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# LIVE HOG AND PORK IMPORTS: PAST AND PROJECTED CONSEQUENCES FOR THE U.S. PORK SECTOR

**Jon A. Brandt, Robert E. Young, II, Shamsul Alam, and Abner W. Womack**

**Abstract**

The U.S. pork sector is modeled to simulate the effects of alternative import levels on prices, production, consumption, farm receipts, and consumer expenditures. Over the 1983–1985 period, producers annually received $600 million less due to increasing imports than if imports had remained at the 1979–1982 average. Farm prices and slaughter were lower by $2.21 per hundredweight and 1.1 million head annually, respectively. Four simulations reflecting alternative import paths over the period 1986–1992 were examined. With lower imports (relative to current levels), production and farm prices rise significantly in the long run; consumers purchase less and pay more.

*Key words*: econometric model, simulation, imports, pork, hogs.

During the early 1970s, imports of pork were only slightly higher than exports. However, through the 1980s, pork imports have risen substantially while exports have dropped. Imports averaged 550 million pounds per year during the 1979–1982 period then rose to 954 million pounds in 1984 and 1,128 million pounds in 1985. Live hog imports have increased five-fold from 206 thousand head per year (1979–1982 average) to 1.23 million head in 1985. Live hog and pork product imports in 1985 constituted slightly more than 8 percent of total pork supply. Nearly all of the live hog imports are from Canada.

This rise in imports has come at a time when the U.S. agricultural sector is in financial crisis. Hog producers in the corn belt states are among the most financially stressed groups (FAPRI Staff Report), making their attention to these imports even more critical. Based on these recent import increases, the National Pork Producers Council and Wilson Foods Corporation petitioned the International Trade Commission (ITC) to examine whether injury to the U.S. pork industry has occurred (Sandstrom). Issues of who gains and who loses when trade is restricted and the magnitude of these gains and losses arise. This analysis addresses such issues.

In this paper the effects of pork imports are analyzed through an econometric model of the industry, which includes supply and demand components of hogs and pork at the producer and consumer levels and similar components for competing protein sources such as beef, chicken, turkey, and eggs. As such, the analysis is comprehensive in that factors affecting producer and consumer behavior are included explicitly within the model. Effects from product and live-animal imports on the complete sector—from breeding herd size through slaughter, production, consumption, and the associated price signals—are explored.

The paper is organized as follows. The theoretical impacts of processed product and live-animal imports on producer and consumer sectors are illustrated graphically. A section briefly documents the hog-pork model specification and includes selected model validation statistics. The simulated effects of alternative pork import levels on selected price and quantity variables are presented for both short and long run cases. The analysis quantifies these import shocks on producers' revenues and consumers' expenditures. Policy implications are discussed.

## A GRAPHICAL ANALYSIS OF IMPORT EFFECTS

The theoretical effects of product flows into a country can be illustrated through a

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graphical analysis. In this example, the analysis is partial in that it considers only the effects on producers and consumers, it considers only the impacts on the U.S., and it considers only a single commodity. Schmitz provides a long list of trade studies related to agriculture based on this type of partial equilibrium analysis. In those studies, as here, the supply and demand equations were estimated econometrically.

Figure 1 illustrates the effects on the U.S. pork sector of imports at both the farm and retail level. Diagramming the effects of these trade flows is a bit complicated because both live hogs and pork products are imported. As a result, both producer behavior and processor (packer) behavior are affected. Ignore initially any imports (i.e., consider only the heavy solid supply and demand relationships in panels [a], [c], [d], and [f]). Equilibrium retail price and disappearance would be found at the intersection of total marketing group (packer) supply ($S_{pt}$) to the market and consumer demand ($D_r$) in panel (f). In the absence of imports, domestic pork supply in panel (d) equals total supply in panel (f). Derived demand for live hogs by packers intersects with total slaughter to generate a farm price (panel [c]). Domestic slaughter (based on U.S. produced hogs) equals total slaughter when imports are zero, and thus slaughter from U.S. produced hogs is determined in panel (a).

When net live hog imports (panel [b]) are added to the domestically produced supply schedule, the total hog slaughter schedule (panel [c]) rotates to the right to $S'_{ht}$. Kindleberger (pp. 322–324) suggests that the supply elasticity of the exporting country will be higher than that of the importing country. Heller notes that a large country (in terms of trade) faces a less-than-perfectly-elastic foreign supply curve. This is reflected in panel (b) where the percentage change in quantity is higher than in panel (a) for a given percentage change in price. Because the intersection of derived demand and live hog supply occurs at a lower farm price in panel (c), the pork supply schedule to the retail market from hogs slaughtered in the U.S. shifts to the right, panel (d). Added to that is the import supply schedule ($S_{pi}$) of pork products, panel (e), which generates the total supply of pork, $S'_{pt}$, to the retail market. This supply is shifted and rotated to right of the original schedule in panel (f).

No shifts in demand occur since consumers are assumed to show no preference toward or

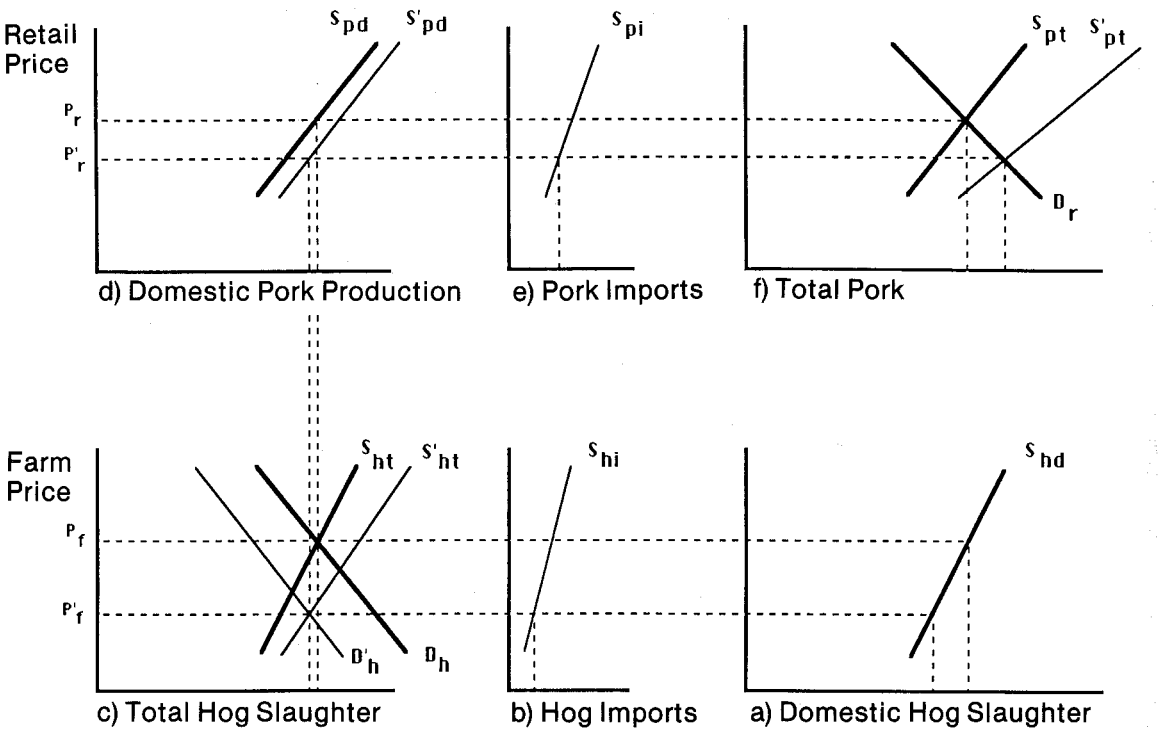


Figure 1. Effects of Hog and Pork Imports on the U.S. Pork Industry.

away from imported pork.[1] Thus, the additional pork on the market can only be sold at a lower price (where $S'_{pt}$ intersects $D_r$). After some initial adjustment, this lower retail price causes packers to shift their long-run derived demand for live hogs (domestic and imported) to the left (to $D'_h$ in panel [c]).[2] Derived demand and total live hog supply intersect at a lower farm price, $P'_f$. Panel (a) indicates domestic live hog slaughter is lower due to the import effects. Total slaughter, panel (c), is also lower reflecting the dominating impact of the larger pork product imports relative to live hog imports.

As a result of increased pork imports, domestic hog production and farm prices fall in the long run. Retail price is lower and per capita consumption is higher. Changes in consumer expenditures on pork will depend on the elasticity of the demand schedule; however, expenditures would fall if the demand for pork is inelastic. As adjustments occur in the industry and as competing products affect demand for and supply of pork, the equilibrium price-quantity relationships may change. The magnitude of these impacts depends on the respective supply and demand elasticities at farm and retail levels as well as the effects of product substitution from competing sources.

From this conceptual design, measures could be developed to examine the welfare impacts on producers and consumers resulting from this shift in pork supply. The literature contains several theoretical and empirical examples of welfare (i.e., consumer surplus and producer welfare) effects in the livestock industry resulting from trade (Brandt et al., 1986; Hayami; Freebairn and Rausser). Just et al. provide alternative methods for investigating the impacts of trade on domestic behavior of producers and consumers. Figure 1 suggests that consumers gain through reduced price and increased consumption (and reduced expenditure if the demand for pork is in the inelastic region). Producers would reduce the size of the breeding herd and production in response to lower farm prices. Farm revenues would drop.

The distribution of effects on producers, packers, and/or consumers may be of vital concern particularly if the level of aggregate imports begins to cause changes in individual behavior in an industry of non-homogeneous participants. Consequently, producers of the product (in the case of U.S. hog producers—432,000 operators [USDA)], which are far fewer in number than consumers of the product, are more likely to organize to obtain controls restricting imports than consumers would be to fight them. The legal action being pursued by the National Pork Producers Council is evidence of such a situation.

## AN ECONOMETRIC MODEL OF THE HOG-PORK INDUSTRY

In order to quantify the recent and expected changes in live hog and pork product import levels on the U.S. pork industry, an econometric model of the pork sector is employed. This is part of a larger model of the major U.S. crop and livestock commodities, developed and maintained at the University of Missouri. The advantage of using a model of this type is that the analysis can trace the impacts of exogenous shocks (such as expanded imports) on all endogenous variables not only on the commodity of interest, but also on related commodities. In addition, feedback and substitution effects from competing commodities (e.g., beef, chicken, turkey) become part of the analysis.

Figure 2 depicts the product flow from the farm through the processor to the retail level and illustrates the price signals at the farm and retail levels. Ten behavioral equations (see Appendix Table 1) and seven identities constitute the model of the U.S. hog-pork industry which was estimated over the period 1961–1984 using annual data. The model is patterned after those of Heien and Yanagida and Conway. Other relevant econometric models of the U.S. pork industry are reviewed in Brandt et al. (1985b).

Five behavioral equations model farm supply including sows farrowing (equation 1), pigs added to the breeding herd (equation 2), domestic barrow and gilt slaughter (equation 3), sow slaughter (equation 4), and boar slaughter (equation 5). These reflect both long-run investment/disinvestment decisions as well as short-run marketing (slaughter) decisions.

Pork production (equation 6) is largely de-

[1]Live animals imported from Canada are virtually the same as those produced in the U.S., and, therefore, the products generated from these animals are expected to be of the same quality and composition. It might be argued that Danish hams are preferred to American hams, but research is unavailable to either support or refute this hypothesis. Any bias in the analysis that may result from this assumption is likely to be small.

[2]Derived demand for live hogs will shift to the left as the lower retail price changes the packer profitability situation.

termined by slaughter levels. Processor (derived) demand for slaughter animals (equation 7) reflects signals from the retail market as well as processor behavior (represented by fuel prices and by product value). The sow price equation (equation 8) completes the behavioral relationships in the slaughter and production sector. Retail (consumer) demand for pork (equation 9) and ending pork stocks (equation 10) represent the final behavioral relationships in the market chain. Substitution effects from competing commodities (beef and chicken) specifically enter the pork model in the retail demand equation.

Based on the F– and t-statistics and $R^2$ results in Appendix Table 1, the model appears to fit the data reasonably well. Only one behavioral equation (ending pork stocks) had an $R^2$ of less than .80 and six were greater than .90. Model performance statistics based on a Gauss-Seidel simultaneous solution over a recent validation period (1970–1984) are presented in Table 1. In all cases, mean percentage errors were less than 4 percent. Retail prices had lower absolute and squared errors than the corresponding farm-level prices. Also, prices tended to have higher errors than the corresponding quantities. Percentage root mean squared errors were around 5 percent except for barrow and gilt and retail prices and sow slaughter. A comparison of actual values with forecasted values of the endogenous variables for 1985 (outside the period of estimation) in Table 1 suggests that considerably greater accuracy is achieved in the slaughter and production variables than in the price variables. The over-prediction of retail price in 1985 is a concern and suggests that declining pork demand has not been captured completely by this equation specification. Additional descriptive and performance evaluation information is documented in Brandt et al. (1985b). Although comparable validation statistics for the chicken, egg, and turkey models suggest that the hog-pork subsector has been somewhat more difficult to model over the last two decades (Brandt et al., 1985a; Salathe et al.), the performance of the model in replicating actual behavior appears to be quite good.

## SIMULATION PROCEDURES

The econometric model was used to simulate the impacts of alternative live hog and pork product imports on the various components of the domestic pork sector. The experiment was designed to examine both recent and current effects (1983–1985) and longer-term impacts (1986–1992). This division of periods allows an examination of what actually has occurred in the pork industry, particularly with respect to the rapid rise in imports, and an anticipation

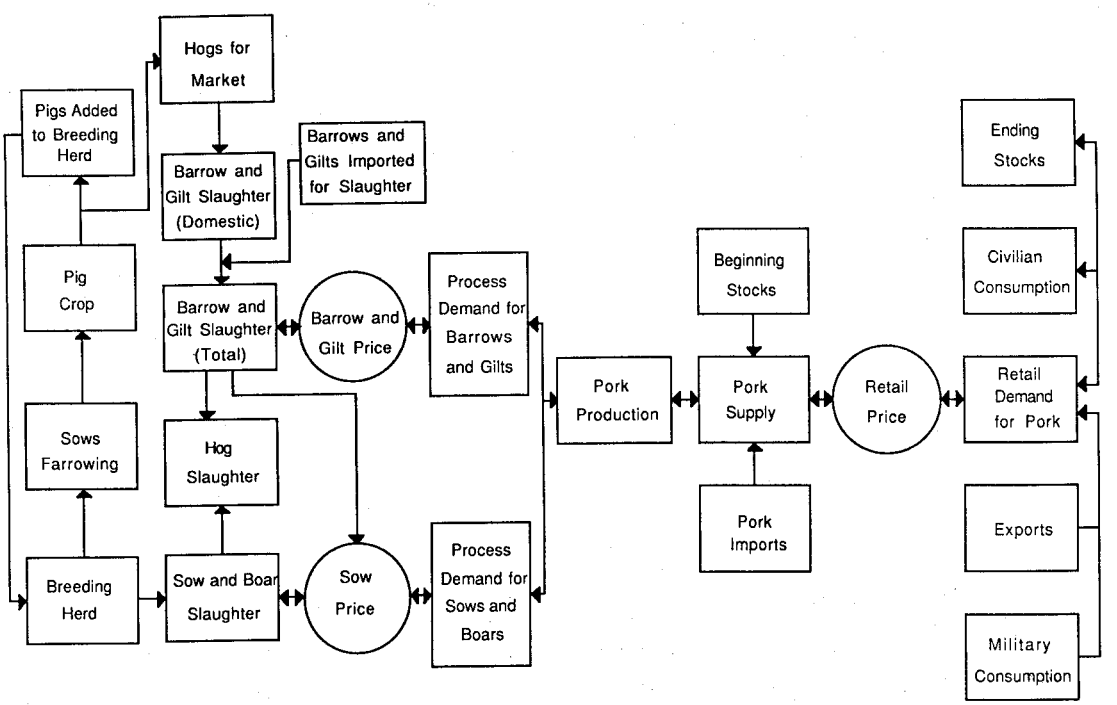


Figure 2. Hog-Pork Sector (Annual Model).

TABLE 1: SELECTED VALIDATION STATISTICS OF THE CNFAP HOG-PORK MODEL, UNITED STATES, 1970-1984 AND 1985

| Variable | 1970-1984 | | | | | 1985 | | |
|---|---|---|---|---|---|---|---|---|
| | Actual Mean | Estimate Mean | Mean % Error | Mean Absolute % Error | % Root Mean Squared Error | Actual | Estimate | % Error |
| Barrow & gilt price ($/cwt.) | 40.15 | 40.59 | -1.18 | 9.74 | 12.10 | 44.77 | 52.66 | -17.62 |
| Retail price ($/lb.) | 1.29 | 1.28 | -.77 | 6.66 | 8.14 | 1.62 | 1.77 | -9.26 |
| Sow slaughter (mil. head) | 5.30 | 5.47 | -3.50 | 8.52 | 10.19 | 4.01 | 4.02 | -.25 |
| Barrow & gilt slaughter (mil. head) | 78.32 | 78.58 | -.37 | 4.65 | 4.90 | 79.60 | 78.93 | .84 |
| Pork production (bil. lbs.) | 14.40 | 14.47 | -.52 | 4.67 | 5.20 | 14.80 | 14.52 | 1.99 |
| Pig crop (mil. head) | 90.38 | 91.86 | -1.75 | 4.00 | 4.51 | 86.01 | 86.97 | -1.12 |
| Breeding herd (mil. head) | 8.33 | 8.57 | -3.08 | 4.08 | 5.52 | 6.78 | 6.94 | -2.36 |
| Market hogs (mil. head) | 50.34 | 50.08 | .56 | 4.00 | 4.40 | 47.21 | 44.64 | 5.45 |
| Sows farrowing (mil. head) | 12.47 | 12.68 | -1.80 | 3.97 | 4.51 | 11.24 | 11.61 | -3.29 |
| Per capita consumption (retail) (lbs.) | 60.64 | 61.47 | -1.47 | 4.38 | 4.95 | 62.04 | 61.84 | .32 |

of future effects under alternative scenarios, after allowing greater time for industry adjustment.

Figure 3 is useful in describing the alternative scenarios examined. It shows the historical pattern of live hog and processed pork imports (carcass basis) over the period 1970-1985. (It should be noted that live hog imports typically are included in U.S. commercial slaughter in USDA reported data. These import data were first separated from domestically produced hogs for slaughter and then added to processed pork imports [carcass]). The figure illustrates the substantial rise in imports since 1981.

In order to analyze the impact of imports over the recent 1983-1985 period, two simulations were run using the econometric model. In the first simulation, actual (historical) values of the import variables were used. Pork imports rose from 778 million pounds (carcass) in 1983 to 1,336 million pounds in 1985. In the second simulation, pork imports (live and product) were set equal to their average level of 574 million pounds over the 1979-1982 period.

The right side of Figure 3 illustrates the four longer-term scenarios examined in this analysis. The baseline scenario (I) reflects an extension of the 1985 import level. A second

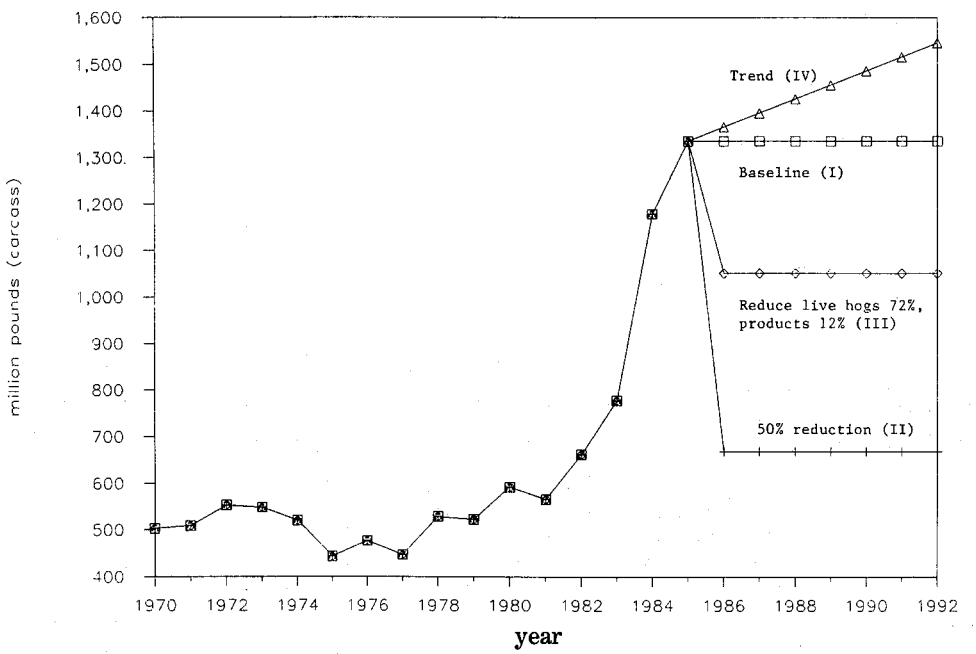


Figure 3. Live Hog and Pork Imports to the United States, 1970-1992 year.

scenario (II) reduces exports to 50 percent of the 1985 import levels from 1986 through 1992. Such a scenario might correspond to returning to import levels prior to the substantial build-up of the 1982–1985 period. Imports in this scenario are about 15 percent higher than the average of the 1979–1982 period. The third scenario (III) is based on the January through June 1986 rate of pork product and live hog imports extended through 1992. This rate was 88 percent of 1985 imports for pork products and 28 percent for live hogs. Because the ITC ruled in late 1985 that countervailing duties would be imposed on live hogs (from Canada) but not on pork products, this scenario was designed to quantify the possible effects of this type of ruling. Finally, a scenario (IV) was designed to measure the effects on the pork industry of a modest 2 percent per year increase in pork (from higher product and lower live hog) imports over the period 1986–1992. While these scenarios do not reflect all of the possible pork import effects, they do provide a relatively wide range of import policies.

## SIMULATION RESULTS

Table 2 reflects the results of selected price, quantity, and revenue variables of the alternative simulations. Column one illustrates the effects of pork imports over the recent short-term period. Columns two through four reflect the likely effects of imports over the longer, seven-year period, 1986–1992. Exogenous data needed to drive the model over the future time period were obtained from a recent 10-year forecast of the agricultural sector available in 1986 (Wharton Econometric Forecasting Associates).

Table 2 (column one) illustrates that over the recent three-year period, domestic production and farm prices were substantially lower using the actual import levels than if the average level of imports from 1979–1982 had been maintained over the 1983–1985 simulation period.[3] Barrow and gilt prices were lower by more than $2 per hundredweight, and slaughter of domestically produced hogs was lower by over one million head resulting in reduced total producer revenue of more than $600 million per year when actual imports (as opposed to the average import levels of the 1979–1982 period) were used in the simulation. Total pork supply was higher and consumers benefited. They paid about a nickel per pound less while consuming about one pound per person per year more. In total, consumer expenditures were reduced by $275 million per year with the actual import path (relative to the expenditure path obtained using 1979–1982 average imports).

TABLE 2: CURRENT AND PROJECTED IMPACTS OF ALTERNATIVE PORK IMPORT LEVELS ON THE U.S. PORK SECTOR

| Change in Variable: | Units | Short-Term | Annual Average, 1986–1992 | | |
|---|---|---|---|---|---|
| | | Annual Average, 1983–1985[a] | Reduce Imports 50%[b] | Reduce Hogs 72% Reduce Pork 12%[c] | Trend[d] |
| | | (1) | (2) | (3) | (4) |
| Retail price | $/lb. | −.05 | −.03 | −.02 | .01 |
| Barrow & gilt price | $/cwt. | −2.21 | −1.13 | −.60 | .36 |
| Barrow & gilt domestic slaughter | mil. head | −1.12 | −2.92 | −1.20 | .50 |
| Pork supply | mil. lbs. | 323.67 | 135.00 | 63.28 | −35.43 |
| Consumption per capita | pounds | 1.13 | .46 | .21 | −.12 |
| Farm receipts | mil. dollars | −601.47 | −652.76 | −309.48 | 134.45 |
| Consumer expenditures | mil. dollars | −275.30 | −296.27 | −121.96 | 85.57 |

[a]Reflects imports at actual 1983–1985 levels minus the average of 1979–1982 levels.

[b]Reflects imports held at the 1985 level (Scenario I) minus imports projected at 50 percent of the 1985 level for 1986–1992 (Scenario II).

[c]Reflects projected Scenario I imports minus Scenario III imports which have live hog imports reduced by 88 percent and pork imports reduced by 28 percent from the 1985 level for 1986–1992.

[d]Reflects projected Scenario I imports minus Scenario IV imports which are trended upward at rate of 2.2 percent per year from 1986–1992 (4.9 percent per year increase in products and 6.8 percent per year reduction in live hogs).

[3]Over the three year period 1983–1985, the model solution from the simulation using actual import levels had average errors of 2.70 percent for barrow and gilt price, .74 percent for slaughter, and .12 percent for per capita consumption relative to observed levels, an indication of relatively good model performance.

Over the 1983–1985 period, imports (live and product) actually averaged about 520 million pounds more than the 1979–1982 average level. From this one can derive that farm prices were reduced by about $.43 per hundredweight for each 100 million pound increase over the 1979–1982 average level. While this analysis does not explicitly deal with the Canadian import issue, live and product imports from Canada during the 1983–1985 years averaged about 550 million pounds (carcass weight). Thus, the short-term impact of Canadian imports over this period is estimated to reduce prices by about $2.35 per hundredweight. This would only represent the price effect and would not include additional losses to U.S. producers associated with reduced production as part of the adjustment process. The scenario using actual 1983–1985 imports indicated domestic production was 2 percent lower compared to the results of the scenario using 1979–1982 average import levels. Rowsell and Kenyon provide additional detail regarding the causes and price impacts on the U.S. hog industry due to Canadian imports. Their result suggests a $2–4 per hundredweight reduction in the U.S. seven-market price level in 1983 and 1984, consistent with the level suggested here.

Over the longer term, the pork industry would be expected to adjust to anticipated import policies. A comparison of a restrictive import policy (Scenario II) which reduces imports to about 50 percent of the 1985 level with a policy which allows imports to continue at the 1985 level (Scenario I) is reflected in column two of Table 2. If the 1985 import levels were to continue through 1992 (baseline), barrow and gilt prices would annually average $1.13 per hundredweight lower than if imports were reduced by 50 percent. Slaughter would be 2.9 million head lower per year. Pork supply would be higher, however, by about 135 million pounds (or about one percent of the total supply) as domestic production would fall by less than the difference in imports. As a result, consumers would purchase about one-half pound per capita more pork. With lower slaughter and lower prices, farm receipts would average $650 million less annually under the Scenario I solution (associated with an extension of the 1985 import level) relative to the reduced import option (Scenario II). Consumers would pay almost $300 million less per year while consuming more pork.

A comparison of columns one and two suggests that the longer-term price effect ($−.20 per hundredweight per 100 million pound import increase) is less than one-half the short-term effect ($−.43). However, producers have a longer period to adjust production and that reduction is greater (437 thousand fewer head slaughtered per 100 million pound import increase in the longer period compared to 214 thousand fewer head in the shorter period). This result supports the short-term asset fixity hypothesis and the need for longer-term analysis in order to observe the impacts of delayed adjustment.

Column three compares the baseline simulation with a scenario that cuts live hog imports to 28 percent of the 1985 level and product imports to 88 percent of their current level.[4] Barrow and gilt prices would average $.60 per hundredweight less per year (due to greater supply from the higher import levels associated with the baseline scenario). Slaughter would be 1.2 million head per year less. Retail prices would be about $.02 per pound lower and per capita consumption under the baseline would be about .2 pounds higher than the scenario based on the rate of imports during the first six months of 1986. Producers would receive $310 million less per year in revenues under baseline simulation; consumers would spend $122 million less per year.

A closer look at numbers in columns two and three and the import paths in Figure 3 illustrates the importance of pork products relative to live hog imports. Imports of pork products averaged almost 5.5 times the level of live hog imports (carcass weight basis) over the 1983–1985 period. Thus a large reduction in live hogs and only a small drop in product imports (column three) will not benefit the U.S. pork industry nearly so much as moderate but equal percentage reductions in each area (column two). U.S. producers would get about $.55 per hundredweight more (on all hogs), slaughter about 1.7 million more head per year of domestically produced hogs, and receive about $340 million more revenue per

[4]In mid-1985, the ITC ruled that live hogs imported from Canada into the U.S. injured domestic producers of hogs and allowed countervailing duties to be assessed against those animals. However, the ITC denied import duties on Canadian pork sold in the U.S. Since that ruling, imports (particularly live hogs) have fallen. This scenario reflects a recognition of anticipated lower imports by extending the rate of imports during January through June 1986 through the 1992 period. The scenario does not explicitly deal with the effect of Canadian imports on the U.S. industry, but it does illustrate the relatively lower impact of live hog import reductions (compared to only modest declines in product imports).

year under a 50 percent import (live and product) reduction (Scenario II) relative to a 72 percent live and 12 percent product import reduction (Scenario III). These results illustrate dramatically why U.S. pork producers have continued to argue for product import reductions in spite of the ITC ruling which has effectively reduced live hog importation from Canada. Rowsell and Kenyon also concluded that restricting live hog importation from Canada will not prevent Canadian imports from depressing U.S. hog prices.

Finally, a fourth scenario was designed to examine the impacts of imports which were allowed to increase from 1986–1992 at a slow rate of growth (Figure 3). If the ITC remains firm in its ruling regarding product importation, an increase in imports over the next several years is not unlikely if the value of the U.S. dollar remains strong relative to the Canadian dollar. Canada can produce and slaughter hogs domestically and then export products to the U.S. Scenario I would generate $.36 per hundredweight higher prices than Scenario IV (increasing imports). U.S. producers would slaughter 500 thousand more head per year, generating an increase in revenue of $134 million per year. Consumers, however, would pay one cent more per pound and consume about .1 pound per person less under the baseline (compared to these increased imports). Total consumer expenditures would be about $85 million more annually due to reduced total pork supply. The impacts of a modest growth trend (Scenario IV) on producer revenues and consumer expenditures are considerably smaller than those of either Scenarios II or III relative to the baseline (Scenario I).

The longer time period allows greater adjustment to occur in the pork sector. Because of the biological lag in breeding, farrowing, production, and slaughter, all effects from an exogenous shift would not be fully reflected in the endogenous variables in a three-year period. Indeed, during the 1983–1985 period, the level of imports was increasing at a fast rate. Holding import levels constant (in all but the trend scenario) over a seven-year period may provide more accurate indications of the longer-term effects of the import changes. Even this time period, however, may be too short to allow the industry to have reached equilibrium.

## CONCLUSIONS

The evidence suggests that producers of pork in the U.S. have lost revenue due to increased levels of pork and live hog imports over the past several years. For the industry, these losses are substantial, particularly given the severe financial situation faced by many producers. Hog producers in the U.S. were estimated to have received about $600 million per year less in revenues over the 1983–1985 period due to expanded hog and pork imports (relative to a scenario holding imports at the 1979–1982 average levels). This represents about six percent of aggregate producer revenue. Domestic slaughter would have been higher by about 5.3 percent over the period under the lower import scenario. A 100 million pound increase in imports was estimated to lower farm price by roughly $.43 per hundredweight. Consumers paid slightly lower prices from higher imports relative to what they would have paid had import levels remained at their 1979–1982 average. It must be recognized that possible structural changes in pork demand not captured in the model specification may cause some overestimation of import effects.

Four scenarios which examine the effects of alternative import paths on the U.S. pork industry over a longer seven-year (1986–1992) horizon were developed. One which extends the observed 1985 import levels of live hog and pork products through 1992 was selected as the basis for comparison. That baseline path suggests substantially reduced U.S. producer prices, slaughter, and revenue relative to a scenario which lowered imports by 50 percent in 1986 and held them at that level through 1992. (Even this lower level is above any observed import figure prior to 1983.) Consumers benefit through lower prices and reduced expenditures. The results suggest a shrinking domestic herd over the longer run with imports held at the 1985 level. While consumers as individuals would not likely notice these effects in terms of price or expenditures, the substantially fewer hog producers are far more likely to be affected individually.

While this analysis does not attempt to prescribe import policy, it does quantify the effects of alternative import levels on the domestic pork sector and on consumers. Restrictions to pork imports protect the U.S. industry leading to higher domestic production and higher farm prices. Consumers would have to pay more and receive less as a result of restrictive policies. Because of higher domestic farm prices, packers and processors would also have higher purchasing costs under restricted imports relative to the lower-

priced live hog and product imports under freer trade conditions.

The results illustrate that pork imports, whether entering the U.S. as live hogs or as processed products, eventually reduce U.S. farm prices and domestic production because of increased supply. Although the ITC recently ruled that subsidized Canadian live hog production would be subject to a tariff when entering the U.S., it differentiated between live hogs and pork products. This analysis suggests that in terms of reduced revenues to U.S. producers, processed product imports have a far greater effect than live hog imports. Interestingly, the Canadian government currently is considering whether live animals and processed product imports (in their case, beef) should be considered as differentiated forms when their importation results in injury to the domestic (Canadian) industry. Their ruling undoubtedly will be used in the continuing litigation of the U.S. pork import issue.

Finally, the simulation results of the analysis are affected by the nature of the specified econometric model of the livestock sector. They reflect expected effects and are subject to sampling errors. However, based on the performance of the model over the historical period, the results appear to be reasonable and should be useful to policy makers considering import restrictions.

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APPENDIX TABLE 1: REGRESSION RESULTS OF THE U.S. HOG-PORK ECONOMETRIC MODEL, 1961–1984

| | Dependent Variables | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Regressors | (1) Sowfw | (2) Pigbh | (3) Bagsltd | (4) Sowslt | (5) Boarslt | (6) Porkpd | (7) PorksupC[a] | (8) DSowp | (9) PorkconC[a] | (10) Porkstk |
| Intercept | .3714E0 | .2212E1 | −.2470E1 | .3759E1 | −.8872E2 | −.6824E5 | .3057E1 | .6298E−1 | .1229E1 | −.7580E2 |
| Hogbh(t−1) | .0128E1 (4.52)[b] | −.1719E0 (−.99) | | .7164E0 (5.35) | | | | | | |
| Pigbh | .4199E0 (2.54) | | | | | | | | | |
| Bagslt | | | | | | .1627E3 (21.93) | | | | |
| Boarslt + Sowslt | −.1118E0 (−.51) | .9715E0 (5.04) | | | | .2201E3 (3.60) | | | | |
| Hogslt | | | | | | | | −.1718E−2 (−2.25) | | |
| Cornpd | .2035E−3 (1.95) | | | −.4821E−3 (−7.95) | | | | | | |
| Bagp | | .9149E−1 (3.08) | −.1667E0 (−1.57) | −.6404E−1 −(2.30) | | | | | | |
| Bagp(t−1) | | .1060E−1 (.60) | | | | | | | | |
| DBagp | | | | | | | −.8060E0 (−7.02) | | | |
| DWbagp | | | | | | | .1538E−1 (1.47) | | | |
| Fdp | | −.2245E1 (−4.60) | .1667E0 (1.57) | .6404E−1 (2.30) | | | | | | |
| Pigcrp | | | .4445E0 (8.98) | | | | | | | |
| Hogmkt(t−1) | | | .8724E0 (9.26) | | | | | | | |

APPENDIX TABLE 1: REGRESSION RESULTS OF THE U.S. HOG-PORK ECONOMETRIC MODEL, 1961–1984 (CONTINUED)

| Regressors | Dependent Variables (1) Sowfw | (2) Pigbh | (3) Bagsltd | (4) Sowslt | (5) Boarslt | (6) Porkpd | (7) PorksupC[a] | (8) DSowp | (9) PorkconC[a] | (10) Porkstk |
|---|---|---|---|---|---|---|---|---|---|---|
| Sowslt | | | | | .1300E0 (4.82) | | | | | |
| Time | | | | | .4492E−1 (10.66) | .3467E2 (4.16) | | | | |
| DPorkp | | | | | | | .5189E0 (2.69) | .2606E2 (4.72) | −.8804E0 (−9.87) | |
| DFuel | | | | | | | −.5928E0 (−3.72) | | | |
| DByprod | | | | | | | .1057E0 (1.56) | | | |
| DWage | | | | | | | | −.1823E0 (−.12) | | |
| DBeef | | | | | | | | | .4761E0 (6.02) | |
| DChick | | | | | | | | | .5085E−1 (.57) | |
| DIncC | | | | | | | | | .3480E0 (2.74) | |
| Pop | | | | | | | | | −.1395E1 (−4.35) | |
| Porksup | | | | | | | | | | .2289E−1 (3.33) |
| Porkp*Int | | | | | | | | | | −.5025E0 (−.56) |
| $R^2$ | .88 | .88 | .95 | .89 | .90 | .99 | .94 | .94 | .96 | .60 |
| F | 13.40 | 16.18 | 69.24 | 26.59 | 45.17 | 610.79 | 21.44 | 39.10 | 55.35 | 6.76 |

**Variable Identification** [c]

**Endogenous:**

| | |
|---|---|
| Bagslt | Barrow and gilt slaughter, domestic and imports (mil. head) [77.46] |
| Bagsltd | Barrow and gilt slaughter from domestic production (mil. head) [77.31] |
| Bagp | Seven market barrow and gilt price ($/cwt.) [32.25] |
| Boarslt | Boar slaughter (mil. head) [.66] |
| Sowslt | Sow slaughter (mil. head) [5.87] |
| Sowp | Seven market sow price ($/cwt.) [28.13] |
| Hogslt | Hog slaughter (mil. head) [84.00] |
| Hogmkt | Market hogs on farms, December 1 (mil. head) [49.88] |
| Hogbh | Number of breeding hogs on farms, December 1 (mil. head) [8.65] |
| Sowfw | Sows farrowing (mil. head) [12.44] |
| Pigcrp | Pig crop (mil. head) [90.19] |
| Pigbh | Pigs added to the breeding herd (mil. head) [6.89] |
| Porkpd | Pork production, carcass weight (mil. pounds) [14206.21] |
| Porksup | Pork supply, carcass weight (mil. pounds) [14944.63] |
| Porkcon | Pork civilian disappearance (mil. pounds) [14231.07] |
| Porkstk | Ending stocks of pork, carcass weight (mil. pounds) [257.50] |
| Porkp | Retail pork price index (1967=1) [1.56] |

**Exogenous:**

| | |
|---|---|
| Inc | Personal consumer expenditures on nondurable goods and services (bil. $) [856.60] |
| Beef | Retail beef price index (1967=1.00) [1.63] |
| Chick | Retail frying chicken price index (1967=1.00) [1.42] |
| Cornpd | Corn production, October-September (mil. bu.) [5474.95] |
| Wbagp | If PorksupC > PorksupC(t-1), Wbagp = Bagp |
| Fdp | Pork production cost index (1967=1.00) [1.52] |
| Int | Prime commercial paper interest rate, 4–6 mo. (percent) [7.18] |

| | |
|---|---|
| Byprod | Value of pork by-products ($/cwt.) [4.60] |
| Fuel | Fuel and utility price index (1967 = 1.00) [1.76] |
| Time | Trend 1961, . . ., 1984 |
| Wage | Wage rate in meat packing industry ($/hour) [5.27] |
| Pop | Population aged 60 years or older (percent) [14.72] |

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[a]The functional form of this equation is double logarithmic.

[b]Values in parentheses are t-statistics.

[c]Two variables (Beef and Chick) which appear as exogenous in this model are in fact determined within the system when all livestock models are running. Similarly, the feed components of the pork production cost index (Fdp) and corn production (Cornpd) are determined within the crops models. A "D" in front of the variable name in Appendix Table 1 indicates the variable has been deflated. A "C" at the end of the variable name in Appendix Table 1 indicates the variable is in per capita terms. Mean values of the variables over the estimation period are given in brackets.