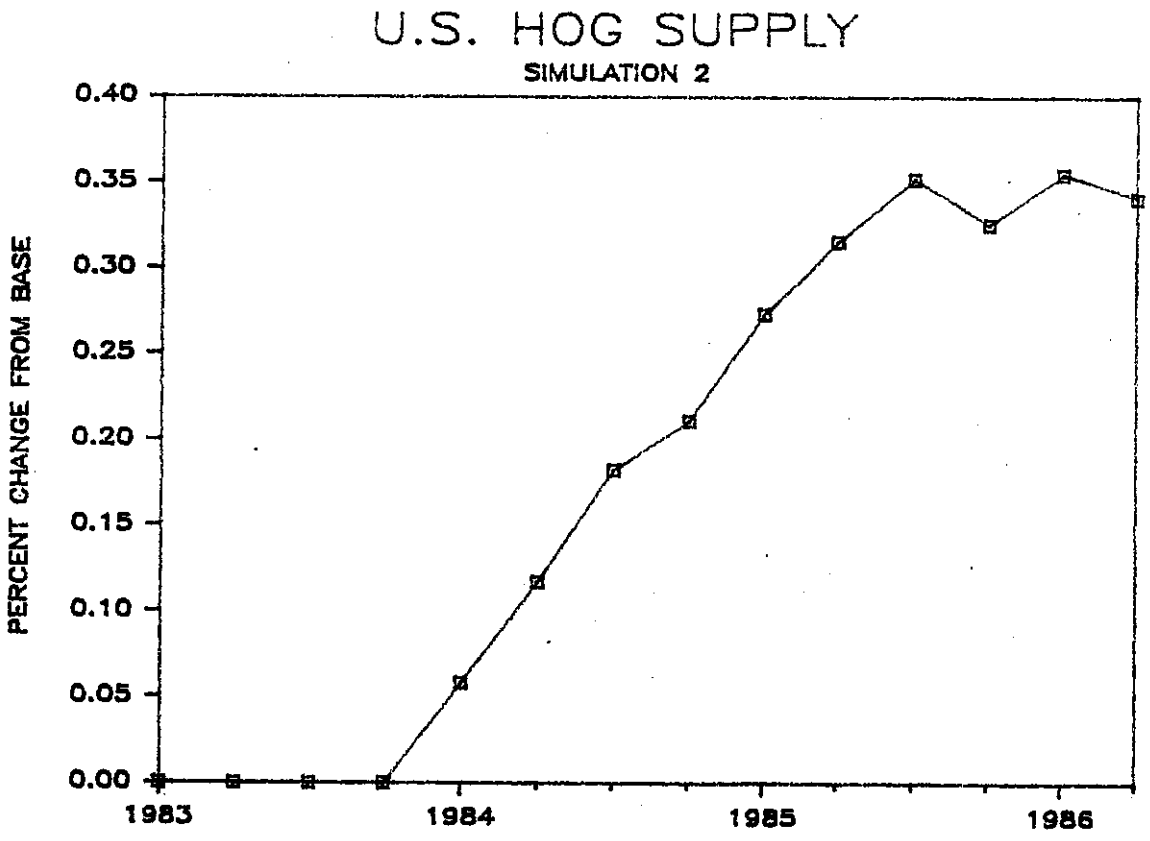
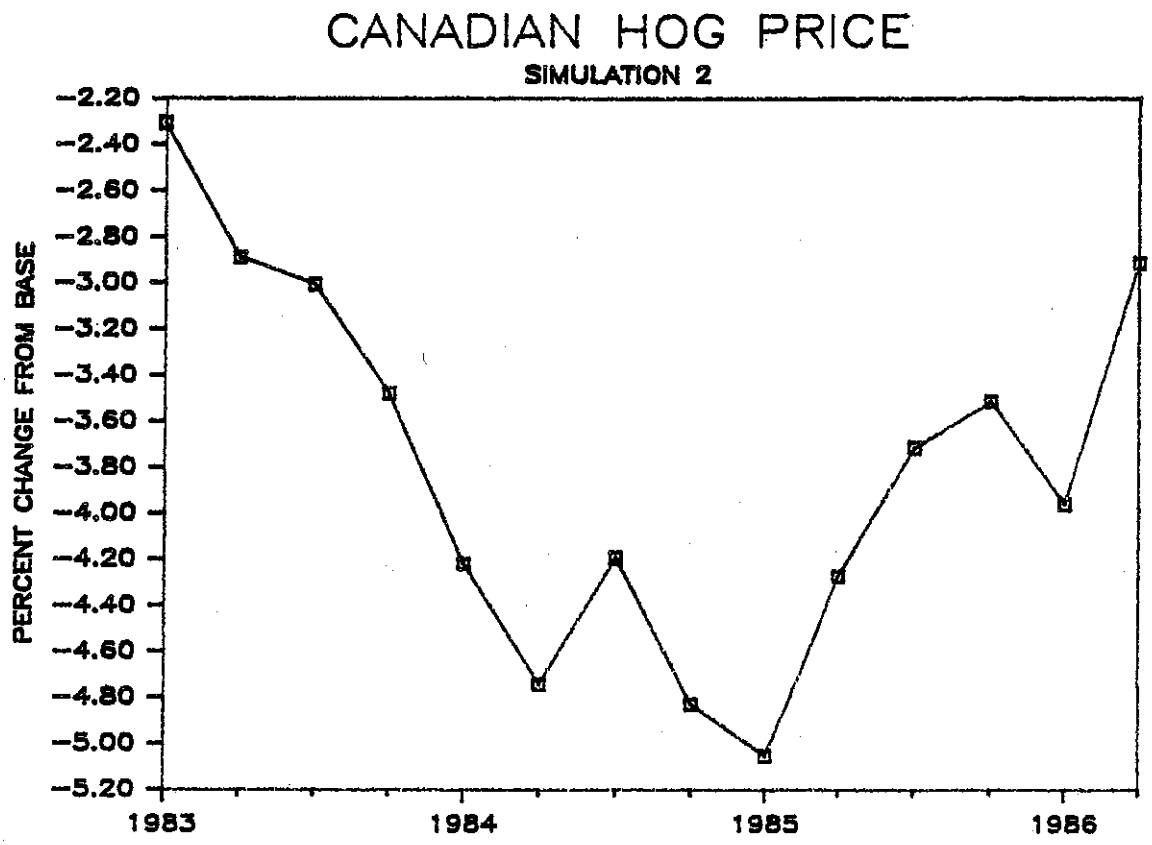


Figure 7: Simulated Effect of a Hog Tariff on U.S. and Canadian Hog Prices



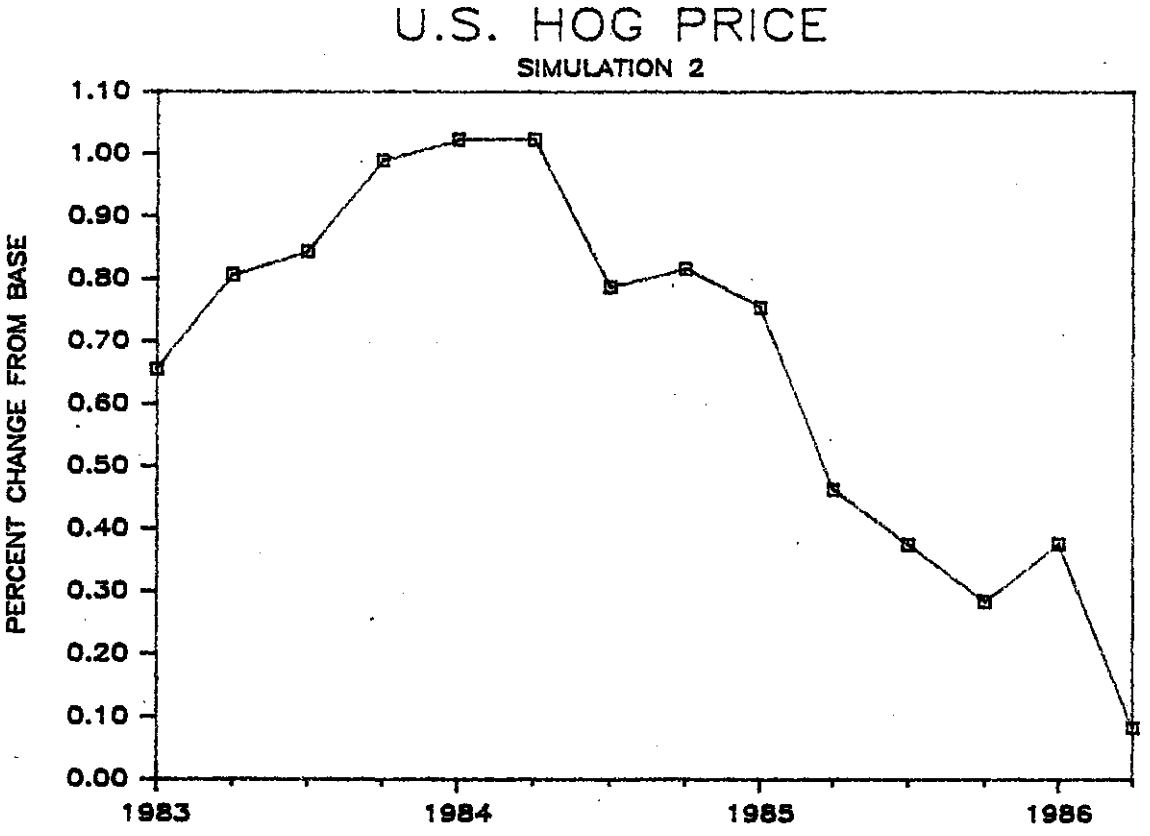
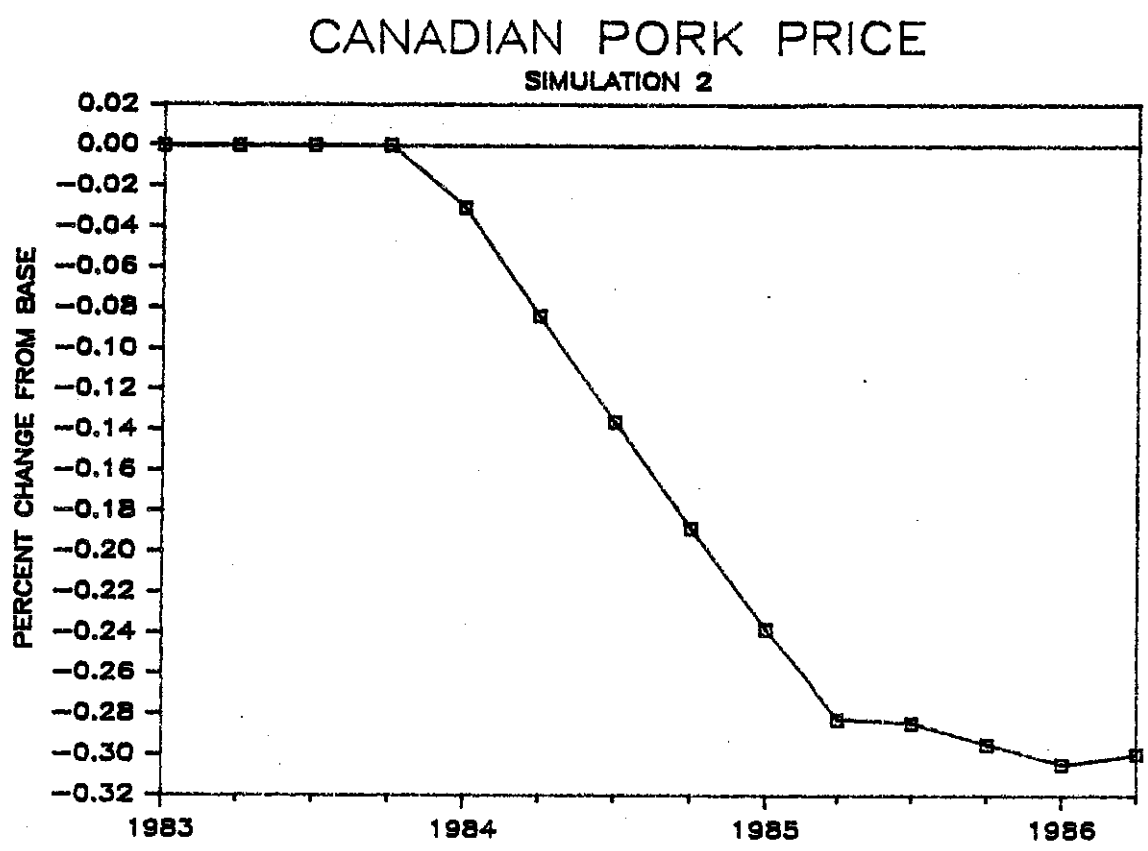


Figure 8: Simulated Effect of a Hog Tariff on U.S. and Canadian Pork Prices



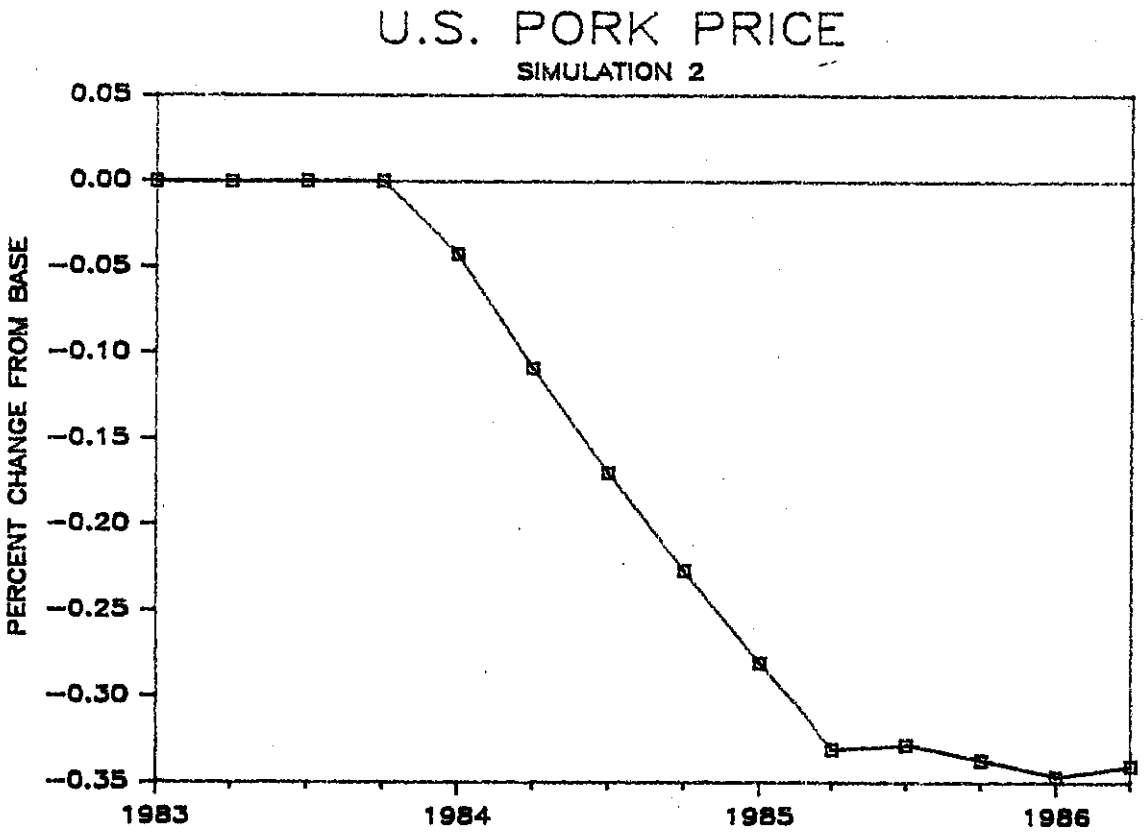
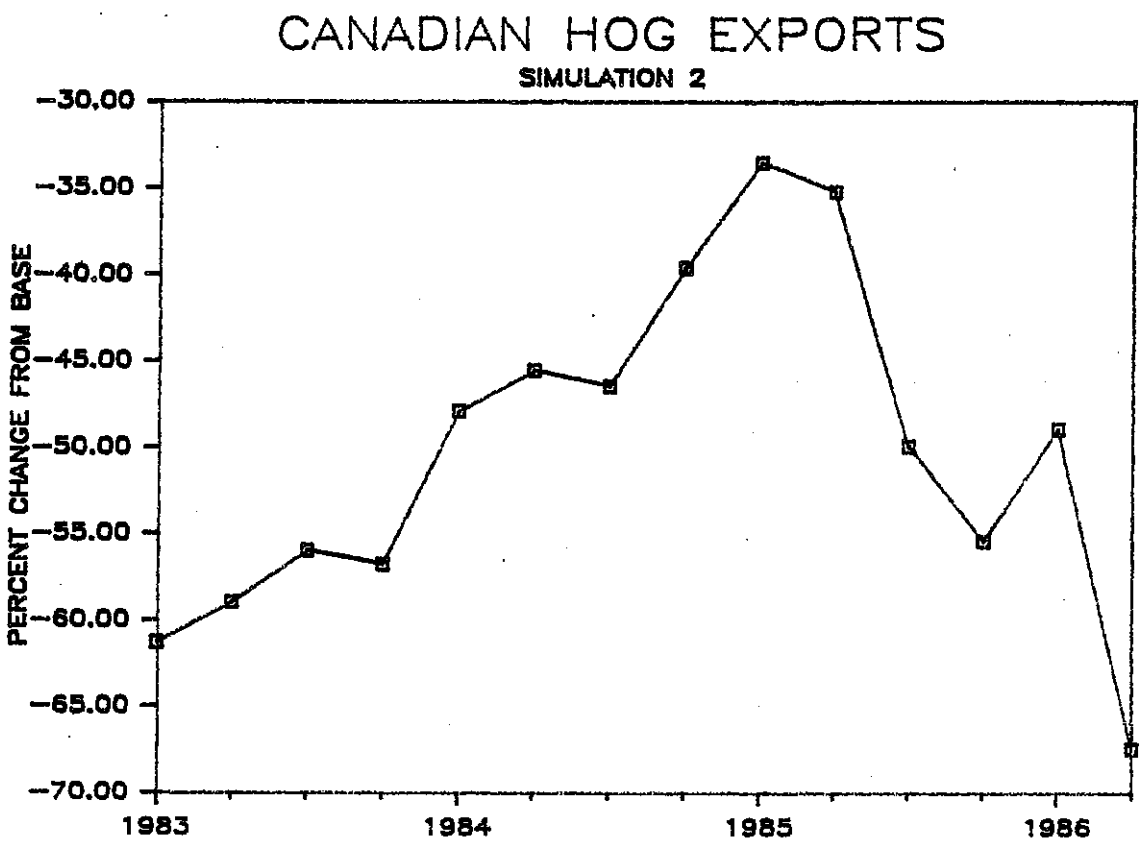
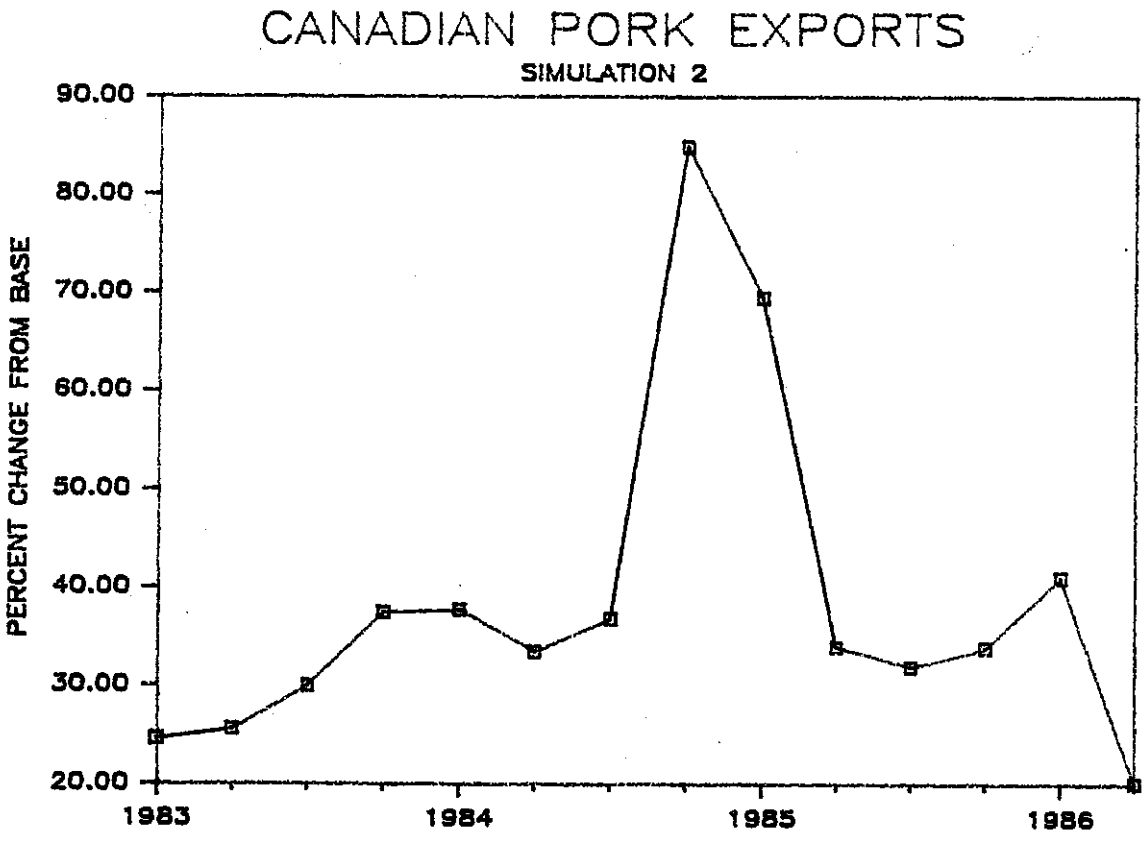


Figure 9: Simulated Effect of a Hog Tariff on Canadian Hog and Pork Exports





the simulation and 50.2% on average.

The decrease in pork supply in the U.S. market results in an increase in pork imports of 20.7 million pounds per quarter, slightly less than the pork equivalent (23.0 mil. lbs/quarter) of lost hog exports (165,617 head/quarter). The price of pork in both countries declines slightly as a result of hog supply increasing more in the U.S. than it declines in Canada.

Initially, net revenues, over feed costs, in Western Canada fall by 1.6% and by 4.7% in Eastern Canada. In the U.S. they rise by 1.0%. Because of the lags in the supply equations the output of hogs begins to react to the duty only after four quarters. The dynamics of the adjustments are as follows. Hog supply in Canada reacts to the lower prices by drifting steadily lower. In Western Canada the final quarter of the simulation evidences a 0.7% drop below the base. Eastern Canada follows a similar pattern with supply declining by 1.1% by the end of the simulation. In contrast the U.S. hog supply rises to 0.3% above the base by the second quarter of 1985 and appears to stabilize at this level.

The maximum increase in the U.S. price of hogs occurs in the fifth quarter following the start of the simulation at 1.0% above the base. From here, as hog supply increases, the price moves lower and finishes the simulation just 0.1% above the base. The Eastern Canada price falls to 5.3% below the base by the first quarter of 1985 and then rises to around 3.7% below the base simulation by the end of the period.

As the U.S. hog price adjusts upwards the demand for hogs in the U.S. begins to decline and averages a fairly consistent 0.6% below the base. This declining hog demand is translated into a decline in U.S. pork supply although for the first four quarters of the simulation North

American hog supply and hence pork supply are unchanged. Consequently, pork prices are also unchanged for the first four quarters. Following this pork prices in both countries decline slightly as the result of a small increase in total hog/pork production.

The increasing demand for pork in the U.S. is met partly by imports from Canada. Exports from Canada increase to reach a level 84.9% above the base halfway through the simulation and then fall back to finish 20.1% above. On average Canada exports 20.7 million more pounds of pork per quarter. Canada's increasing exports are met by higher supplies of pork, increasing as much as 6.2% above the base but averaging 4.7% above the no tariff level. Higher pork supply is translated into higher hog demand on a 1 to 1 ratio. Hog processors in Canada benefit significantly from the hog duty with their welfare increasing, on average, by 9.5%. Conversely, U.S. hog processors' welfare declines by somewhat less than 1%.

5.2 Pork Tariff Only

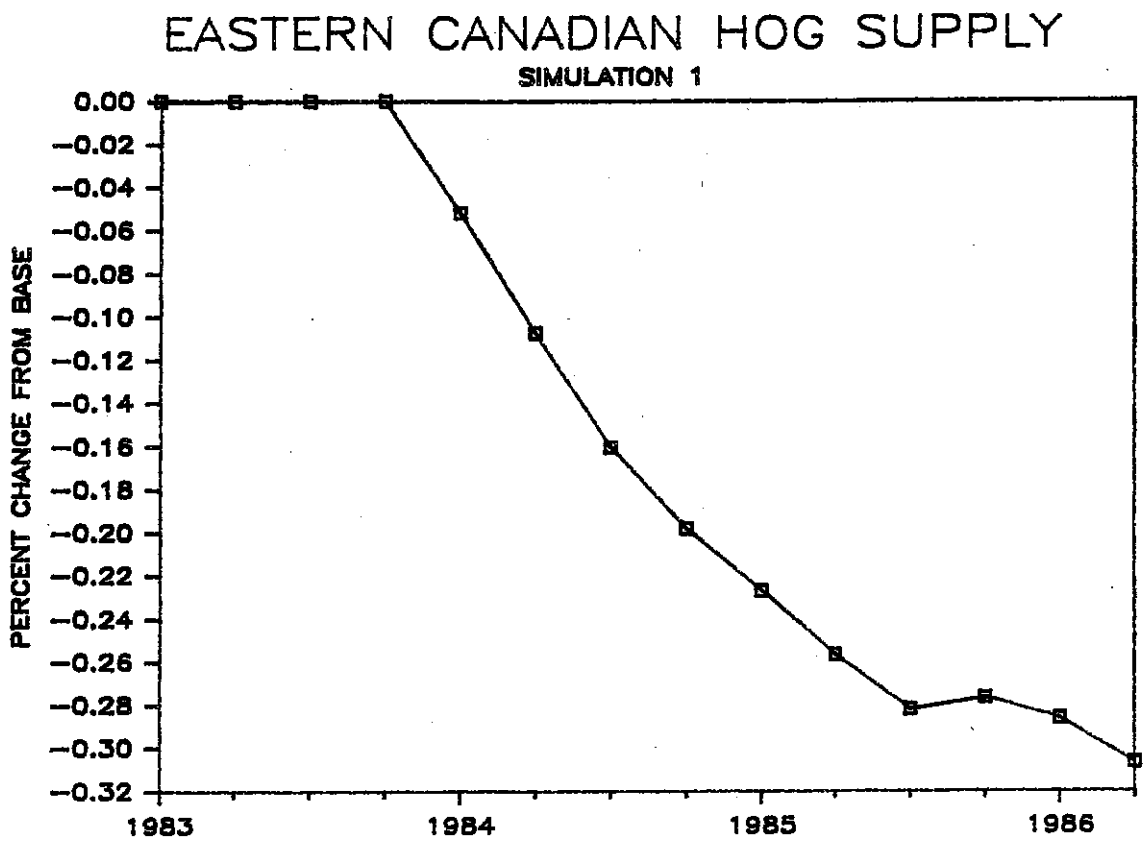
The initial impact of a pork tariff of 5.3 Can. cents per pound on fresh or frozen pork is to lower the pork price in Canada by 1.7% (Table 12) and to raise the price of pork in the U.S. by 0.1%. This indicates that the excess demand curve facing Canadian pork is very elastic. The result is a lower demand for hogs and smaller supply of pork in Canada, averaging 3.4%.

Lower hog demand results in a lower Canadian hog price. Hog prices fall initially by 2.1% in the West and 1.4% in the East. The lower hog price in Canada initially has no effect on supply. Thus a lower level of pork trade is offset by a higher level of hog trade, 44.4% to be precise.

Table 12: Simulated Effects of a Countervailing Duty on Canadian Pork Only, 1983(1) to 1986(2)

	Units	First Quarter		Last Quarter		Average	
		unit Δ	percent Δ	unit Δ	percent Δ	unit Δ	percent Δ
CANADA							
Hog Demand	'000 head	-86.7	-2.6	-98.6	-3.1	-112.2	-3.4
Hog Supply, East	'000 head	0.0	0.0	-7.1	-0.3	-3.8	-0.2
Hog Supply, West	'000 head	0.0	0.0	-4.7	-0.4	-2.9	-0.3
Hog Exports	'000 head	86.7	44.4	86.8	45.0	105.5	32.9
Hog Price, East	C$/car.cwt.	-1.2	-1.4	-0.9	-1.2	-0.9	-1.2
Hog Price, West	C$/car.cwt.	-1.6	-2.1	-1.4	-2.0	-1.3	-1.9
Net Revenue, East	mil. C$	-4.1	-2.3	-3.3	-2.4	-3.4	-3.1
Net Revenue, West	mil. C$	-2.3	-3.0	-2.6	-3.5	-2.2	-3.6
Pork Demand	mil. lbs.	5.1	1.4	4.8	1.3	5.2	1.4
Pork Supply	mil. lbs.	-12.2	-2.6	-13.8	-3.0	-15.6	-3.5
Pork Net Exports	mil. lbs.	-17.6	-25.8	-18.6	-29.2	-20.9	-38.2
Pork Price	index	-2.1	-1.7	-2.2	-1.8	-2.3	-1.9
Processors Prod. Sur.	index	-485.8	-5.2	-593.5	-6.0	-654.6	-6.7
Consumer Surplus	index	767.4	2.8	1347.3	2.5	1363.7	2.8
UNITED STATES							
Hog Demand	'000 head	86.7	0.4	62.4	0.3	88.5	0.4
Hog Supply	'000 head	0.0	0.0	-24.4	-0.1	-17.0	-0.1
Hog Price	US$/live cwt.	-0.2	-0.4	0.0	0.1	-0.1	-0.2
Net Revenue	mil. US$	-9.0	-0.6	-0.5	0.0	-6.3	-0.5
Pork Demand	mil. lbs.	-5.2	-0.2	-10.7	-0.3	-9.2	-0.2
Pork Supply	mil. lbs.	12.2	0.3	7.9	0.2	11.7	0.3
Pork Price	US ¢/lb.	0.0	0.1	0.0	0.5	0.0	0.4
Processors Prod. Sur.	mil. US$	25.7	0.7	24.1	0.6	29.5	0.7
Consumer Surplus	mil. US$	-7.7	-0.3	-18.8	-0.6	-15.9	-0.5

Figure 10: Simulated Effect of a Pork Tariff on Eastern Canada and U.S. Hog Supply



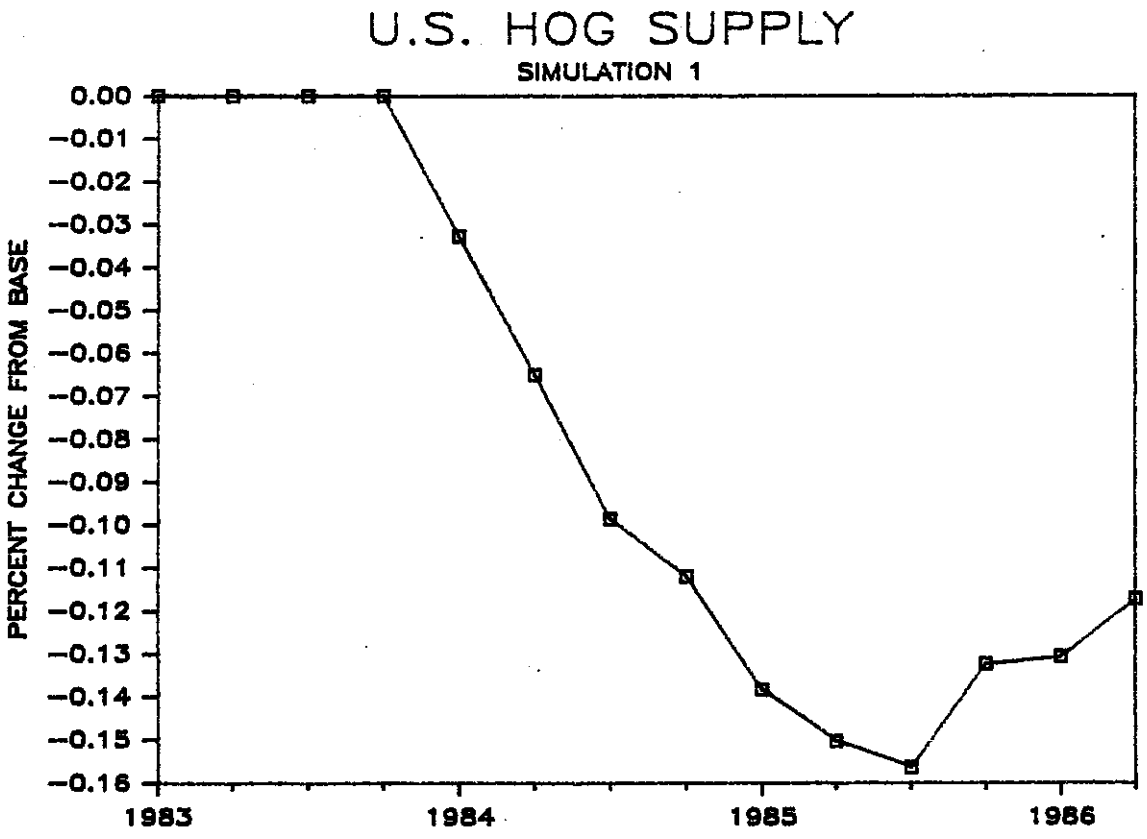
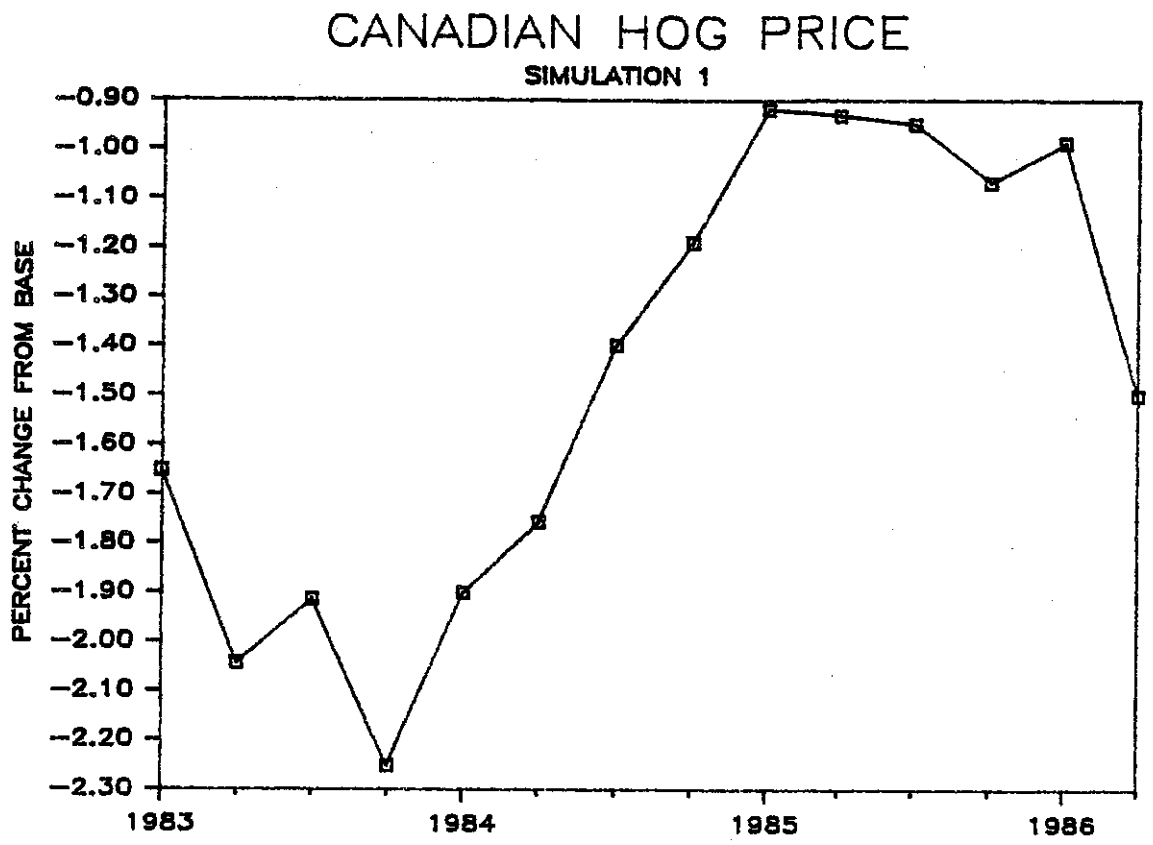


Figure 11: Simulated Effect of a Pork Tariff on the U.S. and Canadian Hog Price



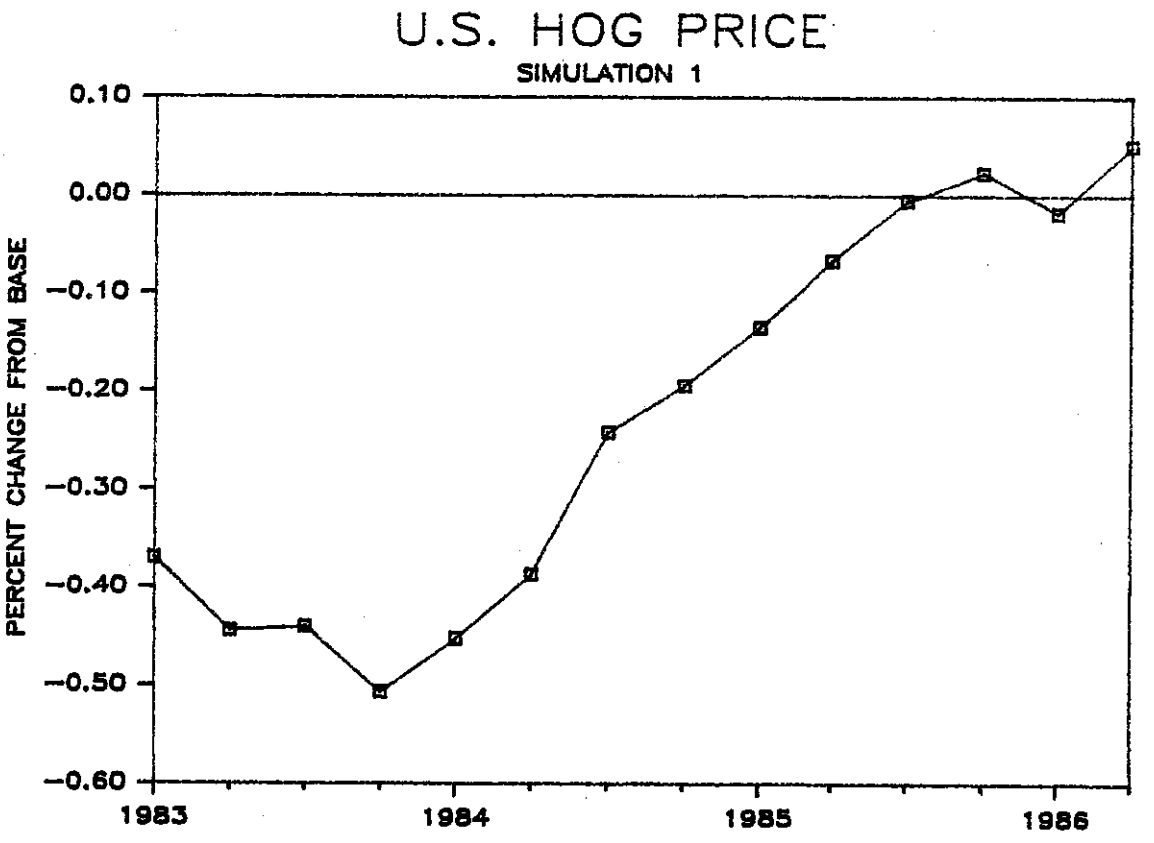
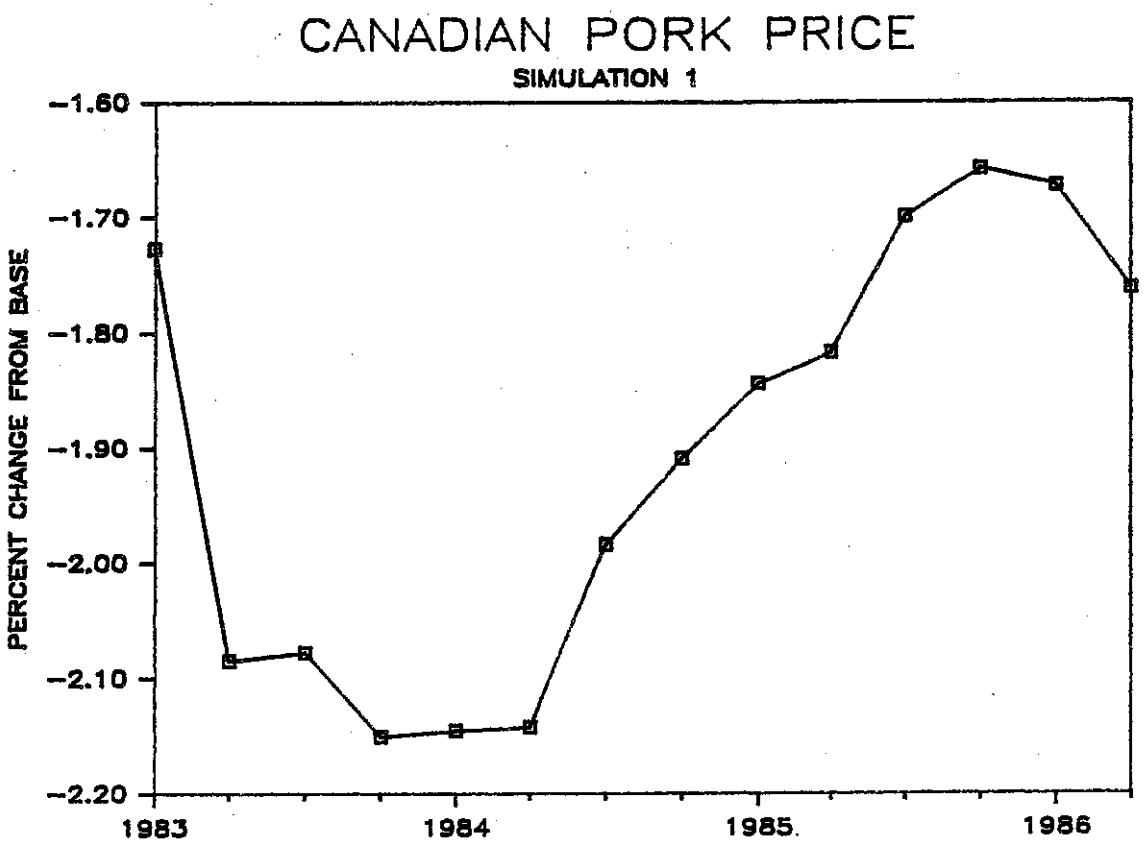


Figure 12: Simulated Effect of a Pork Tariff on U.S. and Canadian Pork Prices



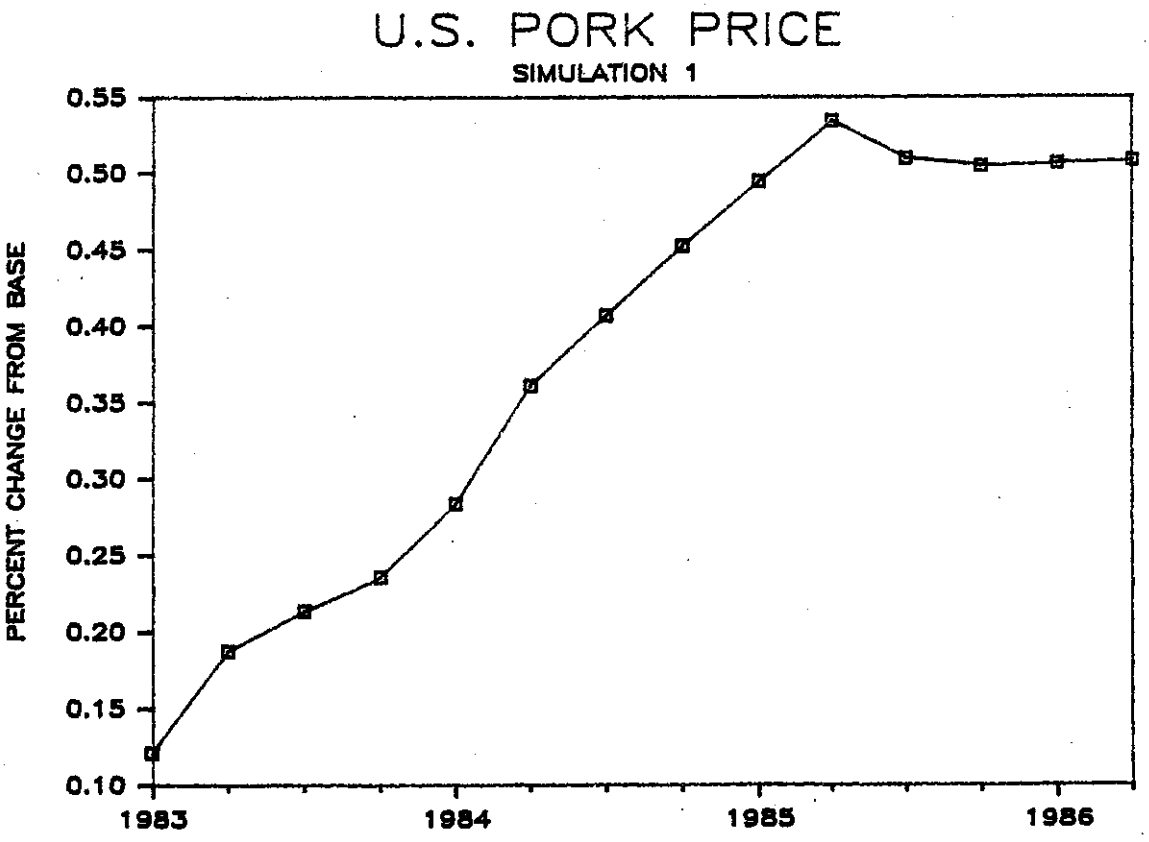
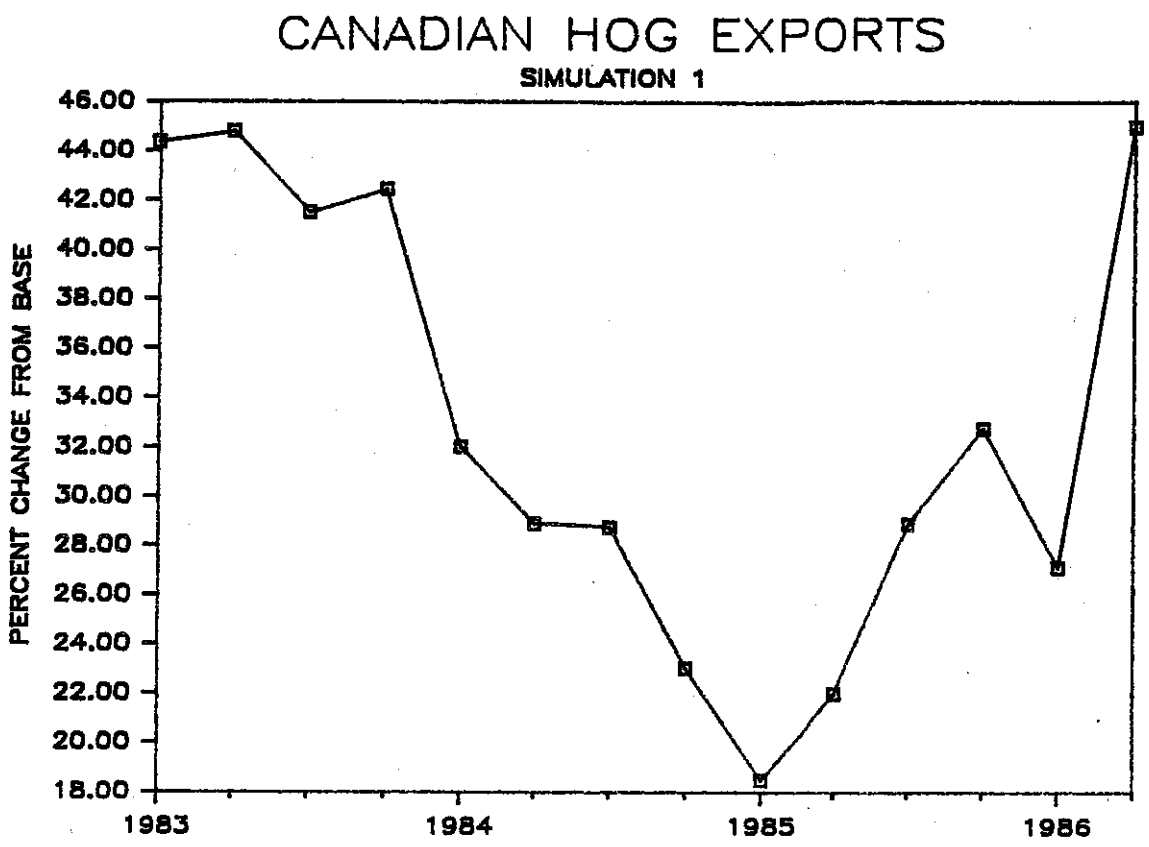
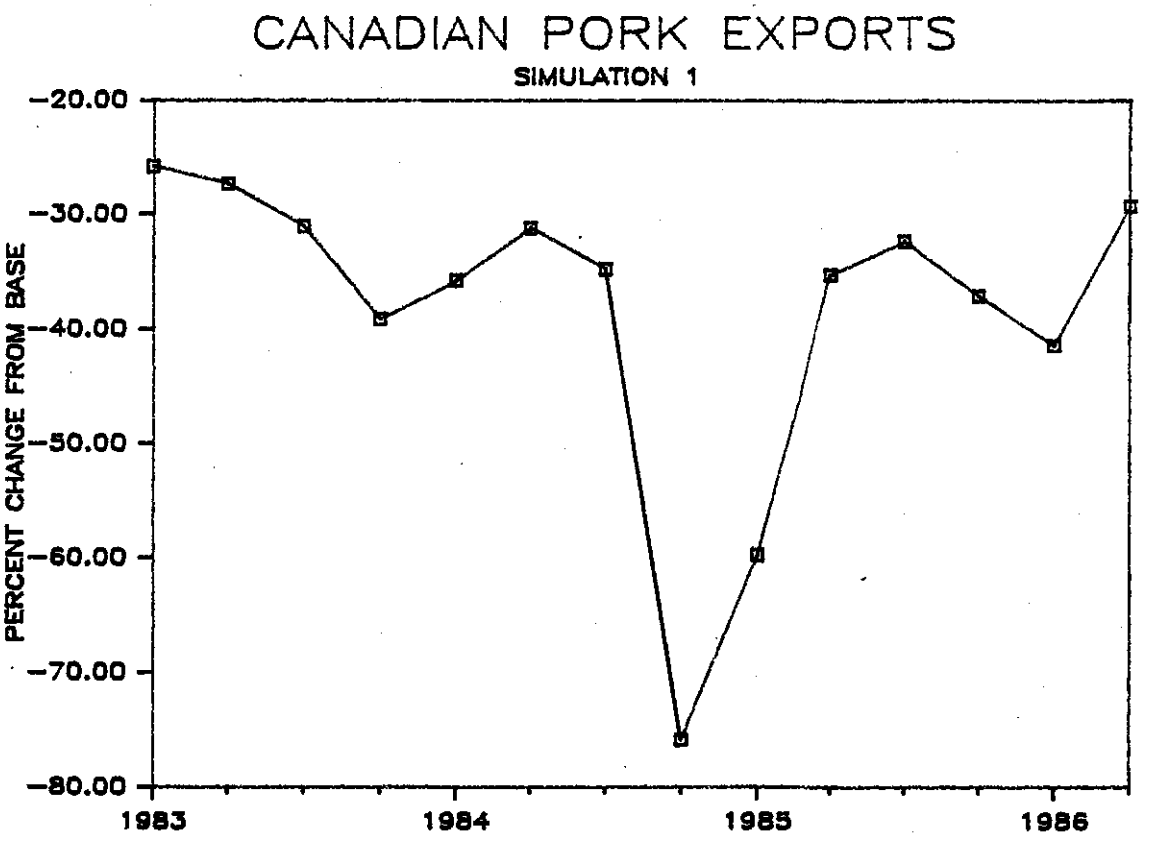


Figure 13: Simulated Effect of a Pork Tariff on Canadian Exports of Hogs and Pork





The larger supply of hogs in the U.S. causes their price to fall by 0.4%. The demand for hogs and the supply of pork in the U.S. increases by 0.4%.

The initial impact then is for pork prices to fall in Canada and rise in the U.S. and hog prices to fall in all regions. Under these conditions the effects on net revenue above feed costs for hog producers are obvious. In Eastern Canada there is an initial 2.3% drop, in Western Canada there is a 3.0% drop and in the U.S. there is a 0.6% drop.

Once again, as the supply side of the model begins to react, adjustments occur. After a four quarter lag in which hog prices have been lower, both Canadian and U.S. hog supply move down until the second quarter of 1985 where they begin to stabilize. The average drop in supply is 0.3% in Western Canada, 0.2% in Eastern Canada and 0.1% in the U.S.

As hog supplies are reduced, the fall in hog prices is first halted and then reversed. After four quarters the Eastern Canada average hog price had fallen by 1.9% from the base level but it then moves steadily higher to only 0.8% below the base level in the penultimate quarter. The U.S. hog price reaches a low of 0.5% below the base in the fourth quarter but then reverses direction to finish slightly above the base level by the end of the simulation.

In Canada, the demand for hogs declines steadily until the first quarter of 1985 where it reaches a maximum of 4.0% below the base before recovering to end the simulation at 3.1% below. The U.S. demand for hogs runs consistently above base levels. Canadian hog processors suffer welfare losses with a pork tariff only (6.7% on average) and U.S. processors gain (0.7%).

The pork tariff reduces trade in pork throughout the simulation at a

fairly consistent level of 20.9 mil. lbs/quarter. Trade in hogs is more cyclical, starting at 86,657 head/quarter above the base level and ending at about the same point, although at its peak hog exports are up by 116,857 head/quarter.

Net revenues above feed costs are lower in all regions declining on average by $2.2, $3.4 and $6.3 million per quarter in Western Canada, Eastern Canada and the U.S., respectively.

5.3 Hog and Pork Tariffs

The simultaneous imposition of a duty on both hogs and pork initially lowers both prices in Canada by 4.8% and 1.7% respectively and raises both prices in the U.S. by 0.4% and 0.1% respectively (Table 13). Looking first at the Canadian market, a lower hog price raises the demand for hogs by 1.9% and thus the supply of pork by 1.9%. The lower pork price raises the demand for pork by 1.4%. The combination of these effects benefits Canadian hog processors.

In the U.S. the demand for hogs drops by 0.3% and the demand for pork drops by 0.2%. The supply of pork drops by 0.3%. The net drop in U.S. supply relative to demand is made up by increasing imports of pork of 4.8%. The supply of hogs is fixed for four quarters so the increasing demand for hogs and pork in Canada translates to hog exports that are lower by 31.6%.

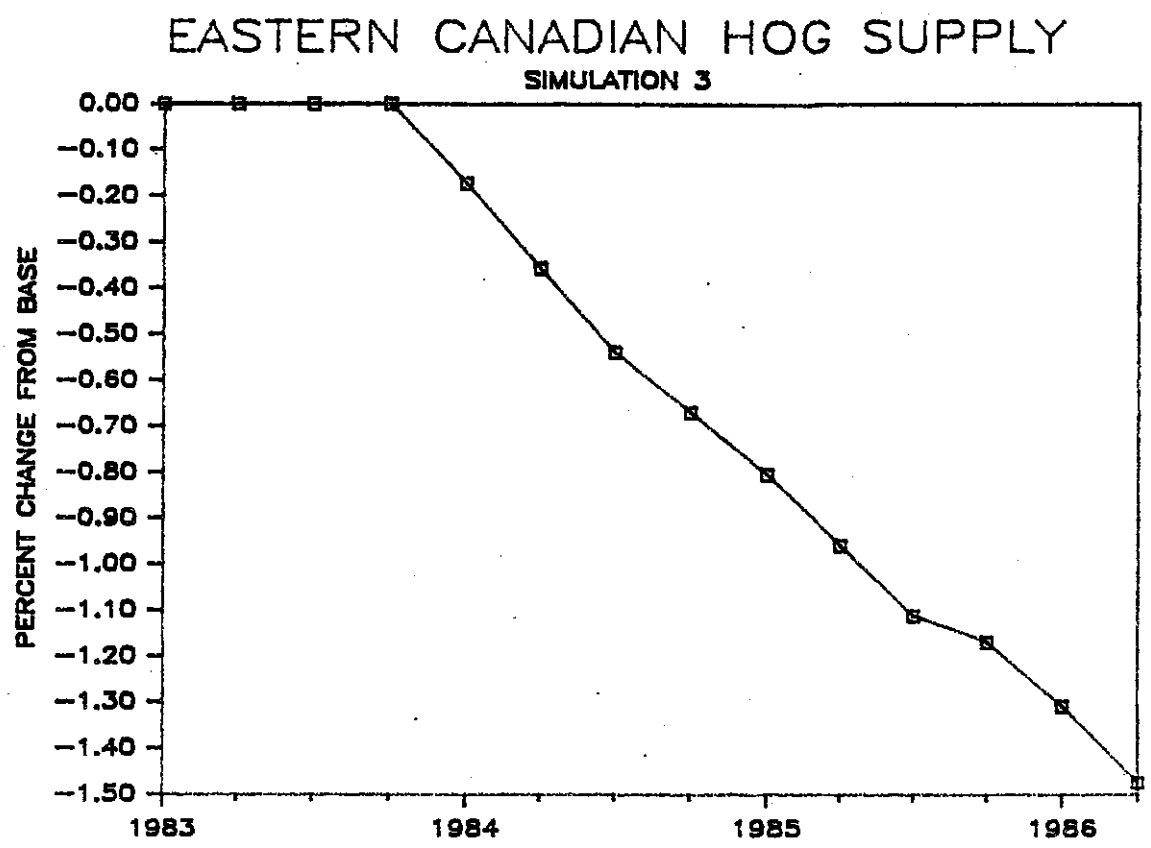
The tariffs work to lower the net revenue above feed costs in Western Canada by 5.7% and in Eastern Canada by 7.7%. In the U.S. net revenues rise by 0.7%.

After four quarters hog supply begins to react to price changes. The lower hog price in Canada causes the supply of hogs to decrease steadily

Table 13: Simulated Effects of a Countervailing Duty on Canadian Hogs and Pork, 1983(1) to 1986(2)

	Units	First Quarter		Last Quarter		Average	
		unit Δ	percent Δ	unit Δ	percent Δ	unit Δ	percent Δ
CANADA							
Hog Demand	'000 head	61.7	1.9	29.4	0.9	60.4	-0.6
Hog Supply, East	'000 head	0.0	0.0	-33.9	-1.5	-15.2	-0.6
Hog Supply, West	'000 head	0.0	0.0	-14.7	-1.3	-7.0	-0.6
Hog Exports	'000 head	-61.7	-31.6	-78.0	-40.4	-82.5	-25.2
Hog Price, East	C$/car.cwt.	-3.9	-4.8	-4.1	-5.5	-4.4	-6.0
Hog Price, West	C$/car.cwt.	-3.1	-4.0	-3.1	-4.4	-3.7	-5.4
Net Revenue, East	mil. C$	-13.5	-7.7	-15.1	-11.0	-16.1	-14.4
Net Revenue, West	mil. C$	-4.5	-5.7	-5.9	-8.0	-6.2	-10.1
Pork Demand	mil. lbs.	5.1	1.4	5.6	1.5	5.7	1.5
Pork Supply	mil. lbs.	8.7	1.9	4.1	0.9	8.4	1.9
Pork Net Exports	mil. lbs.	3.3	4.8	-1.5	-2.4	2.7	5.1
Pork Price	index	-2.1	-1.7	-2.6	-2.1	-2.5	-2.1
Processors Prod. Sur.	index	353.7	3.8	180.6	1.8	360.5	3.7
Consumer Surplus	index	767.4	2.8	1596.3	3.0	1494.5	3.0
UNITED STATES							
Hog Demand	'000 head	-61.7	-0.3	-26.7	-0.1	-56.3	-0.3
Hog Supply	'000 head	0.0	0.0	51.3	0.3	26.3	0.1
Hog Price	US$/live cwt.	0.2	0.4	0.1	0.3	0.3	0.5
Net Revenue	mil. US$	10.8	0.7	10.1	0.8	13.6	1.1
Pork Demand	mil. lbs.	-5.2	-0.2	-3.4	-0.1	-4.2	-0.1
Pork Supply	mil. lbs.	-8.7	-0.3	-1.9	-0.1	-6.9	-0.2
Pork Price	US ¢/lb.	0.0	0.1	0.0	0.2	0.0	0.2
Processors Prod. Sur.	mil. US$	-15.7	-0.2	-1.5	-0.0	-9.3	-0.2
Consumer Surplus	mil. US$	-7.8	-0.3	-5.9	-0.2	-7.2	-0.2

Figure 14: Simulated Effect of Hog and Pork Tariffs on U.S. and Eastern Canada Hog Supply



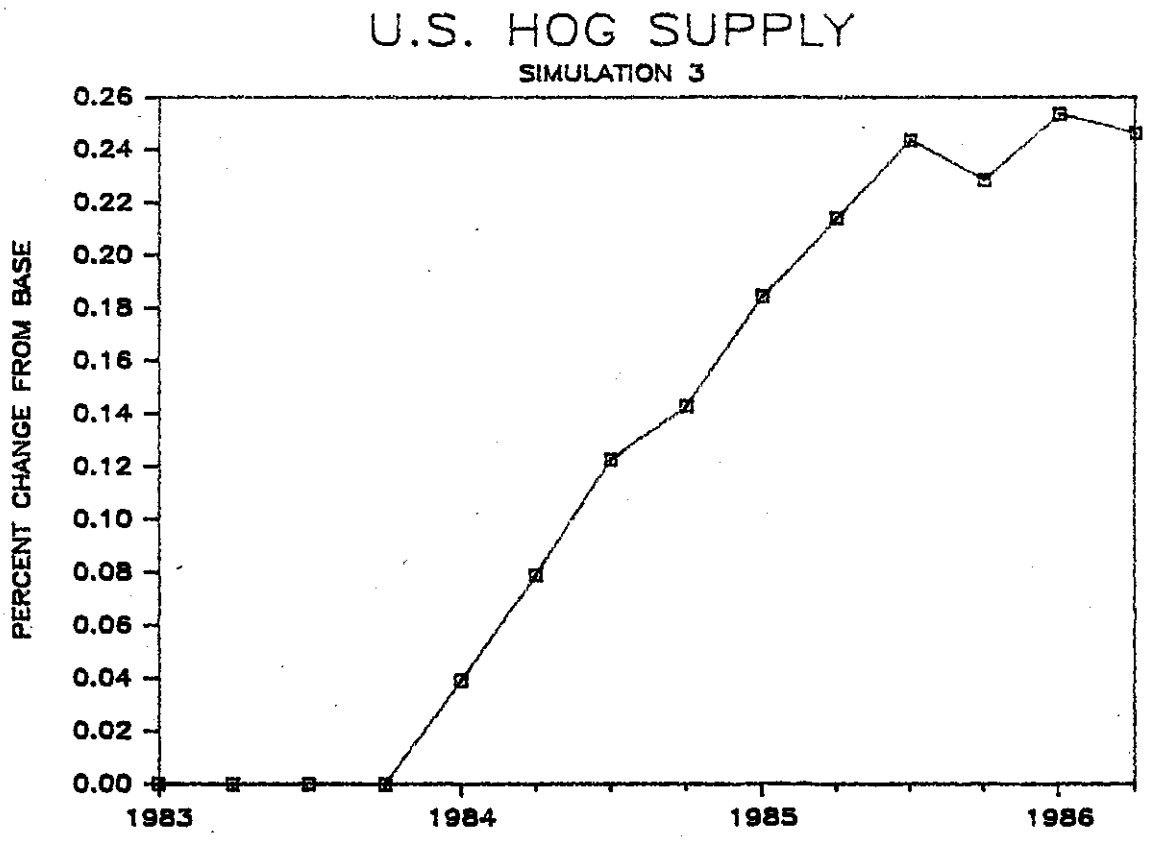
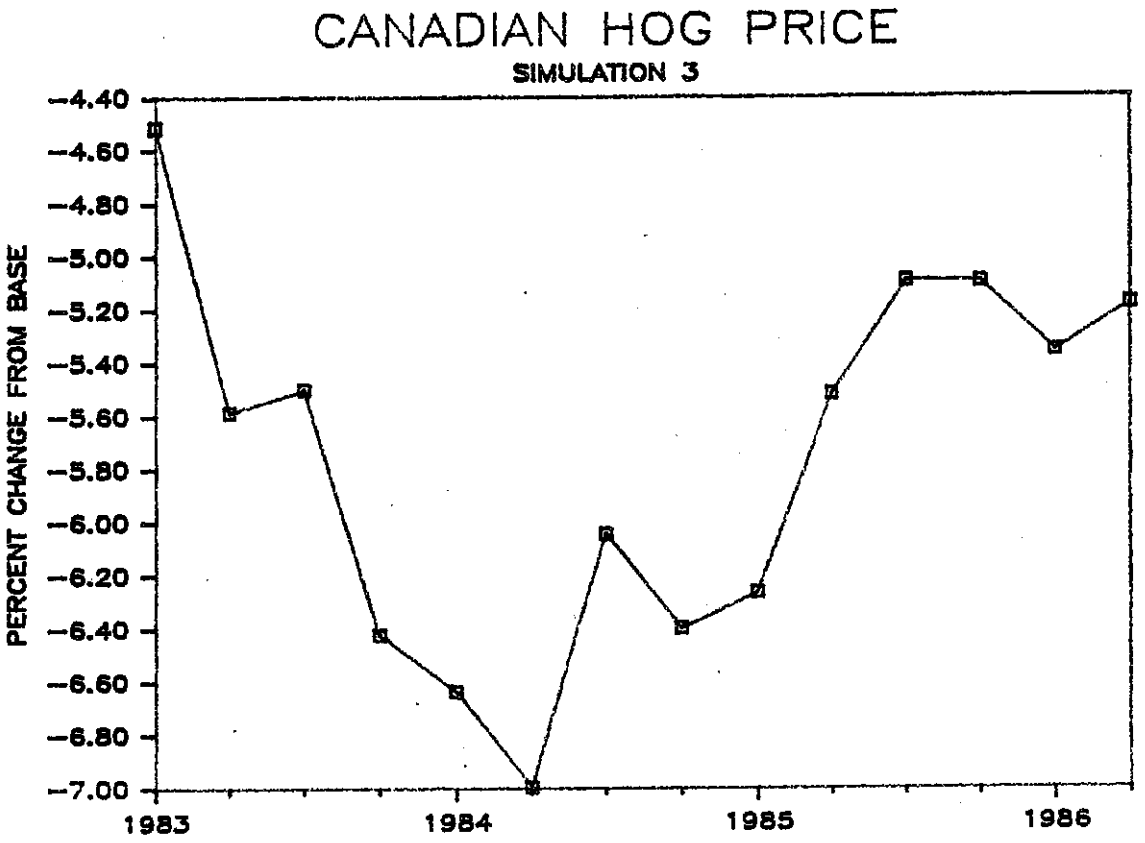


Figure 15: Simulated Effect of Hog and Pork Tariffs on U.S. and Canadian Hog Prices



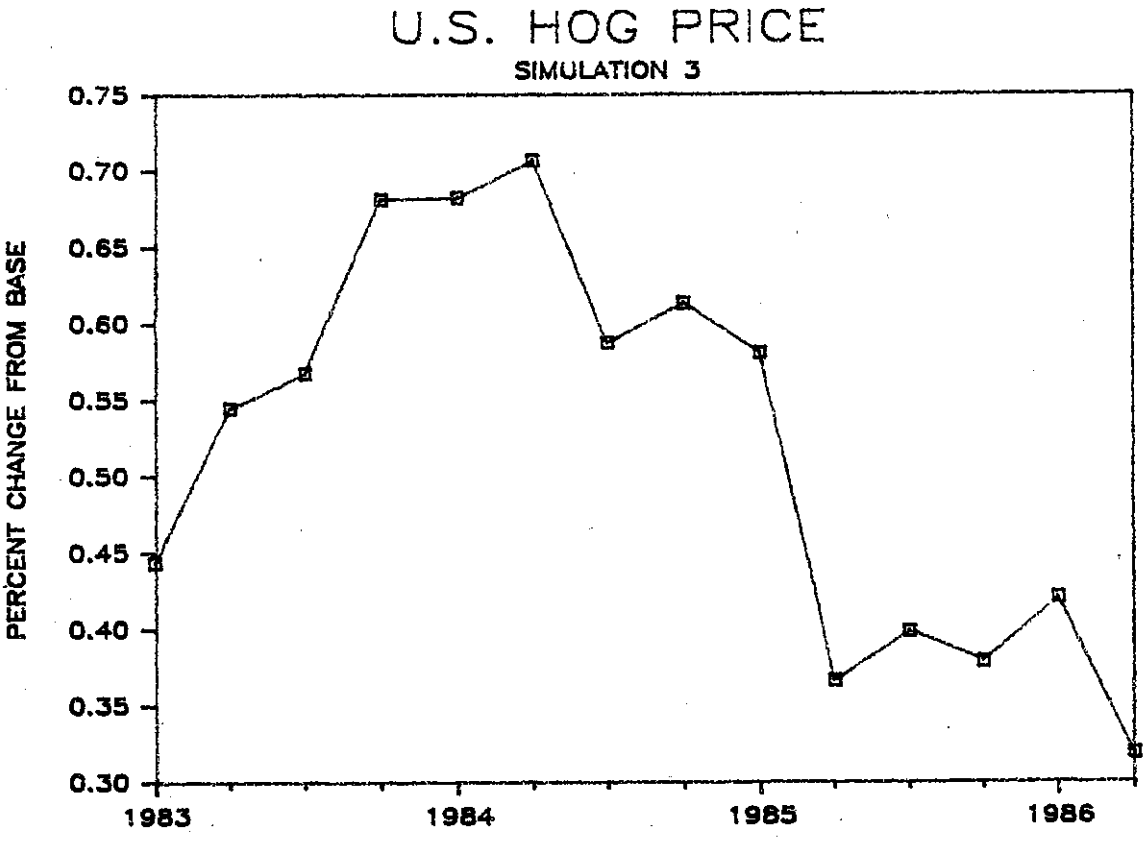
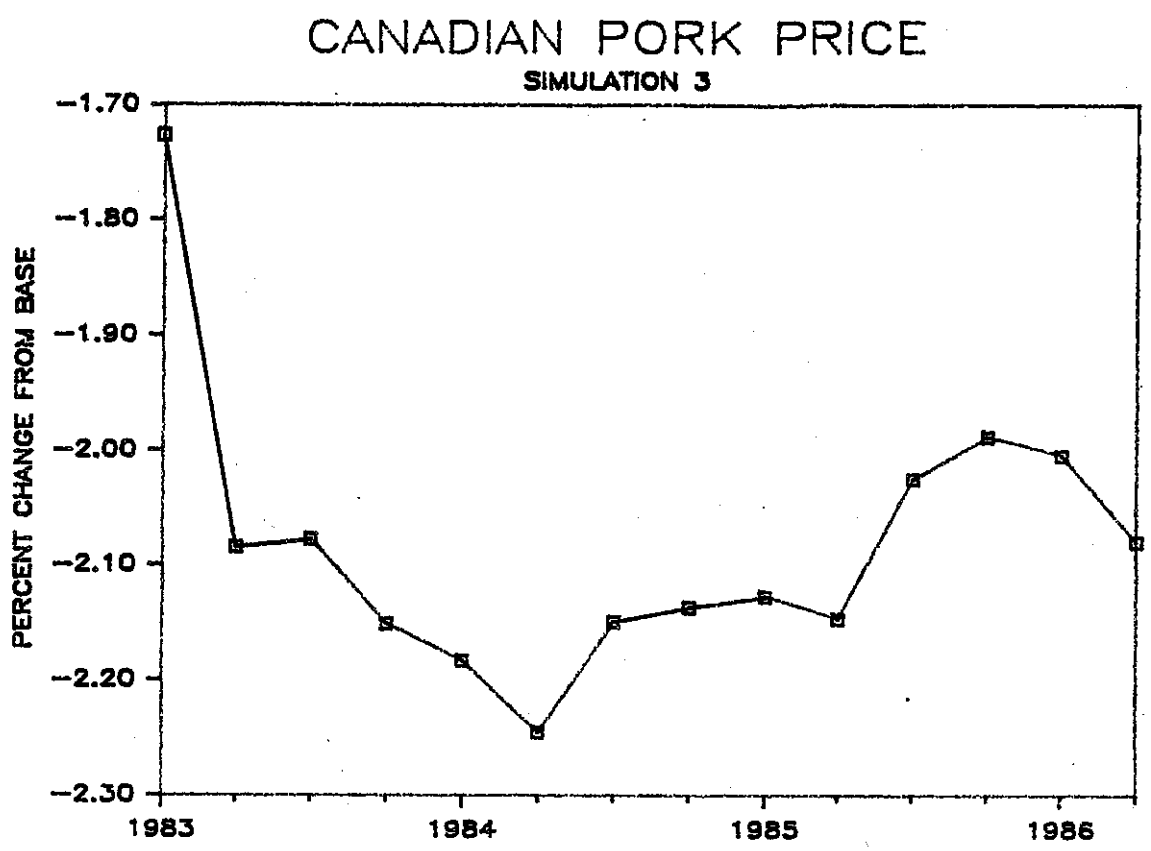


Figure 16: Simulated Effects of Hog and Pork Tariffs on U.S. and Canadian Pork Prices



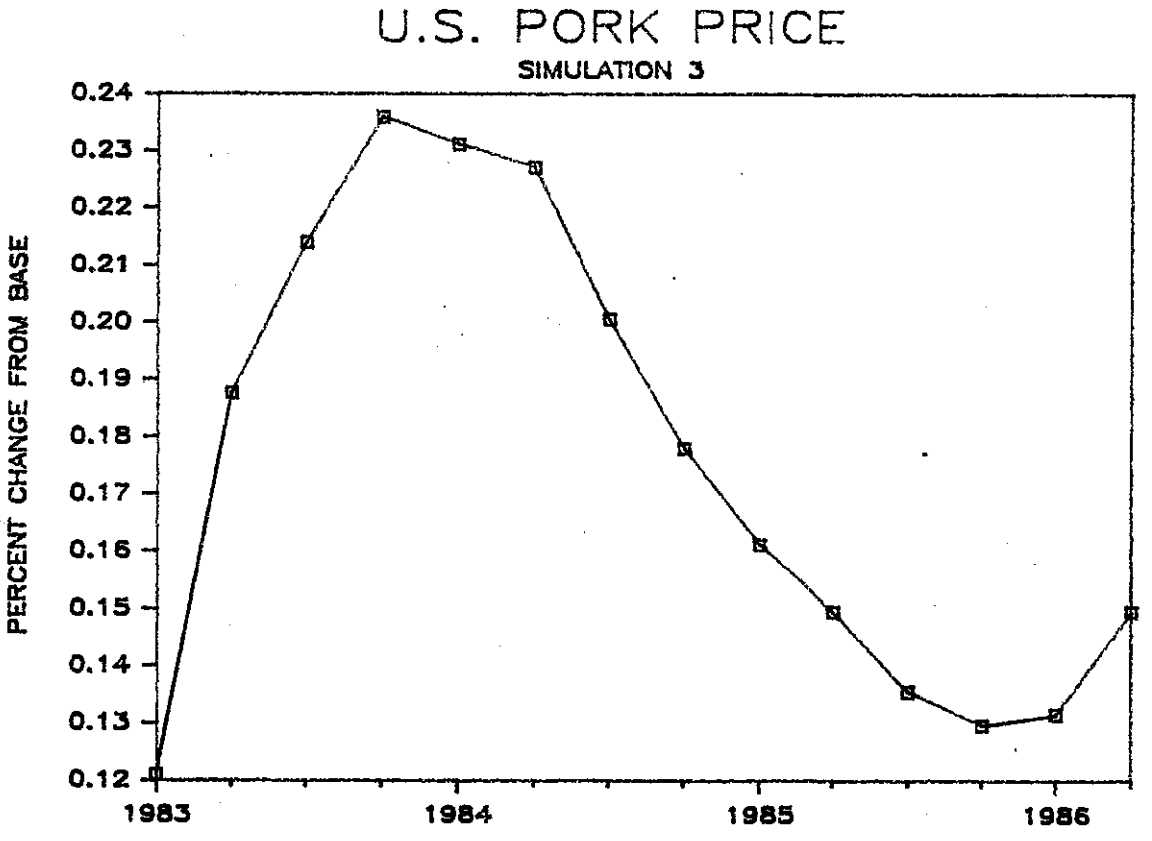
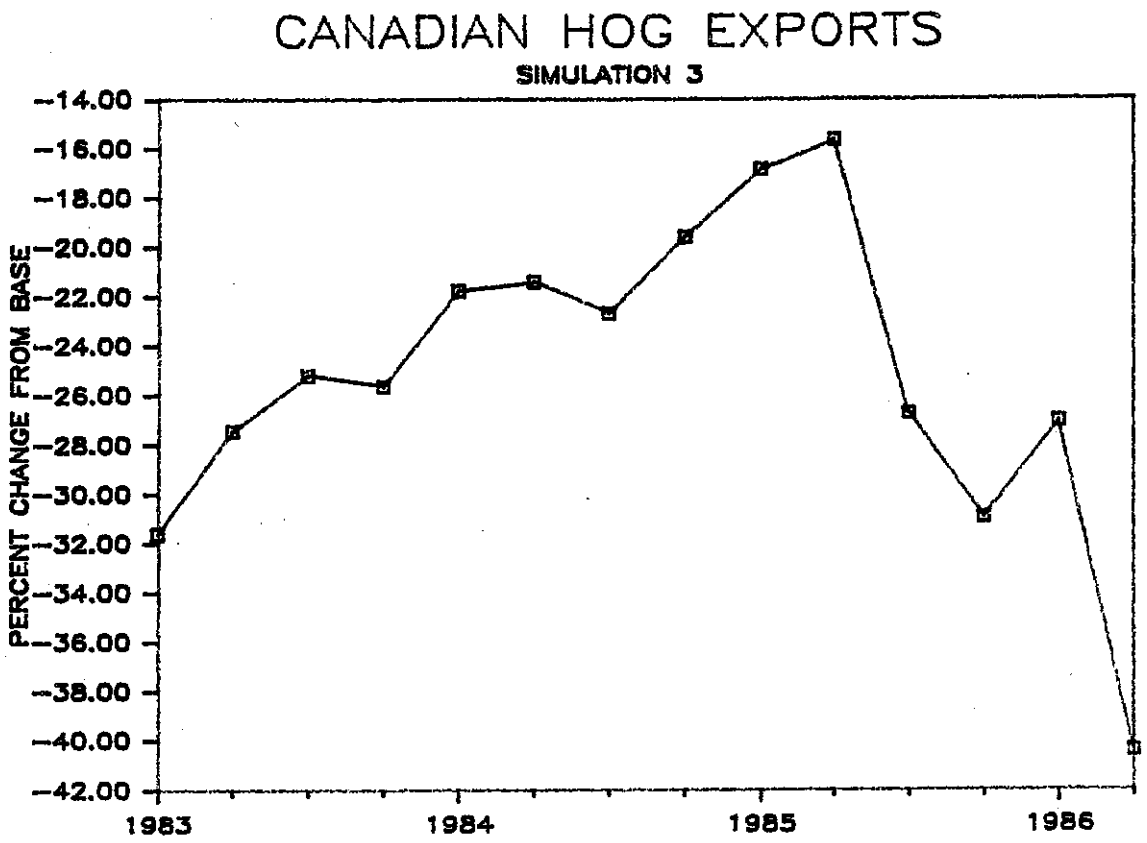
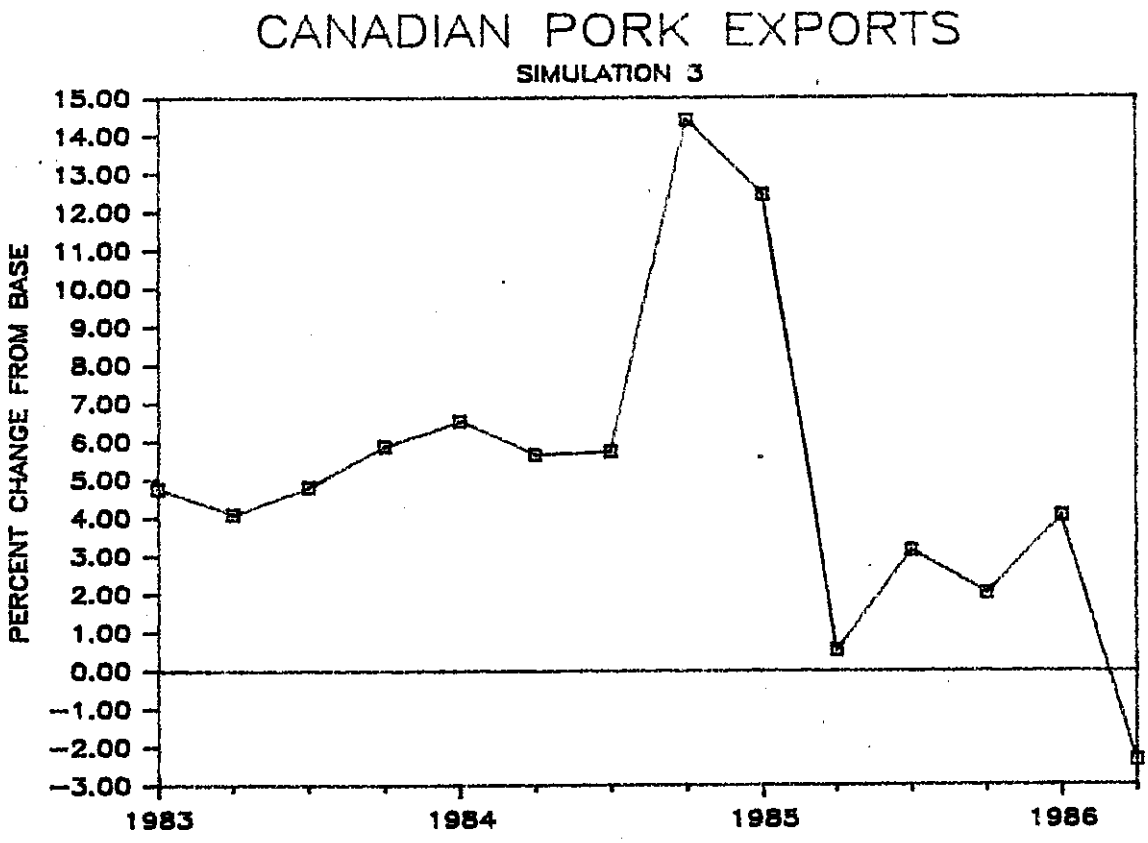


Figure 17: Simulated Effects of Hog and Pork Tariffs on Canadian Hog and Pork Exports





from a fifth quarter drop of 0.2% in Western Canada to 1.3% at the end of the simulation. The U.S. hog supply trends steadily upwards starting at 0.04% above the base and finishing 0.3% above the base.

6.0 SUMMARY AND CONCLUSIONS

In this paper we have estimated an econometric model of the North American hog/pork market that appears capable of capturing the factors that influence trade in live hogs and pork between the United States and Canada.

In using the model to evaluate the effects of bilateral duties it was shown that the impacts on market participants and the size of the impact depend crucially on whether the duties are placed on hogs, pork or both products. These impacts are summarized in Table 14. The model also illustrates the fluidity of trade in hogs and pork.

Table 14: A Summary of the Effects of Countervailing Duties on Canadian and U.S. Consumers, Processors and Producers

	CANADA		
	Hog Duty	Pork Duty	Hog + Pork Duty
Consumers	Gain	Gain	Gain
Processors	Gain	Lose	Gain
Producers	Lose	Lose	Lose

	UNITED STATES		
	Hog Duty	Pork Duty	Hog + Pork Duty
Consumers	Gain	Lose	Lose
Processors	Lose	Gain	Lose
Producers	Gain	Lose	Gain

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APPENDIX A

DATA DESCRIPTION

EXOGENOUS VARIABLES

DHG3	Demand for hogs in Canada by processors, thousand head.
DHG4	Demand for hogs in U.S. by processors, thousand head.
DPK3	Disappearance of pork in Canada, million pounds.
DPK4	Disappearance of pork in U.S., million pounds.
EXHG3	Exports of hogs from Canada to the U.S., thousand head.
IPK3	Closing stocks of pork in Canada, million pounds.
IPK4	Closing stocks of pork in U.S., million pounds.
NT3PK4	Exports of fresh and frozen pork from Canada to the U.S., million pounds.
PHG1	Price of index 100 hogs in Western Canada, $/cwt.
PHG2	Price of index 100 hogs in Eastern Canada, $/cwt.
PHG3	Price of index 100 hogs, Canada average (.379 PHG1 + .621 PHG2).
PHG4	U.S. seven market price of hogs, $/cwt.
QPK3	Canadian production of pork, million pounds.
QPK4	U.S. production of pork, million pounds.
RPPK3	Canadian CPI for pork, 1981 = 100.
RPPK4	U.S. retail price of pork, cents/pound.
SHG1	Supply of hogs in Western Canada, thousand head.
SHG2	Supply of hogs in Eastern Canada, thousand head.
SHG4	Supply of hogs in U.S., thousand head.

EXOGENOUS VARIABLES

CPI3	Consumer Price Index for Canada, 1981 = 100.
CPI4	Consumer Price Index for the U.S., 1967 = 100.

CWHG1	Western Canada average carcass weight, pounds.
CWHG2	Eastern Canada average carcass weight, pounds.
CWHG3	Canada average carcass weight, pounds.
CWHG4	U.S. average carcass weight, pounds.
DQUEX	Linear time trend, 1977 3 to 1980 1, value of 0 before 1977 3 and a value of 11 after 1980 1.
ER34	Exchange rate $Can/$U.S.
FPCO2	Price of Corn in Ontario, $/tonne.
NT3PK9	Canadian net exports of pork to countries other than the U.S., million pounds.
NT4PK9	U.S. net exports of pork to countries other than Canada, million pounds.
OPBA3X	Off-board price of Prairie Barley, $/tonne.
PCDY3	Canadian per capita disposable income, $/capita.
PCDY4	U.S. per capita disposable income, $/capita.
PCO4	Price of No. 2 Yellow Corn in Chicago, $/tonne.
POPN3	Canadian population, millions.
POPN4	U.S. population, millions.
RPBF3	Canadian CPI for Beef, 1981 = 100.
RPBF4	U.S. retail price of Beef, cents/pound.
RPCK4	U.S. retail price of Chicken, cents/pound.
TAR4HG3	Tariffs on Hogs shipped to the U.S., $4.39 Can/live cwt. starting in 1985(2).
WAPK3	Canadian average weekly earnings in packing plants $/week.
WAPK4	U.S. average weekly earnings in packing plants $/week.
WPI3	Canadian Industry selling price index, 1981 = 100.
WPI4	U.S. wholesale price index, 1967 = 100.