Using partial budgets to analyze selected management practices associated with reduced preweaning mortality

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Summary

To illustrate the usefulness of the partial budget technique in analyzing four management variables associated with reduced preweaning mortality: all-in-all-out (AIAO) pig flow, power washing farrowing crates after every farrowing, observing a long idle time between farrowings, and washing sows prefarrowing.

The partial budget technique is a simple, yet powerful technique that can be easily set up as a spreadsheet. This analysis technique can help practitioners analyze the financial advisability of adopting a given management strategy in their clients' herds.

Keywords: swine, partial budget, economic analysis, preweaning mortality

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Preweaning mortality has historically been a problem for veterinarians and producers.[1-5] While it is important to find management techniques that reduce preweaning mortality, it is also necessary to determine whether these strategies would be economically feasible to implement. The partial budget is a simple economic analysis technique that can nonetheless be a powerful tool in helping determine the financial feasibility of a given management strategy. In this paper, we describe the partial budget technique and, using data from the NAHMS National Swine Survey as example variables, illustrate its use.

Partial budgets

Partial budgets use the following formula to estimate the change in farm profit or loss that would occur when a management change is made in the operation of the farm:

	increased revenues
+	decreased costs
-	increased costs
-	decreased revenues
=	change in revenue

Because a given management change will affect only some expenses or income items, only the expenses and income that would be altered by the change are entered into a partial budget. A partial budget model does not take into account any changes in income or expenses that would be the same whether or not the management change was made.[6] A simple partial budget can be calculated manually or can be easily constructed on a spreadsheet (Figure 1). *[Editors' note: A partial budget spreadsheet template, compatible with Microsoft® Excel™, is available for download at the AASP web site. Follow the links to this article at* `http://www.aasp.org/shap/issues/v5n3/`*.]*

Using the partial budget

The management variables serving as examples in this analysis represent the four management variables that were observed in the NAHMS National Swine Survey to significantly reduce preweaning mortality.[1] (The data collection protocol of this survey has been described elsewhere.[2]) Bowman, et al.,[1] investigated the impact on preweaning mortality of several facility attributes and management variables, including flooring type, supplemental piglet heat, cleaning method, length of idle time, cleaning frequency, sow washing, and all-in-all-out (AIAO) versus continuous swine flow in farrowing rooms. They analyzed these variables, along with farm size and region of the country, using a regression model. Bowman, et al., found that four of these management variables significantly reduced preweaning mortality. We have included these four for further economic analysis:

- sow farrowing flow (AIAO versus continuous flow),
- pressure washing farrowing crates with disinfectant (the method most commonly used to clean farrowing crates) after every farrowing,
- washing sows before farrowing, and
- long idle time (> 2 days) between farrowings.

(We did not include the nonmanagement variables Bowman, et al., found significant in their study. Facility attribute variables are beyond the scope of this paper, which focuses on cost:benefit analysis of management parameters to help veterinary practitioners make economic judgements related to the daily management and operation of an average swine farm.)

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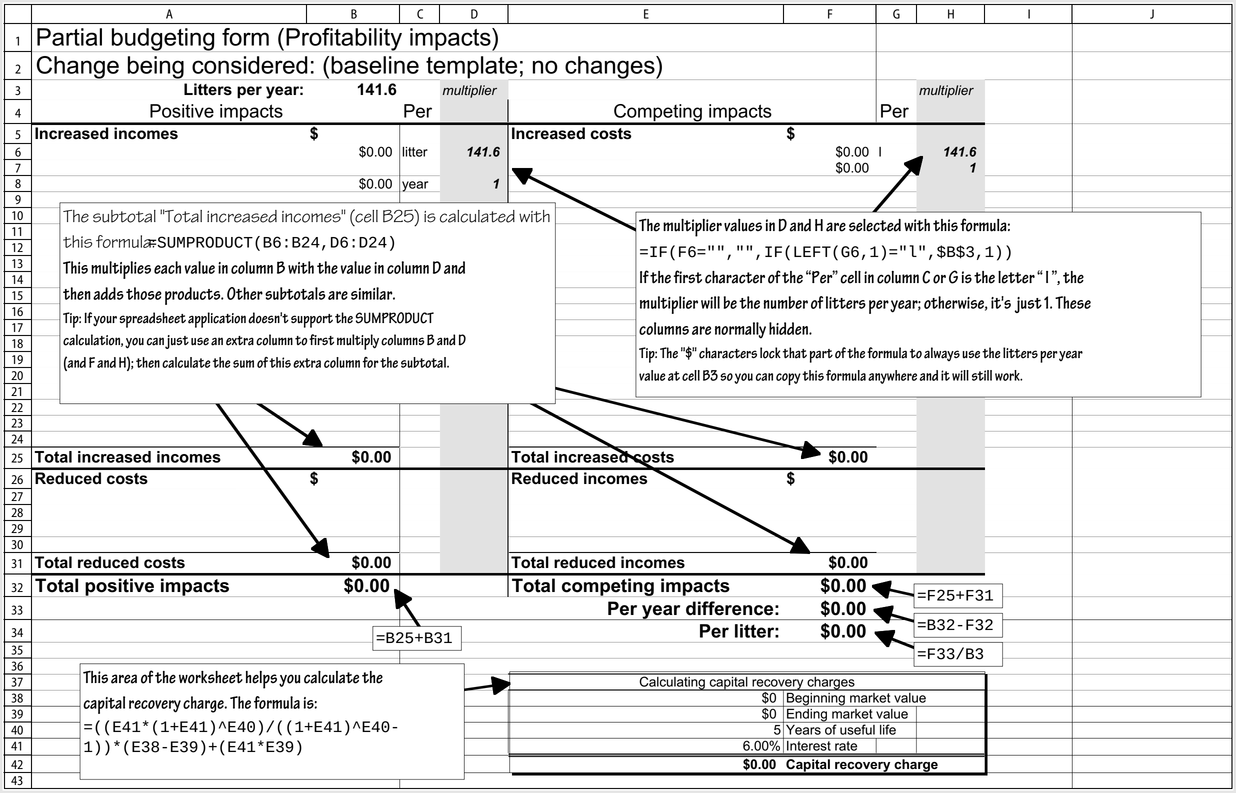
Figure 1



A partial budget template

Model assumptions

In our example analyses, our partial budget models all assume a hypothetical 85-sow, total confinement hog operation with 15 farrowing crates producing 160 litters per year.

The 85-sow hypothetical operation we used as our baseline in the model is small compared to many swine operations in the country today. However, we selected a farm of this size for our model because small hog operations still represent the average Midwestern hog operation. As of December 1995:

in Illinois there were 580,000 breeding swine on 9600 farms for a per-farm mean of 60 sows, and
in Iowa there were 1,520,000 breeding swine on 25,000 hog farms for a per-farm mean of 61 sows.[7]

It is important for veterinarians to address issues of swine health affecting farms that, although declining in number, still represent the greatest number of swine enterprises. We believe that swine practice must address the economic health as well as the physical health of the operation. The partial budgeting technique applies to large operations as well as small ones, and can be used to input variables from a large unit as well as the 85-sow operation we used as our baseline.

We used the following assumptions to calculate an initial baseline revenue for our hypothetical herd:

percent farrowings from first-litter gilts: 35%;
death losses of market hogs after weaning: 6.5%;
price per lb of market hogs: $0.465;
cost per lb of feed: $0.069;
feed conversion weaning to market: 3.33;
gilt farrow rate: 85%; and
sale weight of market hogs: 241 lb; and
pigs weaned per litter: 8.14 +/- 0.08 SD, which is a national swine population estimate based on data collected in the NAHMS National Swine Survey.[5]

In addition to these model settings, we assumed in our analysis that the baseline herd:

used continuous animal flow,
did not wash sows before farrowing,
did not wash the facility between farrowings, and
had an idle time of 1-2 days between farrowings.

A partial budget analysis was then used to predict the effect of each management change on our hypothetical farm based on the change in piglets weaned per litter associated with each management variable. The change in revenue was divided by the number of litters to give cost or benefit in dollars per litter for each management variable for our hypothetical farm.

Capital recovery charges

Two of the management variables (longer idle times and washing sows before they farrow) require no initial capital expenditures to implement. Two of them, however (AIAO animal flow and pressure washing) do require significant initial capital expenditures to implement. For example, in our hypothetical model, we assumed that converting continuous-flow facilities to AIAO would have a fixed cost of $4000. We assumed that a unit would have a fixed cost of $3000 to purchase a high-pressure power washer for washing facilities between sow groups. It is necessary to properly account for fixed costs in the partial budget model to determine an accurate measure of the advisability of implementing various management strategies that require an initial outlay of capital.

Fixed costs for capital items consist mostly of capital recovery charges (CRC).[6] The CRC value can substitute for depreciation, interest, repairs, taxes, and insurance. Capital recovery charges provide an accurate measure of fixed costs over time because the calculation takes into account the time value of money. The CRCs reflect changes in the market value of the asset over time. Ultimately, CRCs represent the annual opportunity cost of owning capital items.

The formula for calculating the CRC is:

$$\text{CRC}=\frac{i\left(1+i\right)^{n}}{\left(1+i\right)^{n}-1}\left(BV - EV\right)+(i - EV)$$

where:

- i = annual interest rate
- n = number of years of useful life
- BV = beginning market value
- EV = ending market value

Once calculated, these capital recovery charges can be used as inputs into the standard partial budget (Figure 1).

All of the management strategies we analyzed in our partial budget model represent efforts to reduce preweaning mortality by reducing the pathogen load in the farrowing phase.[8] Because the NAHMS study did not collect data that would allow us to ascertain whether concentrations of pathogens were indeed reduced in the farrowing units included in the survey,[5] we lack the means to assess the correlation between the observed decreases in preweaning mortality and reduced disease. For this reason, we have not included in our partial budget some of the decreased costs (e.g., reduced veterinary costs, reduced medication, etc.) that would probably accompany reduced disease in farrowing units.

Examples using the model

Increased idle time

In the NAHMS survey, producers were asked to indicate whether they normally observed an idle time between farrowing groups of 1-2 days, 3-5 days, 1 week, 2 weeks, or 1 month or more. In the Bowman study,[1] increasing idle time beyond 2 days was associated with decreased piglet mortality of 1.17 piglet deaths per 1000 piglet days and increase piglets weaned per litter of 0.2063 (Table 1).

It is unlikely that respondents who indicated that they observed no idle time between farrowings actually achieved 100% crate occupancy. Our example assumes 160 litters over 13 farrowing cycles per crate per year. This number of cycles has an inherent idle time of 2 days per cycle (365 days ÷ 13 = 28 days, but each farrow period averages 26 days). For our baseline herd, we assume that there will be an inherent 1- to 2-day idle time between farrowings (93.33% real occupancy at 160 litters). Thus, we input an additional 2 days of idle time into our partial budget model. This reduces litters per female year in our partial budget from the original 160 litters to 149.3 litters per female per year (160 ξ 0.9333 = 149.33). We did not anticipate that leaving facilities idle for a longer period between farrowings would result in any additional out-of-pocket expenses to a unit, so we added no additional expense to our partial budget model (Figure 2).

In our example, the partial budget analysis demonstrates a severe economic penalty for our hypothetical farm when farrowing crates are left idle for more than 2 days between farrowings. In operations that leave crates idle for 1-2 extra days over 13 farrowing cycles, there will be a penalty of 13-26 idle crate days in a given year. Idle time in the farrowing house reduces litters per female year. For the hypothetical herd in our partial budget analysis, the cost to the producer for loss of crate use exceeds the benefit gained from disease reduction (Figure 2). This example

Table 1

Summary of mortality reduction for selected vairables in part from Bowman, Ott, and Bush[1]

Management variable	AIAO	Pressure wash / disinfect	Extra idle time	Sow washing
Reduced death*	1.29	1.96	1.17	0.0099
Extra pigs per litter	0.2273	0.3449	0.2063	0.00169
Probability > P	0.0058	0.0301	0.0181	0.0549
90% confidence interval†	0.53–2.02	0.50–3.32	0.41–1.91	—
Partial R^2	.0219	.0208	.0077	.0048

* Reduced piglet death per 1000 piglet days

† Source: Bowman, Ott and Bush[1] -- additional information supplied by the authors

illustrates the fact that just because a given variable reduces disease and increases piglet survival, it may not be advisable to implement the practice.

Sow washing

The Bowman, et al.,[1] study found that washing sows before they farrow was associated with a statistically significant reduction in preweaning mortality, yielding an extra 0.00169 piglets per litter--a reduced death incidence of 0.0099 piglet deaths per 1000 piglet days. We therefore added 0.00169 piglets to the partial budget to analyze the sow washing management strategy. We did not anticipate that initiating a sow-washing management strategy would result in any additional expenses to a unit (we are assuming that existing labor could be used), so we added no additional expense to our partial budget model (Figure 3). Sow washing in our model resulted in a $0.55 loss per litter.

It is likely that sow washing, which had a negligible impact on revenues in our hypothetical simulation, is highly confounded with another variable, such as facility washing.

AIAO pig flow

After accounting for farm size and region of the country, Bowman, et al.,[1] found that there were 1.29 fewer piglet deaths per 1000 piglet days in AIAO facilities compared with facilities managed using continuous animal flow.[1] Thus, we increased the number of pigs weaned per litter in the hypothetical model by 1.29. Because it is likely that adopting an AIAO animal flow strategy would reduce breeding efficiency somewhat, we assumed a 2% reduction in scheduling efficiency with AIAO. This leads to a small reduction in litters per female per year (156.8) from the original 160 litters. Converting this reduced mortality rate to additional piglets weaned, an additional 0.2273 pigs per litter were added to the 8.14 baseline litter size for AIAO over continuous flow (Table 1) in our model.

Also, we anticipated that there would be a one-time expense of $4000 to convert existing facilities to accommodate AIAO animal flow.[9] We assumed that the life of the converted facilities would be 10 years, with a 6% interest rate, and an ending value of $800.00. The capital recovery charges for these inputs were calculated using the standard CRC formula:

Figure 2

	A	B	C	E	F	G
1	Partial budgeting form (Profitability impacts)					
2	Change being considered: Increased idle time (+2 days)					
3	**Litters per year:**	**149.33**				
4						
5	Positive impacts		Per	Competing impacts		Per
6	**Increased incomes**	**$**		**Increased costs**	**$**	
7	Increased value of litter at market	$21.53	litter	**Feed**	**$8.36**	**litter**
8	0.2063 increased pigs per litter			36.3676 extra lb to market per litter		
9	x 0.98 mortality in nursery at 2%			x 3.33 feed:gain ratio		
10	x 0.98 mortality in grower at 2%			= 121.10 lb feed		
11	x 0.98 mortality in finisher at 2%			x $0.07 per lb feed		
12	= 0.194168 increased pigs to market			= $8.36 cost of feed per litter		
13	x 241 lb weight at market					
14	= 46.79447 increased lbs to market per litter					
15	x $0.46 market price per lb					
16	= $21.53 increased value of litter at market					
17	**Total increased incomes**	**$3,215.07**		**Total increased costs**	**$1,248.40**	
18	**Reduced costs**	**$**		**Reduced incomes**	**$**	
19	Pigs not fed	$30.30	litter	Decreased capacity	$60.66	litter
20	0.54721 pigs not fed			10.667 fewer litters		
21	x 241 lb market weight			x 8.14 pigs per litter		
22	= 131.88 lb not produced			x 0.98 x 0.98 x 0.98 mortality		
23	x 3.33 feed:gain ratio			= 81.717 total pigs lost		
24	= 439.12 lb feed not fed			÷ 149.33 litters		
25	x $0.07 per lb feed			= 0.54721 pigs lost per litter		
26	= $30.30 saved feed per litter			x 241 lb weight at market		
27				x $0.46 market price per lb		
28				= $60.66 cost of lost pigs due to decreased capacity		
29						
30	**Total reduced costs**	**$4,524.70**		**Total reduced incomes**	**$9,058.36**	
31	**Total positive impacts**	**$7,739.77**		**Total competing impacts**	**$10,306.76**	
32				**Per year difference:**	**–$2,566.98**	
33				**Per litter:**	**–$17.19**	

Partial budget for increased idle time

Figure 3

	A	B	C	E	F	G
1	Partial budgeting form (Profitability impacts)					
2	Change being considered: Sow washing					
3	**Litters per year:**	**160**				
4						
5	Positive impacts		Per	Competing impacts		Per
6	**Increased incomes**	**$**		**Increased costs**	**$**	
7	**Increased value of litter at market**	**$0.18**	**litter**	**Labor**	**$0.73**	**litter**
8	0.00169 increased pigs per litter			0.1 hours per pig		
9	x 0.98 mortality in nursery at 2%			x 15 pigs per farrowing		
10	x 0.98 mortality in grower at 2%			= 1.5 hours per farrowing		
11	x 0.98 mortality in finisher at 2%			x 13 farrowings per year		
12	= 0.001591 increased pigs to market			= 19.5 hours per year		
13	x 241 lb weight at market			x $6.00 hourly rate		
14	= 0.38333 increased lbs to market per litter			= $117 cost for 75-sow farm		
15	x $0.46 market price per lb			÷ 160 litters per year		
16	= $0.18 increased value of litter at market			= $0.73 labor cost per litter		
17						
18	**Total increased incomes**	**$28.80**		**Total increased costs**	**$116.80**	
19	**Reduced costs**	**$**		**Reduced incomes**	**$**	
20						
21						
22	**Total reduced costs**	**$0.00**		**Total reduced incomes**	**$0.00**	
23	**Total positive impacts**	**$28.80**		**Total competing impacts**	**$116.80**	
24				**Per year difference:**	**–$88.00**	
25				**Per litter:**	**–$0.55**	

Partial budget for sow washing

$$CRC = \frac{0.06(1+0.06)^{10}}{(1+0.06)^{10}-1}(\$4000 - \$800) + (0.06 - \$800)$$

using i = 6%, n = 10 years, BV = $4000, and EV = $800; and inserted into our partial budget (Figure 4).

Since the use of AIAO is thought to reduce disease, veterinary and drug costs should decrease and will further benefit the producer, although these decreased expenses were not entered into the partial budget model.

Adopting an AIAO animal flow strategy may bring other economic benefits that are not accounted for by this model. Because in an AIAO system farrowing occurs within a tighter schedule and less time is needed to supervise farrowings, a labor advantage for AIAO is assumed to exist.

For the hypothetical farm used in our analysis, converting the farrowing facilities to an AIAO animal flow stratetgy resulted in an increased profit. Such returns, however, depend upon many variables and may not be realized in your clients' herds, or may exceed these estimates. Careful economic analysis with a simulation model can help your clients assess the advisability of adopting a technology like AIAO.

Pressure washing

Bowman, et al.,[1] found that cleaning by pressure washing and disinfecting after each farrowing was associated with decreased piglet deaths per 1000 piglet days by 1.96, and increased piglets weaned per litter by 0.3449 compared to not cleaning after every farrowing (Table 1).

We specifically focused our analysis of power washing with disinfectant because it is the most common type of cleaning method used for cleaning the farrowing house. Because power washing after every farrowing does not reduce farrowing crate use, our budget assumes no loss of efficiency in the farrowing house. Thus, we input 160 litters per year into our model. We assumed $6.00 per hour labor and 15 minutes to clean each crate as an additional expense for this strategy, resulting in a total additional annual labor charge of $392. There would also be an additional $30 per year for electricity to run the washer (Figure 5).

The cost of a high-pressure washer for cleaning farrowing crates is $1200-$3000. Again, we must calculate the CRC formula to determine the fixed costs of a pressure washing system over time, and input the resulting value into our partial budget. For this calculation, we assume that the pressure washer costs $3000 and will last 5 years. Thus, with an interest rate of 6%, we have the following equation:

$$CRC = \frac{0.06(1+0.06)^{5}}{(1+0.06)^{5}-1}(\$3000 - \$0) + (0.06 - \$0)$$

using i = 6%, n = 5 years, BV = $3000, and EV = $0.0.

This gives us an annual CRC of $712.19 -- about 25% of the original cost. This is higher than the 12.5%-17% that is the rule of thumb return expected for machinery; however, in this case there is no salvage

Figure 4

	A	B	C	E	F	G
1	Partial budgeting form (Profitability impacts)					
2	Change being considered: AIAO					
3	**Litters per year:**	**156.8**				
4						
5	Positive impacts		Per	Competing impacts		Per
6	**Increased incomes**	**$**		**Increased costs**	**$**	
7	Increased value of litter at market	$23.72	litter	Feed	$11.85	litter
8	0.2273 increased pigs per litter			51.558 extra lb to market per litter		
9	x 0.98 mortality in nursery at 2%			÷ 3.33 feed:gain ratio		
10	x 0.98 mortality in grower at 2%			= 171.69 lb feed		
11	x 0.98 mortality in finisher at 2%			x $0.07 per lb feed		
12	= 0.21393 increased pigs to market			= $11.85 cost of feed per litter		
13	x 241 lb weight at market					
14	= 51.558 increased lb to market per litter			**Capital recovery charge**	**$482.78**	**year**
15	x $0.46 market price per lb			• $4000 beginning market value		
16	= $23.72 increased value of litter at market			• $800 ending market value		
17				• 10 years useful life		
18				• 6.00% interest rate		
19				(for one-time costs to convert facilities from continuous flow to AIAO)		
20	**Total increased incomes**	**$3,719.30**		**Total increased costs**	**$2,340.86**	
21	**Reduced costs**	**$**		**Reduced incomes**	**$**	
22	Pigs not fed	$8.66	litter	Decreased litters	$2,717.84	year
23	0.15635 pigs not fed			3.2 fewer litters		
24	x 241 lb market weight			x 8.14 pigs per litter		
25	= 37.691 lb not produced			x 0.98 mortality in nursery at 2%		
26	x 3.33 feed:gain ratio			x 0.98 mortality in grower at 2%		
27	= 125.48 lb feed not fed			x 0.98 mortality in finisher at 2%		
28	x $0.07 per lb feed			= 24.516 fewer pigs to market		
29	= $8.66 saved feed per litter			x 241 lb at market		
30				x $0.46 market price per lb		
31	**Labor saved: monitoring**	**$1,950.00**	**year**	= $2717.84 lost		
32	$6.00 cost of labor					
33	x 50 hours required per farrowing with continuous flow					
34	x 0.50 AIAO savings of 50% of monitoring time					
35	= $150 saved per farrowing					
36	x 13 farrowings per year					
37	= $1950 saved per year					
38						
39	Labor saved: cleaning	$175.50	year			
40	6. hours labor with continuous flow					
41	– 3.75 hours with AIAO					
42	= 2.25 hours savings with AIAO					
43	x $6.00 per hour labor cost					
44	x 13 farrowings per year					
45	= $175.50 labor saved per year					
46						
47	**Total reduced costs**	**$3,483.39**		**Total reduced incomes**	**$2,717.84**	
48	**Total positive impacts**	**$7,202.68**		**Total competing impacts**	**$5,058.70**	
49				**Per year difference:**	**$2,143.98**	
50				**Per litter:**	**$13.67**	

Partial budget for conversion from continuous-flow to AIAO facility

value and a short useful life.

Although not accounted for in our model, veterinary and drug cost should also be reduced if a producer began to clean facilities between groups, and that reduction could be substantial.

Sensitivity analysis

To make partial budgets more useful, one can perform further economic analysis to determine what effect various changes to the inputs into the partial budget would have on the profitability of the strategy. This technique is called sensitivity analysis. In our hypothetical model, we determined the effect on profitability of the following possible

Figure 5

	A	B	C	E	F	G
1	Partial budgeting form (Profitability impacts)					
2	Change being considered: Pressure wash and disinfect (Cleaning)					
3	**Litters per year:**	**160**				
4						
5	Positive impacts		Per	Competing impacts		Per
6	**Increased incomes**	**$**		**Increased costs**	**$**	
7	**Increased value of litter at market**	**$35.99**	**litter**	**Feed**	**$18.23**	**litter**
8	0.3449 increased pigs per litter			78.233 extra lb. to market per litter		
9	x 0.98 mortality in nursery at 2%			x 3.33 feed:gain ratio		
10	x 0.98 mortality in grower at 2%			= 260.51 lb. feed		
11	x 0.98 mortality in finisher at 2%			x $0.07 per lb. feed		
12	= 0.32462 increased pigs to market			= $18.23 cost of feed per litter		
13	x 241 lb weight at market					
14	= 78.233 increased lbs to market per litter			Labor	$175.50	year
15	x $0.46 market price per lb.			0.15 hours per crate		
16	= $35.99 increased value of litter at market			x 15 crates for 75-sow farm		
17				x 13 farrowings per year		
18				= 29.25 hours per year		
19				x $6.00 cost of labor per hour		
20				= $175.50 yearly labor cost of cleaning		
21						
22				Capital recovery charge	$712.19	year
23				• $3000 beginning market value		
24				• $0 ending market value		
25				• 5 years useful life		
26				• 6.00% interest rate		
27				(to purchase pressure washer)		
28	**Total increased incomes**	**$5,758.40**		**Total increased costs**	**$3,804.49**	
29	**Reduced costs**	**$**		**Reduced incomes**	**$**	
30						
31						
32	**Total reduced costs**	**$0.00**		**Total reduced incomes**	**$0.00**	
33	**Total positive impacts**	**$5,758.40**		**Total competing impacts**	**$3,804.49**	
34				**Per year difference:**	**$1,953.91**	
35				**Per litter:**	**$12.21**	

Partial budget for pressure washing and disinfecting

changes to inputs:

- increase in the price per lb for hogs to $0.50 per lb and constant feed price at $0.069 per lb,
- decrease in hog prices to $0.45 per lb and increase in feed price to $0.08 per lb,
- decrease in hog prices to $0.40 per lb and increase in feed prices to $0.10 per lb, and
- decrease in hog prices to $0.42 per lb and increase in feed prices to $0.12 per lb (Table 2).

Generally, as the hog:feed ratio decreases--the price of hogs falls or the cost of feed rises---management changes that are profitable in the baseline case remain profitable, but less so. With hogs at $0.50 per lb and feed at $0.07 (a hog:feed ratio of 7.3), pressure washing is worth $25.48 more per litter. But with hogs at $0.42 and feed at $0.12, pressure washing is worth only $3.09 more per litter.

Partial budget analysis, particularly when coupled with sensitivity analysis, can provide practitioners with a reasonably simple yet powerful method to assess the potential financial impact of various management strategies on a given farm.

Implications

- Partial budgeting is a simple yet powerful technique for predicting the financial impact of a proposed management change on individual swine operations.
- When performing partial budget analysis on strategies that would require a significant up-front outlay of capital, it is necessary to calculate capital recovery charges for input into the partial budget model.
- Sensitivity analysis increases the predictive value of partial budget techniques.

A template partial budget template, compatible with Microsoft® Excel™, is available for download at the AASP website. Follow links to this article at: http://www.aasp.org/shap/issues/v5n3/.

Table 2

Sensitivity of savings to hog : feed cost ratio

Hog : feed ratio [Hog price per pound: hog feed price]	savings calculated	AIAO (160 litters per year)	AIAO (157 litters per year)	Pressure wash / disinfect	Extra idle time	Sow washing
7.30	yearly:	$2344.00	$749.00	$4076.00	–($3787.00)	$17.00
[$0.50 : $0.069]	per litter:	14.65	4.78	25.48	–(25.42)	0.1063
5.65	yearly:	1630.00	516.00	2831.00	–(2653.00)	12.00
[$0.45 : $ 0.08]	per litter:	10.19	3.29	17.69	–(17.81)	0.075
4.00	yearly:	690.00	216.00	1199.00	–(1131.00)	5.00
[$0.40 : $ 0.10]	per litter:	4.31	1.38	7.49	–(7.59)	0.031
3.50	yearly:	326.00	118.00	495.00	–(447.00)	3.00
[$0.42 : $ 0.12]	per litter:	2.03	0.75	3.09	–(3.03)	0.02

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