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PRODUCTIVITY VARIATION OVER TIME IN MINNESOTA
FARROW-TO-FINISH SWINE OPERATIONS

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Production risk is generally considered low in swine enterprises relative to crop production risk and relative to price risk in both crop and livestock enterprises. Record data from which probability distributions of swine production performance can be developed are rare, making it difficult to evaluate production risk. Researchers may ignore swine production risk, as in a recent study by Lemieux and Richardson on the impact of porcine somatotropin. They included crop production risk and both crop and hog price risk, but ignored any production risk in the swine enterprise. Another approach is a case study of one or a few specific farms who have kept good records for a number of years (e.g. Gois). This approach has the potential disadvantage that a distribution drawn from a single farm's records may not be representative of the larger population of farms. Also, disasters with a low probability of occurrence may not be considered because of the small number of years of data available.

Disease outbreaks and other events do cause variability in pig growth and mortality over time, and can have severe financial consequences if the farm operation does not have adequate risk bearing capacity. Producers may tend to underestimate the chance of disastrously low production. Jerry Skees, in work done with Kentucky producers, has demonstrated this tendency for the case of corn and soybean production. When interviewed in 1987, the producers tended to forget the effects of the 1983 drought. The majority believed that the worst possible yield for their operation was above the worst yield in their farm records (1983 for most producers). Only 11 percent of the producers believed soybean yields could be worse than the lowest yield in the record data, and three percent for corn yields. It has not been demonstrated whether producers' beliefs are similar with regard to swine production risk, but it seems likely that they would be similar.

One reason for considering swine production risk at this time is that the swine industry is undergoing structural change. An advantage that large, specialized swine operations on the fringes of the Corn Belt are purported to have is a high level of productivity resulting from modern facilities and intensive management. Production contracting is not new in swine and other agricultural commodities, but appears to be on the upswing (Rhodes). Typical swine production contracts shift price risk to the contractor but leave the contractee-producer with varying degrees of production risk under performance bonuses and/or penalties. It is claimed that contract growers are able to profit even at relatively low per-head payment rates by maintaining productivity at high levels.

Cooperatives are another organizational structure which is receiving increased interest as a way to capture economies of size and utilize new technologies (Ginder). The ability of swine production

cooperatives to survive and prosper will depend on their ability to evaluate and manage production risk, among other things.

Finally, the structural change in the industry is making independent producers more aware of the need to adopt production practices which reduce the risk of disease outbreaks and other disasters, as well as tightening up on other sources of increased cost such as feeders out of adjustment. Consistently high productivity will be especially important for producers wishing to finance major investments in new, expanded or renovated facilities. Comparing production averages and variability across a number of farms, and correlating with information on production practices and facilities, may suggest areas where management changes should be made.

This paper provides measures of the variability in two measures of physical productivity - pigs weaned per sow per year and feed per pound of pork produced. These variability measures should be useful for financial modelling of contract arrangements, marketing alternatives and new facility investments.

Record summaries from Iowa Swine Enterprise Record System farms seem to show that only the top 20 percent are competitive (Kliebenstein et al.) For a producer in the top 20 percent now, the question might arise of what your chances are of staying in the top 20 percent next year and beyond. How much of an operation's high level of productivity in a given year is really due to superior management, and how much is the result of chance? How likely is a disease outbreak, resignation of a key employee, or other management problem that cuts productivity?

Production risk is described in this paper in terms of means and standard deviations (S.D.) for two productivity measures, pigs weaned per sow per year[1] and pounds of feed per pound of pork produced. The mean and S.D. for an individual swine operation may be useful in future research such as simulation studies of the probability of financial problems for a representative operation. They may also be useful for working with individual swine producers seeking to evaluate their own risk exposure. The S.D.'s calculated below from a group of farms may be more reliable for this purpose than those from an individual operation.

This paper looks at how the productivity measures of pigs weaned per sow per year and pounds of feed per pound of pork produced varied from year to year over a six year period on farrow-to-finish swine operations in the Southeastern and Southwestern Minnesota Farm Business

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[1] In the FBMA records, replacement breeding animals are included as "sows" in the calculation of per sow data only after they have farrowed (Hawkins et at., page FINAN-19 and page FINANX-75). Litters per sow was multiplied times pigs weaned per litter to arrive at pigs per sow per year. The recommended FBMA procedure for calculating average breeding herd size is to total the monthly numbers over the year and divide by 12.

Associations (FBMA).[2] The six years 1984 through 1989 were included. Twenty-two of the farms had farrow-to-finish swine all six years. Another 35 were Association members all six years, even though they did not all have farrow-to-finish swine all six years. These 57 are referred to below as "six year farms". Another forty-four farms were members at least one but less than all six years, for a total of 101 operations. The enterprises ranged from 24 to 582 sows, with an average of 94. The number of farms by years with the enterprise was:

Years with Farrow-finish Swine	Number of Farms	
	All Farms	Six-Year Farms
6	22	22
5	9	4
4	11	5
3	16	10
2	16	8
1	27	8
All	101	57

The caveat should be mentioned that the physical productivity measures focused on in this paper are not perfectly correlated with profitability. Profitability depends on many factors including the manager's skill in combining resources such as facility investments and labor, in addition to physical productivity. It is possible to achieve relatively high levels of profitability even with low physical productivity, if the reduced hog sales and/or higher feed costs are offset by lower capital costs for facilities, for example. In fact, a minority of the FBMA operations use low-investment individual sow hut systems and are achieving higher-than-average profitability with lower-than-average sow productivity (Lazarus, p. 12). Nevertheless, the industry appears to be moving toward greater standardization in capital-intensive confinement systems where the mix of capital, labor and management is relatively constant. In these units, physical productivity measures such as pigs per sow and feed per pound of pork, determined largely by operator skill and random events such as disease outbreaks, are important determinants of profitability.

The mean and S.D. for each productivity measure was calculated for each of the six-year farms with at least two years of records (a S.D. can not be calculated from only one year's record). The individual farm means and S.D.'s were then averaged across the 49 farms. The averages are:

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[2] See, for example, Economic Report ER89-1, "Southeastern Minnesota Farm Business Association 1988 Annual Report" and Economic Report ER89-2, "Southwestern Minnesota Farm Business Association 1988 Annual Report", Department of Agricultural and Applied Economics, Institute of Agriculture, St. Paul, Minnesota 55108, May, 1989.

	Mean	Standard Deviation
Feed pounds per pound of pork	4.13	0.38
Pigs per sow per year	13.1	2.0

For an operation with average feed efficiency of 4.13 pounds per pound of pork, assuming normality, there is a 15 percent chance in any given year of feed efficiency worse than 4.51 (4.13 mean plus 0.38) and a 15 percent chance that it will be better than 3.75. At an average 13.1 pigs per sow, there is a 15 percent chance in a given year of pigs per sow less than 11.1 and a 15 percent chance of more than 15.1. Looking at two S.D. distance from the means, there is a 2.5 percent chance of being worse than 5.27 pounds of feed per pound of pork or under 9.1 pigs per sow in a given year. This is a relatively crude approach to using the statistics, but serves to illustrate the magnitudes involved. One more sophisticated approach that could be utilized in the future is the moving average technique used in the Agricultural Risk Management Simulator to derive crop yield probability distributions from historical yield records (King).

Higher feed efficiency may result from higher sow productivity because of spreading the sow's feed cost among more offspring, as well as from efficiency in feeding the market hogs themselves. Pigs per sow and feed per pound of pork are not closely correlated, however. The simple correlation coefficient between the two measures was calculated for the 226 yearly records of the six-year farms at -0.190. The relationship between these two measures and a profitability measure was also evaluated for 51 farrow-to-finish enterprises for 1988 only. The profitability measure used was net return over direct and overhead costs per hundredweight of pork produced, as described in Olson, et al., minus an imputed seven dollar per hour charge on unpaid operator labor as described in (Lazarus, 1990a). Equity capital and management are two other costs not valued, mainly to avoid the difficult task of placing a market value on the facilities. Net return over direct, overhead and labor costs per hundredweight was regressed on pigs per sow and on feed per pound of pork in separate regressions. Based on the raw R^2, pigs per sow explained 14 percent of the variation in return, while feed per pound of pork explained 31 percent.

A further step in the analysis was to place each farm into one of five categories with respect to each of the two efficiency measures. Probability matrices were then calculated showing the movement of farms from one category to another in succeeding years. The category breakpoints were set roughly 0.84 and 0.25 S.D.'s above and below the means. This method will place 20 percent of the farms in each category if the measures are normally distributed. The farm numbers did not come out to be exactly 20 percent because of non-normality and rounding. The means, S.D.'s, and breakpoints are:

	Feed Per Pound of Pork Produced	Pigs Weaned Per Sow
Mean, Farms in Associations		
All Six Years	4.08	13.18
Standard Deviation	0.684	3.63
Category Breakpoints		
Top Group	$\leq$ 3.6	$\geq$ 16.0
Second	3.61 - 4.0	13.9 - 15.9
Third	4.01 - 4.3	12.1 - 13.8
Fourth	4.31 - 4.7	10.0 - 12.0
Bottom	> 4.7	< 10.0
Mean, Farms Not in Associations		
All Six Years	4.18	13.00
Standard Deviation	0.659	3.83
Mean, All Farms	4.11	13.12
Standard Deviation	0.677	3.69

The breakpoints were calculated from the means and S.D.'s of the six-year group, and used for the total group as well for consistency, even though the farms not in the group all six years averaged slightly lower in efficiency.

The procedure used was to place each farm in a category for each year. Then a computer program checked each farm to see what category it was in the following year, or if it no longer had a swine enterprise. A crosstab analysis then counted the number of farms either staying in the same category or changing to another category from any given year to the next. These numbers were divided by the total number of farms in the category in the first year to derive the probability measures shown in the tables. Feed per pound of pork and pigs weaned per sow were analyzed independently of each other.

The number of farms that either started a farrow-to-finish enterprise after not having one the previous year, and those who had previously had one and no longer had one next year, were also tabulated. The transitions out of and into the enterprise presented special problems, and were one reason that the probabilities were calculated separately for 1) farms staying in the Associations all six years and 2) those with records for at least one year but not all six years. There are at least four possible explanations for a farm having a swine enterprise record in a given year and not in the next year: 1) the producer quit raising farrow-to-finish swine but remained in farming with other enterprises, and remained a member of the Association, 2) he or she quit swine and quit farming altogether, and thus quit the Association, 3) he or she remained in swine, but did not provide usable records for that year, or 4) quit the Association but remained in farming. An exit from swine or from farming altogether may be due from the financial impact of low performance and profitability of the swine enterprise. Of course, there are many other reasons for exiting as

well, but further research would be necessary to evaluate the reasons for the exits that occurred.

New entrants were identified as those operations which had a swine enterprise in a given year but not in the previous year. Because records were available only for 1984-9, it was not possible to identify new entrants in 1984 because it could not be determined if they had swine in 1983. Likewise, it was not possible to identify those who exited in 1989. the industry-wide trend is to fewer swine operations, so it would be expected that there would be more exiting swine operations in this FBMA data than new entrants. Instead, the number of new entrants and exits are equal. One explanation lies in the fact that while both the total number of swine operations and the total number of farms of all types are declining across the state, the relative proportion of farms with swine is more constant over time. The number of farms in the FBMA is held roughly constant by accepting new entrants to replace those that exit.

In any case, some of the records in the database were identified as having abnormalities involving either the entire farm or only the swine enterprise. These are not included in the tabulations. Any farms in the six-year group, then, who had swine records in one year but not the next were classified as exiting swine. This gives slight underestimates of the probability of exiting swine, and the impact of performance on it, because the group includes only farms who remained in farming as Association members all six years. On the other hand, some farms in the larger overall group may have remained in swine but just dropped out of the Association, so the probabilities of exit calculated from the total group may be slight overestimates. Tables 1 through 4 present both sets of estimates to at least bracket the true probabilities. New entrants into swine were estimated using a similar procedure, so the same caveats hold true there as well.

Table 3 shows feed efficiency based on 213 yearly records from the six-year farms. For a farm initially in the group of 30 records at 3.6 pounds of feed or less per pound of pork, there is only a 13 percent chance of remaining in this range in the second year. The highest probability is that such a farm would move to the category of 3.61-4.0 pounds. It is apparently quite difficult to remain at such a high level of feed efficiency over a period of several years. On the other hand, for records in the 4.31-4.7 range, the highest probability is for moving up into the 4.01-4.3 range next year. It is also interesting to observe that at over 4.7 pounds, the chance of exiting next year is greater than the chance of remaining at the level and at least double the chance of exiting after being at better efficiency levels.

Table 4 shows pigs weaned per sow per year, again for the six-year farms. Higher percentages of the farms are in the highest category (17 percent) and lowest (16 percent) than was the case for feed efficiency (14 and 6 percent, respectively). The probability of remaining in the best group, 16 pigs or over, is greater than it was for staying in the highest category for feed efficiency. There is a greater chance of moving up from the second and fourth categories than of remaining in those categories. Also, there does not appear to be a higher

probability of exiting from the under 10 pigs category than for the better categories, unlike the feed efficiency case.

Tables 5 and 6 are the same as 3 and 4 but including 321 yearly records from the total group of farms in the Associations at least one of the six years. Table 5 shows that, for feed efficiency, the distribution is more spread out than for the six-year farms, with more farms in the high and low categories. For farms in the worst feed efficiency category, the probability of exit is 44 percent, while 18 percent of the records are new entrants. There is not much difference in the spreads in Tables 4 and 6, for pigs per sow. The probabilities of exit (and entry) are higher when all farms are included, as would be expected. Recall that an undetermined number of these farms may have simply not supplied usable records rather than exiting, or may have exited farming for reasons unrelated to the swine enterprise.

The probability matrices in Tables 3 through 6 were used to simulate the number of farms by category for up to six years into the future. The results are not shown here, but in each case the distribution tended to stabilize after about two or three years. This implies that average productivity over the group would level off in a few years if the probabilities are stable over time. In fact, the available data on productivity does not seem to show any levelling off to date, so it seems likely that the probabilities are not stationary over time. Further research could attempt to estimate a more sophisticated predictive Markov process model, however the limited range and lack of representativeness of the data makes this perhaps a doubtful undertaking.

Another use of this data, beyond simply assessing the degree of production risk that is typical of this group of farms as a whole, is to try to identify management strategies and practices used by those farms who have been consistently in the better categories over the six years. These strategies may be useful for other farmers who want to reduce their chance of years of low performance. Three of the 22 farms with swine all six years were under 4.0 pounds of feed per pound of pork all six years. However, the most that any farm was under 3.6 pounds or less, was three years. For pigs weaned per sow, only two farms were over 13.9 in all six years. It appears that a larger sample of farms would be necessary in order to relate management strategies and practices to consistently high productivity.

This analysis suggests that when a producers make a projection of the future productivity and profitability of a swine enterprise, they should review records from as many years as possible, preferably more than one or two, to determine how consistent performance is over time. Most farmers are in agriculture because we are optimistic about the future. But a too-optimistic view that underestimates the production and price risks involved can put the business in financial jeopardy.

Table 1. Farm Annual Records in FBMA by Feed Pounds Per Pound of Pork

Feed Lbs./ Lb. of Pork	Annual Records	Percent
≤3.6	44	17
3.61-4.0	70	26
4.01-4.3	69	26
4.31-4.7	56	21
>4.7	25	10
Total	264	100

Table 2. Farms in FBMA by Pigs Weaned Per Sow Per Year

Pigs/Sow /Year	Farms	Percent
≥16.0	50	19
13.9-16.0	55	21
12.1-13.9	63	24
10-12.1	41	15
<10	55	21
Total	264	100

Table 3. Feed Pounds Per Pound of Pork and Changes From One Year to the Next, Farms in FBMA from 1984 to 1989

	Category in Year 1						
	≤3.6	3.61-4.0	4.01-4.3	4.31-4.7	>4.7	New Entrants	Total
Year 1 Farms	30	52	53	38	12	28	213
Percent	14	24	25	18	6	13	100
	Percent of Year 1 Farms in - - - - Each Category by Year 2 - - - -						Total
Year 2							Farms / Percent
≤3.6	13	23	6	16	8	18	31 / 15
3.61-4.0	33	35	21	18	17	43	60 / 28
4.01-4.3	20	12	42	26	0	25	51 / 24
4.31-4.7	13	19	13	18	17	14	34 / 16
>4.7	3	2	4	5	25	0	9 / 4
Exit	17	10	15	16	33	0	28 / 13
Total	100	100	100	100	100	100	213 / 100

Table 4. Pigs Weaned Per Sow Per Year and Changes From One Year to the Next, Farms in FBMA from 1984 to 1989

	Category in First Year						
Year 2	≥16.0	13.9-15.9	12.1-13.8	10-12.0	<10	New Entrants	Total
Year 1 Farms	37	35	50	28	35	28	213
Percent	17	16	25	13	16	13	100
	Percent of Year 1 Farms in						
Year 2	- - - - Each Category by Year 2 - - - -						Total Farms / Percent
≥16.0	41	31	14	11	11	18	45 / 21
13.9-16.0	27	23	8	32	6	18	38 / 18
12.1-13.9	11	20	34	25	6	29	45 / 21
10-12.1	3	11	14	11	20	18	27 / 13
<10	0	0	10	18	43	18	30 / 14
Exit	19	14	20	4	14	0	28 / 13
Total	100	100	100	100	100	100	213 / 100

Table 5. Feed Pounds Per Pound of Pork and Changes From One Year to the Next, Farms in FBMA at Least One Year

	Category in First Year						
	≤3.6	3.61-4.0	4.01-4.3	4.31-4.7	>4.7	New Entrants	Total
Year 1 Farms	44	70	69	56	25	57	321
Percent	14	22	21	17	8	18	100
	Percent of Year 1 Farms in						
Year 2	- - - - Each Category by Year 2 - - - -						Total Farms / Percent
≤3.6	20	17	09	13	04	18	45 / 14
3.61-4.0	34	36	19	21	12	32	86 / 27
4.01-4.3	14	14	36	21	4	26	69 / 22
4.31-4.7	09	17	14	16	12	14	46 / 14
>4.7	2	3	3	4	24	11	19 / 6
Exit	20	13	19	25	44	0	56 / 17
Total	100	100	100	100	100	100	321 / 100

Table 6. Pigs Weaned Per Sow Per Year and Changes From One Year to the Next, Farms in FBMA at Least One Year

Year 2	Category in First Year ≥16.0	13.9-15.9	12.1-13.8	10-12.0	<10	New Entrants	Total
Year 1 Farms	50	55	63	41	55	57	321
Percent	15	17	20	13	17	18	100

Year 2	Percent of Year 1 Farms in Each Category by Year 2 ≥16.0	13.9-15.9	12.1-13.8	10-12.0	<10	New Entrants	Total Farms	Percent
≥16.0	40	29	11	10	7	21	63	20
13.9-15.9	26	27	13	27	4	25	63	20
12.1-13.8	8	18	29	17	9	21	56	17
10-12.0	2	11	14	10	16	14	37	12
<10	0	0	8	22	38	19	46	14
Exit	24	15	25	15	25	0	56	17
Total	100	100	100	100	100	100	321	100

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