Market Modeling of the Effects of Adoption of New Swine Waste Management Technologies in North Carolina*

Prepared under the Economic Assessment of
Alternative Swine Waste Management Systems:
The Smithfield Foods-Premium Standard Farms
Agreement with the North Carolina Attorney General

Final Report Prepared for
Dr. C.M. (Mike) Williams
Animal and Poultry
Waste Management Center
North Carolina State University
Campus Box 7609
Room 134 Scott Hall
2711 Founder's Drive
Raleigh, NC 27695-7608

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Prepared by
Dr. Michael K. Wohlgenant
William Neal Reynolds Distinguished Professor
Dept. of Ag.& Res. Econ.
North Carolina State University
Raleigh, NC 27695

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Executive Summary

The purpose of the market modeling research (task 2 economic analysis) is to predict the effects on the weaned pig, feeder pig, and market hog markets in North Carolina, other states, and imports from changes in net incremental costs associated with new swine technologies by individual type/size farms in North Carolina obtained from task 1 of the Smithfield Foods-Premium Standard Farms agreement. Given the market level effects, the effects on individual farm type/sizes in North Carolina are computed to determine the distributional effects on the farms adopting the new technologies. In the simulations of the market model, two types of simulations are performed: one where all farms in North Carolina are required to adopt the new technologies, and one where only company-owned farms in North Carolina are required to adopt the new technologies.

The market and farm-level effects are computed using an equilibrium displacement model (EDM). The model consists of a number of equations showing how market supply and demand for weaned pigs, feeder pigs, and market hogs respond to increases in costs on production of pigs in each of these markets in North Carolina. The model used not only has supply/demand relationships for North Carolina but also supply/demand relationships in other states, and international markets. Therefore, all affected markets by introduction of the new technologies are taken into account. In development of the model, particular attention is given to the influence of vertical integration and coordination in the hog market, particularly in North Carolina. In the empirical analysis, the potential effects of market power on price relationships between spot prices and internal company prices and between spot prices and contract prices are investigated. The statistical evidence supports the use of the national spot price of market hogs for North Carolina and other states. If market power is present, its effect is in the market for compensation to growers who contract, but that effect is captured by the coefficient estimates of the estimated supply equations. Overall, the statistical results confirm that the EDM can be developed as though producers and consumers are price takers and that aggregate supply can be obtained as the summation of supplies from three sources: company-owned, contract, and independent farms.

The supply structure of the swine industry is quite complicated and a dynamic model of the farm is used to derive a statistical model to estimate parameters of how producers respond to price and cost changes in the short-run and long-run. The model assumes the farm incurs adjustment costs in changing its herd size (i.e., number of farrowing sows) and cannot adjust instantly to changes in the market. The model also assumes that producers form expectations of future prices and costs and based on these expectations compare the expected benefits with the expected costs of expanding herd size in each time period. In addition to allowing us to trace out the dynamic response of the farm to changes in prices and costs, the model developed also allows separation of the effects of expectations on herd size from adjustment costs on herd size. This is important because producers must make long-run expectations in the face of new technology adoption.

The supply response parameters were estimated with data that allow for variation both across time and state. Moreover, the model accounts for the impact of different size farms on supply response. Importantly, size was not found to be statistically significant after controlling for state where hogs are produced. Therefore, the estimated supply equation can be used to predict the effects on individual farm sizes within North Carolina. Elasticities of supply (degrees of supply response) are calculated from these statistical estimates for North Carolina in the aggregate and for different size categories for market hogs, feeder pigs, and weaned pigs. The supply elasticities are also calculated for different lengths of time taken for adjustment to the increase in costs—1 year (short-run), 5 years (intermediate-run), and 10 years (long-run).

The supply response parameters were estimated with data for farrow-to-finish operations. To obtain supply response parameters for the other type operations, price margin relationships between market hogs and feeder pigs and between market hogs and weaned pigs were estimated and used to obtain supply elasticities for feeder pigs and weaned pigs. These elasticities were then used with statistical results on the relationship between aggregate production and production by size of operation to estimate supply elasticities by size for each type of operation.

Although market hog and feeder pig imports are small shares of total supply (2.2% and 3.3%, respectively), elasticities of supply of imports for market hogs and feeder pigs are necessary to close the EDM. These elasticities are estimated using formulas for excess supply elasticities of pigs from Canada, which accounts for the bulk of pigs coming into the U.S. The formula requires estimates of supply and demand response in Canada and exports of pigs as shares of their domestic production and consumption. These estimates were obtained from published sources and used to develop estimates of import supply elasticities for market hogs and feeder pigs for the SR, IR, and LR.

The demand response of market hogs was determined through use of aggregate data on marketing of market hogs and prices of finished pigs sold for slaughter on the domestic market. The demand response (elasticity) estimated is a derived demand elasticity and accounts for adjustment in all affected downstream markets—pork processing, pork marketing, and pork consumption both domestic and foreign. The statistical analysis was conducted to determine whether "captive supplies" of hog processors (supplies under contract and company-owned) had a significant impact on the market price of hogs. The results indicated no statistical relationship between market structure and price behavior so that price taking behavior could be assumed for this market. Further analysis of market price relationships among states indicated that the law of one price holds, implying that North Carolina and Midwest prices move together over time with one another and are separated only by transfer costs.

To implement the EDM framework empirically requires that the estimated supply/demand functions be linear functions and that the incremental costs of the new technologies shift the supply curves up in a parallel manner. These assumptions are approximated well in this case when applied to the different type/size operations. Therefore, with estimates of the incremental costs as proportions of price for the respective market (market hogs, feeder pigs, weaned pigs), simulations can be conducted of the market impact of introduction of new swine technologies.

The simulation model only computes the effects of introduction of new swine management technologies, *assuming all other determinants of supply/demand remain constant.* Therefore, the simulation results are best viewed as changes from any forecast of future hog prices. With future hog prices expected to continue the long run trend of declining in real terms, the results presented would likely understate, not overstate, the effects on the swine industry. The simulation model also specifically assumes that the new technologies would only be mandated in North Carolina. If the technologies were mandated in other states as well we would expect the results to be different from those reported here. That case was not considered in this research project because it was outside the scope of the research project.

Simulation results were conducted for four different technologies: Barham Farm, Super Soils, EKOKAN, and ReCip Technologies. The costs associated with these different technologies vary greatly from one technology to another and from one type/size category to another. Overall, the results indicate only small effects on market prices, large effects on North Carolina swine production, and small effects on other states and imports. As expected, market prices tend to rise and swine production in North Carolina in all categories falls. Short-run effects are smaller than intermediate-run effects, which in turn are smaller than the long-run effects. When all NC farms are required to adopt, NC production of market hogs falls from 3.1% in the SR to 12.3% in the LR for Barham Farm; NC production of feeder pigs drops between 0.8% in the SR to 2.6% in the LR for Barham Farm; and NC production of weaned pigs drops between 1.9% in the SR to 7.7% in the LR. At the other extreme, when all farms are required to adopt Super Soils NC production of market hogs drops between 15.5% in the SR to 62.7% in the LR; NC production of feeder pigs drops between 10.3% in the SR to 21.1% in the LR; NC production of weaned pigs drops between 10.0% in the SR to 40.2% in the LR. The effects of the other technologies on production lie somewhere between Barham Farm and Super Soils technologies. The distributional effects on size vary from category to category, but generally show larger absolute declines for the smaller size farms.

When only company-owned NC farms are required to adopt, NC production of market hogs, feeder pigs, and weaned pigs decline very little because only a small portion of the farms in NC are company-owned farms. However, the impact on company-owned farms is quite dramatic with production falling in all type/size categories by significant amounts for all four technologies.

The tables in section VI of the report provide details on all the simulations. The non-technical reader can read sections I, II, V, and VI without loss in continuity of the report.

Market Modeling of the Effects of Adoption of New Swine Waste Management Technologies in North Carolina

I. Introduction

The goal of research of the task 2 economic analysis of the Smithfield Foods-Premium Standard Farms Agreement is to develop a model to quantify the impact of new waste management systems on the North Carolina pork industry. Specifically, the goal of this task is to use estimates of incremental costs on individual North Carolina farms (company owned, contract, independent) obtained from the task 1 research and aggregate these estimates to the market levels in North Carolina to estimate the effects on the weaned pig, feeder pig, and finished pig markets. North Carolina does not operate independently of other states so the model is part of a broader model that includes markets for pigs in other states and also markets for pigs and pork in international markets.

In this report, the components of the market model are presented and assumptions underlying the development of these components are enumerated. In addition, the market simulation model is used to simulate the effects of a range of new waste management technologies on the NC and US hog industries.

There are several steps involved in developing the market model. These steps are as follows:

1. Estimation of demand and supply functions for pigs for the different markets. These estimates are obtained using econometric methods from time series and cross-section data. The methodology for obtaining derived demand for market hogs builds on the model developed by Lemieux and Wohlgenant (1989) for the US. Estimates for demand and supply for weaned pigs and feeder pigs and supply of market hogs are obtained using regional time series data for North Carolina and other states included in the aggregate.

2. Quantification of shifts in marginal cost functions for pigs for alternative technologies. The methodology here draws on the framework summarized by Alston, Norton, and Pardey (1995). This approach includes the following steps: (a) deriving linear supply/demand relationships around recent market equilibrium values, (b) assuming parallel shifts in supply curves at the farm level, and (c) aggregating across all farm sizes and types to obtain the new equilibrium quantities and prices. The advantage of this approach is that it allows one to directly use data inputs from task 1 which are expressed in incremental cost per pound of pig.
3. Simulation of the effects of alternative technologies on the North Carolina pork industry. Once the econometric estimates from step 1 are obtained and the cost shift parameters from step 2 are determined, a user-friendly spread sheet model is used to take data output from task1 as input into the market model and to output results from quantifying shifts in marginal costs of producing pigs on North Carolina pig prices and quantities. In addition, estimates of changes in prices and quantities are then used as input into estimating impacts on individual farms by different types and sizes.

In the following sections, the overall structure of the swine market model is presented, the supply and demand components of the model are developed, and the equilibrium displacement model of the industry is presented. Finally, the results of simulations of the market model for new swine waste technologies are presented.

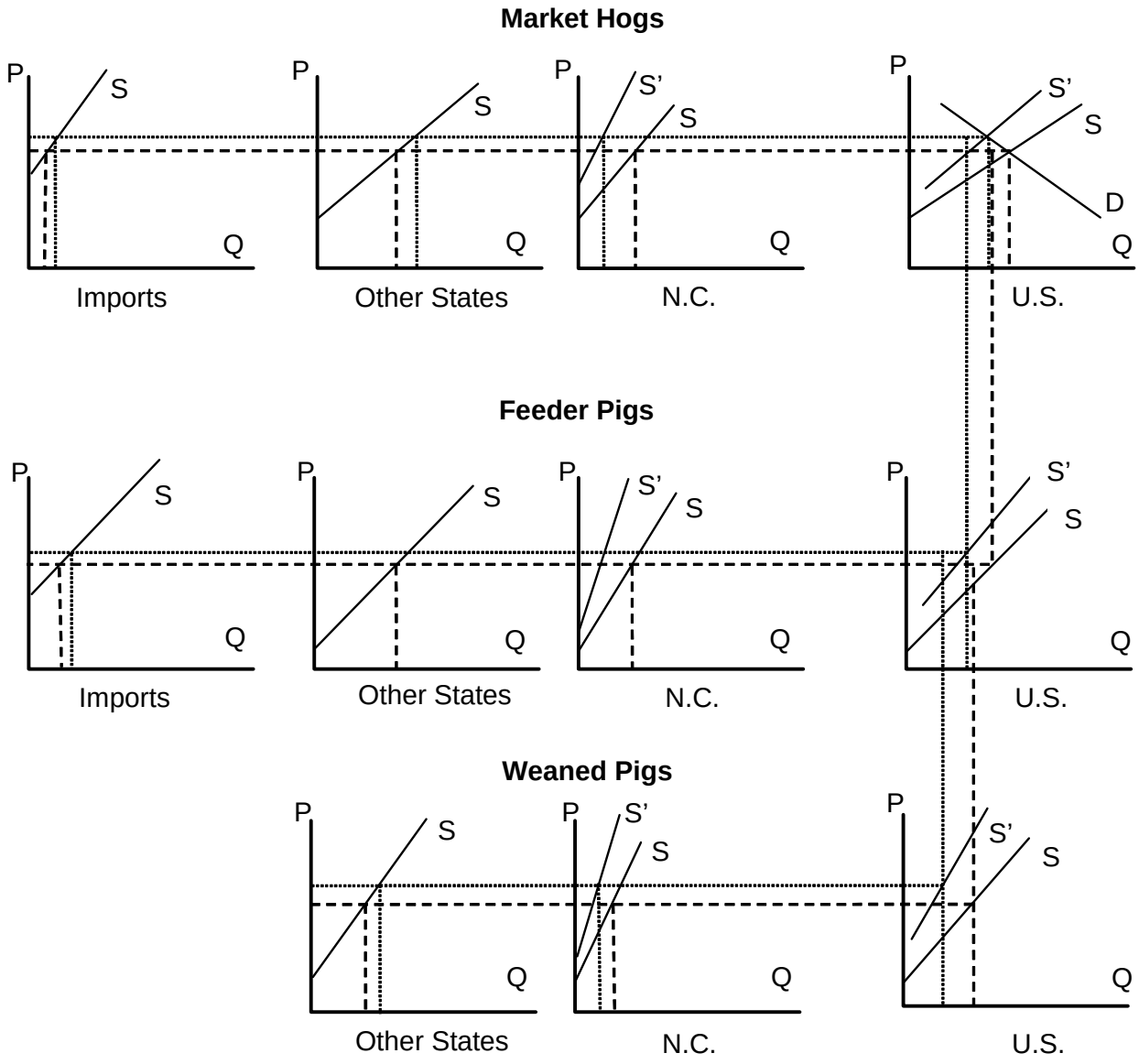
II. Structure of the Swine Market

A. Overall Market Structure with Linkages to Other States and Countries

Figure II1 shows the overall structure of the N.C. swine industry with linkages to other states and countries. The upper set of graphs depicts the market for finished pigs (market hogs), the middle set of graphs depicts the market for feeder pigs, and the bottom set of graphs depict the market for weaned pigs. The initial equilibrium in

the finished pig market is shown in the upper right-hand graph where the supply curve S intersects the demand curve D. The intersection of the equilibrium market price with the supply schedules for imports, supply in other states, and supply in N.C.

Figure II1: Market Equilibrium Adjustment with Introduction of New Swine Waste Technology



determines the respective quantities produced in those regions[1]. Feeder pig production is assumed to be proportional to the U.S. production of market hogs and is shown by the vertical hatched line intersecting the supply curve for feeder pigs in the middle right-hand side graph[2]. In turn, the intersection of this curve with this hatched line determines the market equilibrium price of feeder pigs and allocation of feeder pig production between imports, other states, and N.C. Finally, production of weaned pigs is assumed to be proportional to U.S. production of feeder pigs and market equilibrium occurs in this market where the vertical hatched line intersects the U.S. supply curve of weaned pigs. Again, the allocation of weaned pig production between other states and N.C. is determined where the equilibrium price intersects the supply curves in these states. It is important to note that although total production of feeder pigs is restricted to equal U.S. production of market hogs and total production of weaned pigs is restricted to equal U.S. production of feeder pigs, no such restriction exists between individual states' production of pigs at each stage of production. In other words, the model allows for the fact that N.C. produces a higher proportion of both weaned and feeder pigs than market hogs, and N.C. is a net exporter of both types of pigs to other regions. It is also important to note that demand for market hogs is a derived demand from consumer demand for pork so demand for pork by foreign consumers is reflected in demand for market hogs. Finally, imports are distinguished by market hogs and feeder pigs. Although imports are important to account for in the model, they account for a very small share of total production (2.2% for market hogs; 3.3% for feeder pigs).

To show the impact a new swine waste technology would have on the overall market for swine, the supply curves of weaned pigs, feeder pigs, and market hogs for N.C. produced pigs are shifted upward to reflect the increased cost associated with adopting a given technology. The new market equilibrium can be found by tracing

[1] Prices between regions are not shown but if price differences are fixed costs per unit output they would be shown through upward shifts in the regional graphs to reflect added transfer costs.
[2] Note that the hatched line extending from the market for finished pigs to feeder pigs does not intersect the supply curve in the finished pig market. The gap between this line and the intersection point represents imports of market hogs from Canada. In a similar way, the hatched line extending from the feeder pig market to the weaned pig market is also at a point to the left of the intersection of supply and demand for feeder pigs.

the dotted line from the new equilibrium in the market for finished pigs where the supply curve S' intersects the demand curve D. As one might expect, introduction of a new swine waste technology that is more costly would raise prices of market hogs, feeder pigs, and weaned pigs. Production of all three types of hogs in N.C. would decline but production would increase in other states and imports would expand. How much prices and quantities would change depends upon the slopes (elasticities) of the supply and demand curves. Because the new technology would be required (at least initially) on only N.C. farms, its effect on market prices would likely be small relative to its effects on quantities of pigs produced. Finally, we would expect the effects to be larger over longer periods of time for adjustment than for shorter periods of time.

Figure II1 only shows part of the picture regarding adopting new swine waste technologies. The incremental costs of the new technology can affect different farms in different ways so the incremental costs are first applied to different type/size categories. These type/size categories are as follows:

- Types of operations: farrow-to-finish, feeder-to-finish, farrow-to-feeder, wean-to-feeder, and farrow-to-wean.
- Sizes of operations (steady-state live weight--SSLW): 0-500 AU, 500-1000 AU, 1000-1500 AU, 1500-2000 AU, and 2000+ AU

The 21 different type/size categories with relative pounds of pork (SSLW) are shown in table II1. Given the cost estimates by type/size categories (and relative proportions in each category), incremental cost changes from task 1 are converted to pounds per dollar value of the pig at the appropriate market level and the supply curve for each type/size operation affected is shifted up by that amount. The aggregate impact of incremental cost changes is summarized by the supply curve shifts shown in figure II1.

Table II1. Total Pounds (SSLW) Allocated to each Type/Size Farm Category in N.C.

	0-500	500-1,000	1,000-1,500	1,500-2,000	2,000+	Sum
Farrow-Wean	24,950.58	69,652.72	76,989.37	61,064.34	50,118.20	282,775.21
Farrow-Feeder	19,050.51	41,172.11	22,830.54	10,967.15	7,943.81	101,964.12
Farrow-Finish	13,643.77	12,785.64	15,218.76	26,297.22	24,361.07	92,306.46
Wean-Feeder	67,755.21	0	0	0	0	67,755.21
Feeder-Finish	256,755.25	301,482.50	115,408.98	58,162.93	43,845.60	775,655.26

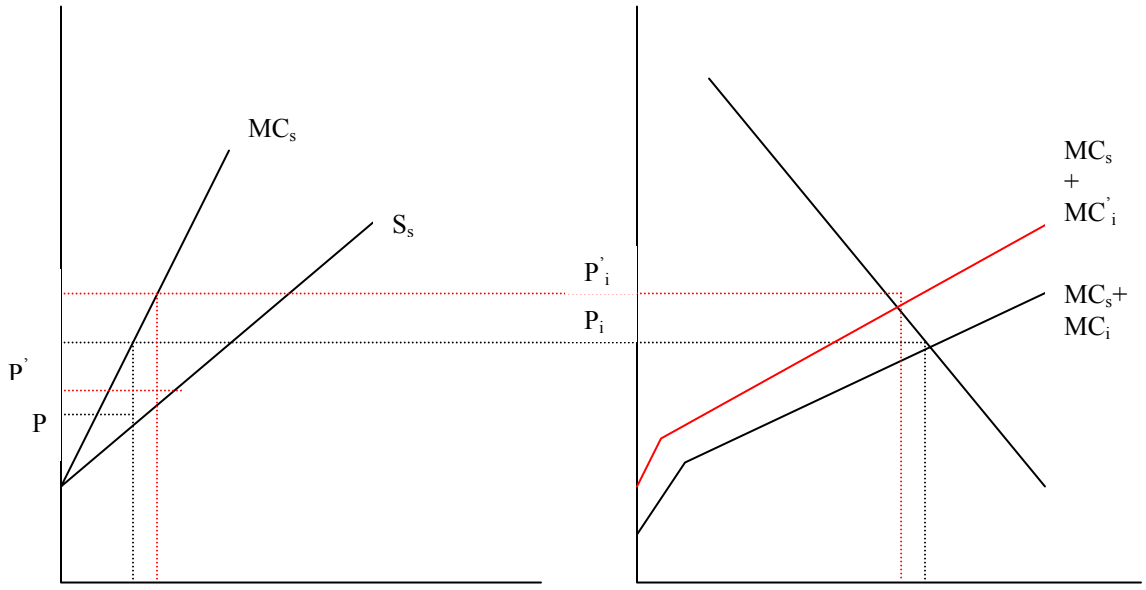
B. Impact of Industrial Organization on the Market Model

It is important to take account of the fact that a large proportion of the swine operations are either contract-farms or company-owned farms. One important question to ask is: How does the presence of vertical organizational structures affect the way in which we model supply response and demand for pigs? One way in which such a vertical organizational structure could manifest itself is in the relationship between the market spot price for hogs and internal prices of company-owned farms and contract prices. Azzam (1998) shows that the higher the proportion of "captive supplies" (i.e., supplies company-owned or under contract) the lower the spot price. This relationship may or may not be due to market power by vertically integrated and contract farms. It could simply be due to differences in marketing services provided by company-owned farms and integrators and transaction costs versus prices from selling on the spot market. In either case, though, we might expect to observe a gap between the spot price and the internal and contract prices.

Figure II2 shows how existence of market power could affect the spot market price. The right-hand panel in this figure shows that the internal price of finished pigs, P_i, is determined by the intersection of market demand and the horizontal summation of marginal cost of producing pigs by integrated firms (MC_i) and the marginal cost of pigs obtained on the spot market (MC_s). The left-hand panel shows the relationship between the internal price and the spot price (P).

The relationship between the two prices is $P(1+\Omega) = P_i$ where Ω is a proportional price wedge. If this wedge is constant, then the two prices move in proportion to one another and the model collapses essentially to the standard competitive supply-demand model where market supply is the horizontal summation of the supply curves (marginal cost curves) from the two sources of pigs. If this is the case, we could define market equilibrium with respect to the spot price as opposed to the internal unobserved price, even if market power was present. However, if the wedge is not constant then the two prices will not necessarily move proportionately with one another and we would need to know what the relationship between the two prices is in order to evaluate the impact of a supply shift on the vertically integrated firms. In light of the importance of these price relationships, analyses are conducted to evaluate whether there is market power in the finished pig market. If so, the analysis would need to be modified to account for market power. If there is no evidence of market power, the analysis can proceed assuming the spot price is an adequate indicator of co-movements in contract and internal company prices.

Figure II2. Relationship Between Marginal Cost of Production and Spot Price of Finished Pigs

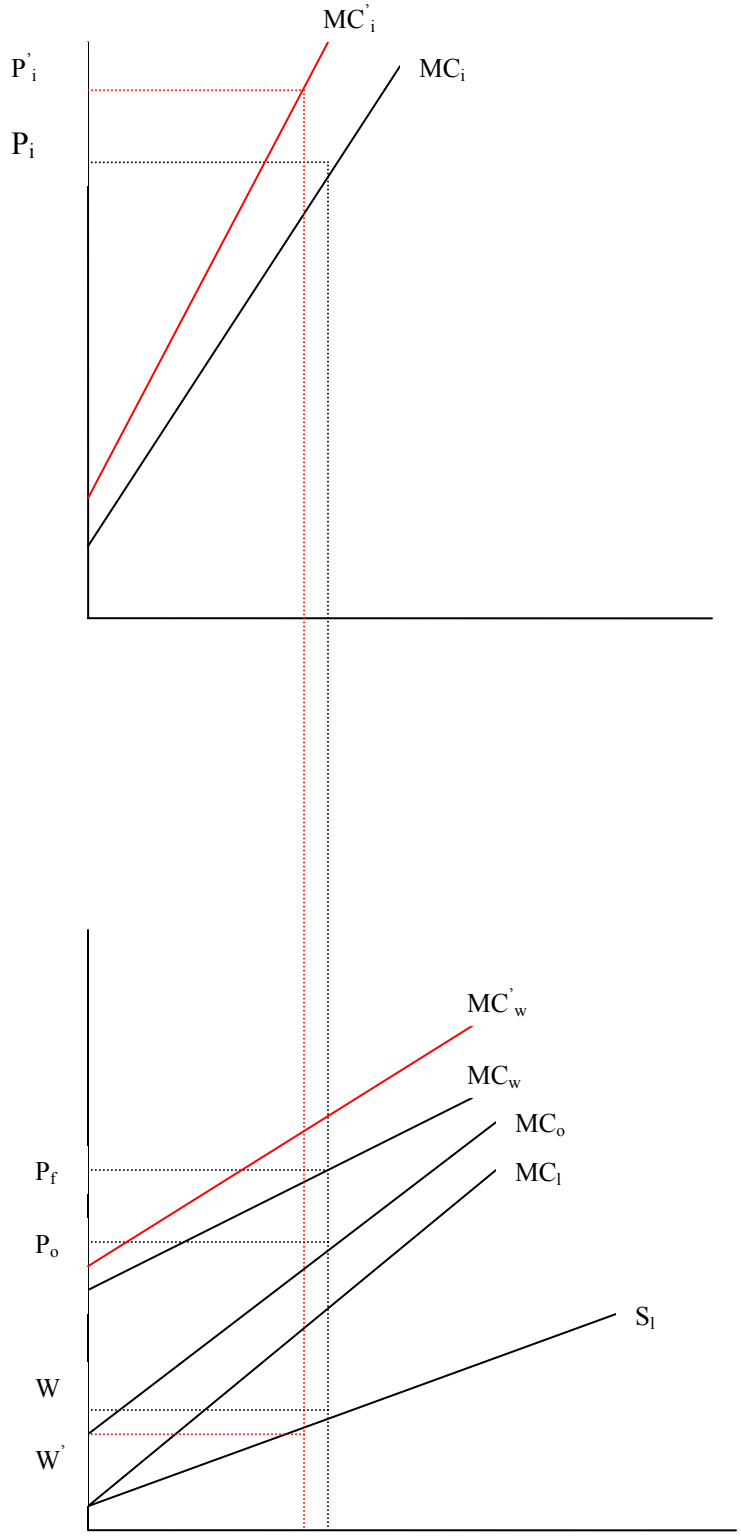


Another issue to address is the influence of vertical integration and contracting on the structure of supply response. As shown in figure II3, the marginal cost of producing finished pigs can be viewed as the vertical summation of the marginal costs of procuring growers' effort (MC_l), grower provided inputs (e.g., manure management, land, labor, utilities, housing facilities, etc.) (MC_w), and integrator supplied inputs (e.g., feed, animals, medication, etc.) (MC_0). In this case, market power is permitted in the market for growers' effort so that there is a divergence between marginal cost and supply of growers' effort. This is often hypothesized to be a main cause and incentive for vertical integration and/or contracting (Sexton and Lavoie 2001). Nevertheless, even in this case we would still expect to have a well-defined supply function for market hogs. As shown in the figure, aggregate marginal cost of market hog supply can be obtained as the vertical summation of marginal costs from grower-provided inputs and integrator-provided inputs. *Equivalently,* if these supplies were provided by independent producers, the marginal cost of market hogs would be the

supply function of independent producers. Therefore, the aggregate marginal cost of providing market hogs can be viewed as the summation of market hogs from three different sources: contract, company-owned, and independent. In appendix A, a simple economic model is used to rigorously prove this result.

Inoue and Vukina (2003) find some evidence that indeed market power exists in the market for growers' effort. Using contract data provided by Premium Standard Farms, a statistical model was estimated to determine if there was a wedge between value marginal product and compensation paid growers for producing finished pigs. If the value marginal product was significantly higher than compensation paid to growers this would indicate the presence of market power. The statistical results show a statistically significant positive wedge between value marginal product and compensation rates. However, as they indicate, their results should be interpreted with caution because the contract data used do not allow for variation in hog price and the time period for analysis had unusually low prices. With higher hog prices, the results might indicate the opposite conclusion. Thus, the jury is still out on whether market power exists in the market for growers' effort.

Figure II3. Marginal Cost of Producing Finished Pigs



The significance of figure II3 is that, regardless of whether there is market power in the market for growers' effort, we can still view the aggregate marginal cost function for market hogs as a supply function. If market power is present, marginal cost would be greater for each level of output due to the divergence between the supply curve of grower effort and marginal cost of grower effort. But this effect will be captured statistically in the estimated supply function and will not affect future predictions unless the gap between marginal cost of effort and supply of grower effort changes. Because there is simply no way to know how contracts will change in the future all we can do is assume that past behavior will continue into the near future. Therefore, whether market power is present in this market has no bearing on the market-level analysis of the effects of new swine waste technologies[3].

In light of the above discussion, the equilibrium displacement model used to simulate the effects of new swine waste technologies can be formulated as though producers are individual price takers and that supply of pigs at any stage of production is the horizontal summation of supply of pigs from alternative sources of supply. The general mathematical form of the model corresponding to figure II1, assuming integration of prices across regions, is shown in table II2. As indicated previously, while market power in the market for grower effort may not have an effect on the specification of the aggregate market model, market power in the output market for market hogs could have negative consequences. Therefore, in the following analysis, considerable attention is given to testing for the existence of market power due to "captive supplies" and for integration of market prices across regions.

[3] The one potentially important effect is welfare effects on integrators. If market power is present, then the reduced returns to integrators could be passed on in part or whole to growers. Unless we know the specific contract provisions between a given grower and integrator (and how the loss will be shared), there is no way to estimate the effect.

Table II2. Model of Swine Market

(1)	$Q_{wp}^{nc} = S_{wp}^{nc}(P_{wp}^{nc}, t_{wp})$	(Supply of NC weaned pigs)
(2)	$Q_{wp}^{os} = S_{wp}^{os}(P_{wp})$	(Supply of OS weaned pigs)
(3)	$Q_{wp} = Q_{wp}^{nc} + Q_{wp}^{os}$	(Total supply of weaned pigs)
(4)	$Q_{wp} = D_{wp}(Q_{fp}^{us})$	(Total demand for weaned pigs)
(5)	$Q_{fp}^{nc} = S_{fp}^{nc}(P_{fp}^{nc}, t_{fp})$	(Supply of NC produced feeder pigs)
(6)	$Q_{fp}^{os} = S_{fp}^{os}(P_{fp})$	(Supply of OS produced feeder pigs)
(7)	$Q_{fp}^{us} = Q_{fp}^{nc} + Q_{fp}^{os}$	(US supply of feeder pigs)
(8)	$Q_{fp}^{m} = S_{fp}^{m}(P_{fp})$	(Supply of feeder pig imports)
(9)	$Q_{fp} = Q_{fp}^{us} + Q_{fp}^{m}$	(Total supply of feeder pigs)
(10)	$Q_{fp} = D_{fp}(Q_{mh}^{us})$	(Total demand for feeder pigs)
(11)	$Q_{mh}^{nc} = S_{mh}^{nc}(P_{mh}^{nc}, t_{mh})$	(Supply of NC market hogs)
(12)	$Q_{mh}^{os} = S_{mh}^{os}(P_{mh})$	(Supply of OS market hogs)
(13)	$Q_{mh}^{us} = Q_{mh}^{nc} + Q_{mh}^{os}$	(US supply of market hogs)
(14)	$Q_{mh}^{m} = S_{mh}^{m}(P_{mh})$	(Supply of market hog imports)
(15)	$Q_{mh} = Q_{mh}^{us} + Q_{mh}^{m}$	(Total supply of market hogs)
(16)	$Q_{mh} = D_{mh}(P_{mh})$	(Total Demand for market hogs)
(17)	$P_{wp}^{nc} = P_{wp} + T_{wp}$	(NC-Other States Weaned Pig Prices)
(18)	$P_{fp}^{nc} = P_{fp} + T_{fp}$	(NC-Other States Feeder Pig Prices)

(19) $P_{mh}^{nc} = P_{mh} + T_{mh}$ (NC-Other States Market Hog Prices)

Notation:

$Q_{wp}^{nc}, Q_{wp}^{os}, Q_{wp}$ = quantity of weaned pigs (wp) produced in North Carolina, other states, and in total;

$Q_{fp}^{nc}, Q_{fp}^{os}, Q_{fp}$ = quantity of feeder pigs (fp) produced in North Carolina (NC), other states (OS), and in total;

$Q_{mh}^{nc}, Q_{mh}^{os}, Q_{mh}^{us}, Q_{mh}^{m}, Q_{mh}$ = quantity of market hogs (mh) produced in North Carolina, other states, total US (us), imported (m), and in total;

$P_{wp}^{nc}, P_{fp}^{nc}, P_{mh}^{nc}$ = market prices of weaned pigs, feeder pigs, and market hogs in North Carolina;

P_{wp}, P_{fp}, P_{mh} = market prices of weaned pigs, feeder pigs, and market hogs in other states;

t_{fp}, t_{wp}, t_{mh} = technical change in feeder pig, weaned pig, and market hog production;

T_{wp}, T_{fp}, T_{mh} = transfer costs for shipping weaned pigs, feeder pigs, and market hogs from North Carolina to the Mid-west.

III. Modeling Supply Response of Swine Producers

A. A dynamic model of swine production

Swine producers are modeled as profit-maximizing price-taking agents. Producers are assumed to make production decisions each real time period based on their expectations of future prices and input costs. The focus will first be on formulation of a supply model for a representative farrow-to-finish operator. Later this specification will be modified to accommodate the other forms of swine operation, including farrow-to-wean, farrow-to-feeder, wean-to-finish, and feeder-to-finish.

The representative farmer[4] produces pounds of market hogs, y_t, with inputs $\mathbf{x}_t = (x_{1t},...,x_{nt})'$ (e.g., feed, labor, veterinary supplies, etc.), according to the production function

$$y_t = f(\mathbf{x_t}, b_t) \qquad \text{(IIIA1)}$$

where b_t is beginning of the period inventory of farrowing sows. Inventories evolve over time according to the relationship

$$b_{t+1} = b_t + i_t - \delta b_t = i_t + (1-\delta)b_t \qquad \text{(IIIA2)}$$

where i_t is the rate of investment during the period and δb_t is the rate of replacement of farrowing sows, assumed to occur at the constant rate δ.

The cost function for producing swine is the solution to the cost minimization problem

$$c(y_t, \mathbf{w}_t, b_t) = \min_{\mathbf{x_t}}[\mathbf{w_t}'\mathbf{x_t} : y_t = f(\mathbf{x_t}, b_t)] \qquad \text{(IIIA3)}$$

[4] Representative of a specific type and size category.

where $\mathbf{w}_t$ denotes the vector of variable input prices. For sake of simplification, assume that the production function has the form

$$y_t = \min\{\alpha b_t, h(\mathbf{x_t})\}$$

where $h(\mathbf{x_t})$ is assumed to be linearly homogenous. This specification of the production process implies that the cost function can be represented as

$$c(y_t, \mathbf{w}_t, b_t) = uc(\mathbf{w}_t)y_t = uc(\mathbf{w}_t)\alpha b_t \qquad \text{(IIIA4)}$$

In this specification, α denotes the number of pounds of live market hogs produced per farrowing sow.[5]

In addition to the above costs, the representative producer also incurs adjustment costs, $c^a(i_t) = \frac{\gamma}{2} i_t^2$. The idea underlying these costs is that costs will rise more rapidly the faster the firm attempts to adjust to market conditions (Mundlak 2001). Lucas (1967) indicates that adjustment costs can be viewed as internal costs associated with devoting more resources to investment (future output) compared to allocating resources to current production. With diminishing marginal returns to each activity, as resources are withdrawn from production to increase capacity for future production, investment costs will rise at an increasing rate.[6]

With this specification of costs, profit per period of time is as follows:

[5] In some specifications, average livestock weights are allowed to depend upon prices so that the producer's decision model consists of two equations: (i) an output equation for production decisions given the inventory level at the beginning of the period, and (2) an inventory equation describing how the size of the breeding herd changes over time. In this case, average weights are found not to respond significantly to changes in prices so only one equation is used to characterize supply response of producers. Marsh (1999) found a similar result for swine and indicates that the result "…is not surprising as hog finishing involves rapid marketing turnover once barrows and gilts reach the 230-260 pound weight range. Turnover is a product of biological factors, farrow-to-finishing technology (i.e., large confinement operations), and increased producer contracting with pork packers…"(p. 323).

[6] In other words, we would expect to observe a concave production possibilities frontier between output and investment for fixed quantities of factor inputs.

$$\pi_t = p_t y_t - uc(\mathbf{w_t}) y_t - c^a(i_t) = [p_t - uc(\mathbf{w_t})]\alpha_t b_t - \frac{\gamma}{2} i_t^2 = m_t b_t - \frac{\gamma}{2} i_t^2 \qquad \text{(IIIA5)}$$

where p_t is price per pound of market hog sold and $m_t = [p_t - uc(\mathbf{w_t})]\alpha_t$.

Let $\beta = (1+r)^{-1} < 1$ be the constant real discount factor. After solving equation (IIIA2) for i_t and substituting into (IIIA5), the expected present value of future profits equals

$$EPV = E\sum_{j=0}^{\infty} \beta^j \pi_{t+j} = E\sum_{j=0}^{\infty} \beta^j \{m_{t+j} b_{t+j} - \frac{\gamma}{2}[b_{t+1+j} - (1-\delta) b_{t+j}]^2\} \qquad \text{(IIIA6)}$$

where E is the expectation operator, conditional upon information available to the firm at the beginning of time period t. The first-order necessary condition for expected profit maximization, equation (IIIA6), is therefore

$$\frac{\partial EPV}{\partial b_{t+1+j}} = E\beta^j \{\beta m_{t+1+j} - \gamma[\, b_{t+1+j} - (1-\delta) b_{t+j}\,]\,]$$

$$+ \gamma\beta(1-\delta)[b_{t+2+j} - (1-\delta) b_{t+1+j}]\} = 0 \qquad \text{(IIIA7)}$$

After taking expectations of both sides, equation (IIIA7) can be expressed as follows:

$$E\beta m_{t+1+j} - \gamma[\; b_{t+1+j} - (1-\delta) b_{t+j}\,] + \gamma\beta(1-\delta)[b_{t+2+j} - (1-\delta) b_{t+1+j}] = 0$$

Re-arranging this equation yields the second-order difference equation:

$$b_{t+2+j} - \theta b_{t+1+j} + \beta^{-1} b_{t+j} = -\omega E m_{t+1+j} \qquad \text{(IIIA8)}$$

where $\theta = \beta^{-1}(1-\delta)^{-1} + (1-\delta)$ and $\omega = \gamma^{-1}(1-\delta)^{-1}$. Using the lag operator, $Lz_t = z_{t-1}, L^{-1}z_t = z_{t+1}$, equation (IIIA8) can be expressed as

$$(1 - \theta L + \beta^{-1}L^2)b_{t+2+j} = -\omega E m_{t+1+j} \qquad \text{(IIIA9)}$$

To solve the above equation, note that the left-hand side of equation (IIIA9) can be written as

$$(1 - \theta L + \beta^{-1}L^2) = (1 - \lambda_1 L)(1 - \lambda_2 L) \qquad \text{(IIIA10)}$$

implying that $\lambda_1 + \lambda_2 = \theta, \lambda_1\lambda_2 = \beta^{-1}$ where $0 < \lambda_1 < 1 < \beta^{-1} < \lambda_2$. The characteristic roots are the solutions to the quadratic equation on the left-hand side of (IIIA10); this quadratic equation has solutions:

$$\lambda_1 = \frac{\theta - (\theta^2 - 4\beta^{-1})^{1/2}}{2}, \lambda_2 = \frac{\theta + (\theta^2 - 4\beta^{-1})^{1/2}}{2} \qquad \text{(IIIA11)}$$

Note also $(1 - \lambda_2 L) = -(1 - \lambda_2^{-1}L^{-1})\lambda_2 L = -(1 - \lambda_1\beta L^{-1})(\lambda_1\beta)^{-1}L$. Solving equation (IIIA9) for end-of-the period inventory level yields:

$$-(1 - \lambda_1 L)\ (1 - \lambda_1\beta L^{-1})(\lambda_1\beta)^{-1}Lb_{t+2+j} = -\omega E m_{t+1+j}$$

or

$$(1 - \lambda_1 L)b_{t+1+j} = \lambda_1\beta\omega(1 - \lambda_1\beta L^{-1})^{-1}E m_{t+1+j}$$

Multiplying through by the lag operators and evaluating the solution at j=0 we obtain the solution for end-of-the period inventory of farrowing sows:

$$b_{t+1} = \lambda_1 b_t + \lambda_1 \beta \omega \sum_{j=0}^{\infty} (\lambda_1 \beta)^j E m_{t+1+j} \qquad \text{(IIIA12)}$$

Equation (IIIA12) shows that the end-of-the period inventory of farrowing sows is determined by the beginning-of-the period inventory and the present discounted value of future quasi-rents from holding sows. The complete supply model of the representative producer then consists of equation (IIIA12) plus output of market hogs which is determined from the equation

$$y_t = \alpha_t b_{t.} \qquad \text{(IIIA13)}$$

Equations (IIIA12) and (IIIA13) indicate that the supply structure is recursive, where output is determined by previous decisions regarding the size of the inventory of sows. With a recursive supply structure, market price would then be determined through the inverse demand function for market hogs, given the predetermined level of production.

Equation (IIIA12) shows that the inventory equation depends upon future output price and input price expectations. It is customary to relate these expectations to observable variables using models of expectation formulation. The most general and rigorous approach is to assume agents form rational expectations (RE), which says that expectations of the economic agent are the same as the expected market outcome. Empirically, the RE has been implemented in various ways, ranging from fully imposing all the restrictions implied by the theory to a less restrictive form of the RE called quasi-rational expectations (QRE), which is consistent with the idea of RE but ignores some of the restrictions implied by the RE (Nerlove and Bessler, 2001). QRE is implemented by assuming that the agent's expectation of, say, price p_{t+j}, $\mathrm{E}\, p_{t+j} = E\left\langle p_{t+j} \,\middle|\, p_t, p_{t-1}, \ldots \right\rangle$ is a conditional expectation, where the equation for forecasting is obtained, for example, from the best-fitting ARIMA model. QRE is extremely easy to apply relative to the RE model and forecasts generated by it are asymptotically equivalent to the RE under correct specification. In assessing the advantage of this expectations modeling approach, Nerlove and Bessler (2001, p.199) state that "…adoption of the RE as a maintained

hypothesis and application in the form of QRE would allow a highly desirable concentration on the substance of the behavioral part of the model, and strikes us as the way to go."

In the analysis that follows, it is assumed that the firm uses past information on prices alone to forecast future prices and past information on input prices alone to forecast future input prices. Optimal predictors are obtained using time series analysis. It is also assumed that changes in unit feed costs approximate changes in production input prices. Feed typically accounts for about 80 percent of total variable production costs in farrow-to-finish swine operations and feed prices are the most variable of all input prices[7]. As discussed further below, analysis of time series suggests that these expectations can be modeled as

$$\begin{aligned} p_t &= \psi_0 + \psi_1 p_{t-1} + u_{pt}, \\ w_t &= \rho_0 + \rho_1 w_{t-1} + u_{wt} \end{aligned} \qquad \text{(IIIA14)}$$

This specification implies that the producer's expectations for price and unit feed costs take the form

$$\begin{aligned} Ep_{t+j+1} &= \psi_0 \sum_j \psi_1^j + \psi_1^{j+1} p_t, \\ Ew_{t+j+1} &= \rho_0 \sum_j \rho_1^j + \rho_1^{j+1} w_t \end{aligned} \qquad \text{(IIIA15)}$$

where w_t represents feed costs per cwt gain during the period. If we also assume $\alpha_{t+1} = \alpha$, then equation (IIIA12) can be represented for statistical analysis as[8]

[7] Other variable production costs include veterinary supplies, energy costs, and labor costs, none of which is a very large share of costs.

[8] In the statistical analysis the results were found to be virtually the same whether the number of pigs per litter (main determinant of α) were included or excluded from the model.

$$b_{t+1} = \pi_0 + \lambda_1 b_t + \alpha\beta\lambda_1\omega\frac{\psi_1 p_t}{(1-\beta\lambda_1\psi_1)} - \alpha\beta\lambda_1\varsigma\frac{\rho_1 w_t}{(1-\beta\lambda_1\rho_1)} + u_{bt} \qquad \text{(IIIA16)}$$

where π_0 is a constant (representing the intercept terms in IIIA15), $\zeta = a\omega$, and u_{bt} represents a random error term[9].

The main advantage of estimating model (IIIA16) is because with estimates of the parameters of the price forecasting equations, (IIIA15), the deeper structural parameters of supply response ($\alpha\beta\lambda_1\omega$, $\alpha\beta\lambda_1\varsigma$) can be separated from the parameters generating price expectations. With these parameter estimates, we can use equation (IIIA12) to develop different supply elasticities for different lengths of run, given alternative assumptions on how price expectations are formed. This is particularly important in this application because the environment in which policy is made may affect price expectations in ways different from what has occurred in the past. In other words, the estimated forms of equations (IIIA15) and (IIIA16) will be valid only if supply response evolves in the same way it has in the past.

B. Modeling supply response for different markets

In the previous section, the distinction between farrow-to-finish, farrow-to-feeder, and farrow-to-wean production processes was ignored. Data are only available for farrow-to-finish operations so some methodology needs to be developed to relate these parameter estimates to these other types of production processes. Theory suggests that, under fairly general conditions, we could derive a supply relationship for feeder-to-finish and wean-to-finish through relating the price of market hogs to the prices of feeder pigs and wean pigs, respectively, and then substituting for that relationship into equation (IIIA16).

The theory of market middlemen behavior forms the conceptual basis for modeling the relationship between different stages of swine production down-stream from the

[9] The constant a is included to represent the effect of per unit feed costs on supply response. That is, for empirical analysis $m_t = p_t - uc_t$ is replaced with $m_t = p_t - aw_t$.

alternative farrowing operations. In the short run, producers would purchase pigs from the up-stream market (weaned or feeder pigs) and feed them to market weight. Producers would hold animals up to the point where the expected gain from holding them to a larger weight was equal to the marginal holding cost, which would include feeding from the purchase weight to the market weight (Rosen 1987). Equilibrium adjustment would occur to the point where price of market hogs equals the sum of procurement costs and holding costs. Over longer period of times, the equilibrium price relationship would be the determining factor of middlemen behavior because inventory variation would be limited. Therefore, the behavioral relationships between weaned pigs and finished pigs, and between feeder pigs and finished pigs would take the general forms:

$$\begin{aligned} p_{mht} &= f_{wp}(p_{wpt}, \mathbf{w}_{\mathbf{wpt}}) \\ p_{mht} &= f_{fp}(p_{fpt}, \mathbf{w}_{\mathbf{fpt}}) \end{aligned} \qquad \text{(IIIB1)}$$

where the subscripts denote market hogs (mh), weaned pigs (wp), and feeder pigs (fp). The first equation captures behavior of wean-to-finish operators and the second equation depicts behavior of feeder-to-finish operators.

Empirically, three different price elasticities of supply are required: (1) elasticities of market hogs, (2) elasticities of feeder pigs, and (3) elasticities of weaned pigs. Parametric forms of equations (IIIB1) together with equation (IIIA16) can be used to obtain derived supply elasticities for each one of these markets.[10] Elasticities between each market level are related as follows[11]:

[10] Conceptually, elasticities that take into account all adjustments in the up-stream markets are wanted because these elasticities for each market should be general equilibrium elasticities. In this context, the relevant elasticities then are derived industry supply elasticties, which are determined from the equilibrium solution of the up-stream supply functions and price relationships between the different market levels in the down-stream markets when there are fixed input proportions (Gardner 1979).

[11] Muth (1964, p. 228) shows that the industry supply elasticity with two factors when supply of one of the factors, say A, is perfectly elastic to the industry, is $e = \left(\frac{k_A \sigma + e_B}{k_B} \right)$, where k_A is the cost share of factor A , k_B is the cost share of factor B, σ is the elasticity of substitution between the two factors, and

$$\varepsilon_{wp} = \eta_{mhwp}\varepsilon_{mh}$$
$$\varepsilon_{fp} = \eta_{mhfp}\varepsilon_{mh} \qquad \text{(IIIB2)}$$

where ε_{wp} is the (derived) elasticity of supply of weaned pigs with respect to the price of weaned pigs, ε_{fp} is the (derived) elasticity of supply of feeder pigs with respect to the price of feeder pigs, ε_{mh} is the elasticity of supply of market hogs with respect to the price of market hogs, η_{mhwp} is the elasticity of price transmission between market hog and weaned pig prices, and η_{mhfp} is the elasticity of price transmission between market hog and feeder pig prices.

In the empirical analysis, econometric estimates of the elasticity of market hogs will be computed for different lengths of run and these estimates with estimates of the elasticities of price transmission will be used to estimate supply elasticities for weaned pigs and feeder pigs for different lengths of run. Elasticities of price transmission will be obtained from the estimated price relationships associated with the equations (IIIB1).

C. Modeling supply response of imported pigs

Total supply of market hogs consists of the supply of market hogs produced domestically and imports, virtually all from Canada. In the same way, total supply of feeder pigs consists of the supply of feeder pigs produced domestically and imports. Conceptually, the supply curve of imported pigs can be viewed as the excess supply curve of pigs from

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e_B is the elasticity of supply of factor B. In this case, σ is zero, so $e = \frac{e_B}{k_B}$. If e is the elasticity of market hogs and e_B is the elasticity of weaned pigs (respectively, feeder pigs), then we obtain the formulas in (IIIB2) when the elasticities of price transmission are evaluated as the cost shares. In long-run equilibrium, the elasticity of price transmission estimates from (IIIB1) should equal their respective cost shares. In the empirical analysis, however, we let this parameter be determined by the data.

Canada. Mathematically, the elasticity of the excess supply curve with respect to price is calculated as follows:

$$\varepsilon_i^m = \frac{\varepsilon_i^{ca}}{k_{ip}^{ca}} - \frac{\eta_i^{ca}}{k_{ic}^{ca}} \qquad i = mh,\ fp \qquad \text{(IIIC1)}$$

where ε_i^m is the elasticity of import supply of swine type *i* (mh = market hogs, fp = feeder pigs) from Canada, ε_i^{ca} is the domestic elasticity of supply of swine type *i* in Canada, η_i^{ca} is the domestic demand elasticity for swine type *i* in Canada, k_{ip}^{ca} is imports of swine type *i* as a share of total Canadian supply, and k_{ic}^{ca} is imports of swine type *i* as a share of domestic Canadian demand.

Empirically, the equations in (IIIC1) will be estimated using published estimates of supply and demand elasticities for Canadian swine and data on import shares. Direct estimation of these elasticities is outside the scope of the present study, but estimates of these elasticities are necessary in order to close the market equilibrium model.

D. Econometric estimates of supply response

1. *Dynamic supply response estimates*

The model to be estimated consists of equations (IIIA15) and (IIIA16). Given the structure of the model, the structural parameters are just identified so equation (IIIA16) can be estimated as a reduced-form equation and values of the underlying structural parameters deduced using the estimated parameters of the ARIMA models in (IIIA15).

The inventory equation, (IIIA16), to be estimated can be rewritten as follows:

$$b_{it+1} = \pi_0 + \pi_1 b_{it} + \pi_2 p_{it} + \pi_3 w_{it} + \sum_i \tau_i state_i + \sum_j \kappa_j cl_{jt} + u_{bit} \qquad \text{(IIID1)}$$

where b_{it} is the number of sows farrowing in the *ith* state from December of the current year to February of the following year (1000 head), p_{it} is the price of hogs (barrows, gilts, and sows combined, dollars per cwt) in the *ith* state in year *t*, w_{it} is unit feed cost (dollars per pound of feed, 18% soybean meal and 80% corn), $state_i$ is a dummy variable for the *ith* state and cl_{jt} is the proportion of farms in the *jth* size category for year *t*.[12]

The parameters of equation (IIID1) were estimated using a set of pooled cross-section time-series data for 16 hog producing states over the years 1993-2001, a total of 144 observations. Hog prices and feed costs are deflated by the consumer price index (CPI) for all items. The states included in the estimation are Arkansas, Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Carolina, Ohio, Oklahoma, Pennsylvania, South Dakota, Wisconsin, and other states. For all states, data are available by year for hog prices and corn prices. Soybean meal prices are available by year by region.[13]

Farm size category variables are included in the model to account for differences among farms and states in farm size on supply response. USDA reports number of farms for 1993-2001 in six different size categories (1-99; 100-499; 500-999; 1000-1999; 2000-4999; and 5000+ head inventory). Stoker (1986) has developed a method for using such data to test for aggregation bias from aggregating across individual producers. In particular, he shows that distributional effects can be accounted for and tested for through use of cell proportion data, such as the case here. As long as the cell proportion categories do not change over time, consistent parameter estimates of the macroeconomic equation (in this case IIID1) can be obtained by including cell proportions as regressors

[12] See Appendix B for variable sources and specific definitions of variables used in the empirical analysis.

[13] The regions are as follows: Appalachian (KY, NC, TN, VA, and WV); Corn Belt (IL, IN, IA, MO, and OH); Delta States (AR, MS, and LA); Lake States (MI, MN, and WI); Mountain (AZ, CO, ID, MT, NV, NM, UT, and WY); Northeast (CT, DE, ME, MD, MA, NH, NJ, NY, PA, RI, and VT); Northern Plains (KS, ND, NE, and SD); Pacific (CA, OR, and WA); Southeast (AL, GA, FL, and SC); Southern Plains (OK and TX).

in the model. Stoker (1986) also shows that the joint test that all the cell proportions is zero is equivalent to testing that the underlying microeconomic relations (i.e., individual producer supply equations) are linear.[14]

The aggregate supply model, equation (IIID1), was estimated assuming states could be treated as fixed effects or random effects. A Hausman (1978) test for correlation between the cross-sectional characteristics and the included explanatory variables, however, indicated rejection of the random effects specification in favor of the fixed effects specification.[15] Therefore, the model used is the one shown in equation (IIID1) with zero-one dummy variables used to account for fixed effects of individual states.

The estimation results of equation (IIID1) are presented in table III1. The parameters were estimated with SAS PROC TSREG. In accordance with the restrictions of the model, the first two size categories (1-99 head, 100-499 head) have been deleted from the model and are reflected by the intercept and price coefficient (Stoker 1986). Moreover, the last "state", other hog-producing states (OS), has been deleted and its effect is measured by the intercept. The state dummy variables are Arkansas (AR), Illinois (IN), Indiana (IN), Iowa (IA), Kansas (KS), Michigan (MI), Minnesota (MN), Missouri (MO), Nebraska (NE), North Carolina (NC), Ohio (OH), Oklahoma (OK), Pennsylvania (PA), South Dakota (SD), and Wisconsin (WI).

Two sets of econometric results are presented, one with number of pigs per litter included and one without that variable included.[16] Within each one of these sets, results with and without farm size variables are included. As can be seen in all cases, neither the variable

[14] The intuition of this condition is that, with linear relationships, the mean response of the macroeconomic equation will equal the average response of all the microeconomic equations. Stoker (1986) shows that representation of aggregation bias by cell proportions is a general way to represent aggregation bias, whether the microeconomic relations are linear or non-linear.

[15] See, e.g., Kmenta (1986, pp. 634-635) for discussion of how to apply the Hausman specification test.

[16] Note from equation (A5) that $m_t = [p_t - uc(\mathbf{w_t})]\alpha_t$. If we take a linear approximation of this equation, we find that net returns per sow can be represented as a linear function of price, unit production costs, and the parameter α, the main determinant of which is number of pigs per litter.

number of pigs per litter nor size variables has a statistically significant effect[17]. The latter result is of particular significance because, as discussed previously, this test is equivalent to a test of aggregation bias and linearity of the aggregate supply response. Therefore, we find that the empirical analysis supports using an aggregate supply equation differentiated by state that is independent of the farm size[18]. One reason size may not be important is that size variation may be closely associated with individual states. In particular, note that many of the state variables are highly significant and that their significance increases when the size variables are deleted.

The specifications for price and feed input price expectations were determined using time-series methods. Two different data sets were used in the estimation: an aggregate time series data set to determine the particular ARIMA model to be used for each variable, and the cross-section time-series data set for individual states to estimate the parameters on the lag distributions. The reason for using the aggregate time series data was to have additional observations to identify the lag lengths for the two price series. These results are shown in table III2 for the two data sets. State dummies were initially included in the model but were found to be statistically insignificant as a group and therefore were deleted. The time series estimates confirm that first-order autoregressive equations, as shown in (IIIA14), fit the data adequately. Estimates of the autoregressive parameters for six lags indicated that none of the single parameters was significant, and the Box-Pierce portmanteau tests for the adequacy of the ARIMA process were statistically insignificant.[19] As can be seen from the table, the statistical results confirm the use of first-order autoregressive processes to characterize the quasi-rational expectations models used for the supply response equation. In addition to determining the

[17] The p-values associated with F-values of 1.09 for Model A and 1.05 for Model B are 0.37 and 0.38, respectively.

[18] The model was also estimated with the last four years deleted for NC to account for the impact of the moratorium on hog production. The results were found to be virtually the same so all the observations were retained in the empirical model.

[19] The calculated values for the portmanteau tests are shown in the last row of the table. These statistics are distributed chi-squared with 6-1=5 degrees of freedom, the value of which at the 5% level is 11.0705. From the table, both estimated values are substantially lower than the cut-off value of 11.0705 indicating failure to reject the ARIMA specifications.

Table III1. Econometric Estimates of Sow Inventory Equation, Equation IIID1.

Variable/Model	Model A	Model B	Model C	Model D
Constant	-32.08	-13.55	-12.45	-3.337
Sow begin inv.	0.8414***	0.7753***	0.8370***	0.7735***
Hog price	0.7785***	0.6969***	0.7742***	0.6968***
Feed cost	-369.5*	-333.3*	-378.4*	-345.285**
Pigs/litter	2.269	1.137		
500-999 head	35.44		33.27	
1000-1999 head	65.30		66.00	
2000-4999 head	167.9		179.0	
Over 5000 head	-445.3		-447.4	
State=AR	7.304	7.951	8.287	8.749
State=IL	37.35	84.07***	39.67	85.20***
State=IN	15.80	37.73***	16.67	38.25***
State=IA	11.66	28.55***	12.48	29.08***
State=KS	9.573	11.05	10.26	11.43
State=MI	1.146	2.116	1.548	2.449
State=MN	25.63	46.38***	27.43	47.29***
State=MO	25.79**	36.76***	27.09**	37.44***
State=NE	132.1***	128.1***	134.0***	129.6***
State=NC	10.40	25.06***	11.63	25.65***
State=OH	5.637	9.221	6.132	9.467
State=OK	36.44***	34.60***	38.60***	35.80***
State=PA	53.59***	67.54***	55.06***	68.31***
State=SD	7.277	9.054	8.025	9.623
State=WI	2.646	3.396	3.468	3.771
R-squared	0.9917	0.9914	0.9917	0.9914
F-value	1.09		1.05	

Note: * denotes significance at 0.10 level, ** at 0.05 level, and *** at 0.01 level.

Table III2. Econometric Estimates of Price Expectations Models for Supply Response Model, Equations IIIA14.

Variable/Model	Hog Price	Feed Price	Hog Price	Feed Price
Constant	45.66 (13.014)	0.0810 (0.0262)	25.07 (3.579)	0.0082 (0.0037)
Lagged Hog Price	0.4147 (0.1619)		0.4490 (0.0746)	
Lagged Feed Price		0.5377 (0.1452)		0.8539 (0.0541)
Trend	-1.1130 (0.3358)	-0.0022 (0.0007)		
R-squared	0.81	0.85		
Chi-squared statistic	4.41	1.27		

Note: The first two columns are results for time series data while the last two columns are results for time-series/cross-section data; values in parentheses are estimated standard errors of the coefficients; and the values in the last row are for the portmanteau tests for adequacy of the fitted ARIMA model.

lag order of hog price and feed price in the supply equation, the estimated price equations above can be used with the reduced-form econometric estimates in equation (IIID1) to identify and estimate the structural parameters of the supply response equation so that the expectation variables can be separated from the deeper structural parameters of the model. Using equation (IIIA16) (with the estimated parameters from the two tables above) the supply response equation with respect to future hog prices as indicated by (IIIA12) can be written as

$$b_{it+1} = const + 0.7735 b_{it} + 1.035 \sum_{j=0}^{\infty} (0.7367)^j \, Ep_{it+1+j} \qquad \text{(IIID2)}$$

Equation (IIID2) can be used to generate supply elasticities given appropriate assumptions about price expectations[20]. As discussed below, using the methodology for quantifying the effects of research on supply and market response, equation (IIID2) is used to quantify shifts in supply from incremental cost changes for different lengths of run.

2. *Estimates of Feeder Pig-Market Hog and Weaned Pig-Market Hog Price Relationships*

Estimates of the price linkage equations (IIIB1) are required to estimate supply elasticities for the feeder pig and weaned pig markets. The equations estimated were linear dynamic equations with feed prices (18% soybean meal and 80% corn) used to account for changes in costs. The models were estimated with weekly price data over the time period 1998-2002 and were estimated with the error correction dynamic formulation

$$\Delta p_t = \alpha_i + \beta_{1i}\Delta p_{t-1} + \beta_{2i} p_{t-1} + \boldsymbol{\gamma}'\boldsymbol{\Delta}\mathbf{x_t} + \boldsymbol{\kappa}'\boldsymbol{\Delta}\mathbf{x_{t-1}} + \boldsymbol{\xi}'\mathbf{x_{t-1}} + u_{it} \qquad \text{(IIID3)}$$

where p_t is the price of finished hogs and $\mathbf{x_t}$ represents the vector of explanatory variables (price of weaned pigs, price of feeder pigs, feed prices).

The results of the estimation are presented in table III3. The lag order was tested by including additional lagged values of the first-differenced explanatory variables but in no instance were they found to be significant. Analysis of the 12 lags for the autoregressive parameters of the residuals indicated no evidence of additional autocorrelation in the residuals.

Overall, the statistical results are as expected indicating a positive long-run or steady-state relationship between market hog/feeder pig prices and market hog/weaned pig prices. These steady-state price relationships are computed by setting the first-

[20] In deriving the parameter estimates the assumption was made that the discount factor $\beta = 1/1.05 = 0.952381.$

Table III3. Econometric Estimates of Price Relationships between Market Hogs, Feeder Pigs, and Weaned Pigs, Equations IIID3.

Variable/Model	Δ hog price	Δ hog price
Constant	2.417 (2.141)	1.201 (2.189)
Δ hog price (t-1)	0.2716 (0.0611)	0.2648 (0.0615)
Hog price (t-1)	-0.0674 (0.0178)	-0.0575 (0.0178)
Δ feeder pig price	-0.0051 (0.0591)	
Δ feeder pig price (t-1)	-0.1151 (0.0590)	
Feeder pig price (t-1)	0.0537 (0.0174)	
Δ weaned pig price		0.1676 (0.0917)
Δ weaned pig price (t-1)		-0.0511 (0.0930)
Weaned pig price (t-1)		0.0810 (0.0333)
Δ feed input price	-36.39 (123.7)	-60.60 (124.3)
Δ feed input price (t-1)	-118.6 (121.8)	-153.1 (121.4)
Feed input price (t-1)	-19.95 (34.30)	-7.804 (34.33)
R-squared	0.13	0.12
Elasticities	0.62	0.74

Note: Values in parentheses are standard errors of the coefficients.

differences in the equations to zero and solving for the marginal effect of feeder pig (respectively, weaned pig) price on market hog price[21]. The elasticities at the sample mean of the data are shown in the last row of the table. These elasticities are the elasticities of price transmission used in calculating elasticities of supply for feeder pigs and weaned pigs as shown in equation (IIIB2).

IV. Modeling Demand Response Parameters

A. Modeling Derived Demand for Market Hogs

The market model requires a specification of derived demand for market hogs. Conceptually, this relationship represents U.S. industry processor demand for finished hogs and is derived from consumer demand for pork from U.S. and foreign consumers of U.S. produced pork. Wohlgenant (2001) shows that a general specification of this relationship is

$$p = D(y, \mathbf{w}_m, \mathbf{z}) \qquad \text{(IVA1)}$$

where $D(\bullet)$ is the inverse derived demand for finished pigs, $\mathbf{w}_m$ is a vector of prices of inputs used in processing and marketing pork (e.g., wage rates, energy prices, transport costs, packaging costs), and $\mathbf{z}$ is a vector of shifters of final consumer demand for pork (e.g., income, prices of substitute meats, population). Even with diverse firms, we expect a negative relationship between hog prices, p, and quantity of hogs procured for processing, y[22]. Increases in marketing input prices can either depress or increase hog prices depending upon whether output effects from marketing input price changes exceed or are offset by substitution effects in the vertical processing chain. In all cases, factors

[21] For example, the marginal effect of a change in feeder pig price on market hog price from table III3 would equal 0.0537/0.0674 = 0.7967.

[22] By diverse firms is meant that firms, while facing similar prices, can have different production possibilities due to differences in specialized factors (e.g., land), and differences due to entrepreneurial capacity so there are both marginal and inframarginal firms in the industry.

that cause consumers to demand more pork products would be expected to increase hog prices.

To obtain empirical estimates of the derived demand relationship for market hogs we require specification of the determinants of demand and a functional form to relate price to quantity procured and the demand shifters. The U.S. Department of Agriculture (U.S.D.A.) publishes a food marketing cost index that is an index of the major input prices used in food processing and marketing. This index, w_{mt}, is used to represent the combined effects of $\mathbf{w}_m$. Conceptually, the vector $\mathbf{z}$ represents demand shifters for domestic demand and export demand for pork. So this vector would theoretically include income and population in countries buying our pork. However, over time the exporting countries have changed. In recent years Japan has been a large purchaser of our exports but in previous years other countries were dominant (Muth et al 2003). Because exports are a relatively small share of all consumption of U.S. pork, the demand shifters included in the model are U.S. per capita income (pi_t), retail prices of beef and poultry (p_{bft}, p_{pyt}), and a time trend (t) to account for trend effects of omitted determinants of demand for pork. For a linear functional form the derived demand for hogs would have the form:

$$p_t = \alpha_0 + \alpha_1 py_t + \alpha_2 w_{mt} + \alpha_3 pi_t + \alpha_4 p_{bft} + \alpha_5 p_{pyt} + \alpha_6 t + u_{pt} \qquad \text{(IVA2)}$$

where py_t represents per capita market hog sales and u_{pt} is a random disturbance term[23].

[23] By convention, we express the demand relationship on a per capita basis by dividing quantity of hogs processed and income by total population.

B. Modeling the Impact of Market Power

As discussed earlier in this report, market power in procurement of market hogs for processing has been a concern and we need to have some way to take this into account empirically and to test for its presence. Paul (1999), Muth and Wohlgenant (1999) discuss how to develop a model for factor demand that allows for market power. Following Muth and Wohlgenant (1999), the raw input procurement decision of an individual processor can be represented as

$$p + \theta y \frac{\partial p}{\partial y} = mvp(y, \mathbf{w_m}, p_{pk}) \qquad \text{(IVB1)}$$

where θ is a parameter that indexes the degree of market power, and p_{pk} is the price of pork. If $\theta = 0$, the firm is a price taker; if $\theta = 1$, the firm is a monopolist. Intermediate values of θ between zero and one are taken to mean some degree of market power that is less than complete. The interpretation of the profit maximizing first-order condition (IVB1) is that the "perceived marginal factor cost" of finished pigs equals the marginal value product of finished pigs. A complete specification of profit-maximizing behavior of the firm in this case would consist of (IVB1) and the firm's short-run supply function conditional on the quantity of the raw material y

$$y_{pk} = S(y, \mathbf{w_m}, p_{pk}) \qquad \text{(IVB2)}$$

where y_{pk} is quantity of pork produced. Suppose these relationships also hold for all the firms in the industry[24]. Also suppose that total demand for pork (domestic plus export demand) is

$$y_{pk} = D(p_{pk}, \mathbf{z}) \qquad \text{(IVB3)}$$

[24] The aggregate relationships in (IVB1) and (IVB2) have the same form as their firm counterparts with θ now interpreted as the average of the input conjectural elasticities of the industry (Muth and Wohlgenant 1999, pp. 311-312).

Equating supply (IVB3) with demand (IVB2) and solving for the pork price gives the reduced-form solution

$$p_{pk} = p_{pk}(y, \mathbf{w_m}, \mathbf{z}) \qquad \text{(IVB4)}$$

Substituting (IVB4) into the right-hand side of (IVB1) then gives

$$p + \theta y \frac{\partial p}{\partial y} = mvp[y, \mathbf{w_m}, p_{pk}(y, \mathbf{w_m}, \mathbf{z})] = D(y, \mathbf{w_m}, \mathbf{z})$$

or $$p = -\theta y \frac{\partial p}{\partial y} + D(y, \mathbf{w_m}, \mathbf{z}) \qquad \text{(IVB5)}$$

Since the function $D(y, \mathbf{w_m}, \mathbf{z})$ has exactly the same interpretation as that in (IVA1) we have retained the original industry derived demand representation of demand for market hogs while generalizing the specification to allow for market power. The first term on the right-hand side of (IVB5), $-\theta y \frac{\partial p}{\partial y}$, represents the mark-down on the price of market hogs due to the influence of additional purchases of hogs on the price of hogs. In other words, if firms have market power in procuring hogs on the open market, each firm's costs will rise as they purchase more on the open market and therefore the added cost of procurement will exceed the price, leading to a mark-down on the price paid for hogs on the cash market.

Equation (IVB5), while forming the basis for estimating and testing for market power, requires a parametric specification. In order to identify the degree of market power, it is necessary to have the slope of the supply function depend upon exogenous supply shifters.[25] In this case, there is a natural way to specify the supply function that

[25] See Muth and Wohlgenant (1999, p. 302) for an extensive discussion of this idea which is analogous to the identification issue in the output market discussed by Bresnahan (1982) and Lau (1982).

incorporates this property. In particular, short-run supply of market hogs is normally specified as a function of the hog-corn or hog-feed ratio, beginning of the period inventory of market hogs (or farrowing sows), number of pigs per litter, and the influence of technical change through genetic changes, etc. (usually represented by trend).[26] For a linear supply model, this specification would be as follows:

$$py_t = \beta_0 + \beta_1 (p / p_f)_t + \beta_2 pb_t + \beta_3 pl_t + \beta_4 t + u_{yt} \qquad \text{(IVB6)}$$

where p_f is the price of feed, pb is the beginning per capita inventory level of farrowing sows, pl is the number of pigs per litter, t is a linear time trend, and u_{yt} is a random disturbance term[27]. Solving (IVB6) for p and differentiating with respect to per capita output py gives $\frac{\partial p_t}{\partial py_t} = \frac{p_{ft}}{\beta_1}$. Therefore, equation (IVB5) after substituting the right-hand side of equation (IVA2) for $D(\bullet)$ can be written as

$$p_t = \alpha_0 - \frac{\theta}{\beta_1} p_{ft} py_t + \alpha_1 py_t + \alpha_2 w_{mt} + \alpha_3 pi_t + \alpha_4 p_{bft} + \alpha_5 p_{pyt} + \alpha_6 t + u_{pt} \qquad \text{(IVB7)}$$

Equations (IVB6) and (IVB7) constitute a non-linear system of simultaneous equations in output and price that can be estimated jointly to determine the existence and degree of market power in the market for finished pigs. These equations assume linear functional forms. For the supply equation this seems as reasonable a priori as any other functional form, but for the input demand relation, equation (IVB7), the linear form may be problematic because it represents a reduced-form relationship for industry derived demand. Therefore, in the empirical analysis we consider other functional relationships be postulating that $D(\bullet)$ can be generalized using the Box-Cox transformation. In

[26] See for example Marsh (1999).
[27] To be consistent with the demand specification, the supply relationship is also expressed on a per capita basis. The statistical results are insensitive to this transformation.

particular, let the right-hand side variable, py_t, be replaced in (IVB7) by the transformed variable, $py_t^{(\lambda)} = \frac{py_t^{\lambda} - 1}{\lambda}$[28]. In the same way, we can transform the other right-hand side variables (except t) so that (IVB7) can be generalized to

$$p_t = \alpha_0 - \frac{\theta}{\beta_1} p_{ft} py_t + \alpha_1 py_t^{(\lambda)} + \alpha_2 w_{mt}^{(\lambda)} + \alpha_3 pi_t^{(\lambda)} + \alpha_4 p_{bft}^{(\lambda)} + \alpha_5 p_{pyt}^{(\lambda)} + \alpha_6 t + u_{pt} \quad \text{(IVB8)}$$

The estimation problem is now estimation of the simultaneous non-linear system of equations represented by (IVB6) and (IVB8). The test for linearity is $H_0 : \lambda = 0$ and the test for price-taking behavior is $H_0 : \theta = 0$.

Two alternative approaches could be taken to specifying marginal factor cost in the way indicated in equation (IVB8). One is to follow the approach of Paul (1999) where she makes the slope of the supply function facing the firm a low order polynomial in the quantity of market hogs. The problem with this approach is that one would be required to have a different functional form for the supply function compared to the input demand function in order to identify the degree of market power. Moreover, this specification violates the principle for identification indicated by Bresnahan (1982) and Lau (1982) to have the slope of the behavioral function depend upon an exogenous shift variable. In this context, Ellis and Halvorson (2002) have suggested making the slope of such a behavioral function some low order polynomial in trend (i.e., $\theta \partial p_t / \partial y_t = \gamma_0 + \gamma_1 t + \gamma_2 t^2$). This would work so long as the industry derived demand function, $D(\bullet)$, is not linear or that the intercept term, γ_0, is equal to zero. Paul (1999) and Ellis and Halvorson (2002) chose the approaches they did because they had little or no information on the underlying behavioral equations, which is not the case here. Because of the natural way in which the hog-feed price ratio is expected to influence short-run supply response, we obtain a

[28] See Greene (1990, pp. 329-331) for discussion of the Box-Cox model when only transforming right-hand side variables.

specification for perceived marginal factor cost that depends on the interaction term, $p_{ft} y_t$, that allows us to identify the degree of market power.

C. Modeling Spatial Price Relationships

One basic concept in economics is the idea that arbitrage will ensure that the prices of a homogenous good at any two locations will differ at most by the cost of moving the commodity from one region to the other. The costs of moving the commodity from one region to another include transport costs and any other costs required to transfer ownership from one party to another. If regional markets are closely related through trade and arbitrage, then we would expect these markets to be linked by a single, unique price, commonly referred to as the Law of One Price (LOP) (Fackler and Goodwin 2001). The significance of the LOP for the present study is that if true it will allow statistical analysis of the regional supply/demand relationships to be conducted as if there is a single market price. Perhaps more importantly, because a high proportion of pigs sold in North Carolina are sold under contract or are priced internally by company-owned farms, a strong price relationship between North Carolina and a central market (e.g., Iowa) would indicate that the central market cash price would be a good measure of movements in both contract and company-owned internal prices.[29]

The approach taken to spatial market integration will be the standard bivariate modeling approach of Richardson (1978) whereby

$$p_{it} = \rho_0 + \sum_i \rho_i state_i + \vartheta p_{0t} + \nu_{it} \qquad \text{(IVC1)}$$

where $state_i$ is the state dummy variable as before ($i = 1$ for state i; $i = 0$ otherwise), and

[29] As discussed earlier in the report, we would expect this to occur because both the marginal cost of contracting and internal marginal cost of company-owned hogs would be expected to equal the cash market price.

p_{0t} represents the base state price (Iowa state price). The test for perfect price integration between regions is $\vartheta = 1$. Failure to reject this hypothesis is equivalent to saying a single-price can be used to represent price movements in all regions, including North Carolina.

D. Econometric Estimates of Demand and Spatial Price Relationships

1. *Tests for market power and derived demand estimates*

In light of the previous discussion, it is useful to proceed by first estimating the general model that accounts for both market power and generalized functional form and find a parsimonious model to characterize industry derived demand for market hogs. The two equations to estimate jointly are equations (IVB6) and (IVB8). The data used to estimate the parameters are annual time series data over the period 1970-2001 with prices and income deflated by the CPI. Data sources and other details are provided in appendix B.

Table IV1 reports econometric results for equations (IVB6) and (IVB8) estimated with the full information maximum likelihood method (FIML) using SAS PROC MODEL. Model A is the full model with estimates for both the market power parameter θ and parameter associated with the Box-Cox transformation λ. Model B contains the restricted model where λ=1, corresponding to the linear form. The results for model A suggest that θ=0 and λ=1. A formal test for this is the likelihood ratio test which is computed as -2 Log likelihood ratio. Between model A and model B, the value of the test statistic is 0.1706. The likelihood ratio test statistic is distributed chi-squared with 2 degrees of freedom. Comparing the computed value of 0.1706 with the tabled chi-squared values indicates that the p-value is greater than 0.75. This means that we fail to reject the null hypothesis of linear demand response. Given linearity (λ=1), we next test to see if θ=0. These results are shown by model C which indicates that the numerical estimate of this parameter is nearly zero. Indeed, both t-statistic and likelihood ratio test (p-value > 0.10) indicate failure to reject the null hypothesis $\theta = 0$. Therefore, we fail to reject both price-taking behavior in the market for finished hogs and linear demand response.

It is also of interest to note that the price-feed ratio in the supply equation for hogs is statistically insignificant at conventional levels. This suggests that short-run market supply is unresponsive to market hog and feed price changes[30]. This result validates the assumption made earlier in the supply response section where we assumed that supply response reflects only changes in the size of the herd or swine operation, not changes in the average weights of hogs marketed. The lack of price responsiveness in the supply equation indicated in table IV1 also suggests that demand and supply are recursive so that the inverse demand equation can be estimated by ordinary least squares assuming that the quantity of hogs marketed is predetermined with respect to the current price. These results are shown by Model D and, as can be seen, the parameters are quite close to those when demand and supply are estimated jointly further confirming that the assumption of recursive supply/demand structure is valid in this instance.

2. Spatial price relationships

Equation (IVC1) is used to test for spatial market integration in the market for finished pigs. The cross-section time-series data set used before consisting of 16 states and 9 years is used for this purpose. As indicated previously, we use Iowa's price as the base price so the actual data set used consists of 15 states and 9 years. These results are obtained using PROC TSREG of SAS and are reported in table (IV2).

In contrast to before, no constant is included so that each dummy variable shows the average difference between price in the given state and Iowa. Prices are expressed in dollars per cwt. The F-test for the null hypothesis that the coefficient associated with the Iowa price equals unity is 2.17 which has a p-value =0.14. Therefore, we fail to reject that the hog markets are integrated. Indeed, the point estimate is very close to one suggesting that the markets are highly integrated. Thus, it seems reasonable to use the average market price (which is based on Iowa-Minnesota prices) as an indicator of price movements in all regions.

[30] The short-run supply elasticity for model C at the sample means is 0.03.

Table IV1. Econometric Estimates of Derived Demand Relation and Short-Run Supply Function, Equations (IVB6) and (IVB8).

Variable / Model	Model A Price	Model A Quantity	Model B Price	Model B Quantity	Model C Price	Model C Quantity	Model D Price
Constant	84.34 (116.2)	-75.01 (21.07)	72.11 (42.89)	-74.66 (20.97)	74.85 (45.63)	-74.50 (17.74)	72.16 (34.38)
Quantity	-3.354 (20.96)		-1.079 (0.3620)		-1.056 (0.2576)		-1.006 (0.1237)
Price-Feed Ratio		0.0063 (0.0045)		0.0061 (0.0043)		0.0057 (0.0045)	
Income	-0.0303 (0.3909)		-0.0027 (0.0028)		-0.0037 (0.0019)		-0.0033 (0.0019)
Beef Price	1.206 (7.785)		0.3612 (0.2382)		0.4459 (0.1661)		0.3880 (0.1116)
Poultry Price	1.441 (9.294)		0.4369 (0.1594)		0.4775 (0.1071)		0.4910 (0.0803)
FMCI	0.3409 (1.957)		0.1287 (0.2822)		0.0864 (0.2457)		0.0912 (0.1811)
Trend	0.2765 (0.5970)		0.1818 (0.5337)	10.65 (2.635)	0.2952 (0.4909)	10.65 (2.635)	0.1624 (0.4206)
λ	0.7527 (1.349)		1.0		1.0		
Beginning Inventories		2965.0 (202.8)		2960.0 (186.8)		2952.0 (203.4)	
Pigs Per Litter		0.2539 (0.1514)		0.2538 (0.1502)		0.2494 (0.1308)	
θ	-0.0036 (0.0071)		-0.0033 (0.0073)				
-Log likelihood	125.5016		125.5869		126.6710		
R-squared							0.9779
D.W.							1.71

Note: Values in parentheses are standard errors of the coefficient estimates.

Table IV2. Econometric Estimates of Spatial Price Equation (IVC1)

Explanatory Variable/Dependent Variable	Price state *i*
State=AR	-5.633***
State=IL	-4.104***
State=IN	-4.131***
State=KS	-4.568***
State=MI	-3.599***
State=MN	-1.194*
State=MO	-4.727***
State=NE	-1.988***
State=NC	-0.4974
State=OH	-2.587***
State=OK	-5.658***
State=PA	-3.052***
State=SD	-5.463***
State=WI	-1.514**
State=OS	-5.693***
Iowa Price	1.017 (0.0113)

Note: * denotes significance at 0.10 level, ** at 0.05 level, and *** at 0.01 level. The value in parenthesis associated with Iowa Price coefficient is the standard error.

V. Equilibrium Displacement Model of the Swine Industry

A. Quantifying the Effects of New Swine Management Technologies

The market interrelationships shown in figure II1 and table II2 can be translated into equations which show displacement of equilibrium prices and quantities from their initial equilibrium values. Since we are interested only in the response of producers and consumers to incremental cost changes from new waste management technologies, the only exogenous shift parameters are incremental cost changes associated with the 21 size/types of farms.

The detailed model, shown in table VA1 is for the case where only a portion of the farms in North Carolina are required to adopt the technology. It can be easily modified to include the case where all farms are covered by defining the uncovered farms as the null set. Within each market, there are two supply relationships, one for farms required to adopt the new technology and one for those not required to adopt. The model notation and equations for each market (finished hog, feeder pig, and weaned pig) are shown in the table.

The model is an equilibrium displacement model (Alston et al 1995) and assumes (approximately) linear supply/demand functions with parallel shifts in the supply curves at the level of individual farms. While these assumptions are more tenuous at the industry level, they can be justified at the (representative type/size) farm level as a good approximation to the effect of change in a new technology (Rose 1980; Davis 1994; Alston et al 1995). With a parallel shift in the farm's supply from the innovation, the representative farm's supply curve has the form

$$\Delta Q = \beta(\Delta P - K)$$

where ΔQ represents the change in production from the initial equilibrium level, ΔP represents the change in price from the initial equilibrium level, and K represents the

incremental cost of the new technology per unit output. Dividing both sides of this equation by the original quantity, Q_0, the supply equation can be expressed in relative change as follows

$$EQ = \varepsilon(EP - k) \qquad \text{(VA1)}$$

where $EQ = \Delta Q / Q_0$, $EP = \Delta P / P_0$, $\varepsilon = \beta P_0 / Q_0$, and $k = K / P_0$. The advantage of this model is that we are able to quantify the effects of new waste management technologies on supply by multiplying the incremental costs (as a proportion of output price) times the elasticity of supply to determine how much supply of the individual farm will shift at the original price. Given the estimates of incremental costs for the 21 type/sizes of farms these supply responses are then aggregated to compute the changes in equilibrium quantities and prices for market hogs, feeder pigs, and weaned pigs as shown in table V1. Once the changes in prices are determined, we then go back to equation (VA1) to determine how much quantity of each representative farm changes in response to the new technology.

B. Elasticities and Baseline Quantities and Prices

The equilibrium displacement model requires elasticity of supply parameters for each size/type farm in NC and supply elasticities for other states and imports. Estimates of supply response for NC and other states are derived from the estimated equation (IIID2) and the elasticities of price transmission in table III3. Import supply elasticities are derived from published estimates.

Equation (IIID2) shows how the number of farrowing sows associated with the *ith* state respond to changes in future expected hog prices in the *ith* state. This equation together with the identify, equation (IIIA13), $y_{it} = \alpha_{it} b_{it}$, defines quantity supplied from the *ith* state. Because average hog weights are not price responsive, the proportionate change in supply with respect to price is equal only to the proportionate change in number of

Table V1. Equilibrium Displacement Model of the Swine Industry

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Notation:

$Ex = dx / x$; j = farm size (1=0-500,000 SSLW; 2=500,000-1,000,000 SSLW; 3=1,000,000-1,500,000 SSLW; 4=1,500,000-2,000,000 SSLW; and 5=2,000,000+ SSLW); ε = price elasticity of supply; η = price elasticity of demand; and k = percent change in production cost (as a proportion of output price).

Finished Pig (Market Hog) Market:

Let $\tilde{k}_l^{\,j} =$ incremental cost for farm type *l* of size *j* [*l* = *fawp* (farrow-to-wean); *fafp* (farrow-to-feeder); *famh* (farrow-to-finish); *wpfp*(wean-to-feeder); and *fpmh* (feeder-to-finish)].

Production of NC finished pigs:

$$E\hat{Q}_{mh}^{nc} = \varepsilon_{mh}^{nc} EP_{mh}^{nc} - (\hat{Q}_{famh}^{nc} / \hat{Q}_{mh}^{nc}) \sum_{j=1}^{5} (\hat{Q}_{famh}^{ncj} / \hat{Q}_{famh}^{nc}) \varepsilon_{famh}^{ncj} k_{famh}^{j} \qquad \text{(Covered farms)}$$

$$- (\hat{Q}_{fpmh}^{nc} / \hat{Q}_{mh}^{nc}) \sum_{j=1}^{5} (\hat{Q}_{fpmh}^{ncj} / \hat{Q}_{fpmh}^{nc}) \varepsilon_{fpmh}^{ncj} k_{fpmh}^{j}$$

$$E\overline{Q}_{mh}^{nc} = 0 \qquad \text{(Uncovered farms)}$$

$$EQ_{mh}^{nc} = (\hat{Q}_{mh}^{nc} / Q_{mh}^{nc}) E\hat{Q}_{mh}^{nc} \qquad \text{(Total)}$$

where $Q_l^{ncj} = \hat{Q}_l^{ncj} + \overline{Q}_l^{ncj}$ is the quantity of SSLW of pork produced from farm type *l* of size *j* in NC, $Q_{mh}^{nc} = Q_{famh}^{nc} + Q_{fpmh}^{nc}$, and ε_l^{ncj} is the price elasticity of (derived) supply of farm type *l* in NC on farms of size j. Covered farms (farms required to adopt technology)

are indicated by a hat "^" and uncovered farms (farms not required to adopt the technology) have zero change in quantity due to moratorium on production.

The incremental cost shift parameters are defined as follows:

$$k^{j}_{famh} = \widetilde{k}^{j}_{famh}$$

$$k^{j}_{fpmh} = \widetilde{k}^{j}_{fpmh} + (55/255)((100/55)(P^{nc}_{fp} / P^{nc}_{mh})\widetilde{k}^{j}_{fafp}$$

where P^{nc}_{fp} is the price for feeder pigs in NC and P^{nc}_{mh} is the market price of finished pigs in NC.

Other states' *(os)* supply:

$$EQ^{os}_{mh} = \varepsilon^{os}_{mh} EP_{mh}$$

where P_{mh} is the market price of finished pigs in other states (Midwest average price).

U.S. supply of finished pigs (*us*):

$$EQ^{us}_{mh} = (Q^{nc}_{mh} / Q^{us}_{mh})EQ^{nc}_{mh} + (Q^{os}_{mh} / Q^{us}_{mh})EQ^{os}_{mh}$$

Import (*m*) supply:

$$EQ^{m}_{mh} = \varepsilon^{m}_{mh} EP^{m}_{mh}$$

Total market supply of finished pigs:

$$EQ_{mh} = (Q_{mh}^{us} / Q_{mh}) EQ_{mh}^{us} + (Q_{mh}^{m} / Q_{mh}) EQ_{mh}^{m}$$

Market demand for finished pigs:

$$EQ_{mh} = \eta EP_{mh}$$

Relationship between market price of NC finished pigs (P_{mh}^{nc}), market price of imported pigs (P_{mh}^{m}), and Midwest market price (P_{mh}):

$$EP_{mh}^{nc} = (P_{mh} / P_{mh}^{nc}) EP_{mh}$$

$$EP_{mh}^{m} = (P_{mh} / P_{mh}^{m}) EP_{mh}$$

Feeder Pig Market:

Production of NC feeder pigs:

$$E\hat{Q}_{fp}^{nc} = \varepsilon_{fp}^{nc} EP_{mh}^{nc} - (\hat{Q}_{wpfp}^{nc} / \hat{Q}_{fp}^{nc}) \varepsilon_{wpfp}^{nc} k_{wpfp}^{j} \qquad \text{(Covered farms)}$$

$$- (\hat{Q}_{fafp}^{nc} / \hat{Q}_{fp}^{nc}) \sum_{j=1}^{5} (\hat{Q}_{fafp}^{ncj} / \hat{Q}_{fafp}^{nc}) \varepsilon_{fafp}^{ncj} k_{fafp}^{j}$$

$$E\overline{Q}_{fp}^{nc} = 0 \qquad \text{(Uncovered farms)}$$

$$EQ_{fp}^{nc} = (\hat{Q}_{fp}^{nc} / Q_{fp}^{nc}) QE\hat{Q}_{fp}^{nc} \qquad \text{(Total)}$$

The incremental cost shift parameters are defined as follows:

$$k^{j}_{fafp} = \widetilde{k}^{j}_{fafp}$$

$$k^{j}_{wpfp} = \widetilde{k}^{j}_{wpfp} + (P^{nc}_{wp} / P^{nc}_{fp})\widetilde{k}^{j}_{fawp}$$

Other states' supply:

$$EQ^{os}_{fp} = \varepsilon^{os}_{fp} EP_{fp}$$

U.S. supply of feeder pigs:

$$EQ^{us}_{fp} = (Q^{nc}_{fp} / Q^{us}_{fp})EQ^{nc}_{fp} + (Q^{os}_{fp} / Q^{us}_{fp})EQ^{os}_{mh}$$

Import supply of feeder pigs:

$$EQ^{m}_{fp} = \varepsilon^{m}_{fp} EP^{m}_{fp}$$

Total market supply of feeder pigs:

$$EQ_{fp} = (Q^{us}_{fp} / Q_{fp})EQ^{us}_{fp} + (Q^{m}_{fp} / Q_{fp})EQ^{m}_{fp}$$

Market demand for feeder pigs:

$$EQ_{fp} = EQ^{us}_{mh}$$

Relationship between market price of NC feeder pigs (P_{fp}^{nc}), market price of imported pigs (P_{fp}^{m}), and Midwest market price (P_{fp}):

$$EP_{fp}^{nc} = (P_{fp} / P_{fp}^{nc}) EP_{fp}$$

$$EP_{fp}^{m} = (P_{fp} / P_{fp}^{m}) EP_{fp}$$

Weaned Pig Market:

Production of NC weaned pigs:

$$E\hat{Q}_{wp}^{nc} = \varepsilon_{wp}^{nc} EP_{wp}^{nc} - \sum_{j=1}^{5} (\hat{Q}_{fawp}^{ncj} / \hat{Q}_{fawp}^{nc}) \varepsilon_{fawp}^{ncj} \tilde{k}_{fawp}^{j} \qquad \text{(Covered farms)}$$

$$E\overline{Q}_{wp}^{nc} = 0 \qquad \text{(Uncovered farms)}$$

$$EQ_{wp}^{nc} = (\hat{Q}_{wp}^{nc} / Q_{wp}^{nc}) EQ_{wp}^{nc} \qquad \text{(Total)}$$

Other states' supply:

$$EQ_{wp}^{os} = \varepsilon_{wp}^{os} EP_{wp}$$

Total market supply of weaned pigs:

$$EQ_{wp} = (Q_{wp}^{nc} / Q_{wp}) EQ_{wp}^{nc} + (Q_{wp}^{os} / Q_{wp}) EQ_{wp}^{os}$$

Market demand for weaned pigs:

$$EQ_{wp} = EQ_{fp}^{us}$$

Relationship between market price of NC weaned pigs (P_{wp}^{nc}) and Midwest market price (P_{wp}):

$$EP_{wp}^{nc} = (P_{wp} / P_{wp}^{nc}) EP_{wp}$$

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farrowing sows with respect to price. Therefore, supply elasticities can be computed using equation (IIID2) given the form of the price expectations.

Because the new swine technologies are expected to permanently replace the existing technologies, it seems reasonable to assume that producers will form long-run price and cost expectations. Therefore, equation (IIID2), by setting all future prices equal to one another, can be represented as

$$b_{i+1} = const + 0.7735 b_i + \frac{1.035}{(1 - 0.7367)} p_i^* = const + 0.7335 b_i + 3.931\, p_i^* \qquad \text{(VB1)}$$

where p_i^* represents the steady-state, or long-run expected, price of state *i*. Elasticities are computed for one-year adjustment (short-run, SR), five-year adjustment (intermediate-run, IR), and ten-year adjustment (long-run, LR). For these different lengths of run the elasticity formulas are as follows:

$$\varepsilon_i^{sr} = \frac{\partial b_{i+1}}{\partial p_i^*}\frac{p_i^*}{b_{i+1}}; \qquad \varepsilon_i^{ir} = \sum_{j=0}^{5}(0.7735)^j \frac{\partial b_{i+1}}{\partial p_i^*}\frac{p_i^*}{b_{i+1}};$$

$$\varepsilon_i^{lr} = \sum_{j=0}^{10}(0.7735)^j \frac{\partial b_{i+1}}{\partial p_i^*}\frac{p_i^*}{b_{i+1}}. \qquad \text{(VB2)}$$

where p_i^* denotes the steady-state, or long-run expected, price of state i.. Elasticities for different lengths of run for NC and aggregate US production for market hogs are derived using these formulas with the relationship in (VB1). The supply elasticity for other states is obtained from the fact that the US aggregate elasticity is a share-weighted sum of elasticities from NC and other states (OS):

$$\varepsilon_{us} = (Q_{os}/Q_{us})\varepsilon_{os} + (Q_{nc}/Q_{us})(P_{us}/P_{nc})\varepsilon_{nc}$$

$$\Rightarrow \varepsilon_{os} = [\varepsilon_{us} - (Q_{nc}/Q_{us})(P_{us}/P_{nc})\varepsilon_{nc}]/(Q_{os}/Q_{us}) \qquad \text{(VB3)}$$

Table V2. Elasticities for Equilibrium Displacement Model

Supply elalsticities for different		Different elasticities for different lengths of run			Demand elasticity
Market	finished pigs	1 year (SR)	5 years (IR)	10 years (LR)	
NC		0.3935	1.256	1.604	
US		1.031	3.292	4.204	-0.509315467
OS		1.099302134	3.5101401	4.4825677	
Imports		1.604	3.022	4.128	
Total		1.042184721	3.2836224	4.1989462	
Market	feeder pigs	1 year	5 years	10 years	
NC		0.211753178	0.6761314	0.8634436	
US		0.63922	2.04104	2.60648	
OS		0.72815158	2.325	2.9691069	
Imports		0.198	0.418	0.628	
Total		0.551494946	1.7538633	2.2428538	
Market	weaned pigs	1 year	5 years	10 years	
NC		0.224574742	0.7170709	0.9157247	
US		0.76294	2.43608	3.11096	
OS		0.887414702	2.8335298	3.6185174	
Total		0.65849714	2.1025922	2.6850844	

Pproduction shares and supply elasticities for adoption of technology by <u>all</u> farms in N.C.:

Thousand pounds SSLW

	0-500	500-1000	1000-1500	1500-2000	2000+	Total
Fa-wean	24,950.58	69,652.72	76,989.37	61,064.34	50,118.20	282,775.21
Fa-fd	19,050.51	41,172.11	22,830.54	10,967.15	7,943.81	101,964.12
Fa-finish	13,643.77	12,785.64	15,218.76	26,297.22	24,361.07	92,306.46
Wean-fd	67,755.21	0	0	0	0	67,755.21
Fd-finish	256,755.25	301,482.50	115,408.98	58,162.93	43,845.60	775,655.26

Shares	0-500	500-1000	1000-1500	1500-2000	2000+
Fa-wean	0.088234679	0.246318339	0.272263506	0.2159466	0.1772369
Fa-fd	0.186835428	0.403790176	0.223907586	0.1075589	0.0779079
Fa-finish	0.147809482	0.138512949	0.164872101	0.2848904	0.2639151
Wean-fd	1	0	0	0	0
Fd-finish	0.331017223	0.388681049	0.148789012	0.0749855	0.0565272

Supply elasticities by size-SR

Elasticities	0-500	500-1000	1000-1500	1500-2000	2000+
Fa-wean	0.509039629	0.182345126	0.16496867	0.207991	0.2534176
Fa-fd	0.226673475	0.104882779	0.189143371	0.3937436	0.5435988
Fa-finish	0.532442162	0.568177925	0.477339705	0.2762466	0.2982019
Wean-fd	0.211753178				
Fd-finish	0.23775198	0.202479643	0.528936907	1.0495357	1.3922507

Supply elasticities by size-IR

Elasticities	0-500	500-1000	1000-1500	1500-2000	2000+
Fa-wean	1.625371928	0.582230993	0.526747684	0.6641187	0.8091666
Fa-fd	0.723772142	0.334892441	0.603937902	1.2572299	1.7357198
Fa-finish	1.699485022	1.813548853	1.523605258	0.8817427	0.9518212
Wean-fd	0.67613139				
Fd-finish	0.758872901	0.646288263	1.688296711	3.3499791	4.4438804

Supply elasticities by size-LR

Elasticities	0-500	500-1000	1000-1500	1500-2000	2000+
Fa-wean	2.075657225	0.743529494	0.672675353	0.848103	1.0333342
Fa-fd	0.924282529	0.427669448	0.771249982	1.6055268	2.2165754
Fa-finish	2.170361445	2.316028949	1.945750664	1.1260473	1.2155424
Wean-fd	0.86344361				
Fd-finish	0.969133864	0.825355393	2.156073188	4.2781581	5.6751466

Production shares and supply elasticities for adoption of technologies by only <u>company-owned</u> farms in North Carolina:

Thousand pounds SSLW

	0-500	500-1000	1000-1500	1500-2000	2000+	Total
Fa-wean	281.45	9,367.96	32,886.35	30,061.03	18,736.78	91,333.57
Fa-fd	1,396.35	17,442.39	12,632.40	3,746.39	2,871.00	38,088.53
Fa-finish	0.00	3,825.90	9,919.00	25,506.00	17,570.80	56,821.70
Wean-fd	3,605.70	0	0	0	0	3,605.70
Fd-finish	5,924.75	17,000.55	28,095.80	8,489.75	17,213.58	76,724.43

Shares	0-500	500-1000	1000-1500	1500-2000	2000+
Fa-wean	0.003081561	0.102568639	0.360068593	0.3291345	0.2051467
Fa-fd	0.036660643	0.457943376	0.331658901	0.0983601	0.075377
Fa-finish	0	0.067331671	0.174563591	0.4488778	0.3092269
Wean-fd	1	0	0	0	0
Fd-finish	0.077221167	0.221579359	0.366191055	0.1106525	0.2243559

Supply elasticities by size-SR

Elasticities	0-500	500-1000	1000-1500	1500-2000	2000+
Fa-wean	0.509039629	0.182345126	0.16496867	0.207991	0.2534176
Fa-fd	0.226673475	0.104882779	0.189143371	0.3937436	0.5435988
Fa-finish	0.532442162	0.568177925	0.477339705	0.2762466	0.2982019
Wean-fd	0.211753178				
Fd-finish	0.23775198	0.202479643	0.528936907	1.0495357	1.3922507

Supply elasticities by size-IR

Elasticities	0-500	500-1000	1000-1500	1500-2000	2000+
Fa-wean	1.625371928	0.582230993	0.526747684	0.6641187	0.8091666
Fa-fd	0.723772142	0.334892441	0.603937902	1.2572299	1.7357198
Fa-finish	1.699485022	1.813548853	1.523605258	0.8817427	0.9518212
Wean-fd	0.67613139				
Fd-finish	0.758872901	0.646288263	1.688296711	3.3499791	4.4438804

Supply elasticities by size-LR

Elasticities	0-500	500-1000	1000-1500	1500-2000	2000+
Fa-wean	2.075657225	0.743529494	0.672675353	0.848103	1.0333342
Fa-fd	0.924282529	0.427669448	0.771249982	1.6055268	2.2165754
Fa-finish	2.170361445	2.316028949	1.945750664	1.1260473	1.2155424
Wean-fd	0.86344361				
Fd-finish	0.969133864	0.825355393	2.156073188	4.2781581	5.6751466

In the derivation, it is assumed that other states price equals the average US price. Elasticities for different lengths of run for market hogs in NC, US, and OS are shown in the top of table V2.

Elasticities for feeder pigs and weaned pigs for US aggregate production are obtained by multiplying the U.S. elasticity for market hogs by the corresponding elasticity of price transmission shown in the last row of table III3. Elasticities for NC production are obtained by dividing the U.S. elasticity by the quantity of NC production as a share of the US average production and multiplying that quantity by the price ratio of NC price to other states' price[31]. Given these elasticities for NC, the elasticities for other states are derived using the formula in VB3. The elasticities for feeder pigs and weaned pigs for NC, US, and OS are shown in the top portion of table V2.

[31] The relationship between the two elasticities can be seen by noting that the elasticity of the aggregate supply elasticity is $\varepsilon_{us} = \sum_i \frac{\partial b_i}{\partial p_{us}} \frac{p_{us}}{\sum b_i} = N \frac{\partial b}{\partial p_{us}} \frac{p_{us}}{\sum b_i} = \frac{\partial b}{\partial p_{us}} \frac{p_{us}}{\bar{b}}$; therefore, the elasticity of supply for NC is $\varepsilon_{nc} = \frac{\partial b_{nc}}{\partial p_{nc}} \frac{p_{nc}}{b_{nc}} = \left[\frac{\partial b}{\partial p_{us}} \frac{p_{us}}{\bar{b}} / (b_{nc} / \bar{b}) \right] \left(\frac{p_{nc}}{p_{us}} \right) = \left[\varepsilon_{us} / (b_{nc} / \bar{b}) \right] \left(\frac{p_{nc}}{p_{us}} \right)$.

Table V3. Baseline Quantities and Prices

finished pigs	baseline quantities (1000 lb)	baseline prices ($/cwt)
nc	224015.4	39.61
us	2285871	40.5
os	2061856	40.5
imports	49032.98	40.5
total	2334904	
feeder pigs	(1000 head)	($/head)
nc	17719.47	42.32
us	100110	45.11
os	82390.53	45.11
imports	3416.37	45.11
total	103526.4	
Weaned pigs	(1000 head)	($/head)
nc	19421.34	28.26
us	100110	30.93
os	80688.66	30.93

Supply elasticities for individual type/size categories for NC produced pigs are shown in the bottom of table V2. These elasticities, for each length of run, are obtained by dividing the elasticity of supply for NC pigs in the aggregate by the share of pigs to total pigs in that size category[32]. The shares used for calculating these elasticities are based on the number of pounds as a share of total SSLW shown in table V2.

The final set of supply elasticities are the import supply elasticities. The formulae used to compute these elasticities are shown in equation IIIC1. The numbers required to calculate these elasticities are shares of market hog imports (respectively, feeder pig imports) in Canadian domestic production and consumption of market hogs (respectively, feeder pigs) and Canadian domestic supply and demand elasticities for market hogs (respectively, feeder pigs). The most recent published supply and demand elasticity estimates are by Moschini and Meilke (1992). They estimate short-run elasticities of supply and demand for market hogs in Canada of 0.042 and -0.225, respectively. Their

[32] The formulas for these elasticities are exactly the same as indicated above for NC in relation to the US except that prices are assumed to be the same across all farm sizes within NC.

long-run estimates of supply and demand for market hogs in Canada are 0.328 and -0.330, respectively. Given the form of their estimated equations, intermediate-level elasticities (5-year adjustment period) of supply and demand for market hogs of 0.163 and -0.329 are obtained[33]. Market shares of imports of Canadian domestic production and consumption of market hogs are 0.15 and 0.17, respectively; market shares of imports of Canadian domestic production and consumption of feeder pigs are 0.49 and 0.96, respectively[34]. For feeder pigs, Canadian domestic supply and demand elasticities were multiplied by the elasticity of price transmission of 0.62 estimated from U.S. feeder pig market hog price data[35]. Market hog imports and feeder pig imports as shares of total supply of market hogs and feeder pigs in 2001-2002 averaged 2.2 percent and 3.3 percent, respectively. Import supply elasticities for market hogs and feeder pigs are shown in the top portion of table V2.

The demand elasticity for market hogs is computed from model D in table IV1. The elasticity of demand is calculated as the inverse of the price flexibility of demand and equals -0.509[36]. The elasticity of demand is shown in the top right-hand side of table V2.

The values listed in table V3 are the baseline quantities and prices. These values are 2001-2002 averages of quantities and prices associated with the finished pig, feeder pig, and weaned pig markets. In deriving these estimates, the pig crop is used to estimate the number of weaned pigs, and the number of pigs under sixty pounds is used to estimate the number of feeder pigs. These numbers for NC as a proportion of US production are then applied to the total pig crop to determine the baseline number of head of weaned pigs and feeder pigs. It is also assumed that the price of imports is the same as the US price. The US price of market hogs is taken to be the average Iowa-Minnesota price.

[33] The intermediate-run elasticities are calculated by multiplying the short-run elasticity (1 year lagged adjustment) by $(1+\beta+\beta^2+\beta^3+\beta^4)$ where β is the coefficient on the lagged dependent variable in the supply (respectively, demand) equation.

[34] In other words, Canadian exports of market hogs to the U.S. were 0.15 of their domestic production and 0.17 of their domestic consumption. Correspondingly, exports of feeder pigs from Canada accounted for 0.49 of production and 0.96 of consumption.

[35] Because of lack of information on the supply and demand elasticities for Canadian produced feeder pigs in Canada, it is assumed that the same elasticity of price transmission estimated for U.S. feeder pigs is the same for Canada.

[36] The elasticity of demand at the sample mean is calculated as [-1/(1.006)](46.8/91.34).

Feeder pig and weaned pig prices are southern and direct FOB averages and delivered average prices in Iowa, respectively.

The equilibrium displacement model in V1 requires estimates of incremental costs by type/size of operation. As discussed previously, these incremental costs need to be expressed as a proportion of the pig price at the appropriate market level (finished pig, feeder pig, or weaned pig). The cost change estimates are for SSLW so these estimates need to be converted to per pound liveweight and a per head basis (in the case of feeder pigs and weaned pigs). Table V4 provides the formulas used for these conversions.

Table V4. Formulas for Calculations of Increase in Cost of Production

Weaned pigs per breeding animal per year can be calculated as follow:

$$\text{Weaned Pigs Produced per Sow per Year} =$$

(1) $$\frac{\text{NC Pig Crop per Year}}{\text{NC Average Breeding Inventory}} = \frac{19\ million}{0.95 * 1\ million} = 20\ pigs$$

NC Average Breeding Inventory is approximated at 1 million heads but it includes both boars and sows. In order to calculate the total number of breeding sows, the total inventory was multiplied by 0.95 to exclude boars.

Using the estimate calculated in equation (1), feeder pig production per sow per year can be expressed as follow:

$$\text{Feeder Pigs Produced per Sow per Year} =$$

(2) $$\text{Weaned Pigs Produced per Sow per Year} * (1 - \text{Nursery Mortality}) =$$

$$20 * (1 - 0.03) = 19.4\ pigs.$$

The Incremental cost for adopting new technologies that was calculated by the model in $ per 1,000 lbs of SSLW can be converted to $ per weaned pig or feeder pig head according to the following formula:

(3) $$\text{Incremental Cost}(\$ / head) = \frac{\text{Technology Incremental Cost}(\$ / 1{,}000\ lbs.\ of\ SSLW}{\text{Weaned or Feeder Pigs Produced per Sow per Year}}$$

Using the estimate calculated in equation (2), market hog production per sow per year in a farrow-finish facility can be calculated according to the following formula:

$$\begin{aligned} &Market\ Hog\ \Pr oduction\ per\ Sow\ per\ Year\ (Farrow-Finish)= \\ &Feeder\ Pigs\ \Pr oduced\ per\ Sow\ per\ Year*(1-Finishing\ Mortality-Cull)= \\ &19.4*(1-0.05-0.04)=17.65\ pigs. \end{aligned} \tag{4}$$

Market hog production for feeder-finish category can be calculated according to the following formulas:

$$\begin{aligned} &Market\ Hog\ \Pr oduction\ per\ Head\ in\ Inventory\ per\ Year\ (heads)= \\ &\frac{Market\ Hogs\ Slaughtered}{Average\ Market\ Hog\ Inventory}=2.6, \end{aligned} \tag{5}$$

and feeder-finish market hog production per head in inventory per year in hundredweights (cwt) is equal to:

$$\begin{aligned} &Market\ Hog\ \Pr oduction\ per\ Head\ in\ Inventory\ per\ Year\ (cwt)= \\ &\frac{Average\ Slaughter\ Weight}{100\ lbs.}*Market\ Hog\ \Pr oduction\ (Head\ in\ Inventory/Year)= \\ &\frac{262\ lbs.}{100\ lbs.}*2.6=2.62*2.6=6.812. \end{aligned} \tag{6}$$

Incremental cost for adopting new technologies that was calculated by the model in $ per 1,000 lbs of SSLW can be converted to $ per 100 lbs. of hog marketed as follows:

$$\begin{aligned} &Incremental\ Cost\ (\$/cwt)= \\ &\frac{Techno\log y\ Incremental\ Cost\ (\$/1{,}000\ of\ SSLW)}{Market\ Hog\ \Pr oduction\ per\ Head\ in\ Inventory\ per\ Year\ (cwt)*\frac{1{,}000}{Avg\ Weight}}= \\ &=\frac{Techno\log y\ Incremental\ Cost\ (\$/1{,}000\ of\ SSLW)}{6.812*\frac{1000}{135}} \end{aligned} \tag{7}$$

Finally, the percentage increase in the cost of production is equal to:

$$(8) \qquad \textit{Increase in Cost of Production}\,(\%) = \frac{\textit{Incremental Cost}\,(\$/\textit{head or}\,\$/\textit{cwt})}{\textit{Base Price}\,(\$/\textit{head or}\,\$/\textit{cwt})},$$

where *Base Price* represent the price of weaned, feeder and market hogs before the adoption of alternative technology.

C. Model Validation and Sensitivity Analysis

The basic philosophy underlying development of the equilibrium displacement model is in the tradition of Popper (1959) that for model validation attention should be given to the degree of confirmation of the model to theory and empirical tests performed. If as the model undergoes more empirical testing the number of instances of agreement with theory increases, our degree of confidence in the model will also grow. This is the case with the components of the economic model developed for the market level analysis where great care has been taken in developing the parameters for the equilibrium displacement model. Crucial assumptions have been tested. Empirical testing has been performed throughout the development of the model and the statistical analysis strongly confirms that the estimated economic model developed conforms to a high degree with industry behavior. Overall, the demand and supply response parameters were estimated and derived from well-established economic theory and the values obtained are credible and consistent with previous research. Using state of the art econometric methodology, the validity of price-taking behavior and price integration across regions were tested and the empirical findings strongly support price-taking behavior and use of a single national market for hogs.

The main source of uncertainty in the model is in the incremental cost changes. The cost estimates obtained from the task 1 economic study are only point estimates and cannot be directly used to provide information about variability in costs. In an attempt to provide information in the variability of these cost estimates, cost functions have been estimated

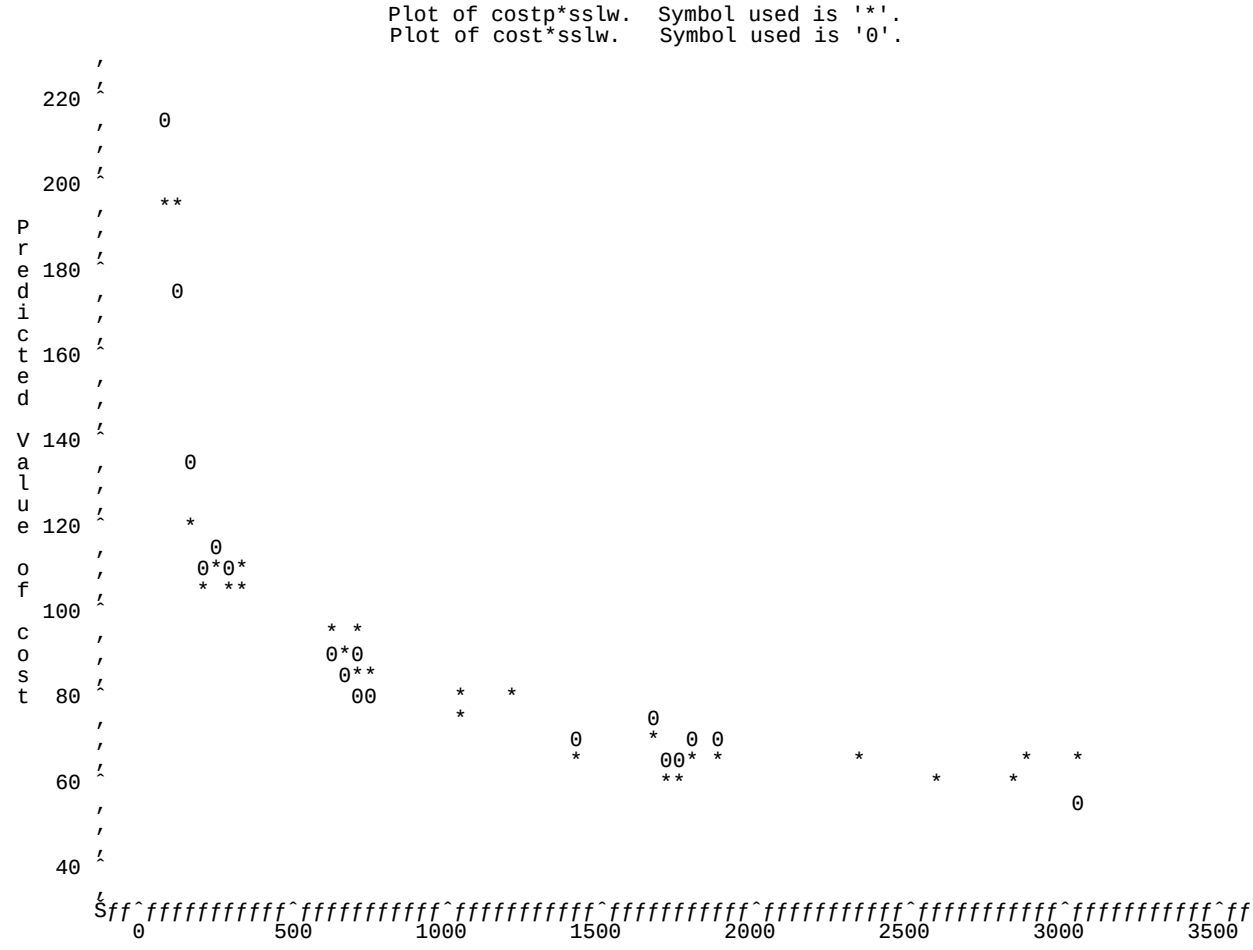
for each of the four technologies. Each cost function was estimated by OLS using the following model:

$$COST_i = \alpha_1 + \alpha_2 D_{2i} + \alpha_3 D_{3i} + \alpha_4 D_{4i} + \alpha_5 D_{5i} + \beta_1 SSLW_i + \beta_2 SSLW_i^2 + u_i$$

where $COST_i$ is the incremental cost ($/1000 pounds SSLW), $SSLW_i$ is steady-state liveweight in 1000 pounds, D_{ki} (k = 2, farrow-to-feeder operation; 3, farrow-to-finish operation; 4, wean-to-feeder operation ; 5, feeder-to-finish operation; the intercept is for farrow-to-wean type operation) is a dummy variable whose value is 1 when the characteristic is present and zero otherwise, and u_i is a random disturbance term. The data used to estimate the parameters for each technology are 41 observations available on cost estimates for each farm type for both DWQ farms and SF/PSF farms. The assumption (which seems reasonable) is made that the cost estimates are mean estimates for each type farm and technology. Note that the functional relationship between COST and SSLW is hypothesized to be quadratic. This relationship was chosen in order to accommodate U-shaped cost curves. Plots of predicted versus actual values of costs using the estimated cost functions are shown in figure V1, where costp is predicted cost and cost is actual cost. Estimated parameters for these cost functions are shown in appendix C.

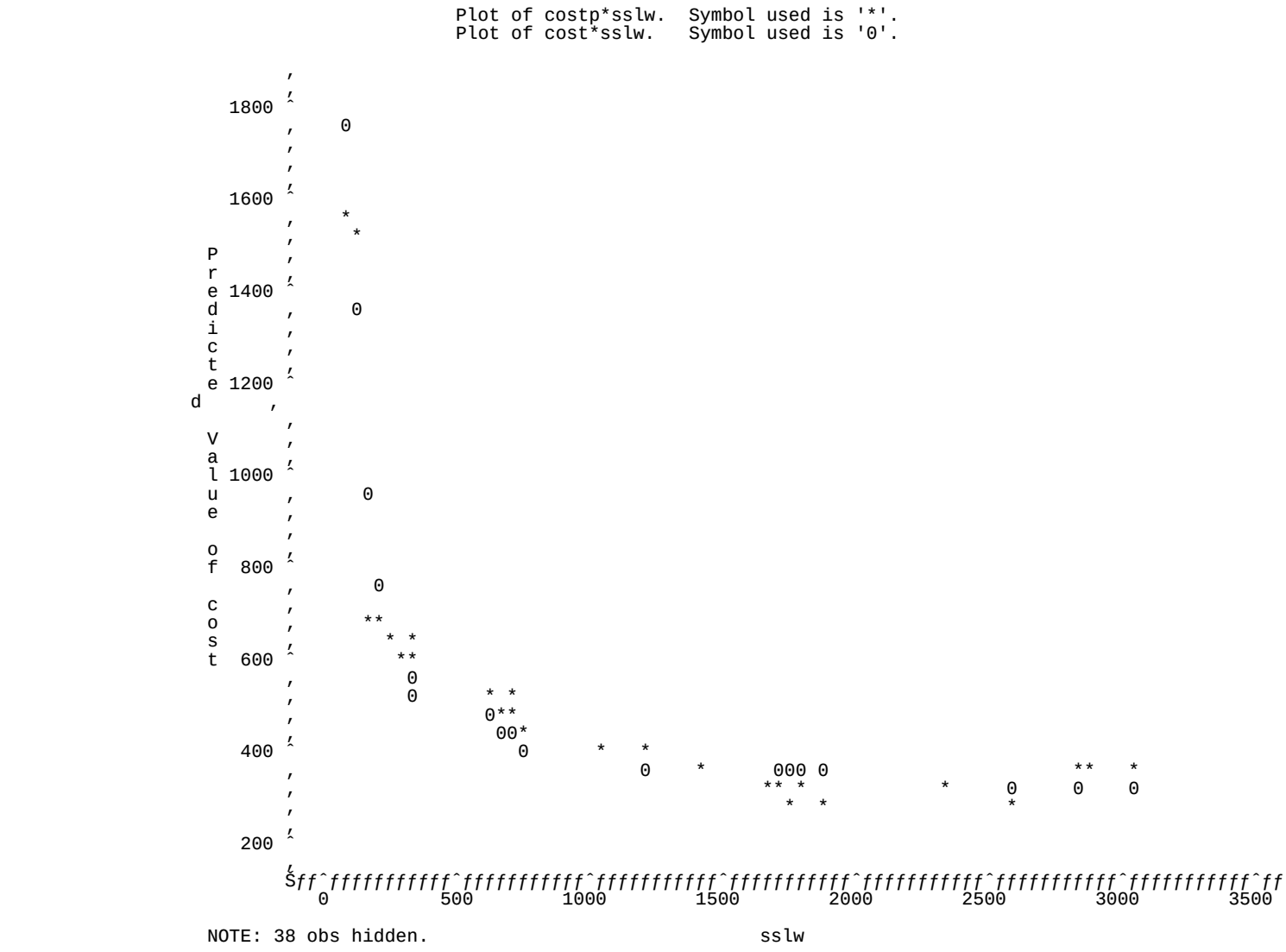
Note that in all cases the correspondence between actual and predicted values is quite close. In some of the estimated functions (e.g., ReCip), there is clear shift in the function when isolating cost relationships for different types of farms. Confidence intervals for the cost estimates are derived from the estimated cost functions at the sample mean values using the methodology of Wooldridge (2003, pp. 202-203) with the standard errors of the predicted value of the means corrected for heteroskedasticity using White's method to compute heteroskedastic-robust standard errors.

Figure VI. Plots of Predicted Versus Actual Values of Costs for Four Swine Waste Management Technologies



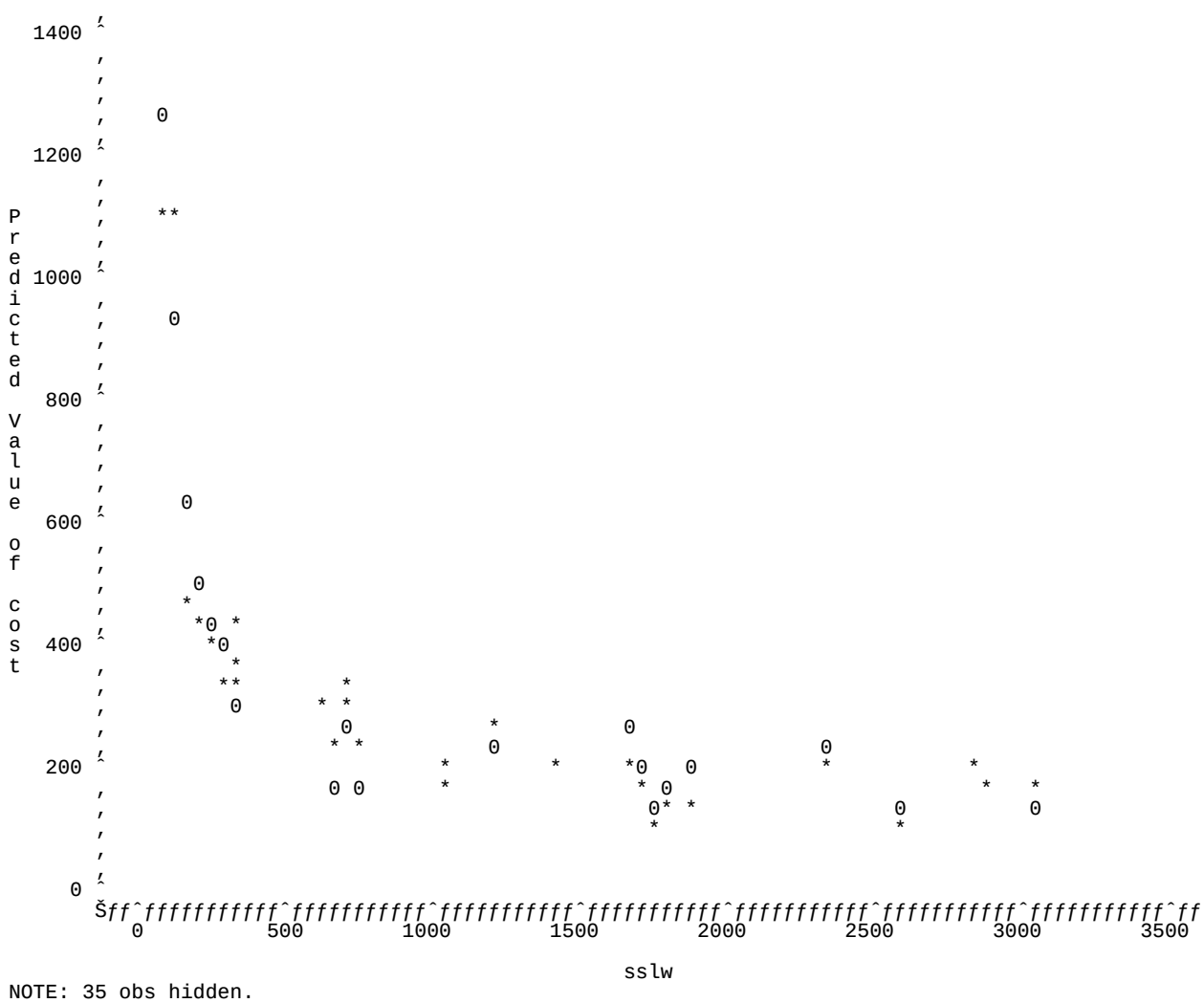
NOTE: 37 obs hidden.

Barham Farm Technology



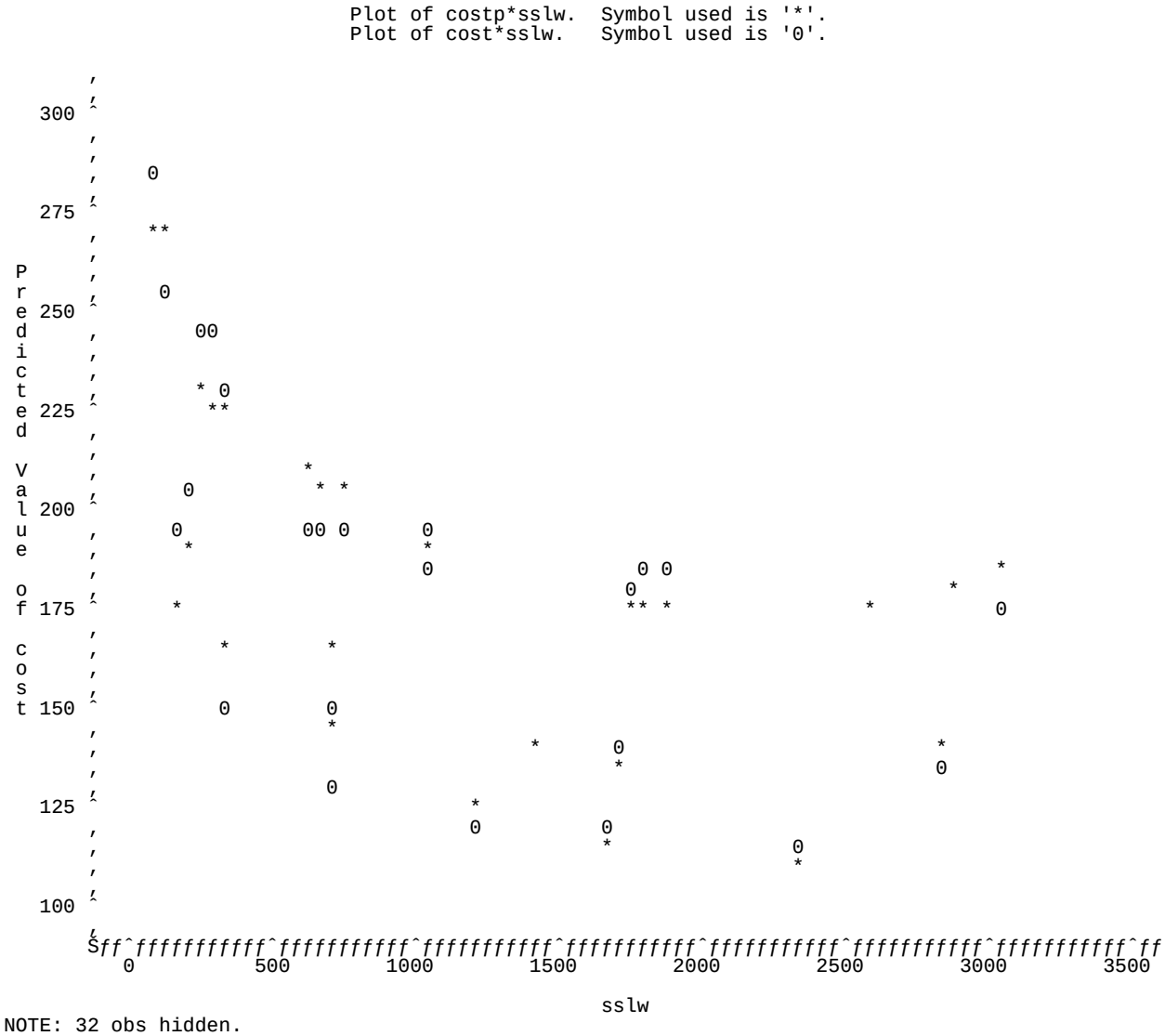
NOTE: 38 obs hidden.

Super Soils Technology



NOTE: 35 obs hidden.

EKOKAN Technology



NOTE: 32 obs hidden.

ReCip Technology

Table V5. Mean Costs and 95% Confidence Intervals

Barham Farm Technology:	Mean Cost = $85.89; 95% Confidence Interval = [$84.02, $87.76].
Super Soils Technology:	Mean Cost = $481.09; 95% Confidence Interval = [$458.64, $503.53].
EKOKAN Technology:	Mean Cost = $286.77; 95% Confidence Interval = [$$268.18, $305.37].
ReCip Technology:	Mean Cost = $173.30; 95% Confidence Interval = [$170.40, $176.19].

The predicted mean costs and 95% confidence intervals by technology are shown in table V5. The strict interpretation of these confidence intervals is that, in repeated sampling, we would expect the mean cost estimates to fall within the bracketed range of cost estimates in 95% of the samples. Confidence intervals for other expected costs (and even for particular costs) could be constructed, but the above confidence intervals should give the researcher some guidance on how reliable the cost estimates are and to establish a range of costs to use in further analysis with the spread-sheet model.

The simulation results presented below evaluate only the impact of introduction of new technologies on the N.C. swine industry, ***holding other factors constant.*** If demand and/or supply relationships should shift in ways to cause the price of swine in the future to change then these changes could either ameliorate or amplify the changes presented below. We cannot forecast the future with certainty so there is no way to know for sure what might happen between now and future time periods. There are commodity price projections available, however, that can be used to assess how reliable the simulation results might be. The most comprehensive projections available are from Iowa State University's Food and Agricultural Policy Research Institute (FAPRI). FAPRI's model projects that the price of barrow and gilts between 2003 and 2013 will increase slightly from $39.45/cwt in 2003 to $40.80/cwt in 2013. Over this 10 year period, they project that the GDP price deflator will increase over 20%. Therefore, the real price of hogs is projected to decline considerably by at least 16%. Therefore, by assuming the same base prices in 2001-2002 apply in future time periods, we would *understate* cost changes and therefore *understate* the changes in quantities on North Carolina farms.

VI. Simulation Results

In this section, simulation results of four technologies (Barham Farm, Super Soils, EKOKAN, and ReCip) are presented. Simulation results are presented for two cases: adoption of each technology by all farms in NC; adoption only by company-owned farms in NC. The same set of elasticities (shown in table V2) are used for adoption by all NC farms and for adoption by only NC company-owned farms. The assumption made in this application is that farms in the same type/size category have the same supply elasticity, whether they are company-owned farms or not. Different proportions of output by type/size farms are used for adoption by all farms versus adoption by company-owned farms. The pounds in SSLW for all farms in N.C. and just for company-owned farms in N.C. are shown in table V2.

The simulations are presented in the order of adoption by all farms of Barham Farm, Super Soils, EKOKAN, and ReCip, respectively. For each technology, the incremental costs by the 21 type/size categories are presented, followed by a summary of market level effects on prices and quantities for NC, other states, imports, and aggregate US. These results are then followed by changes in SSLW by type/size farm category. Three sets of results are presented: SR (1-year adjustment by farmers to technology), IR (5-year adjustment), and LR (10-year adjustment). The last set of simulations, presented in the same fashion as those for all farms in NC, is for company-owned farms only[37]. The results presented are for only the point estimates of costs obtained from the task 1 economic study. For sensitivity analysis of the results to ranges of costs, the user is referred to the confidence intervals reported in table V5. The spread-sheet model that is provided under separate cover has a function based option that can be used to generate cost estimates for all farms adopting and only company-owned farms adopting for one of the four technologies: Barham Farms, Super Soils, EKOKAN, and ReCip.

[37] In solving the model for the new equilibrium quantities, in the case of Super Soils Feeder-Finish sizes 1500-2000 and 2000+ showed more than 100% reduction. These reduced output amounts were set to -100% to reflect the fact that output cannot decline more than 100%.

Table VI.1. Incremental Costs of the Barham Farm Technology for DWQ Permitted Size / Type Combinations

	Size of Farm (1,000 pounds SSLW)				
	0-500	**500-1000**	**1000-1500**	**1500-2000**	**> 2000**
Type of Operation					
Farrow-wean					
Rep. # of sows	752	1,540	2,400	4,000	6,000
Incremental cost ($ / 1,000 lbs. SSLW)*	$104.22	$85.42	$76.66	$66.05	$59.38
Base price ($ / head)	$28.26	$28.26	$28.26	$28.26	$28.26
Incremental cost ($ / head weaned)	$2.26	$1.85	$1.66	$1.43	$1.29
% of price	7.98 %	6.54 %	5.87 %	5.06 %	4.55 %
Farrow-feeder					
Rep. # of sows	500	1,200	2,000	3,600	5,500
Incremental cost ($ / 1,000 lbs. SSLW)*	$114.22	$88.60	$81.97	$70.21	$63.11
Base price ($ / head)	$42.32	$42.32	$42.32	$42.32	$42.32
Incremental cost ($ / feeder pig)	$3.38	$2.62	$2.42	$2.08	$1.87
% of price	7.98 %	6.19 %	5.73 %	4.91 %	4.41 %
Farrow-finish					
Rep. # of sows	150	500	1,000	1,200	2,000
Incremental cost ($ / 1,000 lbs. SSLW)*	$110.86	$77.99	$67.92	$65.13	$59.75
Base price ($ / cwt)	$39.61	$39.61	$39.61	$39.61	$39.61
Incremental cost ($ / cwt)	$3.49	$2.46	$2.14	$2.05	$1.88
% of price	8.81 %	6.20 %	5.40 %	5.18 %	4.75 %
Wean-feeder					
Rep. # of sows	3,840	N/A	N/A	N/A	N/A
Incremental cost ($ / 1,000 lbs. SSLW)*	$177.24	N/A	N/A	N/A	N/A
Base price ($ / head)	$42.32	N/A	N/A	N/A	N/A
Incremental cost ($ / feeder pig)	$0.82	N/A	N/A	N/A	N/A
% of price	1.93 %	N/A	N/A	N/A	N/A
Feeder-finish					
Rep. # of sows	2,448	5,280	8,800	12,240	17,136
Incremental cost ($ / 1,000 lbs. SSLW)*	$112.30	$86.65	$79.47	$72.78	$66.62
Base price ($ / cwt)	$39.61	$39.61	$39.61	$39.61	$39.61
Incremental cost ($ / cwt)	$2.29	$1.76	$1.62	$1.48	$1.36
% of price	5.77 %	4.45 %	4.09 %	3.74 %	3.42 %

* Incremental costs for $ / 1,000 lbs. SSLW are for a pit-recharge system with nitrogen-based land application to forages.

Table VI.2. Summary of Market Level Effects of the Barham Farm Technology—Market Hogs, DWQ, Short Run (SR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / cwt)			**(changes from baseline)**	
North Carolina	$39.61	$39.688	$0.078	0.198 %
Other US States	$40.50	$40.578	$0.078	0.194 %
Aggregate US	$40.50	$40.578	$0.078	0.194 %
Imports	$40.50	$40.578	$0.078	0.194 %
Market Quantities (1,000 lbs. of weight marketed)				
North Carolina	224,015.4	217,169.9	-6,845.5	-3.056 %
Other US States	2,061,855.6	2,066,244.1	4,388.4	0.213 %
Aggregate US	2,285,871.0	2,283,413.9	-2,457.1	-0.107 %
Imports	49,033.0	49,185.3	152.3	0.311 %

Table VI.3. Summary of Market Level Effects of the Barham Farm Technology—Feeder Pigs, DWQ, Short Run (SR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$42.32	$42.354	$0.034	0.079 %
Other US States	$45.11	$45.144	$0.034	0.075 %
Aggregate US	$45.11	$45.144	$0.034	0.075 %
Imports	$45.11	$45.144	$0.034	0.075 %
Market Quantities (1,000 heads marketed)				
North Carolina	17,719.5	17,572.3	-147.2	-0.831 %
Other US States	82,390.5	82,435.2	44.7	0.054 %
Aggregate US	100,110.0	100,007.5	-102.5	-0.102 %
Imports	3,416.4	3,416.9	0.5	0.015 %

Table VI.4. Summary of Market Level Effects of the Barham Farm Technology—Weaned Pigs, DWQ, Short Run (SR),

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$28.26	$28.377	$0.117	0.41 %
Other US States	$30.93	$31.047	$0.117	0.38 %
Aggregate US	$30.93	$31.047	$0.117	0.38 %
Market Quantities (# of head)				
North Carolina	19,421.3	19,051.3	-370.0	-1.91 %
Other US States	80,688.7	80,959.9	271.2	0.34 %
Aggregate US	100,110.0	100,011.2	-98.8	-0.10 %

Table VI.5. Summary of Market Quantities (1,000 lbs. SSLW) and Changes in Market Quantities for Size / Type Combinations—Barham Farm Technology, DWQ Permitted Farms in North Carolina, Short Run (SR)

	Baseline	With Technology Costs	Absolute	Percentage
			(changes from baseline)	
	Market Quantities (1,000 lbs. of SSLW)			
Farrow-Wean				
0-500 AU	24,950.58	23,989.16	-961.42	-3.85 %
500-1,000 AU	69,652.72	68,874.23	-778.5	-1.12 %
1,000-1,500 AU	76,989.37	76,296.11	-693.26	-0.90 %
1,500-2,000 AU	61,064.34	60,474.32	-590.02	-0.97 %
> 2,000 AU	50,118.20	49,593.08	-525.12	-1.05 %
Farrow-Feeder				
0-500 AU	19,050.51	18,709.25	-341.26	-1.79 %
500-1,000 AU	41,172.11	40,908.16	-263.95	-0.64 %
1,000-1,500 AU	22,830.54	22,586.60	-243.94	-1.07 %
1,500-2,000 AU	10,967.15	10,758.70	-208.45	-1.90 %
> 2,000 AU	7,943.81	7,756.79	-187.02	-2.35 %
Farrow-Finish				
0-500 AU	13,643.77	13,018.03	-625.74	-4.59 %
500-1,000 AU	12,785.64	12,349.70	-435.94	-3.41 %
1,000-1,500 AU	15,218.76	14,840.96	-377.80	-2.48 %
1,500-2,000 AU	26,297.22	25,935.53	-361.69	-1.38 %
> 2,000 AU	24,361.07	24,030.45	-330.62	-1.36 %
Wean-Feeder				
0-500 AU	67,755.21	66,724.32	-1,030.89	-1.52 %
500-1,000 AU	N/A	N/A	N/A	N/A
1,000-1,500 AU	N/A	N/A	N/A	N/A
1,500-2,000 AU	N/A	N/A	N/A	N/A
> 2,000 AU	N/A	N/A	N/A	N/A
Feeder-Finish				
0-500 AU	256,755.25	251,480.62	-5,274.63	-2.05 %
500-1,000 AU	301,482.50	297,432.56	-4,049.94	-1.34 %
1,000-1,500 AU	115,408.98	111,692.98	-3,716.00	-3.22 %
1,500-2,000 AU	58,162.93	54,849.54	-3,313.39	-5.70 %
> 2,000 AU	43,845.60	40,841.85	-3,003.75	-6.85 %

Table VI.6. Summary of Market Level Effects of the Barham Farm Technology—Market Hogs, DWQ, Intermediate Run (IR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / cwt)			**(changes from baseline)**	
North Carolina	$39.61	$39.712	$0.102	0.259 %
Other US States	$40.50	$40.602	$0.102	0.253 %
Aggregate US	$40.50	$40.602	$0.102	0.253 %
Imports	$40.50	$40.602	$0.102	0.253 %
Market Quantities (1,000 lbs. of weight marketed)				
North Carolina	224,015.4	202,335.9	-21,679.5	-9.678 %
Other US States	2,061,855.6	2,080,155.8	18,300.2	0.888 %
Aggregate US	2,285,871.0	2,282,491.7	-3,379.3	-0.148 %
Imports	49,033.0	49,407.7	374.7	0.764 %

Table VI.7. Summary of Market Level Effects of the Barham Farm Technology—Feeder Pigs, DWQ, Intermediate Run (IR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$42.32	$42.376	$0.056	0.132 %
Other US States	$45.11	$45.166	$0.056	0.124 %
Aggregate US	$45.11	$45.166	$0.056	0.124 %
Imports	$45.11	$45.166	$0.056	0.124 %
Market Quantities (1,000 heads marketed)				
North Carolina	17,719.5	17,346.5	-372.9	-2.105 %
Other US States	82,390.5	82,628.5	237.9	0.289 %
Aggregate US	100,110.0	99,975.0	-135.0	-0.135 %
Imports	3,416.4	3,418.1	1.8	0.052 %

Table VI.8. Summary of Market Level Effects of the Barham Farm Technology—Weaned Pigs, DWQ, Intermediate Run (IR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$28.26	$28.401	$0.141	0.50 %
Other US States	$30.93	$31.071	$0.141	0.46 %
Aggregate US	$30.93	$31.071	$0.141	0.46 %
Market Quantities (# of head)				
North Carolina	19,421.3	18,251.7	-1,169.7	-6.02 %
Other US States	80,688.7	81,729.5	1,040.8	1.29 %
Aggregate US	100,110.0	99,981.2	-128.8	-0.13 %

Table VI.9. Summary of Market Quantities (1,000 lbs. SSLW) and Changes in Market Quantities for Size / Type Combinations—Barham Farm Technology, DWQ Permitted Farms in North Carolina, Intermediate Run (IR)

	Baseline	With Technology Costs	Absolute	Percentage
			(changes from baseline)	
	Market Quantities (1,000 lbs. of SSLW)			
Farrow-Wean				
0-500 AU	24,950.58	21,880.75	-3,069.83	-12.30 %
500-1,000 AU	69,652.72	67,166.98	-2,485.74	-3.57 %
1,000-1,500 AU	76,989.37	74,775.79	-2,213.58	-2.88 %
1,500-2,000 AU	61,064.34	59,180.39	-1,883.95	-3.09 %
> 2,000 AU	50,118.20	48,441.48	-1,676.72	-3.35 %
Farrow-Feeder				
0-500 AU	19,050.51	17,960.86	-1,089.65	-5.72 %
500-1,000 AU	41,172.11	40,329.33	-842.78	-2.05 %
1,000-1,500 AU	22,830.54	22,051.64	-778.90	-3.41 %
1,500-2,000 AU	10,967.15	10,301.57	-665.58	-6.07 %
> 2,000 AU	7,943.81	7,346.64	-597.17	-7.52 %
Farrow-Finish				
0-500 AU	13,643.77	11,646.49	-1,997.28	-14.64 %
500-1,000 AU	12,785.64	11,394.17	-1,391.48	-10.88 %
1,000-1,500 AU	15,218.76	14,012.88	-1,205.88	-7.92 %
1,500-2,000 AU	26,297.22	25,142.76	-1,154.46	-4.39 %
> 2,000 AU	24,361.07	23,305.76	-1,055.31	-4.33 %
Wean-Feeder				
0-500 AU	67,755.21	64,463.56	-3,291.65	-4.86 %
500-1,000 AU	N/A	N/A	N/A	N/A
1,000-1,500 AU	N/A	N/A	N/A	N/A
1,500-2,000 AU	N/A	N/A	N/A	N/A
> 2,000 AU	N/A	N/A	N/A	N/A
Feeder-Finish				
0-500 AU	256,755.25	239,919.34	-16,835.91	-6.56 %
500-1,000 AU	301,482.50	288,555.61	-12,926.89	-4.29 %
1,000-1,500 AU	115,408.98	103,547.99	-11,860.99	-10.28 %
1,500-2,000 AU	58,162.93	47,587.04	-10,575.89	-18.18 %
> 2,000 AU	43,845.60	34,258.02	-9,587.58	-21.87 %

Table VI.10. Summary of Market Level Effects of the Barham Farm Technology—Market Hogs, DWQ, Long Run (LR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / cwt)			**(changes from baseline)**	
North Carolina	$39.61	$39.715	$0.105	0.266 %
Other US States	$40.50	$40.605	$0.105	0.260 %
Aggregate US	$40.50	$40.605	$0.105	0.260 %
Imports	$40.50	$40.605	$0.105	0.260 %
Market Quantities (1,000 lbs. of weight marketed)				
North Carolina	224,015.4	196,355.8	-27,659.6	-12.347 %
Other US States	2,061,855.6	2,085,895.6	24,040.0	1.166 %
Aggregate US	2,285,871.0	2,282,251.4	-3,619.6	-0.158 %
Imports	49,033.0	49,559.5	526.5	1.074 %

Table VI.11. Summary of Market Level Effects of the Barham Farm Technology—Feeder Pigs, DWQ, Long Run (LR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$42.32	$42.380	$0.060	0.141 %
Other US States	$45.11	$45.170	$0.060	0.132 %
Aggregate US	$45.11	$45.170	$0.060	0.132 %
Imports	$45.11	$45.170	$0.060	0.132 %
Market Quantities (1,000 heads marketed)				
North Carolina	17,719.5	17,256.0	-463.5	-2.616 %
Other US States	82,390.5	82,714.0	323.5	0.393 %
Aggregate US	100,110.0	99,970.0	-140.0	-0.140 %
Imports	3,416.4	3,419.2	2.8	0.083 %

Table VI.12. Summary of Market Level Effects of the Barham Farm Technology—Weaned Pigs, DWQ, Long Run (LR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$28.26	$28.404	$0.144	0.51 %
Other US States	$30.93	$31.074	$0.144	0.47 %
Aggregate US	$30.93	$31.074	$0.144	0.47 %
Market Quantities (# of head)				
North Carolina	19,421.3	17,929.6	-1,491.7	-7.68 %
Other US States	80,688.7	82,047.8	1,359.1	1.68 %
Aggregate US	100,110.0	99,977.4	-132.6	-0.13 %

Table VI.13. Summary of Market Quantities (1,000 lbs. SSLW) and Changes in Market Quantities for Size / Type Combinations—Barham Farm Technology, DWQ Permitted Farms in North Carolina, Long Run (LR)

	Baseline	With Technology Costs	Absolute	Percentage
			(changes from baseline)	
	Market Quantities (1,000 lbs. of SSLW)			
Farrow-Wean				
0-500 AU	24,950.58	21,030.30	-3,920.28	-15.71 %
500-1,000 AU	69,652.72	66,478.34	-3,174.38	-4.56 %
1,000-1,500 AU	76,989.37	74,162.55	-2,826.82	-3.67 %
1,500-2,000 AU	61,064.34	58,658.48	-2,405.87	-3.94 %
> 2,000 AU	50,118.20	47,976.97	-2,141.23	-4.27 %
Farrow-Feeder				
0-500 AU	19,050.51	17,658.98	-1,391.53	-7.30 %
500-1,000 AU	41,172.11	40,095.85	-1,076.27	-2.61 %
1,000-1,500 AU	22,830.54	21,835.86	-994.68	-4.36 %
1,500-2,000 AU	10,967.15	10,117.18	-849.97	-7.75 %
> 2,000 AU	7,943.81	7,181.21	-762.60	-9.60 %
Farrow-Finish				
0-500 AU	13,643.77	11,093.11	-2,550.66	-18.69 %
500-1,000 AU	12,785.64	11,008.63	-1,777.01	-13.90 %
1,000-1,500 AU	15,218.76	13,678.76	-1,540.00	-10.12 %
1,500-2,000 AU	26,297.22	24,822.89	-1,474.33	-5.61 %
> 2,000 AU	24,361.07	23,013.37	-1,347.70	-5.53 %
Wean-Feeder				
0-500 AU	67,755.21	63,551.65	-4,203.56	-6.20 %
500-1,000 AU	N/A	N/A	N/A	N/A
1,000-1,500 AU	N/A	N/A	N/A	N/A
1,500-2,000 AU	N/A	N/A	N/A	N/A
> 2,000 AU	N/A	N/A	N/A	N/A
Feeder-Finish				
0-500 AU	256,755.25	235,254.62	-21,500.63	-8.37 %
500-1,000 AU	301,482.50	284,973.96	-16,508.54	-5.48 %
1,000-1,500 AU	115,408.98	100,261.66	-15,147.32	-13.12 %
1,500-2,000 AU	58,162.93	44,656.78	-13,506.15	-23.22 %
> 2,000 AU	43,845.60	31,601.76	-12,243.84	-27.92 %

Table VI.14. Incremental Costs of the Super Soils Technology for DWQ Permitted Size / Type Combinations

	Size of Farm (1,000 pounds SSLW)				
	0-500	**500-1000**	**1000-1500**	**1500-2000**	**> 2000**
Type of Operation					
Farrow-wean					
Rep. # of sows	752	1,540	2,400	4,000	6,000
Incremental cost ($ / 1,000 lbs. SSLW)*	$565.32	$439.07	$388.45	$358.34	$329.81
Base price ($ / head)	$28.26	$28.26	$28.26	$28.26	$28.26
Incremental cost ($ / head weaned)	$12.24	$9.51	$8.41	$7.76	$7.14
% of price	43.31 %	33.64 %	29.76 %	27.45 %	25.27 %
Farrow-feeder					
Rep. # of sows	500	1,200	2,000	3,600	5,500
Incremental cost ($ / 1,000 lbs. SSLW)*	$688.50	$474.88	$409.20	$361.14	$351.38
Base price ($ / head)	$42.32	$42.32	$42.32	$42.32	$42.32
Incremental cost ($ / feeder pig)	$20.36	$14.04	$12.10	$10.68	$10.39
% of price	48.12 %	33.19 %	28.60 %	25.24 %	24.56 %
Farrow-finish					
Rep. # of sows	150	500	1,000	1,200	2,000
Incremental cost ($ / 1,000 lbs. SSLW)*	$807.07	$443.57	$342.78	$346.33	$313.42
Base price ($ / cwt)	$39.61	$39.61	$39.61	$39.61	$39.61
Incremental cost ($ / cwt)	$25.41	$13.97	$10.79	$10.90	$9.87
% of price	64.15 %	35.26 %	27.25 %	27.53 %	24.91 %
Wean-feeder					
Rep. # of sows	3,840	N/A	N/A	N/A	N/A
Incremental cost ($ / 1,000 lbs. SSLW)*	$1,405.24	N/A	N/A	N/A	N/A
Base price ($ / head)	$42.32	N/A	N/A	N/A	N/A
Incremental cost ($ / feeder pig)	$6.49	N/A	N/A	N/A	N/A
% of price	15.33 %	N/A	N/A	N/A	N/A
Feeder-finish					
Rep. # of sows	2,448	5,280	8,800	12,240	17,136
Incremental cost ($ / 1,000 lbs. SSLW)*	$586.34	$440.89	$333.46	$323.63	$305.96
Base price ($ / cwt)	$39.61	$39.61	$39.61	$39.61	$39.61
Incremental cost ($ / cwt)	$11.94	$8.98	$6.79	$6.59	$6.23
% of price	30.14 %	22.66 %	17.14 %	16.64 %	15.73 %

* Incremental costs for $ / 1,000 lbs. SSLW are for a pit-recharge system with nitrogen-based land application to forages.

Table VI.15. Summary of Market Level Effects of the Super Soils Technology—Market Hogs, DWQ, Short Run (SR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / cwt)			**(changes from baseline)**	
North Carolina	$39.61	$40.008	$0.398	1.006 %
Other US States	$40.50	$40.898	$0.398	0.983 %
Aggregate US	$40.50	$40.898	$0.398	0.983 %
Imports	$40.50	$40.898	$0.398	0.983 %
Market Quantities (1,000 lbs. of weight marketed)				
North Carolina	224,015.4	189,259.7	-34,755.7	-15.515 %
Other US States	2,061,855.6	2,084,145.5	22,289.9	1.081 %
Aggregate US	2,285,871.0	2,273,405.2	-12,465.8	-0.545 %
Imports	49,033.0	49,806.4	773.4	1.577 %

Table VI.16. Summary of Market Level Effects of the Super Soils Technology—Feeder Pigs, DWQ, Short Run (SR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$42.32	$43.294	$0.974	2.301 %
Other US States	$45.11	$46.084	$0.974	2.159 %
Aggregate US	$45.11	$46.084	$0.974	2.159 %
Imports	$45.11	$46.084	$0.974	2.159 %
Market Quantities (1,000 heads marketed)				
North Carolina	17,719.5	15,891.3	-1,828.2	-10.317 %
Other US States	82,390.5	83,685.6	1,295.1	1.572 %
Aggregate US	100,110.0	99,576.9	-533.1	-0.533 %
Imports	3,416.4	3,431.0	14.6	0.427 %

Table VI.17. Summary of Market Level Effects of the Super Soils Technology—Weaned Pigs, DWQ, Short Run (SR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$28.26	$28.879	$0.619	2.19 %
Other US States	$30.93	$31.549	$0.619	2.00 %
Aggregate US	$30.93	$31.549	$0.619	2.00 %
Market Quantities (# of head)				
North Carolina	19,421.3	17,486.0	-1,935.4	-9.97 %
Other US States	80,688.7	82,122.6	1,434.0	1.78 %
Aggregate US	100,110.0	99,608.6	-501.4	-0.50 %

Table VI.18. Summary of Market Quantities (1,000 lbs. SSLW) and Changes in Market Quantities for Size / Type Combinations—Super Soils Technology, DWQ Permitted Farms in North Carolina, Short Run (SR)

	Baseline	With Technology Costs	Absolute	Percentage
			(changes from baseline)	
	Market Quantities (1,000 lbs. of SSLW)			
Farrow-Wean				
0-500 AU	24,950.58	19,728.33	-5,222.25	-20.93 %
500-1,000 AU	69,652.72	65,658.90	-3,993.82	-5.73 %
1,000-1,500 AU	76,989.37	73,488.09	-3,501.29	-4.55 %
1,500-2,000 AU	61,064.34	57,856.03	-3,208.31	-5.25 %
> 2,000 AU	50,118.20	47,187.49	-2,930.71	-5.85 %
Farrow-Feeder				
0-500 AU	19,050.51	17,072.13	-1,978.38	-10.38 %
500-1,000 AU	41,172.11	39,838.39	-1,333.72	-3.24 %
1,000-1,500 AU	22,830.54	21,695.03	-1,135.51	-4.97 %
1,500-2,000 AU	10,967.15	9,976.67	-990.48	-9.03 %
> 2,000 AU	7,943.81	6,982.79	-961.02	-12.10 %
Farrow-Finish				
0-500 AU	13,643.77	9,056.68	-4,587.09	-33.62 %
500-1,000 AU	12,785.64	10,297.45	-2,488.19	-19.46 %
1,000-1,500 AU	15,218.76	13,312.55	-1,906.21	-12.53 %
1,500-2,000 AU	26,297.22	24,370.51	-1,926.71	-7.33 %
> 2,000 AU	24,361.07	22,624.39	-1,736.69	-7.13 %
Wean-Feeder				
0-500 AU	67,755.21	61,737.21	-6,018.01	-8.88 %
500-1,000 AU	N/A	N/A	N/A	N/A
1,000-1,500 AU	N/A	N/A	N/A	N/A
1,500-2,000 AU	N/A	N/A	N/A	N/A
> 2,000 AU	N/A	N/A	N/A	N/A
Feeder-Finish				
0-500 AU	256,755.25	227,688.66	-29,066.59	-11.32 %
500-1,000 AU	301,482.50	280,480.27	-21,002.23	-6.97 %
1,000-1,500 AU	115,408.98	98,854.09	-16,554.89	-14.34 %
1,500-2,000 AU	58,162.93	42,703.95	-15,458.98	-26.58 %
> 2,000 AU	43,845.60	29,101.02	-14,744.58	-33.63 %

Table VI.19. Summary of Market Level Effects of the Super Soils Technology—Market Hogs, DWQ, Intermediate Run (IR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / cwt)			**(changes from baseline)**	
North Carolina	$39.61	$40.130	$0.520	1.313 %
Other US States	$40.50	$41.020	$0.520	1.284 %
Aggregate US	$40.50	$41.020	$0.520	1.284 %
Imports	$40.50	$41.020	$0.520	1.284 %
Market Quantities (1,000 lbs. of weight marketed)				
North Carolina	224,015.4	113,943.6	-110,071.7	-49.136 %
Other US States	2,061,855.6	2,154,759.9	92,904.2	4.506 %
Aggregate US	2,285,871.0	2,268,703.5	-17,167.5	-0.751 %
Imports	49,033.0	50,935.1	1,902.1	3.879 %

Table VI.20. Summary of Market Level Effects of the Super Soils Technology—Feeder Pigs, DWQ, Intermediate Run (IR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$42.32	$42.910	$0.590	1.394 %
Other US States	$45.11	$45.700	$0.590	1.308 %
Aggregate US	$45.11	$45.700	$0.590	1.308 %
Imports	$45.11	$45.700	$0.590	1.308 %
Market Quantities (1,000 heads marketed)				
North Carolina	17,719.5	14,518.5	-3,201.0	-18.065 %
Other US States	82,390.5	84,895.9	2,505.4	3.041 %
Aggregate US	100,110.0	99,414.4	-695.6	-0.695 %
Imports	3,416.4	3,435.0	18.7	0.547 %

Table VI.21. Summary of Market Level Effects of the Super Soils Technology—Weaned Pigs, DWQ, Intermediate Run (IR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$28.26	$28.999	$0.739	2.62 %
Other US States	$30.93	$31.669	$0.739	2.39 %
Aggregate US	$30.93	$31.669	$0.739	2.39 %
Market Quantities (# of head)				
North Carolina	19,421.3	13,302.0	-6,119.4	-31.51 %
Other US States	80,688.7	86,153.5	5,464.9	6.77 %
Aggregate US	100,110.0	99,455.5	-654.5	-0.65 %

Table VI.22. Summary of Market Quantities (1,000 lbs. SSLW) and Changes in Market Quantities for Size / Type Combinations—Super Soils Technology, DWQ Permitted Farms in North Carolina, Intermediate Run (IR)

	Baseline	With Technology Costs	Absolute	Percentage
			(changes from baseline)	
	Market Quantities (1,000 lbs. of SSLW)			
Farrow-Wean				
0-500 AU	24,950.58	8,275.85	-16,674.73	-66.83 %
500-1,000 AU	69,652.72	56,900.38	-12,752.34	-18.31 %
1,000-1,500 AU	76,989.37	65,809.71	-11,179.66	-14.52 %
1,500-2,000 AU	61,064.34	50,820.15	-10,244.19	-16.78 %
> 2,000 AU	50,118.20	40,760.39	-9,357.81	-18.67 %
Farrow-Feeder				
0-500 AU	19,050.51	12,733.52	-6,316.99	-33.16 %
500-1,000 AU	41,172.11	36,913.52	-4,258.59	-10.34 %
1,000-1,500 AU	22,830.54	19,204.83	-3,625.71	-15.88 %
1,500-2,000 AU	10,967.15	7,804.54	-3,162.61	-28.84 %
> 2,000 AU	7,943.81	4,875.25	-3,068.57	-38.63 %
Farrow-Finish				
0-500 AU	13,643.77	0.00	13,643.77	-100.00 %
500-1,000 AU	12,785.64	4,843.67	-7,941.97	-62.12 %
1,000-1,500 AU	15,218.76	9,134.38	-6,084.38	-39.98 %
1,500-2,000 AU	26,297.22	20,147.41	-6,149.81	-23.39 %
> 2,000 AU	24,361.07	18,817.80	-5,543.27	-22.75 %
Wean-Feeder				
0-500 AU	67,755.21	48,539.62	-19,215.59	-28.36 %
500-1,000 AU	N/A	N/A	N/A	N/A
1,000-1,500 AU	N/A	N/A	N/A	N/A
1,500-2,000 AU	N/A	N/A	N/A	N/A
> 2,000 AU	N/A	N/A	N/A	N/A
Feeder-Finish				
0-500 AU	256,755.25	163,978.52	-92,776.73	-36.13 %
500-1,000 AU	301,482.50	234,446.14	-67,036.36	-22.24 %
1,000-1,500 AU	115,408.98	62,567.94	-52,841.04	-45.79 %
1,500-2,000 AU	58,162.93	8,819.91	-49,343.03	-84.84 %
> 2,000 AU	43,845.60	0.00	-43,845.60	-100.00 %

Table VI.23. Summary of Market Level Effects of the Super Soils Technology—Market Hogs, DWQ, Long Run (LR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / cwt)			**(changes from baseline)**	
North Carolina	$39.61	$40.145	$0.535	1.350 %
Other US States	$40.50	$41.035	$0.535	1.321 %
Aggregate US	$40.50	$41.035	$0.535	1.321 %
Imports	$40.50	$41.035	$0.535	1.321 %
Market Quantities (1,000 lbs. of weight marketed)				
North Carolina	224,015.4	83,581.7	-140,433.6	-62.689 %
Other US States	2,061,855.6	2,183,911.5	122,055.9	5.920 %
Aggregate US	2,285,871.0	2,267,493.3	-18,377.7	-0.804 %
Imports	49,033.0	51,706.0	2,673.0	5.451 %

Table VI.24. Summary of Market Level Effects of the Super Soils Technology—Feeder Pigs, DWQ, Long Run (LR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$42.32	$42.879	$0.559	1.320 %
Other US States	$45.11	$45.669	$0.559	1.238 %
Aggregate US	$45.11	$45.669	$0.559	1.238 %
Imports	$45.11	$45.669	$0.559	1.238 %
Market Quantities (1,000 heads marketed)				
North Carolina	17,719.5	13,967.2	-3,752.3	-21.176 %
Other US States	82,390.5	87,820.0	3,029.4	3.677 %
Aggregate US	100,110.0	99,387.1	-722.9	-0.722 %
Imports	3,416.4	3,442.9	26.6	0.778 %

Table VI.25. Summary of Market Level Effects of the Super Soils Technology—Weaned Pigs, DWQ, Long Run (LR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$28.26	$29.015	$0.755	2.67 %
Other US States	$30.93	$31.685	$0.755	2.44 %
Aggregate US	$30.93	$31.685	$0.755	2.44 %
Market Quantities (# of head)				
North Carolina	19,421.3	11,616.7	-7,804.6	-40.19 %
Other US States	80,688.7	87,820.0	7,131.4	8.84 %
Aggregate US	100,110.0	99,436.8	-673.2	-0.67 %

Table VI.26. Summary of Market Quantities (1,000 lbs. SSLW) and Changes in Market Quantities for Size / Type Combinations—Super Soils Technology, DWQ Permitted Farms in North Carolina, Long Run (LR)

	Baseline	With Technology Costs	Absolute	Percentage
			(changes from baseline)	
	Market Quantities (1,000 lbs. of SSLW)			
Farrow-Wean				
0-500 AU	24,950.58	3,656.4	-21,294.22	-85.35 %
500-1,000 AU	69,652.72	53,367.53	-16,285.19	-23.38 %
1,000-1,500 AU	76,989.37	62,712.55	-14,276.82	-18.54 %
1,500-2,000 AU	61,064.34	47,982.15	-13,082.19	-21.42 %
> 2,000 AU	50,118.20	38,167.95	-11,950.25	-23.84 %
Farrow-Feeder				
0-500 AU	19,050.51	10,983.49	-8,067.02	-42.35 %
500-1,000 AU	41,172.11	35,733.74	-5,438.37	-13.21 %
1,000-1,500 AU	22,830.54	18,200.38	-4,630.16	-20.28 %
1,500-2,000 AU	10,967.15	6,928.39	-4,038.77	-36.83 %
> 2,000 AU	7,943.81	4,025.14	-3,918.67	-49.33 %
Farrow-Finish				
0-500 AU	13,643.77	0.00	-13,643.77	-100.00 %
500-1,000 AU	12,785.64	2,643.19	-10,142.45	-79.33 %
1,000-1,500 AU	15,218.76	7,448.58	-7,770.18	-51.06 %
1,500-2,000 AU	26,297.22	18,443.48	-7,853.74	-29.87 %
> 2,000 AU	24,361.07	17,281.93	-7,079.14	-29.06 %
Wean-Feeder				
0-500 AU	67,755.21	43,216.23	-24,538.98	-36.22 %
500-1,000 AU	N/A	N/A	N/A	N/A
1,000-1,500 AU	N/A	N/A	N/A	N/A
1,500-2,000 AU	N/A	N/A	N/A	N/A
> 2,000 AU	N/A	N/A	N/A	N/A
Feeder-Finish				
0-500 AU	256,755.25	138,272.87	-118,482.38	-46.15 %
500-1,000 AU	301,482.50	215,872.38	-85,610.12	-28.40 %
1,000-1,500 AU	115,408.98	47,927.28	-67,481.70	-58.47 %
1,500-2,000 AU	58,162.93	0.00	-58,162.93	-100.00 %
> 2,000 AU	43,845.60	0.00	-43,845.600	-100.00 %

Table VI.27. Incremental Costs of the EKOKAN Technology for DWQ Permitted Size / Type Combinations

	Size of Farm (1,000 pounds SSLW)				
	0-500	**500-1000**	**1000-1500**	**1500-2000**	**> 2000**
Type of Operation					
Farrow-wean					
Rep. # of sows	752	1,540	2,400	4,000	6,000
Incremental cost ($ / 1,000 lbs. SSLW)*	$369.21	$185.80	$197.80	$127.10	$117.42
Base price ($ / head)	$28.26	$28.26	$28.26	$28.26	$28.26
Incremental cost ($ / head weaned)	$7.99	$4.02	$4.28	$2.75	$2.54
% of price	28.29 %	14.23 %	15.15 %	9.74 %	9.00 %
Farrow-feeder					
Rep. # of sows	500	1,200	2,000	3,600	5,500
Incremental cost ($ / 1,000 lbs. SSLW)*	$458.16	$198.61	$198.16	$161.04	$162.76
Base price ($ / head)	$42.32	$42.32	$42.32	$42.32	$42.32
Incremental cost ($ / feeder pig)	$13.55	$5.87	$5.86	$4.76	$4.81
% of price	32.02 %	13.88 %	13.85 %	11.25 %	11.37 %
Farrow-finish					
Rep. # of sows	150	500	1,000	1,200	2,000
Incremental cost ($ / 1,000 lbs. SSLW)*	$558.34	$285.25	$202.03	$216.04	$190.82
Base price ($ / cwt)	$39.61	$39.61	$39.61	$39.61	$39.61
Incremental cost ($ / cwt)	$17.58	$8.98	$6.36	$6.80	$6.01
% of price	44.38 %	22.67 %	16.06 %	17.17 %	15.17 %
Wean-feeder					
Rep. # of sows	3,840	N/A	N/A	N/A	N/A
Incremental cost ($ / 1,000 lbs. SSLW)*	$1,025.30	N/A	N/A	N/A	N/A
Base price ($ / head)	$42.32	N/A	N/A	N/A	N/A
Incremental cost ($ / feeder pig)	$4.73	N/A	N/A	N/A	N/A
% of price	11.18 %	N/A	N/A	N/A	N/A
Feeder-finish					
Rep. # of sows	2,448	5,280	8,800	12,240	17,136
Incremental cost ($ / 1,000 lbs. SSLW)*	$361.97	$281.79	$303.86	$267.59	$260.70
Base price ($ / cwt)	$39.61	$39.61	$39.61	$39.61	$39.61
Incremental cost ($ / cwt)	$7.37	$5.74	$6.19	$5.45	$5.31
% of price	18.61 %	14.49 %	15.62 %	13.76 %	13.40 %

* Incremental costs for $ / 1,000 lbs. SSLW are for a pit-recharge system with nitrogen-based land application to forages.

Table VI.28. Summary of Market Level Effects of the EKOKAN Technology—Market Hogs, Short Run (SR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / cwt)			**(changes from baseline)**	
North Carolina	$39.61	$39.871	$0.261	0.659 %
Other US States	$40.50	$40.761	$0.261	0.645 %
Aggregate US	$40.50	$40.761	$0.261	0.645 %
Imports	$40.50	$40.761	$0.261	0.645 %
Market Quantities (1,000 lbs. of weight marketed)				
North Carolina	224,015.4	201,222.6	-22,792.7	-10.175 %
Other US States	2,061,855.6	2,076,472.3	14,616.7	0.709 %
Aggregate US	2,285,871.0	2,277,695.0	-8,176.0	-0.358 %
Imports	49,033.0	49,540.2	507.2	1.034 %

Table VI.29. Summary of Market Level Effects of the EKOKAN Technology—Feeder Pigs, Short Run (SR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$42.32	$42.646	$0.326	0.771 %
Other US States	$45.11	$45.436	$0.326	0.724 %
Aggregate US	$45.11	$45.436	$0.326	0.724 %
Imports	$45.11	$45.436	$0.326	0.724 %
Market Quantities (1,000 heads marketed)				
North Carolina	17,719.5	16,940.3	-779.1	-4.397 %
Other US States	82,390.5	82,824.7	434.2	0.527 %
Aggregate US	100,110.0	99,765.1	-344.9	-0.345 %
Imports	3,416.4	3,421.3	4.9	0.143 %

Table VI.30. Summary of Market Level Effects of the EKOKAN Technology—Weaned Pigs, Short Run (SR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$28.26	$28.527	$0.267	0.94 %
Other US States	$30.93	$31.197	$0.267	0.86 %
Aggregate US	$30.93	$31.197	$0.267	0.86 %
Market Quantities (# of head)				
North Carolina	19,421.3	18,474.7	-946.6	-4.87 %
Other US States	80,688.7	81,306.5	617.8	0.77 %
Aggregate US	100,110.0	99,781.2	-328.8	-0.33 %

Table VI.31. Summary of Market Quantities (1,000 lbs. SSLW) and Changes in Market Quantities for Size / Type Combinations—EKOKAN Technology, DWQ Permitted Farms in North Carolina, Short Run (SR)

	Baseline	With Technology Costs	Absolute	Percentage
			(changes from baseline)	
	Market Quantities (1,000 lbs. of SSLW)			
Farrow-Wean				
0-500 AU	24,950.58	21,478.06	-3,472.52	-13.92 %
500-1,000 AU	69,652.72	67,964.80	-1,687.92	-2.42 %
1,000-1,500 AU	76,989.37	75,184.69	-1,804.68	-2.34 %
1,500-2,000 AU	61,064.34	59,947.58	-1,116.76	-1.83 %
> 2,000 AU	50,118.20	49,095.63	-1,022.57	-2.04 %
Farrow-Feeder				
0-500 AU	19,050.51	17,701.20	-1,349.31	-7.08 %
500-1,000 AU	41,172.11	40,606.06	-566.05	-1.37 %
1,000-1,500 AU	22,830.54	22,265.85	-564.69	-2.47 %
1,500-2,000 AU	10,967.15	10,514.48	-452.67	-4.13 %
> 2,000 AU	7,943.81	7,485.95	-457.86	-5.76 %
Farrow-Finish				
0-500 AU	13,643.77	10,467.74	-3,176.03	-23.28 %
500-1,000 AU	12,785.64	11,186.47	-1,599.17	-12.51 %
1,000-1,500 AU	15,218.76	14,100.11	-1,118.65	-7.35 %
1,500-2,000 AU	26,297.22	25,097.68	-1,199.55	-4.56 %
> 2,000 AU	24,361.07	23,307.15	-1,053.92	-4.33 %
Wean-Feeder				
0-500 AU	67,755.21	63,551.67	-4,203.54	-6.20 %
500-1,000 AU	N/A	N/A	N/A	N/A
1,000-1,500 AU	N/A	N/A	N/A	N/A
1,500-2,000 AU	N/A	N/A	N/A	N/A
> 2,000 AU	N/A	N/A	N/A	N/A
Feeder-Finish				
0-500 AU	256,755.25	238,292.21	-18,463.04	-7.19 %
500-1,000 AU	301,482.50	289,788.17	-11,694.33	-3.88 %
1,000-1,500 AU	115,408.98	103,029.45	-12,379.53	-10.73 %
1,500-2,000 AU	58,162.93	47,529.77	-10,633.16	-18.28 %
> 2,000 AU	43,845.60	33,400.47	-10,445.13	-23.82 %

Table VI.32. Summary of Market Level Effects of the EKOKAN Technology—Market Hogs, Intermediate Run (IR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / cwt)			**(changes from baseline)**	
North Carolina	$39.61	$39.951	$0.341	0.861 %
Other US States	$40.50	$40.841	$0.341	0.842 %
Aggregate US	$40.50	$40.841	$0.341	0.842 %
Imports	$40.50	$40.841	$0.341	0.842 %
Market Quantities (1,000 lbs. of weight marketed)				
North Carolina	224,015.4	151,830.6	-72,184.8	-32.223 %
Other US States	2,061,855.6	2,122,782.0	60,926.4	2.955 %
Aggregate US	2,285,871.0	2,274,612.6	-11,258.4	-0.493 %
Imports	49,033.0	50,280.4	1,247.4	2.544 %

Table VI.33. Summary of Market Level Effects of the EKOKAN Technology—Feeder Pigs, Intermediate Run (IR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$42.32	$42.616	$0.296	0.700 %
Other US States	$45.11	$45.406	$0.296	0.657 %
Aggregate US	$45.11	$45.406	$0.296	0.657 %
Imports	$45.11	$45.406	$0.296	0.657 %
Market Quantities (1,000 heads marketed)				
North Carolina	17,719.5	16,007.5	-1,712.0	-9.661 %
Other US States	82,390.5	83,649.2	1,258.7	1.528 %
Aggregate US	100,110.0	99,656.7	-453.3	-0.453 %
Imports	3,416.4	3,425.8	9.4	0.275 %

Table VI.34. Summary of Market Level Effects of the EKOKAN Technology—Weaned Pigs, Intermediate Run (IR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$28.26	$28.606	$0.346	1.22 %
Other US States	$30.93	$31.276	$0.346	1.12 %
Aggregate US	$30.93	$31.276	$0.346	1.12 %
Market Quantities (# of head)				
North Carolina	19,421.3	16,438.1	-2,983.2	-15.36 %
Other US States	80,688.7	83,242.7	2,554.0	3.17 %
Aggregate US	100,110.0	99,680.8	-429.2	-0.43 %

Table VI.35. Summary of Market Quantities (1,000 lbs. SSLW) and Changes in Market Quantities for Size / Type Combinations—EKOKAN Technology, DWQ Permitted Farms in North Carolina, Intermediate Run (IR)

	Baseline	With Technology Costs	Absolute	Percentage
			(changes from baseline)	
	Market Quantities (1,000 lbs. of SSLW)			
Farrow-Wean				
0-500 AU	24,950.58	13,862.78	-11,087.80	-44.44 %
500-1,000 AU	69,652.72	64,263.17	-5,389.55	-7.74 %
1,000-1,500 AU	76,989.37	71,227.00	-5,762.37	-7.48 %
1,500-2,000 AU	61,064.34	57,498.51	-3,565.83	-5.84 %
> 2,000 AU	50,118.20	46,853.11	-3,265.09	-6.51 %
Farrow-Feeder				
0-500 AU	19,050.51	14,742.14	-4,308.37	-22.62 %
500-1,000 AU	41,172.11	39,364.71	-1,807.40	-4.39 %
1,000-1,500 AU	22,830.54	21,027.48	-1,803.06	-7.90 %
1,500-2,000 AU	10,967.15	9,521.77	-1,445.38	-13.18 %
> 2,000 AU	7,943.81	6,481.86	-1,461.95	-18.40 %
Farrow-Finish				
0-500 AU	13,643.77	3,506.30	-10,137.47	-74.30 %
500-1,000 AU	12,785.64	7,681.29	-5,104.35	-39.92 %
1,000-1,500 AU	15,218.76	11,648.18	-3,570.58	-23.46 %
1,500-2,000 AU	26,297.22	22,468.43	-3,828.79	-14.56 %
> 2,000 AU	24,361.07	20,997.09	-3,363.98	-13.81 %
Wean-Feeder				
0-500 AU	67,755.21	54,333.23	-13,421.99	-19.81 %
500-1,000 AU	N/A	N/A	N/A	N/A
1,000-1,500 AU	N/A	N/A	N/A	N/A
1,500-2,000 AU	N/A	N/A	N/A	N/A
> 2,000 AU	N/A	N/A	N/A	N/A
Feeder-Finish				
0-500 AU	256,755.25	197,823.67	-58,931.58	-22.95 %
500-1,000 AU	301,482.50	264,155.73	-37,326.77	-12.38 %
1,000-1,500 AU	115,408.98	75,895.17	-39,513.81	-34.24 %
1,500-2,000 AU	58,162.93	24,223.28	-33,939.65	-58.35 %
> 2,000 AU	43,845.60	10,506.12	-33,339.48	-76.04 %

Table VI.36. Summary of Market Level Effects of the EKOKAN Technology—Market Hogs, Long Run (LR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / cwt)			**(changes from baseline)**	
North Carolina	$39.61	$39.961	$0.351	0.886 %
Other US States	$40.50	$40.851	$0.351	0.866 %
Aggregate US	$40.50	$40.851	$0.351	0.866 %
Imports	$40.50	$40.851	$0.351	0.866 %
Market Quantities (1,000 lbs. of weight marketed)				
North Carolina	224,015.4	131,919.4	-92,096.0	-41.111 %
Other US States	2,061,855.6	2,141,901.6	80,046.0	3.882 %
Aggregate US	2,285,871.0	2,273,821.0	-12,050.0	-0.527 %
Imports	49,033.0	50,786.0	1,753.0	3.575 %

Table VI.37. Summary of Market Level Effects of the EKOKAN Technology—Feeder Pigs, Long Run (LR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$42.32	$42.618	$0.298	0.704 %
Other US States	$45.11	$45.408	$0.298	0.661 %
Aggregate US	$45.11	$45.408	$0.298	0.661 %
Imports	$45.11	$45.408	$0.298	0.661 %
Market Quantities (1,000 heads marketed)				
North Carolina	17,719.5	15,632.9	-2,086.6	-11.776 %
Other US States	82,390.5	84,006.3	1,615.8	1.961 %
Aggregate US	100,110.0	99,639.2	-470.8	-0.470 %
Imports	3,416.4	3,430.5	14.2	0.415 %

Table VI.38. Summary of Market Level Effects of the EKOKAN Technology—Weaned Pigs, Long Run (LR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$28.26	$28.616	$0.356	1.26 %
Other US States	$30.93	$31.286	$0.356	1.15 %
Aggregate US	$30.93	$31.286	$0.356	1.15 %
Market Quantities (# of head)				
North Carolina	19,421.3	15,618.2	-3,803.1	-19.58 %
Other US States	80,688.7	84,050.3	3,361.6	4.17 %
Aggregate US	100,110.0	99,668.5	-441.5	-0.44 %

Table VI.39. Summary of Market Quantities (1,000 lbs. SSLW) and Changes in Market Quantities for Size / Type Combinations—EKOKAN Technology, DWQ Permitted Farms in North Carolina, Long Run (LR)

	Baseline	With Technology Costs	Absolute	Percentage
			(changes from baseline)	
	Market Quantities (1,000 lbs. of SSLW)			
Farrow-Wean				
0-500 AU	24,950.58	10,791.06	-14,159.52	-56.75 %
500-1,000 AU	69,652.72	62,770.08	-6,882.64	-9.88 %
1,000-1,500 AU	76,989.37	69,630.63	-7,358.75	-9.56 %
1,500-2,000 AU	61,064.34	56,510.65	-4,553.69	-7.46 %
> 2,000 AU	50,118.20	45,948.57	-4,169.63	-8.32 %
Farrow-Feeder				
0-500 AU	19,050.51	13,548.57	-5,501.94	-28.88 %
500-1,000 AU	41,172.11	38,864.00	-2,308.11	-5.61 %
1,000-1,500 AU	22,830.54	20,527.97	-2,302.57	-10.09 %
1,500-2,000 AU	10,967.15	9,121.35	-1,845.80	-16.83 %
> 2,000 AU	7,943.81	6,076.85	-1,866.96	-23.50 %
Farrow-Finish				
0-500 AU	13,643.77	697.51	-12,946.26	-94.89 %
500-1,000 AU	12,785.64	6,267.03	-6,518.61	-50.98 %
1,000-1,500 AU	15,218.76	10,658.88	-4,559.88	-29.96 %
1,500-2,000 AU	26,297.22	21,407.59	-4,889.63	-18.59 %
> 2,000 AU	24,361.07	20,065.04	-4,296.03	-17.63 %
Wean-Feeder				
0-500 AU	67,755.21	50,614.86	-17,140.35	-25.30 %
500-1,000 AU	N/A	N/A	N/A	N/A
1,000-1,500 AU	N/A	N/A	N/A	N/A
1,500-2,000 AU	N/A	N/A	N/A	N/A
> 2,000 AU	N/A	N/A	N/A	N/A
Feeder-Finish				
0-500 AU	256,755.25	181,495.50	-75,259.75	-29.31 %
500-1,000 AU	301,482.50	253,813.60	-47,668.90	-15.81 %
1,000-1,500 AU	115,408.98	64,947.07	-50,461.91	-43.72 %
1,500-2,000 AU	58,162.93	14,819.62	-43,343.31	-74.52 %
> 2,000 AU	43,845.60	1,268.75	-42,576.86	-97.11 %

Table VI.40. Incremental Costs of the ReCip Technology for DWQ Permitted Size / Type Combinations

	Size of Farm (1,000 pounds SSLW)				
	0-500	**500-1000**	**1000-1500**	**1500-2000**	**> 2000**
Type of Operation					
Farrow-wean					
Rep. # of sows	752	1,540	2,400	4,000	6,000
Incremental cost ($ / 1,000 lbs. SSLW)*	$245.83	$200.44	$188.33	$176.05	$167.95
Base price ($ / head)	$28.26	$28.26	$28.26	$28.26	$28.26
Incremental cost ($ / head weaned)	$5.32	$4.34	$4.08	$3.81	$3.64
% of price	18.83 %	15.36 %	14.43 %	13.49 %	12.87 %
Farrow-feeder					
Rep. # of sows	500	1,200	2,000	3,600	5,500
Incremental cost ($ / 1,000 lbs. SSLW)*	$271.94	$201.70	$194.61	$181.01	$174.28
Base price ($ / head)	$42.32	$42.32	$42.32	$42.32	$42.32
Incremental cost ($ / feeder pig)	$8.04	$5.97	$5.76	$5.35	$5.15
% of price	19.00 %	14.10 %	13.60 %	12.65 %	12.18 %
Farrow-finish					
Rep. # of sows	150	500	1,000	1,200	2,000
Incremental cost ($ / 1,000 lbs. SSLW)*	$245.13	$158.62	$143.37	$139.69	$133.10
Base price ($ / cwt)	$39.61	$39.61	$39.61	$39.61	$39.61
Incremental cost ($ / cwt)	$7.72	$4.99	$4.51	$4.40	$4.19
% of price	19.48 %	12.61 %	11.40 %	11.10 %	10.58 %
Wean-feeder					
Rep. # of sows	3,840	N/A	N/A	N/A	N/A
Incremental cost ($ / 1,000 lbs. SSLW)*	$343.23	N/A	N/A	N/A	N/A
Base price ($ / head)	$42.32	N/A	N/A	N/A	N/A
Incremental cost ($ / feeder pig)	$1.58	N/A	N/A	N/A	N/A
% of price	3.74 %	N/A	N/A	N/A	N/A
Feeder-finish					
Rep. # of sows	2,448	5,280	8,800	12,240	17,136
Incremental cost ($ / 1,000 lbs. SSLW)*	$176.86	$138.02	$119.69	$118.03	$111.58
Base price ($ / cwt)	$39.61	$39.61	$39.61	$39.61	$39.61
Incremental cost ($ / cwt)	$3.60	$2.81	$2.44	$2.40	$2.27
% of price	9.09 %	7.10 %	6.15 %	6.07 %	5.74 %

* Incremental costs for $ / 1,000 lbs. SSLW are for a pit-recharge system with nitrogen-based land application to forages.

Table VI.41. Summary of Market Level Effects of the ReCip Technology—Market Hogs, Short Run (SR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / cwt)			**(changes from baseline)**	
North Carolina	$39.61	$39.759	$0.149	0.377 %
Other US States	$40.50	$40.649	$0.149	0.369 %
Aggregate US	$40.50	$40.649	$0.149	0.369 %
Imports	$40.50	$40.649	$0.149	0.369 %
Market Quantities (1,000 lbs. of weight marketed)				
North Carolina	224,015.4	210,970.6	-13,044.8	-5.823 %
Other US States	2,061,855.6	2,070,221.1	8,365.4	0.406 %
Aggregate US	2,285,871.0	2,281,191.7	-4,679.3	-0.205 %
Imports	49,033.0	49,323.3	290.3	0.592 %

Table VI.42. Summary of Market Level Effects of the ReCip Technology—Feeder Pigs, Short Run (SR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$42.32	$42.517	$0.197	0.465 %
Other US States	$45.11	$45.307	$0.197	0.436 %
Aggregate US	$45.11	$45.307	$0.197	0.436 %
Imports	$45.11	$45.307	$0.197	0.436 %
Market Quantities (1,000 heads marketed)				
North Carolina	17,719.5	17,260.5	-459.0	-2.590 %
Other US States	82,390.5	82,652.1	261.5	0.317 %
Aggregate US	100,110.0	99,912.6	-197.4	-0.197 %
Imports	3,416.4	3,419.3	2.9	0.086 %

Table VI.43. Summary of Market Level Effects of the ReCip Technology—Weaned Pigs, Short Run (SR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$28.26	$28.573	$0.313	1.11 %
Other US States	$30.93	$31.243	$0.313	1.01 %
Aggregate US	$30.93	$31.243	$0.313	1.01 %
Market Quantities (# of head)				
North Carolina	19,421.3	18,507.6	-913.7	-4.70 %
Other US States	80,688.7	81,414.2	725.5	0.90 %
Aggregate US	100,110.0	99,921.8	-188.2	-0.19 %

Table VI.44. Summary of Market Quantities (1,000 lbs. SSLW) and Changes in Market Quantities for Size / Type Combinations—ReCip Technology, DWQ Permitted Farms in North Carolina, Short Run (SR)

	Baseline	With Technology Costs	Absolute	Percentage
			(changes from baseline)	
	Market Quantities (1,000 lbs. of SSLW)			
Farrow-Wean				
0-500 AU	24,950.58	22,699.48	-2,251.11	-9.02 %
500-1,000 AU	69,652.72	67,843.26	-1,809.46	-2.60 %
1,000-1,500 AU	76,989.37	75,297.75	-1,691.62	-2.20 %
1,500-2,000 AU	61,064.34	59,492.20	-1,572.14	-2.57 %
> 2,000 AU	50,118.20	48,264.88	-1,493.32	-2.98 %
Farrow-Feeder				
0-500 AU	19,050.51	18,249.92	-800.59	-4.20 %
500-1,000 AU	41,172.11	40,583.49	-588.62	-1.43 %
1,000-1,500 AU	22,830.54	22,263.32	-567.23	-2.48 %
1,500-2,000 AU	10,967.15	10,440.97	-526.18	-4.80 %
> 2,000 AU	7,943.81	7,437.94	-505.87	-6.37 %
Farrow-Finish				
0-500 AU	13,643.77	12,255.77	-1,388.00	-10.17 %
500-1,000 AU	12,785.64	11,897.16	-888.48	-6.95 %
1,000-1,500 AU	15,218.76	14,418.34	-800.42	-5.26 %
1,500-2,000 AU	26,297.22	25,518.04	-779.18	-2.96 %
> 2,000 AU	24,361.07	23,619.95	-741.12	-3.04 %
Wean-Feeder				
0-500 AU	67,755.21	65,480.47	-2,274.74	-3.36 %
500-1,000 AU	N/A	N/A	N/A	N/A
1,000-1,500 AU	N/A	N/A	N/A	N/A
1,500-2,000 AU	N/A	N/A	N/A	N/A
> 2,000 AU	N/A	N/A	N/A	N/A
Feeder-Finish				
0-500 AU	256,755.25	246,980.04	-9,775.21	-3.81 %
500-1,000 AU	301,482.50	294,076.96	-7,405.54	-2.46 %
1,000-1,500 AU	115,408.98	108,694.81	-6,714.17	-5.82 %
1,500-2,000 AU	58,162.93	51,723.68	-6,439.25	-11.07 %
> 2,000 AU	43,845.60	37,719.02	-6,126.58	-13.97 %

Table VI.45. Summary of Market Level Effects of the ReCip Technology—Market Hogs, Intermediate Run (IR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / cwt)			**(changes from baseline)**	
North Carolina	$39.61	$39.805	$0.195	0.493 %
Other US States	$40.50	$40.695	$0.195	0.482 %
Aggregate US	$40.50	$40.695	$0.195	0.482 %
Imports	$40.50	$40.695	$0.195	0.482 %
Market Quantities (1,000 lbs. of weight marketed)				
North Carolina	224,015.4	182,702.6	-41,312.8	-18.442 %
Other US States	2,061,855.6	2,096,727.0	34,871.3	1.691 %
Aggregate US	2,285,871.0	2,279,429.6	-6,441.4	-0.282 %
Imports	49,033.0	49,746.9	714.0	1.456 %

Table VI.46. Summary of Market Level Effects of the ReCip Technology—Feeder Pigs, Intermediate Run (IR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$42.32	$42.486	$0.166	0.393 %
Other US States	$45.11	$45.276	$0.166	0.369 %
Aggregate US	$45.11	$45.276	$0.166	0.369 %
Imports	$45.11	$45.276	$0.166	0.369 %
Market Quantities (1,000 heads marketed)				
North Carolina	17,719.5	16,754.0	-965.4	-5.448 %
Other US States	82,390.5	83,096.6	706.1	0.857 %
Aggregate US	100,110.0	99,850.7	-259.3	-0.259 %
Imports	3,416.4	3,421.6	5.3	0.154 %

Table VI.47. Summary of Market Level Effects of the ReCip Technology—Weaned Pigs, Intermediate Run (IR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$28.26	$28.618	$0.358	1.27 %
Other US States	$30.93	$31.288	$0.358	1.16 %
Aggregate US	$30.93	$31.288	$0.358	1.16 %
Market Quantities (# of head)				
North Carolina	19,421.3	16,526.6	-2,894.7	-14.90 %
Other US States	80,688.7	83,337.7	2,649.1	3.28 %
Aggregate US	100,110.0	99,864.3	-245.7	-0.25 %

Table VI.48. Summary of Market Quantities (1,000 lbs. SSLW) and Changes in Market Quantities for Size / Type Combinations—ReCip Technology, DWQ Permitted Farms in North Carolina, Intermediate Run (IR)

	Baseline	With Technology Costs	Absolute	Percentage
			(changes from baseline)	
	Market Quantities (1,000 lbs. of SSLW)			
Farrow-Wean				
0-500 AU	24,950.58	17,762.76	-7,187.82	-28.81 %
500-1,000 AU	69,652.72	63,875.10	-5,777.62	-8.29 %
1,000-1,500 AU	76,989.37	71,587.99	-5,401.38	-7.02 %
1,500-2,000 AU	61,064.34	56,044.48	-5,019.86	-8.22 %
> 2,000 AU	50,118.20	45,349.99	-4,768.21	-9.51 %
Farrow-Feeder				
0-500 AU	19,050.51	16,494.21	-2,556.30	-13.42 %
500-1,000 AU	41,172.11	39,292.63	-1,879.48	-4.56 %
1,000-1,500 AU	22,830.54	21,019.38	-1,811.16	-7.93 %
1,500-2,000 AU	10,967.15	9,287.04	-1,680.11	-15.32 %
> 2,000 AU	7,943.81	6,328.55	-1,615.26	-20.33 %
Farrow-Finish				
0-500 AU	13,643.77	9,213.46	-4,430.31	-32.47 %
500-1,000 AU	12,785.64	9,949.73	-2,835.91	-22.18 %
1,000-1,500 AU	15,218.76	12,663.91	-2,554.85	-16.79 %
1,500-2,000 AU	26,297.22	23,810.20	-2,487.02	-9.46 %
> 2,000 AU	24,361.07	21,995.50	-2,365.57	-9.71 %
Wean-Feeder				
0-500 AU	67,755.21	60,491.94	-7,263.27	-10.72 %
500-1,000 AU	N/A	N/A	N/A	N/A
1,000-1,500 AU	N/A	N/A	N/A	N/A
1,500-2,000 AU	N/A	N/A	N/A	N/A
> 2,000 AU	N/A	N/A	N/A	N/A
Feeder-Finish				
0-500 AU	256,755.25	225,554.07	-31,201.18	-12.15 %
500-1,000 AU	301,482.50	277,845.00	-23,637.50	-7.84 %
1,000-1,500 AU	115,408.98	93,978.24	-21,430.74	-18.57 %
1,500-2,000 AU	58,162.93	37,609.70	-20,553.23	-35.34 %
> 2,000 AU	43,845.60	24,290.38	-19,555.22	-44.60 %

Table VI.49. Summary of Market Level Effects of the ReCip Technology—Market Hogs, Long Run (LR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / cwt)			**(changes from baseline)**	
North Carolina	$39.61	$39.811	$0.201	0.507 %
Other US States	$40.50	$40.701	$0.201	0.496 %
Aggregate US	$40.50	$40.701	$0.201	0.496 %
Imports	$40.50	$40.701	$0.201	0.496 %
Market Quantities (1,000 lbs. of weight marketed)				
North Carolina	224,015.4	171,306.9	-52,708.5	-23.529 %
Other US States	2,061,855.6	2,107,666.5	45,810.8	2.222 %
Aggregate US	2,285,871.0	2,278,973.4	-6,897.6	-0.302 %
Imports	49,033.0	50,036.2	1,003.3	2.046 %

Table VI.50. Summary of Market Level Effects of the ReCip Technology—Feeder Pigs, Long Run (LR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$42.32	$42.486	$0.166	0.392 %
Other US States	$45.11	$45.276	$0.166	0.368 %
Aggregate US	$45.11	$45.276	$0.166	0.368 %
Imports	$45.11	$45.276	$0.166	0.368 %
Market Quantities (1,000 heads marketed)				
North Carolina	17,719.5	16,550.7	-1,168.8	-6.596 %
Other US States	82,390.5	83,290.1	899.5	1.092 %
Aggregate US	100,110.0	99,840.8	-269.2	-0.269 %
Imports	3,416.4	3,424.3	7.9	0.231 %

Table VI.51. Summary of Market Level Effects of the ReCip Technology—Weaned Pigs, Long Run (LR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$28.26	28.624	$0.364	1.29 %
Other US States	$30.93	31.294	$0.364	1.18 %
Aggregate US	$30.93	31.294	$0.364	1.18 %
Market Quantities (# of head)				
North Carolina	19,421.3	15,728.4	-3,692.9	-19.01 %
Other US States	80,688.7	84,128.9	3,440.2	4.26 %
Aggregate US	100,110.0	99,857.3	-252.7	-0.25 %

Table VI.52. Summary of Market Quantities (1,000 lbs. SSLW) and Changes in Market Quantities for Size / Type Combinations—ReCip Technology, DWQ Permitted Farms in North Carolina, Long Run (LR)

	Baseline	With Technology Costs	Absolute	Percentage
			(changes from baseline)	
	Market Quantities (1,000 lbs. of SSLW)			
Farrow-Wean				
0-500 AU	24,950.58	15,771.49	-9,179.09	-36.79 %
500-1,000 AU	69,652.72	62,274.50	-7,378.22	-10.59 %
1,000-1,500 AU	76,989.37	70,091.62	-6,897.75	-8.96 %
1,500-2,000 AU	61,064.34	54,653.80	-6,410.54	-10.50 %
> 2,000 AU	50,118.20	44,029.03	-6,089.17	-12.15 %
Farrow-Feeder				
0-500 AU	19,050.51	15,786.03	-3,264.48	-17.14 %
500-1,000 AU	41,172.11	38,771.95	-2,400.16	-5.83 %
1,000-1,500 AU	22,830.54	20,517.63	-2,312.91	-10.13 %
1,500-2,000 AU	10,967.15	8,821.59	-2,145.56	-19.56 %
> 2,000 AU	7,943.81	5,881.06	-2,062.75	-25.97 %
Farrow-Finish				
0-500 AU	13,643.77	7,985.95	-5,657.82	-41.47 %
500-1,000 AU	12,785.64	9,163.99	-3,621.65	-28.33 %
1,000-1,500 AU	15,218.76	11,956.04	-3,262.72	-21.44 %
1,500-2,000 AU	26,297.22	23,121.12	-3,176.10	-12.08 %
> 2,000 AU	24,361.07	21,350.07	-3,021.00	-12.40 %
Wean-Feeder				
0-500 AU	67,755.21	58,479.76	-9,275.45	-13.69 %
500-1,000 AU	N/A	N/A	N/A	N/A
1,000-1,500 AU	N/A	N/A	N/A	N/A
1,500-2,000 AU	N/A	N/A	N/A	N/A
> 2,000 AU	N/A	N/A	N/A	N/A
Feeder-Finish				
0-500 AU	256,755.25	216,909.16	-39,846.09	-15.52 %
500-1,000 AU	301,482.50	271,295.75	-30,186.75	-10.01 %
1,000-1,500 AU	115,408.98	88,040.42	-27,368.56	-23.71 %
1,500-2,000 AU	58,162.93	31,915.02	-26,247.91	-45.13 %
> 2,000 AU	43,845.60	18,872.22	-24,973.38	-56.96 %

Table VI.53. Incremental Costs of the Barham Farm Technology for Smithfield/Premium Standard Size / Type Combinations

	Size of Farm (1,000 pounds SSLW)				
	0-500	**500-1000**	**1000-1500**	**1500-2000**	**> 2000**
Type of Operation					
Farrow-wean					
Rep. # of sows	650	1,700	2,400	4,000	7,000
Incremental cost ($ / 1,000 lbs. SSLW)*	$110.82	$82.30	$76.66	$66.05	$56.69
Base price ($ / head)	$28.26	$28.26	$28.26	$28.26	$28.26
Incremental cost ($ / head weaned)	$2.40	$1.78	$1.66	$1.43	$1.23
% of price	8.49 %	6.31 %	5.87 %	5.06 %	4.34 %
Farrow-feeder					
Rep. # of sows	675	1,200	2,000	3,419	5,500
Incremental cost ($ / 1,000 lbs. SSLW)*	$111.80	$88.60	$81.97	$71.80	$63.10
Base price ($ / head)	$42.32	$42.32	$42.32	$42.32	$42.32
Incremental cost ($ / feeder pig)	$3.31	$2.62	$2.42	$2.12	$1.87
% of price	7.81 %	6.19 %	5.73 %	5.02 %	4.41 %
Farrow-finish					
Rep. # of sows	N/A	500	1,000	1,200	2,000
Incremental cost ($ / 1,000 lbs. SSLW)*	N/A	$77.99	$67.92	$65.13	$59.75
Base price ($ / cwt)	N/A	$39.61	$39.61	$39.61	$39.61
Incremental cost ($ / cwt)	N/A	$2.46	$2.14	$2.05	$1.88
% of price	N/A	6.20 %	5.40 %	5.18 %	4.75 %
Wean-feeder					
Rep. # of sows	2,808	N/A	N/A	N/A	N/A
Incremental cost ($ / 1,000 lbs. SSLW)*	$212.79	N/A	N/A	N/A	N/A
Base price ($ / head)	$42.32	N/A	N/A	N/A	N/A
Incremental cost ($ / feeder pig)	$0.98	N/A	N/A	N/A	N/A
% of price	2.32 %	N/A	N/A	N/A	N/A
Feeder-finish					
Rep. # of sows	1,240	5,100	8,800	12,246	17,136
Incremental cost ($ / 1,000 lbs. SSLW)*	$134.69	$88.16	$79.46	$72.76	$66.62
Base price ($ / cwt)	$39.61	$39.61	$39.61	$39.61	$39.61
Incremental cost ($ / cwt)	$2.74	$1.80	$1.62	$1.48	$1.36
% of price	6.92 %	4.53 %	4.08 %	3.74 %	3.42 %

* Incremental costs for $ / 1,000 lbs. SSLW are for a pit-recharge system with nitrogen-based land application to forages.

Table VI.54. Summary of Market Level Effects of the Barham Farm Technology—Market Hogs, SF/PSF, Short Run (SR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / cwt)			**(changes from baseline)**	
North Carolina	$39.61	$39.802	$0.192	0.484 %
Other US States	$40.50	$40.692	$0.192	0.473 %
Aggregate US	$40.50	$40.692	$0.192	0.473 %
Imports	$40.50	$40.692	$0.192	0.473 %
Market Quantities (1,000 lbs. of weight marketed)				
North Carolina	224,015.4	207,291.5	-16,723.8	-7.465 %
Other US States	2,061,855.6	2,072,578.9	10,723.3	0.520 %
Aggregate US	2,285,871.0	2,279,870.5	-6,000.5	-0.263 %
Imports	49,033.0	49,405.1	372.1	0.759 %

Table VI.55. Summary of Market Level Effects of the Barham Farm Technology—Feeder Pigs, SF/PSF, Short Run (SR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$42.32	$42.203	-$0.117	-0.276 %
Other US States	$45.11	$44.993	-$0.117	-0.259 %
Aggregate US	$45.11	$44.993	-$0.117	-0.259 %
Imports	$45.11	$44.993	-$0.117	-0.259 %
Market Quantities (1,000 heads marketed)				
North Carolina	17,719.5	17,627.1	-92.3	-0.521 %
Other US States	82,390.5	82,235.2	-155.4	-0.189 %
Aggregate US	100,110.0	99,862.3	-247.7	-0.247 %
Imports	3,416.4	3,414.6	-1.8	-0.051 %

Table VI.56. Summary of Market Level Effects of the Barham Farm Technology—Weaned Pigs, SF/PSF, Short Run (SR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$28.26	$28.308	$0.048	0.17 %
Other US States	$30.93	$30.978	$0.048	0.15 %
Aggregate US	$30.93	$30.978	$0.048	0.15 %
Market Quantities (# of head)				
North Carolina	19,421.3	19,069.4	-352.0	-1.81 %
Other US States	80,688.7	80,799.4	110.8	0.14 %
Aggregate US	100,110.0	99,868.8	-241.2	-0.24 %

Table VI.57. Summary of Market Quantities (1,000 lbs. SSLW) and Changes in Market Quantities for Size / Type Combinations—Barham Farm Technology, Smithfield/Premium Standard Farms in North Carolina, Short Run (SR)

	Baseline	With Technology Costs	Absolute	Percentage
			(changes from baseline)	
	Market Quantities (1,000 lbs. of SSLW)			
Farrow-Wean				
0-500 AU	281.45	269.53	-11.92	-4.24 %
500-1,000 AU	9,367.96	9,263.15	-104.81	-1.12 %
1,000-1,500 AU	32,886.35	32,576.92	-309.44	-0.94 %
1,500-2,000 AU	30,061.03	29,755.24	-305.79	-1.02 %
> 2,000 AU	18,736.78	18,538.60	-198.18	-1.06 %
Farrow-Feeder				
0-500 AU	1,396.35	1,370.75	-25.60	-1.83 %
500-1,000 AU	17,442.39	17,324.07	-118.32	-0.68 %
1,000-1,500 AU	12,632.40	12,488.93	-143.47	-1.14 %
1,500-2,000 AU	3,746.39	3,668.30	-78.09	-2.08 %
> 2,000 AU	2,871.00	2,797.87	-73.13	-2.55 %
Farrow-Finish				
0-500 AU	N/A	N/A	N/A	N/A
500-1,000 AU	3,825.90	3,701.66	-124.24	-3.25 %
1,000-1,500 AU	9,919.00	9,686.30	-232.70	-2.35 %
1,500-2,000 AU	25,506.00	25,175.33	-330.67	-1.30 %
> 2,000 AU	17,570.80	17,347.31	-223.49	-1.27 %
Wean-Feeder				
0-500 AU	3,605.70	3,542.59	-63.11	-1.75 %
500-1,000 AU	N/A	N/A	N/A	N/A
1,000-1,500 AU	N/A	N/A	N/A	N/A
1,500-2,000 AU	N/A	N/A	N/A	N/A
> 2,000 AU	N/A	N/A	N/A	N/A
Feeder-Finish				
0-500 AU	5,924.75	5,791.76	-132.99	-2.24 %
500-1,000 AU	17,000.55	16,779.34	-221.21	-1.30 %
1,000-1,500 AU	28,095.80	27,233.70	-862.10	-3.07 %
1,500-2,000 AU	8,489.75	8,027.86	-461.89	-5.44 %
> 2,000 AU	17,213.58	16,102.87	-1,110.71	-6.45 %

Table VI.58. Summary of Market Level Effects of the Barham Farm Technology—Market Hogs, SF/PSF, Intermediate Run (IR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / cwt)			**(changes from baseline)**	
North Carolina	$39.61	$39.860	$0.250	0.632 %
Other US States	$40.50	$40.750	$0.250	0.618 %
Aggregate US	$40.50	$40.750	$0.250	0.618 %
Imports	$40.50	$40.750	$0.250	0.618 %
Market Quantities (1,000 lbs. of weight marketed)				
North Carolina	224,015.4	171,051.0	-52,964.4	-23.643 %
Other US States	2,061,855.6	2,106,559.3	44,703.7	2.168 %
Aggregate US	2,285,871.0	2,277,610.3	-8,260.7	-0.361 %
Imports	49,033.0	49,948.2	915.3	1.867 %

Table VI.59. Summary of Market Level Effects of the Barham Farm Technology—Feeder Pigs, SF/PSF, Intermediate Run (IR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$42.32	$42.279	-$0.041	-0.097 %
Other US States	$45.11	$45.069	-$0.041	-0.091 %
Aggregate US	$45.11	$45.069	-$0.041	-0.091 %
Imports	$45.11	$45.069	-$0.041	-0.091 %
Market Quantities (1,000 heads marketed)				
North Carolina	17,719.5	17,569.0	-150.4	-0.849 %
Other US States	82,390.5	82,216.6	-174.0	-0.211 %
Aggregate US	100,110.0	99,785.6	-324.4	-0.324 %
Imports	3,416.4	3,415.1	-1.3	-0.038 %

Table VI.60. Summary of Market Level Effects of the Barham Farm Technology—Weaned Pigs, SF/PSF, Intermediate Run (IR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$28.26	$28.366	$0.106	0.37 %
Other US States	$30.93	$31.036	$0.106	0.34 %
Aggregate US	$30.93	$31.036	$0.106	0.34 %
Market Quantities (# of head)				
North Carolina	19,421.3	18,326.2	-1,095.1	-5.64 %
Other US States	80,688.7	81,468.9	780.2	0.97 %
Aggregate US	100,110.0	99,795.1	-314.9	-0.31 %

Table VI.61. Summary of Market Quantities (1,000 lbs. SSLW) and Changes in Market Quantities for Size / Type Combinations—Barham Farm Technology, Smithfield/Premium Standard Farms in North Carolina, Intermediate Run (IR)

	Baseline	With Technology Costs	Absolute	Percentage
			(changes from baseline)	
	Market Quantities (1,000 lbs. of SSLW)			
Farrow-Wean				
0-500 AU	281.45	243.39	-38.06	-13.52 %
500-1,000 AU	9,367.96	9,033.30	-334.66	-3.57 %
1,000-1,500 AU	32,886.35	31,898.32	-988.03	-3.00 %
1,500-2,000 AU	30,061.03	29,084.62	-976.41	-3.25 %
> 2,000 AU	18,736.78	18,103.99	-632.79	-3.38 %
Farrow-Feeder				
0-500 AU	1,396.35	1,314.60	-81.75	-5.85 %
500-1,000 AU	17,442.39	17,064.58	-377.81	-2.17 %
1,000-1,500 AU	12,632.40	12,174.31	-458.09	-3.63 %
1,500-2,000 AU	3,746.39	3,497.05	-249.34	-6.66 %
> 2,000 AU	2,871.00	2,637.50	-233.50	-8.13 %
Farrow-Finish				
0-500 AU	N/A	N/A	N/A	N/A
500-1,000 AU	3,825.90	3,429.35	-396.55	-10.36 %
1,000-1,500 AU	9,919.00	9,176.24	-742.76	-7.49 %
1,500-2,000 AU	25,506.00	24,450.54	-1,055.46	-4.14 %
> 2,000 AU	17,570.80	16,857.44	-713.36	-4.06 %
Wean-Feeder				
0-500 AU	3,605.70	3,404.18	-201.52	-5.59 %
500-1,000 AU	N/A	N/A	N/A	N/A
1,000-1,500 AU	N/A	N/A	N/A	N/A
1,500-2,000 AU	N/A	N/A	N/A	N/A
> 2,000 AU	N/A	N/A	N/A	N/A
Feeder-Finish				
0-500 AU	5,924.75	5,500.27	-424.48	-7.16 %
500-1,000 AU	17,000.55	16,294.47	-706.08	-4.15 %
1,000-1,500 AU	28,095.80	25,344.09	-2,751.71	-9.79 %
1,500-2,000 AU	8,489.75	7,015.47	-1,474.28	-17.37 %
> 2,000 AU	17,213.58	13,668.34	-3,545.24	-20.60 %

Table VI.62. Summary of Market Level Effects of the Barham Farm Technology—Market Hogs, SF/PSF, Long Run (LR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / cwt)			**(changes from baseline)**	
North Carolina	$39.61	$39.867	$0.257	0.650 %
Other US States	$40.50	$40.757	$0.257	0.635 %
Aggregate US	$40.50	$40.757	$0.257	0.635 %
Imports	$40.50	$40.757	$0.257	0.635 %
Market Quantities (1,000 lbs. of weight marketed)				
North Carolina	224,015.4	156,441.4	-67,573.9	-30.165 %
Other US States	2,061,855.6	2,120,586.6	58,730.9	2.848 %
Aggregate US	2,285,871.0	2,277,028.0	-8,843.0	-0.387 %
Imports	49,033.0	50,319.2	1,286.2	2.623 %

Table VI.63. Summary of Market Level Effects of the Barham Farm Technology—Feeder Pigs, SF/PSF, Long Run (LR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$42.32	$42.290	-$0.030	-0.070 %
Other US States	$45.11	$45.080	-$0.030	-0.066 %
Aggregate US	$45.11	$45.080	-$0.030	-0.066 %
Imports	$45.11	$45.080	-$0.030	-0.066 %
Market Quantities (1,000 heads marketed)				
North Carolina	17,719.5	17,547.0	-172.5	-0.973 %
Other US States	82,390.5	82,229.5	-161.0	-0.195 %
Aggregate US	100,110.0	99,776.5	-333.5	-0.333 %
Imports	3,416.4	3,415.0	-1.4	-0.041 %

Table VI.64. Summary of Market Level Effects of the Barham Farm Technology—Weaned Pigs, SF/PSF, Long Run (LR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$28.26	$28.373	$0.113	0.40 %
Other US States	$30.93	$31.043	$0.113	0.37 %
Aggregate US	$30.93	$31.043	$0.113	0.37 %
Market Quantities (# of head)				
North Carolina	19,421.3	18,027.7	-1,393.7	-7.18 %
Other US States	80,688.7	81,758.3	1,069.7	1.33 %
Aggregate US	100,110.0	99,786.0	-324.0	-0.32 %

Table VI.65. Summary of Market Quantities (1,000 lbs. SSLW) and Changes in Market Quantities for Size / Type Combinations—Barham Farm Technology, Smithfield/Premium Standard Farms in North Carolina, Long Run (LR)

	Baseline	With Technology Costs	Absolute	Percentage
			(changes from baseline)	
	Market Quantities (1,000 lbs. of SSLW)			
Farrow-Wean				
0-500 AU	281.45	232.84	-48.61	-17.27 %
500-1,000 AU	9,367.96	8,940.59	-427.38	-4.56 %
1,000-1,500 AU	32,886.35	31,624.60	-1,261.75	-3.84 %
1,500-2,000 AU	30,061.03	28,814.13	-1,246.90	-4.15 %
> 2,000 AU	18,736.78	17,928.69	-808.09	-4.31 %
Farrow-Feeder				
0-500 AU	1,396.35	1,291.95	-104.40	-7.48 %
500-1,000 AU	17,442.39	16,959.92	-482.47	-2.77 %
1,000-1,500 AU	12,632.40	12,047.40	-585.00	-4.63 %
1,500-2,000 AU	3,746.39	3,427.97	-318.42	-8.50 %
> 2,000 AU	2,871.00	2,572.81	-298.19	-10.39 %
Farrow-Finish				
0-500 AU	N/A	N/A	N/A	N/A
500-1,000 AU	3,825.90	3,319.48	-506.42	-13.24 %
1,000-1,500 AU	9,919.00	8,970.44	-948.56	-9.56 %
1,500-2,000 AU	25,506.00	24,158.11	-1,347.89	-5.28 %
> 2,000 AU	17,570.80	16,659.78	-911.02	-5.18 %
Wean-Feeder				
0-500 AU	3,605.70	3,348.35	-257.35	-7.14 %
500-1,000 AU	N/A	N/A	N/A	N/A
1,000-1,500 AU	N/A	N/A	N/A	N/A
1,500-2,000 AU	N/A	N/A	N/A	N/A
> 2,000 AU	N/A	N/A	N/A	N/A
Feeder-Finish				
0-500 AU	5,924.75	5,382.66	-542.09	-9.15 %
500-1,000 AU	17,000.55	16,098.84	-901.71	-5.30 %
1,000-1,500 AU	28,095.80	24,581.67	-3,514.13	-12.51 %
1,500-2,000 AU	8,489.75	6,606.99	-1,882.76	-22.18 %
> 2,000 AU	17,213.58	12,686.07	-4,527.51	-26.30 %

Table VI.66. Incremental Costs of the Super Soils Technology for Smithfield/Premium Standard Size / Type Combinations

	Size of Farm (1,000 pounds SSLW)				
	0-500	**500-1000**	**1000-1500**	**1500-2000**	**> 2000**
Type of Operation					
Farrow-wean					
Rep. # of sows	650	1,700	2,400	4,000	7,000
Incremental cost ($ / 1,000 lbs. SSLW)*	$641.86	$414.96	$388.45	$358.34	$320.85
Base price ($ / head)	$28.26	$28.26	$28.26	$28.26	$28.26
Incremental cost ($ / head weaned)	$13.90	$8.98	$8.41	$7.76	$6.95
% of price	49.17 %	31.79 %	29.76 %	27.45 %	24.58 %
Farrow-feeder					
Rep. # of sows	675	1,200	2,000	3,419	5,500
Incremental cost ($ / 1,000 lbs. SSLW)*	$554.47	$474.88	$409.20	$372.37	$351.38
Base price ($ / head)	$42.32	$42.32	$42.32	$42.32	$42.32
Incremental cost ($ / feeder pig)	$16.40	$14.04	$12.10	$11.01	$10.39
% of price	38.75 %	33.19 %	28.60 %	26.02 %	24.56 %
Farrow-finish					
Rep. # of sows	N/A	500	1,000	1,200	2,000
Incremental cost ($ / 1,000 lbs. SSLW)*	N/A	$443.57	$342.78	$346.33	$313.42
Base price ($ / cwt)	N/A	$39.61	$39.61	$39.61	$39.61
Incremental cost ($ / cwt)	N/A	$13.97	$10.79	$10.90	$9.87
% of price	N/A	35.26 %	27.25 %	27.53 %	24.91 %
Wean-feeder					
Rep. # of sows	2,808	N/A	N/A	N/A	N/A
Incremental cost ($ / 1,000 lbs. SSLW)*	$1,838.92	N/A	N/A	N/A	N/A
Base price ($ / head)	$42.32	N/A	N/A	N/A	N/A
Incremental cost ($ / feeder pig)	$8.49	N/A	N/A	N/A	N/A
% of price	20.06 %	N/A	N/A	N/A	N/A
Feeder-finish					
Rep. # of sows	1,240	5,100	8,800	12,246	17,136
Incremental cost ($ / 1,000 lbs. SSLW)*	$986.39	$452.67	$333.46	$323.55	$305.96
Base price ($ / cwt)	$39.61	$39.61	$39.61	$39.61	$39.61
Incremental cost ($ / cwt)	$20.08	$9.22	$6.79	$6.59	$6.23
% of price	50.71 %	23.27 %	17.14 %	16.63 %	15.73 %

* Incremental costs for $ / 1,000 lbs. SSLW are for a pit-recharge system with nitrogen-based land application to forages.

Table VI.67. Summary of Market Level Effects of the Super Soils Technology—Market Hogs, SF/PSF, Short Run (SR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / cwt)			**(changes from baseline)**	
North Carolina	$39.61	$40.547	$0.937	2.365 %
Other US States	$40.50	$41.437	$0.937	2.313 %
Aggregate US	$40.50	$41.437	$0.937	2.313 %
Imports	$40.50	$41.437	$0.937	2.313 %
Market Quantities (1,000 lbs. of weight marketed)				
North Carolina	224,015.4	142,269.6	-81,745.8	-36.491 %
Other US States	2,061,855.6	2,114,279.7	52,424.1	2.543 %
Aggregate US	2,285,871.0	2,256,549.3	-29,321.7	-1.283 %
Imports	49,033.0	50,852.0	1,819.1	3.710 %

Table VI.68. Summary of Market Level Effects of the Super Soils Technology—Feeder Pigs, SF/PSF, Short Run (SR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$42.32	$42.653	$0.333	0.788 %
Other US States	$45.11	$45.443	$0.333	0.739 %
Aggregate US	$45.11	$45.443	$0.333	0.739 %
Imports	$45.11	$45.443	$0.333	0.739 %
Market Quantities (1,000 heads marketed)				
North Carolina	17,719.5	16,051.5	-1,668.0	-9.413 %
Other US States	82,390.5	82,834.0	443.5	0.538 %
Aggregate US	100,110.0	98,885.5	-1,224.5	-1.223 %
Imports	3,416.4	3,421.4	5.0	0.146 %

Table VI.69. Summary of Market Level Effects of the Super Soils Technology—Weaned Pigs, SF/PSF, Short Run (SR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$28.26	28.540	$0.280	0.99 %
Other US States	$30.93	31.210	$0.280	0.91 %
Aggregate US	$30.93	31.210	$0.280	0.91 %
Market Quantities (# of head)				
North Carolina	19,421.3	17,593.6	-1,827.8	-9.41 %
Other US States	80,688.7	81,337.2	648.6	0.80 %
Aggregate US	100,110.0	98,930.8	-1,179.2	-1.18 %

Table VI.70. Summary of Market Quantities (1,000 lbs. SSLW) and Changes in Market Quantities for Size / Type Combinations—Super Soils Technology, Smithfield/Premium Standard Farms in North Carolina, Short Run (SR)

	Baseline	With Technology Costs	Absolute	Percentage
			(changes from baseline)	
	Market Quantities (1,000 lbs. of SSLW)			
Farrow-Wean				
0-500 AU	281.45	212.42	-69.03	-24.53 %
500-1,000 AU	9,367.96	8,841.86	-526.11	-5.62 %
1,000-1,500 AU	32,886.35	31,325.63	-1,560.72	-4.75 %
1,500-2,000 AU	30,061.03	28,406.57	-1,654.46	-5.50 %
> 2,000 AU	18,736.78	17,616.72	-1,120.06	-5.98 %
Farrow-Feeder				
0-500 AU	1,396.35	1,276.20	-120.15	-8.60 %
500-1,000 AU	17,442.39	16,849.68	-592.71	-3.40 %
1,000-1,500 AU	12,632.40	11,967.96	-664.45	-5.26 %
1,500-2,000 AU	3,746.39	3,374.15	-372.25	-9.94 %
> 2,000 AU	2,871.00	2,500.06	-370.94	-12.92 %
Farrow-Finish				
0-500 AU	N/A	N/A	N/A	N/A
500-1,000 AU	3,825.90	3,110.90	-715.00	-18.69 %
1,000-1,500 AU	9,919.00	8,740.97	-1,178.03	-11.88 %
1,500-2,000 AU	25,506.00	23,733.04	-1,772.96	-6.95 %
> 2,000 AU	17,570.80	16,389.41	-1,181.39	-6.72 %
Wean-Feeder				
0-500 AU	3,605.70	3,207.88	-397.82	-11.03 %
500-1,000 AU	N/A	N/A	N/A	N/A
1,000-1,500 AU	N/A	N/A	N/A	N/A
1,500-2,000 AU	N/A	N/A	N/A	N/A
> 2,000 AU	N/A	N/A	N/A	N/A
Feeder-Finish				
0-500 AU	5,924.75	5,034.16	-890.59	-15.03 %
500-1,000 AU	17,000.55	15,842.18	-1,158.37	-6.81 %
1,000-1,500 AU	28,095.80	24,267.60	-3,828.20	-13.63 %
1,500-2,000 AU	8,489.75	6,327.91	-2,161.84	-25.46 %
> 2,000 AU	17,213.58	11,750.71	-5,462.87	-31.74 %

Table VI.71. Summary of Market Level Effects of the Super Soils Technology—Market Hogs, SF/PSF, Intermediate Run (IR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / cwt)			**(changes from baseline)**	
North Carolina	$39.61	$40.668	$1.058	2.671 %
Other US States	$40.50	$41.558	$1.058	2.613 %
Aggregate US	$40.50	$41.558	$1.058	2.613 %
Imports	$40.50	$41.558	$1.058	2.613 %
Market Quantities (1,000 lbs. of weight marketed)				
North Carolina	224,015.4	0.0	-224.015.4	-100.000 %
Other US States	2,061,855.6	2,250,934.0	189,078.4	9.170 %
Aggregate US	2,285,871.0	2,250,934.0	-34,937.0	-1.528 %
Imports	49,033.0	52,904.2	3,871.2	7.895 %

Table VI.72. Summary of Market Level Effects of the Super Soils Technology—Feeder Pigs, SF/PSF, Intermediate Run (IR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$42.32	$42.473	$0.153	0.361 %
Other US States	$45.11	$45.263	$0.153	0.338 %
Aggregate US	$45.11	$45.263	$0.153	0.338 %
Imports	$45.11	$45.263	$0.153	0.338 %
Market Quantities (1,000 heads marketed)				
North Carolina	17,719.5	15,688.8	-2,030.7	-11.460 %
Other US States	82,390.5	83,038.8	648.3	0.787 %
Aggregate US	100,110.0	98,727.5	-1,382.5	-1.381 %
Imports	3,416.4	3,421.2	4.8	0.141 %

Table VI.73. Summary of Market Level Effects of the Super Soils Technology—Weaned Pigs, SF/PSF, Intermediate Run (IR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$28.26	$28.849	$0.589	2.08 %
Other US States	$30.93	$31.519	$0.589	1.90 %
Aggregate US	$30.93	$31.519	$0.589	1.90 %
Market Quantities (# of head)				
North Carolina	19,421.3	13,738.8	-5,682.6	-29.26 %
Other US States	80,688.7	85,039.3	4,350.6	5.39 %
Aggregate US	100,110.0	98,778.0	-1,332.0	-1.33 %

Table VI.74. Summary of Market Quantities (1,000 lbs. SSLW) and Changes in Market Quantities for Size / Type Combinations—Super Soils Technology, Smithfield/Premium Standard Farms in North Carolina, Intermediate Run (IR)

	Baseline	With Technology Costs	Absolute	Percentage
			(changes from baseline)	
	Market Quantities (1,000 lbs. of SSLW)			
Farrow-Wean				
0-500 AU	281.45	61.04	-220.41	-78.31 %
500-1,000 AU	9,367.96	7,688.10	-1,679.86	-17.93 %
1,000-1,500 AU	32,886.35	27,902.96	-4,983.40	-15.15 %
1,500-2,000 AU	30,061.03	24,778.31	-5,282.72	-17.57 %
> 2,000 AU	18,736.78	15,160.41	-3,576.37	-19.09 %
Farrow-Feeder				
0-500 AU	1,396.35	1,012.70	-383.65	-27.48 %
500-1,000 AU	17,442.39	15,549.87	-1,892.52	-10.85 %
1,000-1,500 AU	12,632.40	10,510.82	-2,121.58	-16.79 %
1,500-2,000 AU	3,746.39	2,557.81	-1,188.58	-31.73 %
> 2,000 AU	2,871.00	1,686.58	-1,184.42	-41.25 %
Farrow-Finish				
0-500 AU	N/A	N/A	N/A	N/A
500-1,000 AU	3,825.90	1,543.71	-2,282.19	-59.65 %
1,000-1,500 AU	9,919.00	6,158.87	-3,760.13	-37.91 %
1,500-2,000 AU	25,506.00	19,846.94	-5,659.06	-22.19 %
> 2,000 AU	17,570.80	13,799.97	-3,770.83	-21.46 %
Wean-Feeder				
0-500 AU	3,605.70	2,335.46	-1,270.24	-35.23 %
500-1,000 AU	N/A	N/A	N/A	N/A
1,000-1,500 AU	N/A	N/A	N/A	N/A
1,500-2,000 AU	N/A	N/A	N/A	N/A
> 2,000 AU	N/A	N/A	N/A	N/A
Feeder-Finish				
0-500 AU	5,924.75	3,082.12	-2,842.63	-47.98 %
500-1,000 AU	17,000.55	13,303.20	-3,697.35	-21.75 %
1,000-1,500 AU	28,095.80	15,876.69	-12,219.12	-43.49 %
1,500-2,000 AU	8,489.75	1,589.45	-6,900.30	-81.28 %
> 2,000 AU	17,213.58	0.00	-17,213.58	-100.00 %

Table VI.75. Summary of Market Level Effects of the Super Soils Technology—Market Hogs, SF/PSF, Long Run (LR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / cwt)			**(changes from baseline)**	
North Carolina	$39.61	$40.463	$0.853	2.154 %
Other US States	$40.50	$41.353	$0.853	2.107 %
Aggregate US	$40.50	$41.353	$0.853	2.107 %
Imports	$40.50	$41.353	$0.853	2.107 %
Market Quantities (1,000 lbs. of weight marketed)				
North Carolina	224,015.4	0.0	-224,015.4	-100.000 %
Other US States	2,061,855.6	2,256,553.4	194,697.8	9.443 %
Aggregate US	2,285,871.0	2,256,553.4	-29,317.6	-1.283 %
Imports	49,033.0	53,296.9	4,263.9	8.696 %

Table VI.76. Summary of Market Level Effects of the Super Soils Technology—Feeder Pigs, SF/PSF, Long Run (LR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$42.32	$42.511	$0.191	0.452 %
Other US States	$45.11	$45.301	$0.191	0.424 %
Aggregate US	$45.11	$45.301	$0.191	0.424 %
Imports	$45.11	$45.301	$0.191	0.424 %
Market Quantities (1,000 heads marketed)				
North Carolina	17,719.5	15,562.8	-2,156.6	-12.171 %
Other US States	82,390.5	83,427.4	1,036.9	1.259 %
Aggregate US	100,110.0	98,990.3	-1,119.7	-1.119 %
Imports	3,416.4	3,425.5	9.1	0.266 %

Table VI.77. Summary of Market Level Effects of the Super Soils Technology—Weaned Pigs, SF/PSF, Long Run (LR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$28.26	$28.911	$0.651	2.30 %
Other US States	$30.93	$31.581	$0.651	2.10 %
Aggregate US	$30.93	$31.581	$0.651	2.10 %
Market Quantities (# of head)				
North Carolina	19,421.3	12,203.6	-7,217.8	-37.16 %
Other US States	80,688.7	86,832.4	6,143.7	7.61 %
Aggregate US	100,110.0	99,035.9	-1,074.1	-1.07 %

Table VI.78. Summary of Market Quantities (1,000 lbs. SSLW) and Changes in Market Quantities for Size / Type Combinations—Super Soils Technology, Smithfield/Premium Standard Farms in North Carolina, Long Run (LR)

	Baseline	With Technology Costs	Absolute	Percentage
			(changes from baseline)	
	Market Quantities (1,000 lbs. of SSLW)			
Farrow-Wean				
0-500 AU	281.45	0.00	-281.45	-100.00 %
500-1,000 AU	9,367.96	7,222.72	-2,145.24	-22.90 %
1,000-1,500 AU	32,886.35	26,522.38	-6,363.97	-19.35 %
1,500-2,000 AU	30,061.03	23,314.81	-6,746.22	-22.44 %
> 2,000 AU	18,736.78	14,169.63	-4,567.15	-24.38 %
Farrow-Feeder				
0-500 AU	1,396.35	906.42	-489.93	-35.09 %
500-1,000 AU	17,442.39	15,025.28	-2,416.81	-13.86 %
1,000-1,500 AU	12,632.40	9,923.06	-2,709.34	-21.45 %
1,500-2,000 AU	3,746.39	2,228.53	-1,517.86	-40.52 %
> 2,000 AU	2,871.00	1,358.45	-1,512.55	-52.68 %
Farrow-Finish				
0-500 AU	N/A	N/A	N/A	N/A
500-1,000 AU	3,825.90	911.38	-2,914.52	-76.18 %
1,000-1,500 AU	9,919.00	5,117.05	-4,801.95	-48.41 %
1,500-2,000 AU	25,506.00	18,278.99	-7,227.02	-28.33 %
> 2,000 AU	17,570.80	12,755.19	-4,815.61	-27.41 %
Wean-Feeder				
0-500 AU	3,605.70	1,983.56	-1,622.14	-44.99 %
500-1,000 AU	N/A	N/A	N/A	N/A
1,000-1,500 AU	N/A	N/A	N/A	N/A
1,500-2,000 AU	N/A	N/A	N/A	N/A
> 2,000 AU	N/A	N/A	N/A	N/A
Feeder-Finish				
0-500 AU	5,924.75	2,294.51	-3,630.24	-61.27 %
500-1,000 AU	17,000.55	12,278.78	-4,721.77	-27.77 %
1,000-1,500 AU	28,095.80	12,491.13	-15,604.67	-55.54 %
1,500-2,000 AU	8,489.75	0.00	-8,489.75	-100.00 %
> 2,000 AU	17,213.58	0.00	-17,213.58	-100.00 %

Table VI.79. Incremental Costs of the EKOKAN Technology for Smithfield/Premium Standard Size / Type Combinations

	Size of Farm (1,000 pounds SSLW)				
	0-500	**500-1000**	**1000-1500**	**1500-2000**	**> 2000**
Type of Operation					
Farrow-wean					
Rep. # of sows	650	1,700	2,400	4,000	7,000
Incremental cost ($ / 1,000 lbs. SSLW)*	$425.82	$169.13	$197.80	$127.10	$130.72
Base price ($ / head)	$28.26	$28.26	$28.26	$28.26	$28.26
Incremental cost ($ / head weaned)	$9.22	$3.66	$4.28	$2.75	$2.83
% of price	32.62 %	12.96 %	15.15 %	9.74 %	10.01 %
Farrow-feeder					
Rep. # of sows	675	1,200	2,000	3,419	5,500
Incremental cost ($ / 1,000 lbs. SSLW)*	$342.65	$198.61	$198.16	$169.23	$162.76
Base price ($ / head)	$42.32	$42.32	$42.32	$42.32	$42.32
Incremental cost ($ / feeder pig)	$10.13	$5.87	$5.86	$5.00	$4.81
% of price	23.95 %	13.88 %	13.85 %	11.83 %	11.37 %
Farrow-finish					
Rep. # of sows	N/A	500	1,000	1,200	2,000
Incremental cost ($ / 1,000 lbs. SSLW)*	N/A	$285.25	$202.03	$216.04	$190.82
Base price ($ / cwt)	N/A	$39.61	$39.61	$39.61	$39.61
Incremental cost ($ / cwt)	N/A	$8.98	$6.36	$6.80	$6.01
% of price	N/A	22.67 %	16.06 %	17.17 %	15.17 %
Wean-feeder					
Rep. # of sows	2,808	N/A	N/A	N/A	N/A
Incremental cost ($ / 1,000 lbs. SSLW)*	$1,395.06	N/A	N/A	N/A	N/A
Base price ($ / head)	$42.32	N/A	N/A	N/A	N/A
Incremental cost ($ / feeder pig)	$6.44	N/A	N/A	N/A	N/A
% of price	15.21 %	N/A	N/A	N/A	N/A
Feeder-finish					
Rep. # of sows	1,240	5,100	8,800	12,246	17,136
Incremental cost ($ / 1,000 lbs. SSLW)*	$706.92	$291.64	$303.86	$267.46	$260.70
Base price ($ / cwt)	$39.61	$39.61	$39.61	$39.61	$39.61
Incremental cost ($ / cwt)	$14.39	$5.94	$6.19	$5.45	$5.31
% of price	36.34 %	14.99 %	15.62 %	13.75 %	13.40 %

* Incremental costs for $ / 1,000 lbs. SSLW are for a pit-recharge system with nitrogen-based land application to forages.

Table VI.80. Summary of Market Level Effects of the EKOKAN Technology—Market Hogs, SF/PSF, Short Run (SR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / cwt)			**(changes from baseline)**	
North Carolina	$39.61	$40.258	$0.648	1.637 %
Other US States	$40.50	$41.148	$0.648	1.601 %
Aggregate US	$40.50	$41.148	$0.648	1.601 %
Imports	$40.50	$41.148	$0.648	1.601 %
Market Quantities (1,000 lbs. of weight marketed)				
North Carolina	224,015.4	167,438.1	-56,577.3	-25.256 %
Other US States	2,061,855.6	2,098,136.5	36,280.8	1.760 %
Aggregate US	2,285,871.0	2,265,574.5	-20,296.5	-0.888 %
Imports	49,033.0	50,291.9	1,258.9	2.567 %

Table VI.81. Summary of Market Level Effects of the EKOKAN Technology—Feeder Pigs, SF/PSF, Short Run (SR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$42.32	$42.037	-$0.283	-0.670 %
Other US States	$45.11	$44.827	-$0.283	-0.628 %
Aggregate US	$45.11	$44.827	-$0.283	-0.628 %
Imports	$45.11	$44.827	-$0.283	-0.628 %
Market Quantities (1,000 heads marketed)				
North Carolina	17,719.5	17,256.5	-463.0	-2.613 %
Other US States	82,390.5	82,013.7	-376.8	-0.457 %
Aggregate US	100,110.0	99,270.2	-839.9	-0.839 %
Imports	3,416.4	3,412.1	-4.2	-0.124 %

Table VI.82. Summary of Market Level Effects of the EKOKAN Technology—Weaned Pigs, SF/PSF, Short Run (SR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$28.26	$28.277	$0.017	0.06 %
Other US States	$30.93	$30.947	$0.017	0.06 %
Aggregate US	$30.93	$30.947	$0.017	0.06 %
Market Quantities (# of head)				
North Carolina	19,421.3	18,564.7	-856.6	-4.41 %
Other US States	80,688.7	80,729.1	40.5	0.05 %
Aggregate US	100,110.0	99,293.9	-816.1	-0.82 %

Table VI.83. Summary of Market Quantities (1,000 lbs. SSLW) and Changes in Market Quantities for Size / Type Combinations—EKOKAN Technology, Smithfield/Premium Standard Farms in North Carolina, Short Run (SR)

	Baseline	With Technology Costs	Absolute	Percentage
			(changes from baseline)	
	Market Quantities (1,000 lbs. of SSLW)			
Farrow-Wean				
0-500 AU	281.45	234.80	-46.65	-16.57 %
500-1,000 AU	9,367.96	9,147.68	-220.28	-2.35 %
1,000-1,500 AU	32,886.35	32,067.60	-818.75	-2.49 %
1,500-2,000 AU	30,061.03	29,456.09	-604.94	-2.01 %
> 2,000 AU	18,736.78	18,264.21	-472.57	-2.52 %
Farrow-Feeder				
0-500 AU	1,396.35	1,318.44	-77.91	-5.58 %
500-1,000 AU	17,442.39	17,176.22	-266.17	-1.53 %
1,000-1,500 AU	12,632.40	12,285.52	-346.88	-2.75 %
1,500-2,000 AU	3,746.39	3,562.06	-184.33	-4.92 %
> 2,000 AU	2,871.00	2,683.03	-187.97	-6.55 %
Farrow-Finish				
0-500 AU	N/A	N/A	N/A	N/A
500-1,000 AU	3,825.90	3,368.62	-457.28	-11.95 %
1,000-1,500 AU	9,919.00	9,236.18	-682.82	-6.88 %
1,500-2,000 AU	25,506.00	24,411.40	-1,094.60	-4.29 %
> 2,000 AU	17,570.80	16,861.85	-708.95	-4.03 %
Wean-Feeder				
0-500 AU	3,605.70	3,318.10	-287.60	-7.98 %
500-1,000 AU	N/A	N/A	N/A	N/A
1,000-1,500 AU	N/A	N/A	N/A	N/A
1,500-2,000 AU	N/A	N/A	N/A	N/A
> 2,000 AU	N/A	N/A	N/A	N/A
Feeder-Finish				
0-500 AU	5,924.75	5,306.36	-618.39	-10.44 %
500-1,000 AU	17,000.55	16,357.32	-643.23	-3.78 %
1,000-1,500 AU	28,095.80	25,227.29	-2,868.51	-10.21 %
1,500-2,000 AU	8,489.75	7,005.77	-1,483.98	-17.48 %
> 2,000 AU	17,213.58	13,347.08	-3,866.50	-22.46 %

Table VI.84. Summary of Market Level Effects of the EKOKAN Technology—Market Hogs, SF/PSF, Intermediate Run (IR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / cwt)			**(changes from baseline)**	
North Carolina	$39.61	$40.456	$0.846	2.137 %
Other US States	$40.50	$41.346	$0.846	2.090 %
Aggregate US	$40.50	$41.346	$0.846	2.090 %
Imports	$40.50	$41.346	$0.846	2.090 %
Market Quantities (1,000 lbs. of weight marketed)				
North Carolina	224,015.4	44,834.7	-179,180.6	-79.986 %
Other US States	2,061,855.6	2,213,090.1	151,234.4	7.335 %
Aggregate US	2,285,871.0	2,257,924.8	-27,946.2	-1.223 %
Imports	49,033.0	52,129.3	3,096.4	6.315 %

Table VI.85. Summary of Market Level Effects of the EKOKAN Technology—Feeder Pigs, SF/PSF, Intermediate Run (IR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$42.32	$42.232	-$0.088	-0.207 %
Other US States	$45.11	$45.022	-$0.088	-0.195 %
Aggregate US	$45.11	$45.022	-$0.088	-0.195 %
Imports	$45.11	$45.022	-$0.088	-0.195 %
Market Quantities (1,000 heads marketed)				
North Carolina	17,719.5	16,993.4	-726.0	-4.097 %
Other US States	82,390.5	82,017.6	-372.9	-0.453 %
Aggregate US	100,110.0	99,011.1	-1,098.9	-1.098 %
Imports	3,416.4	3,413.6	-2.8	-0.081 %

Table VI.86. Summary of Market Level Effects of the EKOKAN Technology—Weaned Pigs, SF/PSF, Intermediate Run (IR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$28.26	28.473	$0.213	0.75 %
Other US States	$30.93	31.143	$0.213	0.69 %
Aggregate US	$30.93	31.143	$0.213	0.69 %
Market Quantities (# of head)				
North Carolina	19,421.3	16,783.1	-2,638.2	-13.58 %
Other US States	80,688.7	82,261.4	1,572.8	1.95 %
Aggregate US	100,110.0	99,044.6	-1,065.4	-1.06 %

Table VI.87. Summary of Market Quantities (1,000 lbs. SSLW) and Changes in Market Quantities for Size / Type Combinations—EKOKAN Technology, Smithfield/Premium Standard Farms in North Carolina, Intermediate Run (IR)

	Baseline	With Technology Costs	Absolute	Percentage
			(changes from baseline)	
	Market Quantities (1,000 lbs. of SSLW)			
Farrow-Wean				
0-500 AU	281.45	132.50	-148.95	-52.92 %
500-1,000 AU	9,367.96	8,664.62	-703.34	-7.51 %
1,000-1,500 AU	32,886.35	30,272.06	-2,614.29	-7.95 %
1,500-2,000 AU	30,061.03	28,129.45	-1,931.58	-6.43 %
> 2,000 AU	18,736.78	17,227.85	-1,508.93	-8.05 %
Farrow-Feeder				
0-500 AU	1,396.35	1,147.58	-248.77	-17.82 %
500-1,000 AU	17,442.39	16,592.52	-849.87	-4.87 %
1,000-1,500 AU	12,632.40	11,524.81	-1,107.59	-8.77 %
1,500-2,000 AU	3,746.39	3,157.82	-588.57	-15.71 %
> 2,000 AU	2,871.00	2,270.82	-600.18	-20.90 %
Farrow-Finish				
0-500 AU	N/A	N/A	N/A	N/A
500-1,000 AU	3,825.90	2,366.31	-1,459.59	-38.15 %
1,000-1,500 AU	9,919.00	7,739.53	-2,179.47	-21.97 %
1,500-2,000 AU	25,506.00	22,012.20	-3,493.80	-13.70 %
> 2,000 AU	17,570.80	15,307.92	-2,262.88	-12.88 %
Wean-Feeder				
0-500 AU	3,605.70	2,687.38	-918.32	-25.47 %
500-1,000 AU	N/A	N/A	N/A	N/A
1,000-1,500 AU	N/A	N/A	N/A	N/A
1,500-2,000 AU	N/A	N/A	N/A	N/A
> 2,000 AU	N/A	N/A	N/A	N/A
Feeder-Finish				
0-500 AU	5,924.75	3,950.93	-1,973.82	-33.31 %
500-1,000 AU	17,000.55	14,947.44	-2,053.11	-12.08 %
1,000-1,500 AU	28,095.80	18,939.90	-9,155.90	-32.59 %
1,500-2,000 AU	8,489.75	3,753.07	-4,736.68	-55.79 %
> 2,000 AU	17,213.58	4,872.22	-12,341.36	-71.70 %

Table VI.88. Summary of Market Level Effects of the EKOKAN Technology—Market Hogs, SF/PSF, Long Run (LR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / cwt)			**(changes from baseline)**	
North Carolina	$39.61	$40.463	$0.853	2.154 %
Other US States	$40.50	$41.353	$0.853	2.107 %
Aggregate US	$40.50	$41.353	$0.853	2.107 %
Imports	$40.50	$41.353	$0.853	2.107 %
Market Quantities (1,000 lbs. of weight marketed)				
North Carolina	224,015.4	0.0	-224,015.4	-100.000 %
Other US States	2,061,855.6	2,256,555.4	194,699.8	9.443 %
Aggregate US	2,285,871.0	2,256,555.4	-29,315.6	-1.282 %
Imports	49,033.0	53,296.9	4,263.9	8.696 %

Table VI.89. Summary of Market Level Effects of the EKOKAN Technology—Feeder Pigs, SF/PSF, Long Run (LR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$42.32	$42.268	-$0.052	-0.123 %
Other US States	$45.11	$45.058	-$0.052	-0.115 %
Aggregate US	$45.11	$45.058	-$0.052	-0.115 %
Imports	$45.11	$45.058	-$0.052	-0.115 %
Market Quantities (1,000 heads marketed)				
North Carolina	17,719.5	16,893.3	-826.2	-4.663 %
Other US States	82,390.5	82,108.5	-282.0	-0.342 %
Aggregate US	100,110.0	99,001.8	-1,108.2	-1.107 %
Imports	3,416.4	3,413.9	-2.5	-0.072 %

Table VI.90. Summary of Market Level Effects of the EKOKAN Technology—Weaned Pigs, SF/PSF, Long Run (LR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$28.26	$28.501	$0.241	0.85 %
Other US States	$30.93	$31.171	$0.241	0.78 %
Aggregate US	$30.93	$31.171	$0.241	0.78 %
Market Quantities (# of head)				
North Carolina	19,421.3	16,070.1	-3,351.3	-17.26 %
Other US States	80,688.7	82,965.8	2,277.2	2.82 %
Aggregate US	100,110.0	99,035.9	-1,074.1	-1.07 %

Table VI.91. Summary of Market Quantities (1,000 lbs. SSLW) and Changes in Market Quantities for Size / Type Combinations—EKOKAN Technology, Smithfield/Premium Standard Farms in North Carolina, Long Run (LR)

	Baseline	With Technology Costs	Absolute	Percentage
			(changes from baseline)	
	Market Quantities (1,000 lbs. of SSLW)			
Farrow-Wean				
0-500 AU	281.45	91.24	-190.22	-67.58 %
500-1,000 AU	9,367.96	8,469.77	-898.20	-9.59 %
1,000-1,500 AU	32,886.35	29,547.81	-3,338.54	-10.15 %
1,500-2,000 AU	30,061.03	27,594.34	-2,466.69	-8.21 %
> 2,000 AU	18,736.78	16,809.82	-1,926.96	-10.28 %
Farrow-Feeder				
0-500 AU	1,396.35	1,078.66	-317.69	-22.75 %
500-1,000 AU	17,442.39	16,357.08	-1,085.31	-6.22 %
1,000-1,500 AU	12,632.40	11,217.97	-1,414.43	-11.20 %
1,500-2,000 AU	3,746.39	2,994.76	-751.63	-20.06 %
> 2,000 AU	2,871.00	2,104.55	-766.45	-26.70 %
Farrow-Finish				
0-500 AU	N/A	N/A	N/A	N/A
500-1,000 AU	3,825.90	1,961.90	-1,864.00	-48.72 %
1,000-1,500 AU	9,919.00	7,135.66	-2,783.34	-28.06 %
1,500-2,000 AU	25,506.00	21,044.17	-4,461.83	-17.49 %
> 2,000 AU	17,570.80	14,680.95	-2,889.85	-16.45 %
Wean-Feeder				
0-500 AU	3,605.70	2,432.98	-1,172.72	-32.52 %
500-1,000 AU	N/A	N/A	N/A	N/A
1,000-1,500 AU	N/A	N/A	N/A	N/A
1,500-2,000 AU	N/A	N/A	N/A	N/A
> 2,000 AU	N/A	N/A	N/A	N/A
Feeder-Finish				
0-500 AU	5,924.75	3,404.05	-2,520.70	-42.55 %
500-1,000 AU	17,000.55	14,378.59	-2,621.96	-15.42 %
1,000-1,500 AU	28,095.80	16,403.07	-11,692.73	-41.62 %
1,500-2,000 AU	8,489.75	2,440.68	-6,049.07	-71.25 %
> 2,000 AU	17,213.58	1,452.80	-15,760.78	-91.56 %

Table VI.92. Incremental Costs of the ReCip Technology for Smithfield/Premium Standard Size / Type Combinations

	Size of Farm (1,000 pounds SSLW)				
	0-500	**500-1000**	**1000-1500**	**1500-2000**	**> 2000**
Type of Operation					
Farrow-wean					
Rep. # of sows	650	1,700	2,400	4,000	7,000
Incremental cost ($ / 1,000 lbs. SSLW)*	$261.28	$196.24	$188.23	$176.05	$169.78
Base price ($ / head)	$28.26	$28.26	$28.26	$28.26	$28.26
Incremental cost ($ / head weaned)	$5.66	$4.25	$4.08	$3.81	$3.68
% of price	20.02 %	15.03 %	14.43 %	13.49 %	13.01 %
Farrow-feeder					
Rep. # of sows	675	1,200	2,000	3,419	5,500
Incremental cost ($ / 1,000 lbs. SSLW)*	$239.25	$201.70	$194.61	$182.84	$174.28
Base price ($ / head)	$42.32	$42.32	$42.32	$42.32	$42.32
Incremental cost ($ / feeder pig)	$7.08	$5.97	$5.76	$5.41	$5.15
% of price	16.72 %	14.10 %	13.60 %	12.78 %	12.18 %
Farrow-finish					
Rep. # of sows	N/A	500	1,000	1,200	2,000
Incremental cost ($ / 1,000 lbs. SSLW)*	N/A	$158.62	$143.37	$139.69	$133.10
Base price ($ / cwt)	N/A	$39.61	$39.61	$39.61	$39.61
Incremental cost ($ / cwt)	N/A	$4.99	$4.51	$4.40	$4.19
% of price	N/A	12.61 %	11.40 %	11.10 %	10.58 %
Wean-feeder					
Rep. # of sows	2,808	N/A	N/A	N/A	N/A
Incremental cost ($ / 1,000 lbs. SSLW)*	$411.40	N/A	N/A	N/A	N/A
Base price ($ / head)	$42.32	N/A	N/A	N/A	N/A
Incremental cost ($ / feeder pig)	$1.90	N/A	N/A	N/A	N/A
% of price	4.49 %	N/A	N/A	N/A	N/A
Feeder-finish					
Rep. # of sows	1,240	5,100	8,800	12,246	17,136
Incremental cost ($ / 1,000 lbs. SSLW)*	$255.53	$139.90	$119.69	$118.01	$111.58
Base price ($ / cwt)	$39.61	$39.61	$39.61	$39.61	$39.61
Incremental cost ($ / cwt)	$5.20	$2.85	$2.44	$2.40	$2.27
% of price	13.14 %	7.19 %	6.15 %	6.07 %	5.74 %

* Incremental costs for $ / 1,000 lbs. SSLW are for a pit-recharge system with nitrogen-based land application to forages.

Table VI.93. Summary of Market Level Effects of the ReCip Technology—Market Hogs, SF/PSF, Short Run (SR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / cwt)			**(changes from baseline)**	
North Carolina	$39.61	$39.984	$0.374	0.944 %
Other US States	$40.50	$40.874	$0.374	0.923 %
Aggregate US	$40.50	$40.874	$0.374	0.923 %
Imports	$40.50	$40.874	$0.374	0.923 %
Market Quantities (1,000 lbs. of weight marketed)				
North Carolina	224,015.4	191,390.6	-32,624.8	-14.564 %
Other US States	2,061,855.6	2,082,777.5	20,921.9	1.015 %
Aggregate US	2,285,871.0	2,274,168.1	-11,702.9	-0.512 %
Imports	49,033.0	49,759.0	726.0	1.481 %

Table VI.94. Summary of Market Level Effects of the ReCip Technology—Feeder Pigs, SF/PSF, Short Run (SR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$42.32	$42.235	-$0.085	-0.200 %
Other US States	$45.11	$45.025	-$0.085	-0.188 %
Aggregate US	$45.11	$45.025	-$0.085	-0.188 %
Imports	$45.11	$45.025	-$0.085	-0.188 %
Market Quantities (1,000 heads marketed)				
North Carolina	17,719.5	17,346.8	-372.7	-2.103 %
Other US States	82,390.5	82,277.8	-112.7	-0.137 %
Aggregate US	100,110.0	99,624.6	-485.4	-0.485 %
Imports	3,416.4	3,415.1	-1.3	-0.037 %

Table VI.95. Summary of Market Level Effects of the ReCip Technology—Weaned Pigs, SF/PSF, Short Run (SR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$28.26	28.441	$0.181	0.64 %
Other US States	$30.93	31.111	$0.181	0.58 %
Aggregate US	$30.93	31.111	$0.181	0.58 %
Market Quantities (# of head)				
North Carolina	19,421.3	18,532.3	-889.1	-4.58 %
Other US States	80,688.7	81,107.1	418.4	0.52 %
Aggregate US	100,110.0	99,639.4	-470.6	-0.47 %

Table VI.96. Summary of Market Quantities (1,000 lbs. SSLW) and Changes in Market Quantities for Size / Type Combinations—ReCip Technology, Smithfield/Premium Standard Farms in North Carolina, Short Run (SR)

	Baseline	With Technology Costs	Absolute	Percentage
			(changes from baseline)	
	Market Quantities (1,000 lbs. of SSLW)			
Farrow-Wean				
0-500 AU	281.45	253.69	-27.76	-9.86 %
500-1,000 AU	9,367.96	9,122.07	-245.89	-2.62 %
1,000-1,500 AU	32,886.35	32,138.30	-748.05	-2.27 %
1,500-2,000 AU	30,061.03	29,257.74	-803.29	-2.67 %
> 2,000 AU	18,736.78	18,149.55	-587.23	-3.13 %
Farrow-Feeder				
0-500 AU	1,396.35	1,342.80	-53.56	-3.84 %
500-1,000 AU	17,442.39	17,180.86	-261.53	-1.50 %
1,000-1,500 AU	12,632.40	12,302.66	-329.74	-2.61 %
1,500-2,000 AU	3,746.39	3,554.95	-191.44	-5.11 %
> 2,000 AU	2,871.00	2,677.79	-193.21	-6.73 %
Farrow-Finish				
0-500 AU	N/A	N/A	N/A	N/A
500-1,000 AU	3,825.90	3,572.35	-253.55	-6.63 %
1,000-1,500 AU	9,919.00	9,424.13	-494.87	-4.99 %
1,500-2,000 AU	25,506.00	24,790.18	-715.82	-2.81 %
> 2,000 AU	17,570.80	17,065.93	-504.87	-2.87 %
Wean-Feeder				
0-500 AU	3,605.70	3,467.86	-137.84	-3.82 %
500-1,000 AU	N/A	N/A	N/A	N/A
1,000-1,500 AU	N/A	N/A	N/A	N/A
1,500-2,000 AU	N/A	N/A	N/A	N/A
> 2,000 AU	N/A	N/A	N/A	N/A
Feeder-Finish				
0-500 AU	5,924.75	5,662.55	-262.20	-4.43 %
500-1,000 AU	17,000.55	16,599.12	-401.43	-2.36 %
1,000-1,500 AU	28,095.80	26,545.44	-1,550.36	-5.52 %
1,500-2,000 AU	8,489.75	7,596.03	-893.72	-10.53 %
> 2,000 AU	17,213.58	14,944.06	-2,269.52	-13.18 %

Table VI.97. Summary of Market Level Effects of the ReCip Technology—Market Hogs, SF/PSF, Intermediate Run (IR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / cwt)			**(changes from baseline)**	
North Carolina	$39.61	$40.098	$0.488	1.232 %
Other US States	$40.50	$40.988	$0.488	1.205 %
Aggregate US	$40.50	$40.988	$0.488	1.205 %
Imports	$40.50	$40.988	$0.488	1.205 %
Market Quantities (1,000 lbs. of weight marketed)				
North Carolina	224,015.4	120,692.4	-103,322.9	-46.123 %
Other US States	2,061,855.6	2,149,063.6	87,208.0	4.230 %
Aggregate US	2,285,871.0	2,269,756.1	-16,114.9	-0.705 %
Imports	49,033.0	50,818.5	1,785.5	3.641 %

Table VI.98. Summary of Market Level Effects of the ReCip Technology—Feeder Pigs, SF/PSF, Intermediate Run (IR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$42.32	$42.289	-$0.031	-0.074 %
Other US States	$45.11	$45.079	-$0.031	-0.070 %
Aggregate US	$45.11	$45.079	-$0.031	-0.070 %
Imports	$45.11	$45.079	-$0.031	-0.070 %
Market Quantities (1,000 heads marketed)				
North Carolina	17,719.5	17,218.3	-501.1	-2.828 %
Other US States	82,390.5	82,257.3	-133.2	-0.162 %
Aggregate US	100,110.0	99,475.6	-634.4	-0.634 %
Imports	3,416.4	3,415.4	-1.0	-0.029 %

Table VI.99. Summary of Market Level Effects of the ReCip Technology—Weaned Pigs, SF/PSF, Intermediate Run (IR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$28.26	$28.553	$0.293	1.04 %
Other US States	$30.93	$31.223	$0.293	0.95 %
Aggregate US	$30.93	$31.223	$0.293	0.95 %
Market Quantities (# of head)				
North Carolina	19,421.3	16,638.8	-2,782.6	-14.33 %
Other US States	80,688.7	82,856.8	2,168.2	2.69 %
Aggregate US	100,110.0	99,495.6	-614.4	-0.61 %

Table VI.100. Summary of Market Quantities (1,000 lbs. SSLW) and Changes in Market Quantities for Size / Type Combinations—ReCip Technology, Smithfield/Premium Standard Farms in North Carolina, Intermediate Run (IR)

	Baseline	With Technology Costs	Absolute	Percentage
			(changes from baseline)	
	Market Quantities (1,000 lbs. of SSLW)			
Farrow-Wean				
0-500 AU	281.45	192.81	-88.64	-31.50 %
500-1,000 AU	9,367.96	8,582.84	-785.12	-8.38 %
1,000-1,500 AU	32,886.35	30,497.81	-2,388.54	-7.26 %
1,500-2,000 AU	30,061.03	27,496.12	-2,564.91	-8.53 %
> 2,000 AU	18,736.78	16,861.75	-1,875.03	-10.01 %
Farrow-Feeder				
0-500 AU	1,396.35	1,225.35	-171.00	-12.25 %
500-1,000 AU	17,442.39	16,607.32	-835.07	-4.79 %
1,000-1,500 AU	12,632.40	11,579.54	-1,052.86	-8.33 %
1,500-2,000 AU	3,746.39	3,135.12	-611.27	-16.32 %
> 2,000 AU	2,871.00	2,254.09	-616.91	-21.49 %
Farrow-Finish				
0-500 AU	N/A	N/A	N/A	N/A
500-1,000 AU	3,825.90	3,016.60	-809.30	-21.15 %
1,000-1,500 AU	9,919.00	8,339.45	-1,579.55	-15.92 %
1,500-2,000 AU	25,506.00	23,221.19	-2,284.81	-8.96 %
> 2,000 AU	17,570.80	15,959.33	-1,611.47	-9.17 %
Wean-Feeder				
0-500 AU	3,605.70	3,165.57	-440.13	-12.21 %
500-1,000 AU	N/A	N/A	N/A	N/A
1,000-1,500 AU	N/A	N/A	N/A	N/A
1,500-2,000 AU	N/A	N/A	N/A	N/A
> 2,000 AU	N/A	N/A	N/A	N/A
Feeder-Finish				
0-500 AU	5,924.75	5,087.86	-836.89	-14.13 %
500-1,000 AU	17,000.55	15,719.25	-1,281.30	-7.54 %
1,000-1,500 AU	28,095.80	23,147.26	-4,948.54	-17.61 %
1,500-2,000 AU	8,489.75	5,637.12	-2,852.64	-33.60 %
> 2,000 AU	17,213.58	9,969.58	-7,244.00	-42.08 %

Table VI.101. Summary of Market Level Effects of the ReCip Technology—Market Hogs, SF/PSF, Long Run (LR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / cwt)			**(changes from baseline)**	
North Carolina	$39.61	$40.112	$0.502	1.267 %
Other US States	$40.50	$41.002	$0.502	1.240 %
Aggregate US	$40.50	$41.002	$0.502	1.240 %
Imports	$40.50	$41.002	$0.502	1.240 %
Market Quantities (1,000 lbs. of weight marketed)				
North Carolina	224,015.4	92,192.1	-131,823.2	-58.846 %
Other US States	2,061,855.6	2,176,428.0	114,572.3	5.557 %
Aggregate US	2,285,871.0	2,268,620.1	-17,250.9	-0.755 %
Imports	49,033.0	51,542.1	2,509.1	5.117 %

Table VI.102. Summary of Market Level Effects of the ReCip Technology—Feeder Pigs, SF/PSF, Long Run (LR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$42.32	$42.301	-$0.019	-0.045 %
Other US States	$45.11	$45.091	-$0.019	-0.042 %
Aggregate US	$45.11	$45.091	-$0.019	-0.042 %
Imports	$45.11	$45.091	-$0.019	-0.042 %
Market Quantities (1,000 heads marketed)				
North Carolina	17,719.5	17,169.2	-550.3	-3.106 %
Other US States	82,390.5	82,288.2	-102.3	-0.124 %
Aggregate US	100,110.0	99,457.4	-652.6	-0.652 %
Imports	3,416.4	3,415.5	-0.9	-0.026 %

Table VI.103. Summary of Market Level Effects of the ReCip Technology—Weaned Pigs, SF/PSF, Long Run (LR)

	Baseline	With Technology Costs	Absolute	Percentage
Market Prices ($ / head)			**(changes from baseline)**	
North Carolina	$28.26	$28.568	$0.308	1.09 %
Other US States	$30.93	$31.238	$0.308	1.00 %
Aggregate US	$30.93	$31.238	$0.308	1.00 %
Market Quantities (# of head)				
North Carolina	19,421.3	15,877.4	-3,544.0	-18.25 %
Other US States	80,688.7	83,600.7	2,912.0	3.61 %
Aggregate US	100,110.0	99,478.0	-632.0	-0.63 %

Table VI.104. Summary of Market Quantities (1,000 lbs. SSLW) and Changes in Market Quantities for Size / Type Combinations—ReCip Technology, Smithfield/Premium Standard Farms in North Carolina, Long Run (LR)

	Baseline	With Technology Costs	Absolute	Percentage
			(changes from baseline)	
	Market Quantities (1,000 lbs. of SSLW)			
Farrow-Wean				
0-500 AU	281.45	168.25	-113.20	-40.22 %
500-1,000 AU	9,367.96	8,365.34	-1,002.62	-10.70 %
1,000-1,500 AU	32,886.35	29,836.10	-3,050.25	-9.28 %
1,500-2,000 AU	30,061.03	26,785.54	-3,275.49	-10.90 %
> 2,000 AU	18,736.78	16,342.30	-2,394.48	-12.78 %
Farrow-Feeder				
0-500 AU	1,396.35	1,177.98	-218.38	-15.64 %
500-1,000 AU	17,442.39	16,375.97	-1,066.42	-6.11 %
1,000-1,500 AU	12,632.40	11,287.86	-1,344.54	-10.64 %
1,500-2,000 AU	3,746.39	2,965.78	-780.61	-20.84 %
> 2,000 AU	2,871.00	2,083.18	-787.82	-27.44 %
Farrow-Finish				
0-500 AU	N/A	N/A	N/A	N/A
500-1,000 AU	3,825.90	2,792.37	-1,033.53	-27.01 %
1,000-1,500 AU	9,919.00	7,901.80	-2,017.20	-20.34 %
1,500-2,000 AU	25,506.00	22,588.14	-2,917.86	-11.44 %
> 2,000 AU	17,570.80	15,512.84	-2,057.96	-11.71 %
Wean-Feeder				
0-500 AU	3,605.70	3,043.64	-562.06	-15.59 %
500-1,000 AU	N/A	N/A	N/A	N/A
1,000-1,500 AU	N/A	N/A	N/A	N/A
1,500-2,000 AU	N/A	N/A	N/A	N/A
> 2,000 AU	N/A	N/A	N/A	N/A
Feeder-Finish				
0-500 AU	5,924.75	4,855.98	-1,068.77	-18.04 %
500-1,000 AU	17,000.55	15,364.24	-1,636.31	-9.63 %
1,000-1,500 AU	28,095.80	21,776.17	-6,319.63	-22.49 %
1,500-2,000 AU	8,489.75	4,846.74	-3,643.01	-42.91 %
> 2,000 AU	17,213.58	7,962.48	-9,251.10	-53.74 %

Appendix A: Relationship Between Marginal Production Costs and Market Price for the Swine Industry

The purpose of this appendix is to justify use of the equilibrium displacement model for modeling the effects of new waste management technologies on the North Carolina swine industry. The analysis undertaken shows that marginal cost of producing pigs by contract farms and company owned farms are precisely supply functions of market hogs obtained from the two alternative sources of production. Aggregate supply of market hogs is then obtained as the summation of market hogs from all three sources: contract, company-owned, and independent.

The integrator's problem

$$\text{Max} \quad \pi = PQ - C$$

Subject to:

$$Q = f(a, x, y; k)$$
$$C = \sum_{i=1}^{n} w_i'(a_i)a_i + \sum_{i=1}^{n} u'x_i$$

where a_i = vector of grower's abilities (summarizes grower's effort or managerial capacity), x_i = vector of integrator-supplied production inputs (feed, animals, medication, etc.), y_i = vector of grower-supplied production inputs (land, labor, utilities, manure management, housing facilities, etc.), and k = vector of non-specific inputs provided by integrator (capital, management, overhead, etc.).

The grower's problem is

Max $w_i' a_i - c_i$

Subject to:

$$q_i = f_i(a_i, x_i, y_i; k_i)$$
$$c_i = v' y_i$$

where $Q = f(a, x, y; k) = \sum q_i = \sum f_i(a_i, x_i, y_i; k_i)$

The integrator maximizes the Lagrangian

$$\Lambda = PQ - \sum w_i' a_i - \sum u' x_i - \lambda(Q - f(a, x, y; k))$$

The first-order necessary conditions for profit maximization are:

$$\frac{\partial \Lambda}{\partial Q} = P - \lambda = 0,$$
$$\frac{\partial \Lambda}{\partial a_i} = -w_i - \frac{\partial w_i}{\partial a_i} a_i + \lambda \frac{\partial f}{\partial a_i} = 0,$$
$$\frac{\partial \Lambda}{\partial x_i} = -u + \lambda \frac{\partial f}{\partial x_i} = 0.$$

The grower's problem

Alternatively, the grower minimizes the Lagrangian function

$$L = v'y_i + \mu_i(q_i - f_i(a_i, x_i, y_i; k_i)$$

It's first-order necessary condition for cost minimization is:

$$\frac{\partial L}{\partial y_i} = v - \mu_i \frac{\partial f}{\partial y_i} = 0.$$

Relationship between integrator and grower

Now, if the integrator controlled all inputs, he would choose y_i such that

$$-v + \lambda \frac{\partial f}{\partial y_i} = 0.$$

Therefore, if $\frac{\partial f}{\partial y_i} = \frac{\partial f_i}{\partial y_i}$ and $\lambda = \mu_i$ for all i the two solutions will be the same.

But if $\frac{\partial f_i}{\partial y_i}$ and v are the same (which they are), then we are ensured that $\lambda = \mu_i$.

Marginal Cost Curve for Contract and/or Company-Owned Farm

Suppose that $q_i = \min\{\frac{a_i}{\alpha_i}, \frac{x_i}{\beta_i}, \frac{y_i}{\gamma_i}\}$, where we assume scalars instead of vectors for sake of convenience. The profit equation then becomes

$$\pi = P\sum_i q_i - \sum_i w_i \alpha_i q_i - \sum_i u\beta_i q_i - \sum_i v\gamma_i q_i$$

By the Kuhn-Tucker theorem, if q^* maximizes profit then

$$\frac{\partial \pi}{\partial q} = P - (w_i^* \alpha_i + \frac{dw_i^*}{da_i} q_i^*) - u\beta_i - v\gamma_i \leq 0,$$
$$\frac{\partial \pi}{\partial q_i} \bullet q_i^* = 0$$
,

When $q_i^* > 0$

$$P = (w_i^* \alpha_i + \frac{dw_i^*}{da_i} q_i^*) + u\beta_i + v\gamma_i$$

and summing over all producers where market marginal cost is equated with each individual market cost

$$P = \frac{1}{n} \sum_i [(w_i^* \alpha_i + \frac{dw_i^*}{da_i} q_i^*) + u\beta_i + v\gamma_i]$$

or

$$P = \frac{1}{n} \sum_i (w_i^* \alpha_i + \frac{dw_i^*}{da_i} q_i^*) + u \frac{1}{n} \sum_i \beta_i + v \frac{1}{n} \sum_i \gamma_i$$

Therefore, in the very short run the output price can be viewed as the vertical summation of the average marginal labor cost of obtaining grower services (abilities) plus the average supply prices of other factors. We would still expect to see a similar relationship between costs of production by stage of process even in the long run. However, the relationship is most transparent in the very short run when input proportions are rigidly fixed.

Appendix B: Data Sources

State level market hog supply data

Data on beginning inventories of farrowing sows (December of previous year-to-February of current year) in 1000 head;
Data on pigs per litter, December (of previous year)-to-February (of current year);
http://usda.mannlib.cornell.edu/reports/nassr/livestock/php-bb/.

Data on feed price, $/pound, ((0.18*MEALP) + (0.80*CORNP))/0.98, by state, where MEALP is soybean meal price and CORNP is corn price;
Data on hog price are prices for barrows, gilts, and sows combined per cwt by state;
http://usda.mannlib.cornell.edu/reports/nassr/livestock/zma-bb/.

Data on proportion of pigs from each size category computed from **A**: number of hog operations with 1-99 heads, **B**: number of hog operations with 100-499 heads, **C**: number of hog operations with 500-999 heads, **D**: number of hog operations with 1,000-1,999 heads, but before 1993 this category include the all the operation with 1,000+ heads, **E**: number of hog operations with 2,000-4,999 heads, **F**: number of hog operations with 5,000+ heads;
http://usda.mannlib.cornell.edu/reports/nassr/livestock/php-bb/.

Aggregate market level data

Data on hog price, barrows and gilts, Iowa-southern Minnesota;
http://www.agecon.ksu.edu/livestock/Web%20Site%20Pages%20Collection/Livestock%20Database%20SubPages/HogPork.shtml.

Data on hog production, commercial slaughter, liveweight pounds; livestock slaughter, annual summary; http://usda.mannlib.cornell.edu/usda/usda.html.

Data on Disposable Personal Income, billion dollars;
http://www.census.gov/prod/www/statistical-abstract-02.html.

Data on CPI: U.S. Department of Labor's "All Urban Consumer Price Index", 1967=100;
http://data.bls.gov/cgi-bin/surveymost?cu.

Data on population, July 1 total population; http://www.usda.gov/nass/pubs/agstats.htm.

Data on consumer price indexes for beef and veal, poultry, 1982-84=100;
http://usda.mannlib.cornell.edu/usda/usda.html.

Data on food marketing cost index, 1982=100;
Economic Research Service, U.S. Department of Agriculture, Howard Elitzak, helitzak@ers.usda.gov.

Data on number of sows farrowing, December-May, 1000 head; http://usda.mannlib.cornell.edu/data-sets/livestock/94006/.

Data on number of pigs per litter, December-to-November; "hogs and pigs"; http://usda.mannlib.cornell.edu/usda/usda.html.

Data on feed costs, feed cost, $/pound, ((0.18*Soybean meal price) + (0.80*Corn price))/0.98; Soybean Meal Price: 48% protein, Decatur, dollars/pound, 1 short ton=2000 pounds;http://jan.mannlib.cornell.edu/reports/erssor/field/ocs-bby/ocs2002.pdf); Corn Price: corn for grain, weighted average of monthly prices, dollars/bushel; http://www.nass.usda.gov:81/ipedb/.

Feeder pig, weaned pig, and market hog weekly price data

Data used are the time period are from January 9, 1998 through December 27, 2002.

Data on weaned pig prices, weaned FOB price (SC), total composite price for early weaned pigs; http://www.ams.usda.gov/mnreports/co_ls255.txt; delivered weaned price (IA), weighted average price of weaned pig delivered to buyer's farm; http://www.ams.usda.gov/mnreports/NW_LS852.txt.

Data on feeder pig prices, feeder FOB price (SC), weighted average of the total composite prices of 40, 45 and 50 pound feeder pigs;http://www.ams.usda.gov/mnreports/co_ls255.txt; delivered feeder price (IA), weighted average price of 40-50lb feeder pig delivered to buyer's farm; http://www.ams.usda.gov/mnreports/NW_LS852.txt.

Data on market hog prices, barrows and gilts, 230-240LBS, carcass prices, Iowa-southern Minnesota; http://www.agecon.ksu.edu/livestock/Web%20Site%20Pages%20Collection/Livestock%20Database%20SubPages/HogPork.shtml.

Data on feed cost, feed cost, $/pound, ((0.18*Soybean meal price) + (0.80*Corn price))/0.98; Missouri cracked corn price and Missouri soybean meal price (48% protein) (personal communication with extension economists at the University of Missouri).

Appendix C: Cost Function Estimates

Notation: COST = Incremental cost for adopting new technology in $ per thousand pounds SSLW, SSLW = steady-state liveweight in 1000 pounds, D2 = dummy variable (=1 if type farm is farrow-to-feeder), D3 = dummy variable (=1 if type farm is farrow-to-finish), D4 = dummy variable (=1 if type farm is wean-to-feeder), and D5 = dummy variable (D5 =1 if type farm is feeder-to-finish). The intercept is for farrow-to-wean type farm. Values in parentheses below the parameter estimates are heteroskedasticity-robust standard errors.

Technology 1: Barham farms

$$COST = 119.44 - 0.0526 \bullet SSLW + 1.12E-05 \bullet SSLW^2$$
$$\quad (3.2603)\ (0.0048) \qquad (1.38E-06)$$
$$+ 4.8325 \bullet D2 - 1.3647 \bullet D3 + 80.691 \bullet D4 + 8.1805 \bullet D5$$
$$\quad (1.8639) \qquad (2.0058) \qquad (12.340) \qquad (2.4417)$$
$$N = 41, \qquad R^2 = 0.9607$$

Technology 2: Super Soils

$$COST = 717.36 - 0.4292 \bullet SSLW + 1.03E-04 \bullet SSLW^2$$
$$\quad (48.846)\ (0.0772) \qquad (2.15E-06)$$
$$+ 23.628 \bullet D2 - 30.952 \bullet D3 + 867.53 \bullet D4 + 39.2438 \bullet D5$$
$$\quad (20.004) \qquad (24.192) \qquad (145.01) \qquad (34.447)$$
$$N = 41, \qquad R^2 = 0.9295$$

Technology 3: EKOKAN

$$COST = 419.18 - 0.3194 \bullet SSLW + 7.66E-05 \bullet SSLW^2$$
$$\quad (37.836)\ (0.0548) \qquad (1.52E-06)$$

$$+ 46.680 \bullet D2 + 82.343 \bullet D3 + 721.54 \bullet D4 + 112.94 \bullet D5$$

(16.064) (18.428) (122.75) (28.365)

$N = 41, \qquad R^2 = 0.9214$

Technology 4: ReCip

$$COST = 246.09 - 0.0714 \bullet SSLW + 1.67\text{E} - 05 \bullet SSLW^2$$

(6.6076) (0.0089) (2.47E-06)

$$+ 2.4214 \bullet D2 - 40.085 \bullet D3 + 30.458 \bullet D4 - 61.132 \bullet D5$$

(3.8536) (3.8330) (11.478) (4.2592)

$N = 41, \qquad R^2 = 0.9484$

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