Do Antibiotics Reduce Production Risk for U.S. Pork Producers? [1]

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ABSTRACT

Production risk from live weight variation of market pigs has become a more important concern in U.S. swine production. Packers are concerned about the variation in carcass size because of the demand for standardized cuts and the use of automation in the slaughter process. Swine producers care about standardized pigs because of revenue implications and possible links to animal health and productivity. Pig size variation can be due to various condition and inputs including antibiotics. However, discussions on risk reduction from antibiotic use have generally not been considered. Our work extends previous studies by systematically examining the aspects of production risk reduction and highlights the potential results of banning antibiotics from a risk perspective.

Using data from National Animal Health Monitoring System 2000 survey data and PigCHAMP, we identify the relationship between antibiotic use and production risk by an econometric model. Applying production costs for feeder to market pigs and a price matrix, the uncertainty in profits is evaluated. The impacts of risk on the decision making of swine producers are examined under the framework of expected utility and stochastic dominance analysis.

Our results show that production risk from weight variability of market hogs is important in determining profits and utility under a pricing system. Production risk (i.e. weight gain variability) is related to the use of sub-therapeutic antibiotics. Swine producers could decrease production risk and enhance utility by adjusting antibiotic use. These results offer some support for optimal use of sub-therapeutic antibiotics.

Keywords: production risk, antibiotics, swine, utility, stochastic dominance.

JEL Codes: Q10, Q12, Q14.

Do Antibiotics Reduce Production Risk for U.S. Pork Producers?

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Introduction

Production risk from weight variation of market pigs has become a more important concern in U.S. swine production. Packers concern about carcass size variation is partly because of the use of automation in the slaughter process and partly because of the desire to provide customers with more consistent cuts. Swine producers also care about weight variation because non-uniformity of weight is costly due to price penalties for pigs marketed at weights outside defined weight intervals. Standardized market pigs reflect the needs and desires of swine producers, packers and consumers.

Production risk mitigation has been investigated in the context of some marketing mechanisms, including insurance, futures markets and production contracts (Kliebenstein and Lawrence). Though used extensively, these risk reduction methods are not effective in dealing with production risk from variation in pig weight. In fact, contracts with packers that require shipment of pigs on specific dates may increase producer risks. Input management can control production risk. One example might be to use antibiotics at sub-therapeutic levels in pig production to decrease variation in pig weights, and hence decrease variation in revenue received.

The impacts from sub-therapeutic use of antibiotics on average daily gain and feed conversion ratio have been examined in many studies (Miller et al.; Hays; Hayes et al.; Zimmerman; Cromwell; Losinger et al.). However, earlier studies did not examine in detail the risk reduction impacts from antibiotic use. Thus, this study extends earlier work on the impacts from antibiotics in swine feeds by integrating risk reduction, and highlights some perspectives of the potential results of banning antibiotics.

We establish relationships between antibiotic use and production risk by an econometric model. Using the results from the model, we evaluate the impacts of risk on the decision making of swine producers under the framework of expected utility and stochastic dominance analysis. The study is aimed to clarify that production risk from weight variation of market hogs is an important factor in profit and utility, to demonstrate the effects of risk on the decision process of the U.S. swine producers. In the end, the study will illustrate that antibiotic use is an effective way to reduce production risk and improve economic returns.

Theoretic Framework

Production risk represents an important dimension of livestock production. It can significantly influence the decision making of risk averse producers. Decisions under conditions of uncertainty have usually been modeled in the framework of expected utility and stochastic dominance analysis.

Dillon (1977) examined the problem of uncertainty in livestock production. Based on his discussion, inputs in swine production could be categorized into controllable inputs, predetermined inputs and uncontrollable inputs. The controllable inputs can be determined by swine producers at the time of decision-making. In swine production, controllable inputs include rations, antibiotic use, and bio-security measures. The predetermined inputs are those that are known, but usually determined in advance of a production stage or outside of the swine production system. Predetermined inputs include inputs such as major facilities, the genetics of pigs, geographic location of the farm, and some environmental factors. Uncontrollable inputs might include weather, possibly prevalence of a specific disease pathogens, and micro-ecology. Uncontrollable inputs can often be known to swine producers at the time of decision-making, but their occurrence may not be controlled.

Pork producers face significant production risks. Production relates in part to uncontrollable inputs, and these risks may never be eliminated. Nevertheless, it is possible to reduce production risk by managing controllable inputs that have some relationships with uncertain inputs. We express our production model as follows.

(1.1) $$y = F(x_1 x_2 \ldots x_k; x_{k+1} x_{k+2} \ldots x_l; x_{l+1} x_{l+2} \ldots x_m)$$

Here y represents the random production yields, $x_1 x_2 \ldots x_k$ a set of controllable inputs, $x_{k+1} x_{k+2} \ldots x_l$ a set of predetermined variables, and $x_{l+1} x_{l+2} \ldots x_m$ represents a set of uncertain variables. The uncertainty in y comes from $x_{l+1} x_{l+2} \ldots x_m$. If relationships exist between set $x_1 x_2 \ldots x_k$ and set $x_{l+1} x_{l+2} \ldots x_m$, then $x_1 x_2 \ldots x_k$ could be used to adjust production risk.

Uncertainty in output can influence producer profits, and make profits a random variable given as

(1.2) $$h(\pi) = h((p_y y - \sum_{i=1}^{k} c_i x_i - F) / x_1 x_2 \ldots x_k)$$

where p_y is the price for market hogs, c_i is the price for a controllable input x_i, F is the fixed costs, and $x_1 x_2 \ldots x_k$ is the set of controllable inputs. Thus, h(π) represents the profit distribution conditional on variability of production yields that are related to the controllable input set.

Decision under Utility Maximization

Under conditions of uncertainty in profits, swine producers make their decisions based on maximization of their expected utility. If an input combination X (a given input vector) leads to a profit set {π}, then the utility for selection of X is equal to

(1.3) $$U(\pi) = E(u(\pi)) = \int_{-\infty}^{\infty} u(\pi) h(\pi / X) d\pi$$

The value of equation (1.3) depends on the functional form of utility and the outcome distribution. Equation (1.3) could be approximated by using Taylor expansion of the distribution. When the first two moments are used, the decision process under conditions of uncertainty can be modeled as

(1.4) $$\begin{aligned} &\underset{x_1 \ldots x_k}{Max} \; U(\pi) = f(E(\pi), V(\pi)) \\ &st. \quad \pi = p_y y - \sum_{i=1}^{k} p_i x_i - F \\ &\qquad y = f(x_1 x_2 \ldots x_k ; x_{k+1} x_{k+2} \ldots x_l ; x_{l+1} x_{l+2} \ldots x_m) \end{aligned}$$

The effects of controllable inputs on producer utility of producers would be estimated with:

(1.5) $$dU/dx_i = \frac{\partial U}{\partial E(\pi)} \Big/ \frac{dE(\pi)}{dx_i} + \frac{\partial U}{\partial V(\pi)} \Big/ \frac{dV(\pi)}{dx_i}$$

Equation (1.5) characterizes the marginal utility of a utility maximizing producer under uncertainty. For risk neutral producers, uncertainty in profits will not affect the value of utility, i.e. $\frac{\partial U}{\partial V} = 0$. For risk averse producers, the utility differs with varying risk, i.e. $\frac{\partial U}{\partial V} < 0$. In most economic analyses, producers are assumed to be risk averse. Thus, variability in production influences producer welfare, and producers have incentives to reduce the risk by using controllable variables.

Decision Based on Stochastic Dominance

Expected utility analysis, although theoretically robust, is difficult to apply because of the need to identify the utility function. In comparison, stochastic dominance analysis (SD) places few restrictions on the utility functions. Using SD, decisions are guided by the entire cumulative distribution function (CDF) of outcome. SD application is a robust alternative to the use of expected utility theory (Hardaker et al.; Dillon)

SD analysis methods often include first, second, and third order stochastic dominance- FSD, SSD, and TSD, respectively. For a probability density function *f(x)*, we define $D_f^1(x) = F(x) = \int_a^R f(x)dx$ $\quad D_f^2(x) = \int_a^R D_f^1(x)dx$ and $D_f^s(x) = \int_a^R D_f^{s-1}(x)dx$. By FSD, we mean that a probability density function *f (x)* is dominant to another probability density function *g (x)* if $D_f^1(x) \le D_g^1(x)$ for all values of R∈ [a, b] and for at least one value of R $D_f^1(x) < D_g^1(x)$. FSD illustrates the behavior of decision makers who prefer more profits to less, but fail to find the dominance relation when the CDF's of available alternatives cross. SSD may rank these decision alternatives. SSD would conclude that a probability distribution *f(x)* is dominant to the probability distribution *g(x)* if $D_f^2(x) \le D_g^2(x)$ for all values of R∈ [a, b] and $D_f^2(x) < D_g^2(x)$ for at least one value of R. An identified dominance under SSD implies that decision makers prefer more profits to less, but also prefer less risk to more for all values of R∈ [a, b]. SSD may not identify dominance between distributions in some cases. TSD functions well in dealing with more general case. A distribution *f(x)* is third order dominant to another distribution *g(x)* if SSD hold between the two and $D_f^3(x) \le D_g^3(x)$ for all values of R, $D_f^3(x) < D_g^3(x)$ for at least one value of R.

In general, stochastic dominance analysis has an advantage compared with utility maximization because of fewer constraints on utility functions. This advantage is offset by limitations in analytical formulation. However, such limitations are now less given improvements in computing techniques.

In our study, the tests of stochastic dominance are done numerically following Ravallion (1994), Davidson and Duclos (1998), and Sahn and Stifel (2002). A t-test with the null hypothesis $H_{0:}$ $D_f^s(x) - D_g^s(x) = 0$ are used to demonstrate the existence of the Sth order dominance between two distributions.

Data

Data in this study are from the three swine surveys conducted in 2000 by the National Animal Health Monitoring System (NAHMS 2000). NAHMS first survey in 2000 was of 2333 swine producers in 17 of the major pork producing states. These 17 states accounted for 94 percent of the U.S. pig inventory and 92 percent of U.S. pork producers with 100 or more pigs. Surveys of subsets of the original 2333 producers provided additional data on productivity measurements, managerial factors, rations, bio-security and the use of antibiotics.

Detailed information on the use of antibiotics was gathered in the NAHMS 2000 survey. The sub-therapeutic use of antibiotics in the grower/finisher stage was well documented.

Data about two dimensions of production risk, namely number of pig deaths and lightweight pigs, are also gathered. Both of these measures contribute to production uncertainty. However, here we focus our attention on only lightweight pigs since we previously have found no impacts from sub-therapeutic use of antibiotics on mortality (Miller et al. 2003)

Our estimates of live weight of market pigs and its variability are based on NAHMS 2000 and PigCHAMP data. Entry age, market age, ADG (average daily gain), days spent in the finished period, and light weight rate of pigs in the grower/finisher stage is available in NAHMS 2000, but entry weight and market weight are not reported. Benchmarking data from PigCHAMP 1999 provided the average market weight and variation in market weight of market hogs. These variables are used to estimate the market weight and its variability.

Data on the use of antibiotics and other input factors in swine production were also collected by NAHMS 2000. These data substantially improve the information available in production risk analysis.

In order that the variability in profits could be accessed, price and cost assumptions are necessary. Packers published the relationship between prices they pay and live market weight of hogs. These packer price matrixes have been used by Boland (1996), USDA (1995) and Miller et al. (2001), to mention a few. Here we use the same price matrix as Miller et al. (2001). Under our pricing matrix, market pigs are divided into lightweight, standard weight and overweight groups. Penalty prices are imposed on lightweight and overweight pigs based on the weight difference from the standard range. The price matrix is shown in table 1 (table 4 in Miller et al., 2001).

Production costs are assumed to be those given for the grower/finisher stage from USDA (2000) and costs of antibiotics from Cromwell (2001). The production costs per hundred pounds of live market weights included feed costs, other operating costs and allocated overhead; costs from 1995-99 were averaged and used in the estimation of economic returns. Antibiotic costs were based on cost of chlortetracycline at \$0.03 per gram at 50 grams per ton of feed. Feed intake was using the feed conversation rate (FCR) from NAHMS 2000 data; the antibiotic costs are estimated to be \$0.0042 per day per pig.

Results and Discussions

Production risk impacts

Our empirical analysis begins with two econometric models:

(3.1) $$ADG = f_1(x_1, x_2, x_3 ....x_k)$$

(3.2) $$SD(y) = f_2(x_1, x_2, x_3 ....x_k)$$

Where *ADG* is the average daily gain and *SD(y)* represents standard deviation of live weight. $x_1, x_2, x_3 ....x_k$ is a set of controllable input. Using OLS, the relationships between *ADG and SD(y*) with antibiotic use and other production inputs are established (see table 2 and table 3).

The use of antibiotics contributes to expected live market weight (derived from estimates of ADG) and the variability of market weight. For *E(y)*, expected market weight, the impact from antibiotic use is in a quadratic function. For *SD(y)*, the effect from antibiotic use is fitted well with a cubic function.

Using the parameters, we estimate live market weight and standard deviation in live market weight for different times antibiotics are fed, ranging from 0 to 110 days. The impacts on expected live market weight from sub-therapeutic use of antibiotics are positive in the range of consideration (Figure 1). Marginal weight gains are positive with antibiotic use less than 85 days. Marginal weight gains approach zero with antibiotics fed at about 85 days, and marginal weight gain becomes negative after that. The impacts from antibiotic use demonstrate a steady marginal reduction in the variance of live market weight for antibiotic use from 1 to 50 days. Beyond that, the marginal effect becomes positive, but the average risk reduction effects from antibiotic use continue until 120 days. In other words, average risk reduction continues essentially through the entire period.

Decision Use under Utility Maximization

Based on the profit function (equation (1.2)), profits per pig with varying antibiotic use are estimated. We present estimates of the means, SD and skewness of profits. We assume no risk on the market side, i.e. fixed and known market prices. But hog prices do vary with live market weight according to the assumed pricing matrix (table1). While other hog attributes affect the market price received, we concentrated our analyses on the live market weight as the attribute of overwhelming importance.

Profits, even in the case of no market risk, become a random variable with a non-normal distribution based on the negative skewness under all cases, although a normal distribution of live market weight is assumed. All three moments of the profit distribution vary with the number of days antibiotics are fed. A risk neutral swine producer would make his decision based on the average profits (Dillon); our analysis suggests the level of antibiotic use be 60 days in the grow-finish stage. However, the decision making of a risk averse swine producers will also consider the variance of profits.

We assume a risk averse swine producer has a quadratic utility given by:

(3.3) $$u(\pi) = \pi + b\,\pi^2$$

where b represents the producers risk aversion coefficient. Thus, the expected utility of a swine producer is given by:

(3.4) $$E(u(\pi)) = E(\pi) + b\,E(\pi^2) = E(\pi) + b\,(E(\pi))^2 + b\,V(\pi)$$

Given E (π) and V (π) (table 4), the utility of a swine producer is estimated (Table 5) based on days antibiotics are fed and various risk aversion coefficients.

The results on expected profit and expected utility (table 4 and table 5) illustrate some relationships between production risk and the use of antibiotics in U.S. swine production. First, the utility value of swine producers is sensitive to changes in number of days antibiotics are fed. Lower and higher antibiotic feeding days correspond to higher production risk (figure 1) and lower utility. The middle level of antibiotic use days is associated with higher profits, decreased risk and higher utility. Second, risk aversion coefficients affect the utility values, but varying the coefficients does not change the result in most cases. Among the seven risk aversion parameters, five support the selection of efficient fed time in the range of 60 days. When the risk aversion coefficient is larger than 0.01, the decision process was not modeled well with a quadratic utility assumption. Third, the variance of live market weight affects the selection of antibiotics as an input.

The results of this study provide evidence that swine producers have incentive to use antibiotics sub-therapeutically in order to decrease live market weight variability. If the decision is based only on an increase in live market weight, the optimal time of antibiotic use is about 85 days. However, when the variance of live-weight was taken into consideration, the efficient fed time of antibiotics reduced to about 60 days if all pigs from a barn are marketed simultaneously.

Decision under Stochastic Dominance

We use stochastic dominance analysis to further test results from the expected utility analyses. The quadratic utility functional form is useful to model the behavior of producers with a risk aversion coefficient less than 0.01, but is ill behaved with a risk aversion coefficient larger than 0.01 where the marginal utility from an extra unit of profits become negative. Considering other alternatives of utility specification and the non-normal distribution of profits, stochastic dominance analysis was used to further test the results.

We obtain a profit distribution under each feeding scenario. Based on the econometric estimates, a normal live market weight distribution with simultaneous marketing of all pigs in a farm with known $E(q)$ and $V(q)$ was established for each case of antibiotic application. Using @RISK software, we model live market weight samples of five thousand from each live market weight distribution. With each of these samples, a profit distribution is derived. We obtained twelve profit distributions. Three major profit distributions are shown graphically (figure 2).

Within the domain of profits, FSD does not occur between any pair of distributions under varying levels of antibiotic use. No stochastic dominant relationship occurred among adjacent pairs of distributions. Two profit distributions with 60 and 70 days of antibiotic fed time overlapped with each other. They are second order dominant to most other distributions, including the distributions from lower and higher antibiotic use. The profit distribution with 60 days of antibiotic use appears to represents the most preferred selection.

SSD suggests that the risk averse swine producer would likely to reduce risk and improve their utility by using antibiotics. Under the assumption of simultaneous marketing, the preferred number of days antibiotics would be fed are for about one half of the feeding period (60-70 days of 114 days total).

The distribution with 70 days of antibiotic use is approximately first order dominant to the profit distribution with no antibiotic use. With twenty tests conducted in the profit range, only one has a t-value of 1.93, all others are larger than 2. This suggests that U.S. swine producers, no matter what their risk preference, will benefit from antibiotic use and have willingness to use antibiotics at sub-therapeutic levels.

The results of SD are similar to our earlier conclusions using expected utility analysis. These further confirm the preference of U.S. swine producers to using antibiotics in the grow/finish stage to reduce production risk and maximize utility.

Caveats of our analysis

This study represents an initial effort to analyze quantitatively the production risk from variation in live market weight of hogs. The conclusions enhance the insight into the understanding of production risk associated with variation of live market weight. However, the lack of information and assumptions used in the study make caveats necessary to help prevent over interpretation of the results.

First, the study assumes that pigs are marketed simultaneously. However, the reality is that swine producers usually market pigs from a barn over a period of time. Pigs are shipped as a truckload reaches optimal market weight. Therefore, our estimates of weight variation of market hogs obtained are theoretically biased. The degree of bias depends on the perspective and is difficult to ascertain. We believe our estimated standard deviation is higher than will be seen by producers who market over a period of time. But also, our estimated standard deviation is lower than would be realized by a producer who did actually market all pigs from a barn at one point in time.

Second, swine producers sometimes reduce the proportion of lightweight market pigs by extending the days to slaughter in the grower/finisher stage. There are tradeoffs between production risk and the costs for extending time to slaughter. A model expansion that could bridge the tradeoff between risk and costs may offer more empirical guidance to swine producers and policy regulators.

Third, average daily gain, entry age and marketing age in NAHMS 2000 are the data sources available for calculating live market weight at the farm. Data quality is a concern considering the large number of missing values and high proportion of data without documented sources. However, there seems to be minimal biases at least related to farm size from missing data (Miller et al., 2003).

These data deficiencies and assumptions may make interpretation of results more difficult. The magnitude of such bias and efficiency is not assessed.

Conclusions

Production risks from variability in live market weight of hogs measures an important dimension of swine production. Live market weight variability significantly affects the profits of swine producers. The variability in live market weight, associated with uncertain inputs, could be partially controlled by adjusting sub-therapeutic antibiotic use. Antibiotic use at all levels could be used to reduce production risk. The most effective and profitable application is about 60-70 days. This is slightly less than the mean of 72 days of antibiotics currently used by producers (NAHMS 2000 data).

Sub-therapeutic use of antibiotics is preferred by swine producers on each of the criteria, including live market weight, profits, utility, and stochastic dominance. If only expected live market weight is considered, swine producers prefer a relatively large number of days sub-therapeutic antibiotics are fed; the number becomes substantial less when the variation in live market weight is considered. However, in all cases, swine producers would prefer to use sub-therapeutic antibiotics in swine production.

The incentive we examined is due to the impacts of antibiotic use on reducing the production risk and enhancing average profits. Other incentives not examined directly include the influence that antibiotic use might have on decreasing swine diseases, enhancing overall swine health and any direct influence this might have on price premiums received by producers.

Our analyses suggest that a ban on the sub-therapeutic use of antibiotics would not be preferred by swine producers. However, public concerns about antibiotic use in swine production are important to consider. Further investigation of the contribution of routine application of antibiotics in swine production on the development of resistance is important.

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Table 1. Price matrix of market weight hogs

Weight class	Price penalty ($/cwt)	Weight class	Price penalty ($/cwt)
<190	7	261 – 271	0
191 – 201	7	271 – 281	0
201 – 211	5	281 – 291	0.5
211 – 221	3	291 – 301	1.5
221 – 230	1	301 – 311	2.5
230 – 241	0	311 – 321	4.5
241 – 251	0	320 <	6.5
251 – 261	0		

Source: Miller et al. (2001)

Table 2. Variables associate with average daily gain

Variable	Description	Estimate	T Value	Pr > |t|
Intercept		1.625	32.39	<.0001
Abxday	Time length of antibiotic use	0.0015	2.76	0.01
AbxdaySQ2	Quadratic term of antibiotic use	-8.E-06	-2.34	0.02
Dcontract	Producer contract dummy	-0.016	-0.63	0.52
Daiao	All-in-all-out system dummy	0.016	0.77	0.44
Off_site2	Off site source dummy	-0.063	-1.28	0.20
RestrictNum	Number of bio security measurements	0.014	2.64	0.01
DeathreasonNum	Number of reasons given for big death	-0.014	-2.27	0.02
Dration3_4	Using 3-4 different rations	0.020	0.59	0.55
Dration5_up	Using 5 or more different rations	0.041	1.23	0.22
VaccNum	Num. of vaccinations	-0.005	-1.27	0.20
SupplNum	Num. of supplements	-0.006	-0.75	0.45

Table 3. Variables associated with Standard deviation of live market weight

Variable	Description	Estimate	T value	Pr > |t|
Intercept		5.648	1.37	0.173
Abxday	Time length of antibiotic use	-0.187	-2.2	0.029
AbxdaySQ2	Quadratic term of antibiotic use	0.003	2.25	0.025
AbxdaySQ3	Cubic term of antibiotic use	-8.E-06	-2.07	0.039
Env-testNum	Num. of air, water tests	0.316	2.82	0.005
VetvisitNum	Num. of veterinary visits	0.424	0.48	0.631
Daiao	All-in-all-out	2.790	1.8	0.073
Dcontract	Contact producer	2.245	1.3	0.196
Northern	Northern region	-1.866	-0.99	0.321
WestCentral	West central Region	-6.878	-3.98	<.0001
IC243	Entry age in G/F stage	0.316	5.64	<.0001

Table 4. Mean, SD and skewness of profit per pig with varying number of days antibiotics were used

Days antibiotics are fed	Profit		
	Mean	Standard deviation	Skewness
0	10.18	4.11	-2.25
10	10.73	3.84	-2.41
20	11.17	3.63	-2.53
30	11.50	3.51	-2.62
40	11.73	3.45	-2.66
50	11.87	3.45	-2.66
60	11.93	3.51	-2.62
70	11.91	3.63	-2.55
80	11.81	3.77	-2.45
90	11.66	3.93	-2.36
100	11.44	4.11	-2.25
110	11.17	4.31	-2.14

Table 5. Utility under varying antibiotics use

	Risk aversion coefficient						
Days antibiotics are fed	-0.10	-0.05	-0.01	-0.005	-0.001	-0.0005	-0.0001
0	-0.18	5.00	9.14	9.66	10.07	10.12	10.16
10	-0.78	4.97	9.58	10.15	10.61	10.67	10.72
20	-1.30	4.93	9.92	10.54	11.04	11.10	11.15
30	-1.72	4.89	10.17	10.84	11.36	11.43	11.48
40	-2.02	4.85	10.35	11.04	11.59	11.66	11.71
50	-2.22	4.82	10.46	11.17	11.73	11.80	11.86
60	-2.31	4.81	10.51	11.22	11.79	11.86	11.92
70	-2.27	4.82	10.49	11.20	11.77	11.84	11.89
80	-2.14	4.84	10.42	11.12	11.67	11.74	11.80
90	-1.94	4.86	10.30	10.98	11.52	11.59	11.65
100	-1.65	4.90	10.13	10.79	11.31	11.37	11.43
110	-1.30	4.93	9.92	10.54	11.04	11.10	11.15

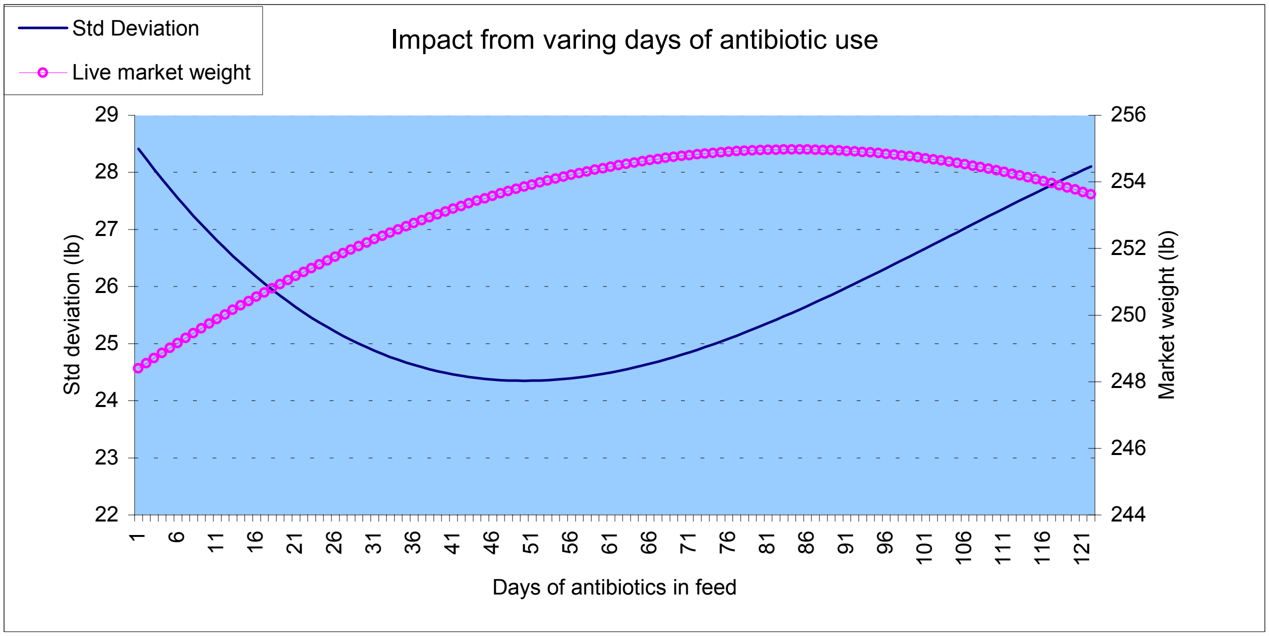

Figure 1. Live market weight added and variability of live market weight with varying antibiotic use

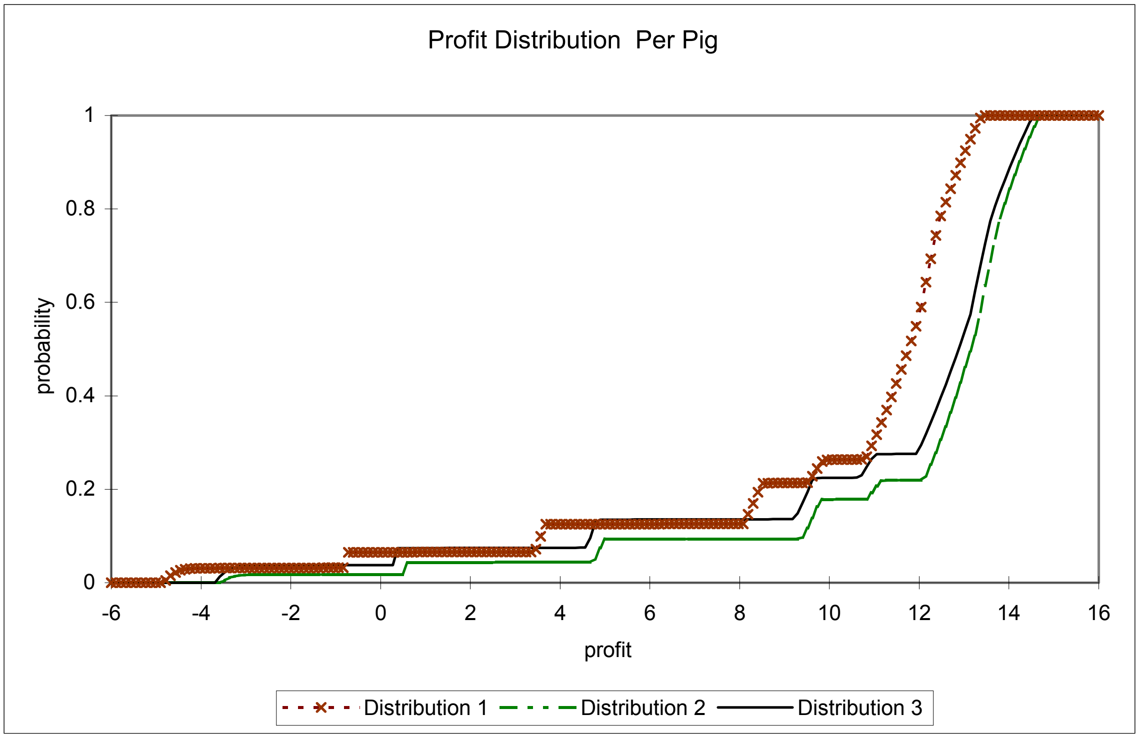

Figure 2. Profit distribution with varying use of antibiotics (Distributions 1, 2 and 3 represent profit distributions with 0, 60 and 110 days of antibiotic use respectively)