Drum SD, Marsh WE. How to use partial budgets to predict the impact of implementing segregated early weaning in a swine herd. *Swine Health Prod.* 1999;7(1):13–18.

How to use partial budgets to predict the impact of implementing segregated early weaning in a swine herd

Steven D. Drum, DVM, MS; William E. Marsh, PhD

Summary

Partial budget analysis is a powerful yet simple technique that enables producers to predict the impact a management intervention will have on profitability in their operations. This article presents a partial budget model to predict how a change from conventional weaning to segregated early weaning, with a concomitant increase in breeding herd size from 250 to 500 breeding females, will effect profitability in a hypothetical herd. Sensitivity analysis is also discussed.

Keywords: swine, partial budgets, segregated early weaning (SEW), sensitivity analysis

Received: December 9, 1997
Accepted: July 14, 1998

Recent changes in the United States swine industry have placed many small producers in a quandary. Although these producers may have debt-free facilities, they feel the economic pressures of an increasingly competitive industry. The operations of these small producers could be made more competitive by implementing new management technologies; for example, production tools such as segregated early weaning (SEW) promise to improve efficiency and provide the opportunity to expand so that producers can capture economies of scale. Investment decisions are easier to make and access to capital is more readily available when one can easily and confidently define the expected costs and benefits of a planned management change. What producers need, then, is a reliable way to estimate the specific economic impact of these management changes.

Partial budgeting is an economic analysis tool that provides a straightforward means for estimating the financial impact of implementing a new technology.[1–3] Partial budgets compare pre- and post-change scenarios by calculating the expected impact on both income and expenses associated with a particular management change. In this paper, we illustrate how partial budgeting can be used to estimate the economic impact of implementing SEW and doubling the size of the breeding herd in a hypothetical operation.

Hypothetical herd defined

The assumptions we used in our hypothetical analysis were drawn from several different sources in order to simulate as realistically as possible a situation in which SEW might be considered an appropriate intervention. The values chosen for production levels in this example are for illustrative purposes only. Actual performance levels can vary dramatically between herds; when using this model, practitioners should input the herd-specific production data from their client's herd.

Our hypothetical operation was modeled on a farrow-to-finish enterprise that is debt-free and has sufficient collateral to finance expansion and construction. New debt will be incurred to finance sow herd expansion, remodeling, and new construction. The formula for interest used in this model used 1 as the number of payments per year. It is not uncommon for farm loans to be amortized using one payment per year. Over the life of a long loan, such as a home mortgage amortized over 30 years, the additional interest is substantial. However, the difference in shorter loans will not be that great. The initial herd size was chosen to reflect the predominant breeding female inventory in the United States (250 head) at the time of this analysis (1997).[4] Breeding female inventory was subsequently doubled to mimic an expansion plan commonly used when implementing SEW (although such an increase in the breeding herd is not a necessary part of implementing SEW). Values for herd reproductive performance that change when weaning age is decreased from 24 to 10 days (weaned pigs per breeding female per year, replacement rate, wean-to-service interval, pigs weaned per litter, and litters per breeding female per year) were estimated from the PigCHAMP® database (Table 1).[5] Nursery grow:finish performance was modeled on results observed in a trial conducted by Drum, et al.[6] The following points further define the hypothetical operation for this example:

- Sow herd expansion is amortized over 3 years and remodeling and construction costs are amortized over 7 years at 8% interest, as calculated by the following formula:

  $$p = A \times (R-1) \div (1-R^{-N})$$
  $$R = (1 + I \div 1)$$

  where:
  p is the payment,
  A is the amount borrowed,
  N is the number of payments,
  I is the annual interest rate, and
  R = (1+I/the number of monthly payments).

- Hand mating will be implemented after expansion, and additional labor will be required for management changes totaling $35,000 per year.
- Construction and remodeling costs used in this example are those

SDD: Remsen Veterinary Clinic, 609 South Cleveland, Remsen, Iowa 51050; **email: drum@nwidt.com**

Table 1

Input assumptions that differ for each scenario

Breeding herd phase	Before	After
Breeding herd size	250	500
Average age at weaning (d)	24	10
Weaned pigs/breeding female/year	19.31	21.83
Replacement rate	45%	50%
Wean-to-service interval	4.1	7.0
Pigs weaned per litter	8.84	9.21
Litter/breeding female/year	2.18	2.37
Hired labor	$0	$35,000
Nursery phase		
Lease payment/pig	$0	$5.00
Days in nursery/pig	32	46
Mortality rate	1%	3%
Nursery feed consumption (lb/head)		
Diet 1	0	3.4
Diet 2	1.2	5.1
Diet 3	12.7	14.1
Diet 4	29.0	35.7
Finisher phase		
Finisher feed consumption (lb/head)		
Diet 1	145.8	133.9
Diet 2	138.2	173.2
Diet 3	163.8	158.6
Diet 4	85.2	75.2

of an actual producer who completed a project of similar size and nature in 1996. Construction costs will vary locally, so the figures used in this example should be regarded as illustrative rather than average.

- No select breeding stock will be sold before or after intervention.
- No nursery pigs or weaned pigs will be sold before or after intervention.
- To simplify calculations, capital recovery costs are ignored. It is intended that this example measure the financial impact to the enterprise after meeting debt obligations.
- Due to local variation, we will ignore the effect of taxes, insurance, and utilities.
- All weight measurements are in lb and financial outcomes are calculated in $US.

Calculations

Our partial budget compared only those budget items that we anticipated would change on the basis of the strategic intervention (Table 1). Pigs weaned per litter was increased in the "after SEW" scenario because we reasoned that fewer pigs would die if removed from the sow before they could be infected with diseases endemic in the gestation facility. Production parameters that would stay the same for both the pre- and post-intervention scenarios were not included in the budget (Table 2).

Table 2

Input assumptions that remain unchanged before and after intervention

Breeding herd		
Breeding/gestation feed consumption per day	5 lb	
Gilt pool feed consumption per day	5 lb	
Gilt pool size as percent of sow herd	6%	
Lactation feed consumption per day	10 lb	
Vaccination cost/parity	$4.50	
Farrowing rate	85%	
Gestation length	114	
Gestation feed price/ton	$155	
Percent of replacement gilts sold as culls	10%	
Lactation feed price/ton	$195	
Cull sow weight	400 lb	
Cull sow price/cwt.	$50	
Cull gilt weight	300 lb	
Cull gilt price/cwt.	$45	
Sow mortality	3%	
Sow:boar ratio	20:1	
Boar replacement rate	50%	
Boar mortality rate	1%	
Piglet treatment cost	$0.32	
Lactating sow treatment cost	$0.50	
Nursery		
Vaccination cost/pig	$0.70	
Treatment cost/pig	$0.15	
Finisher		
Vaccination cost/pig	$0.70	
Treatment cost/pig	$0.20	
Average slaughter weight	240 lb	
Average slaughter price/cwt	$52	
Finisher mortality	1%	
Feed price input $/ton ($/lb)		
Nursery 1	$1150	($0.575)
Nursery 2	$610	($0.305)
Nursery 3	$320	($0.160)
Nursery 4	$225	($0.1125)
Finisher 1	$205	($0.1025)
Finisher 2	$190	($0.095)
Finisher 3	$185	($0.0925)
Finisher 4	$180	($0.090)

Any partial budget uses the same basic equation:

  increased revenues
\+ decreased costs
– increased costs
– decreased revenues
= change in revenue

Implementing an SEW intervention requires an extensive partial

Table 3

Calculated differences between the scenarios

Gilt pool	Before calculation	Before result	After calculation	After result
Gilt pool size	250× 0.06	**15**	500× 0.06	**30**
Gilt days in gilt pool	15× 365.25	**5479**	30× 365.25	**10,958**
Feed consumed (tons)	(5479× 5)÷2000	**13.70**	(10,958× 5)÷2000	**27.39**
Number of gilts replaced per year	45%× 250	**113**	50%× 500	**250**
Number of cull gilts	10%× 113	**11**	10%× 250	**25**
Gilt purchase costs	0	**$0**	250× 260	**$65,000**
Boar purchase costs	0	**$0**	12× $1000	**$12,000**
Breeding/gestation				
Farrowing interval	4.1+114+24	**142.1**	7+114+10	**131**
% of parity in breeding/gestation	(4.1+114)÷142.1	**83.1%**	(7+114)÷131	**92.4%**
Litters/mated female/year	(365.25÷142.1)× 85%	**2.18**	(365.25÷131)× 85%	**2.37**
Pigs/mated female/year	2.18× 8.84	**19.31**	2.37× 9.22	**21.83**
Number of days in breeding/gestation/year	83.1%× 365.25	**303.52**	92.4%× 365.25	**337.49**
Gestation feed consumed/mated female/year (lb)	5× 303.52	**1517.6**	5× 337.49	**1687.45**
Construction costs	$0	**$0**		**$23,000**
Vaccination cost/ year	2.18× $4.50	**$9.8**	2.37× $4.50	**$10.67**
Number of cull females/year	(250× 45%)	**113**	(500× 50%)	**250**
Number of herd boars	250÷20	**13**	500÷20	**25**
Number of boars purchased/year	13× 50%	**7**	25× 50%	**13**
Number of boars sold/year	7–(7× 1%)	**7**	13–(13× 1%)	**13**
Farrowing				
% of parity in lactation	24÷143	**16.9%**	10÷129	**7.6%**
Number of days in lactation	0.169× 365.25	**61.7**	0.076× 365.25	**27.8**
Lactation feed consumed/mated female/year (lb)	61.7× 10	**617**	27.8× 10	**278**
Construction costs	$0			**$38,000**
Nursery				
Feed consumed/pig (lb)	1.2+12.7+29.0	**42.9**	3.4+5.1+14.1+35.7	**58.3**
Mortality/pig day	1%× 32	**.32**	3%× 46	**1.38**
Number of pigs/mated female through nursery	19.31–(19.31× 0.01)	**19.12**	21.83–(21.83× 0.03)	**21.18**
Feed costs/pig	(1.16× 0.305)+(12.7× 0.16)+ (29× 0.1125)	**$5.66**	(3.4× 0.575)+(5.1× 0.305)+ (14.1× 0.16) +(35.7× 0.1125)	**$9.78**
Number of pigs through nursery	19.12× 250	**4780**	21.18× 500	**10590**
Pig lease payments/breeding female	$0	**$0**	21.1× 5	**$105.75**
Finisher				
Feed consumed/pig	145.8+138.2+163.8+85.2	**533.0**	133.9+173.2+158.6+75.2	**540.9**
Number of pigs marketed/mated female/year	19.31–(19.31× 0.01)-((19.31 –(19.31× 0.01)) × 0.01)	**18.93**	21.83–(21.83× 0.03)-– ((21.83–(21.83× 0.03))× 0.01)	**20.96**
Feed cost/pig	(146× 0.1025)+(138× 0.095)- + (164× 0.0925)+(85× 0.09)	**50.90**	(134× 0.1025)+(174× 0.095) + (159× 0.0925)+(75× 0.09)	**$51.63**
Construction costs	$0		3530× $150	**$529,500**

Table 4

Partial budget reflecting a doubling of herd size and change in weaning age

Partial budget	Calculation	Units	Value/units	Total value
Additional returns				
Gilt pool				
Increased number of culls	((25–11)× 300)÷100	42	$45/cwt	$1890
Breeding				
Increased cull sow sales	((250–113)× 400)÷100	548	$50/cwt	$27,400
Increased cull boar sales	((13–7)× 450)÷100	27	$18/cwt	$486
Finishing				
Increased market hog sales	(500× 20.962× 2.4) –(250× 18.93× 2.4)	13794	$52/cwt	$717,288
Increased premium revenue	(500× 20.96× 2.4)–(250× 18.93× 2.4)	13794	$3.50/cwt	$48,279
			TOTAL	**$795,343**
Reduced expenses				
Farrowing				
Decreased lactation feed	((617× 250)–(278× 500))÷2000	7.625	$195/ton	$1487
			TOTAL	**$1487**
Reduced income				$0
			TOTAL	**$0**
Increased expenses				
Gilt pool				
Amortized gilt and boar purchases	$77,000 × ((1+0.08÷1)–1) ÷(1–(1+0.08÷1)$^{(-3)}$)			$29,879
Breeding stock replacement	250–113	137	$260/gilt	$35,620
Feed	((30× 5× 365.25)–(15× 5× 365.25)) ÷2000	13.7	$155/ton	$2124
Veterinary	250–113	137	$4.00/gilt	$548
Breeding/gestation				
Labor	$35,000–0	$35,000		$35,000
Amortized remodeling costs	$23,000 × ((1+0.08÷1)–1) ÷(1–(1+0.08÷1)$^{(-7)}$)			$4418
Boar replacements	((500÷20)× 0.5)–((250÷20)× 0.5)	6	$1000/boar	$6000
Feed	((1687.45× 500)–(1517.6× 250)) ÷2000	232	$155/ton	$35,985
Veterinary	(500× 2.37)–(250× 2.18)	640	$4.50/parity	$2880
Farrowing				
Amortized construction costs	$38,000 × ((1+0.08÷1)–1) ÷(1–(1+0.08÷1)$^{(-7)}$)			$7299
Piglet treatment	(21.83× 500)–(19.31× 250)	6087.5	$0.32/pig	$1948
Lactating sow treatment	(2.37× 500)–(2.18× 250)	640	$0.50/sow	$320
Nursery				
Lease	(21.83× 500)	10,915	$5.00/pig	$54,575
Feed	(21.83× 500× 9.78) –(19.31× 250× 5.66)			$79,425
Vaccination and treatment	(21.83× 50)–(19.31× 250)	6087.5	$2.25/pig	$13,697
Finisher				
Amortized construction costs	$529,500× ((1+0.08÷1)–1) ÷(1–(1+0.08÷1)$^{(-7)}$)			$101,702
Feed 51.63× 500 50.9× 250	(10590× $51.61)–(4780 × $50.89)			$303,296
Veterinary	(21.18× 500)–(19.12× 250)	5810	$0.90/pig	$5229
			Total	**$717,779**

budget because this management strategy will have an impact on production parameters throughout every facet of production (Table 3). In our hypothetical example, the values in the partial budget are input into this equation:

	$795,343 in increased revenues
+	$1487 in decreased costs
–	$717,779 in increased costs
–	$0 in decreased revenues
=	a change in revenue of $79,051 per year (Table 4)

A Microsoft® Excel™-compatible spreadsheet of this model is available for download at the *SHAP* website: `http://www.aasp.org/shap/v7n1/index.html`.

Sensitivity analysis

Partial budget analysis is a way to assess the profitability of prospective decisions or interventions. However, because it is necessary to make assumptions about the parameters used in partial budget analysis, it is desirable to have additional tools that allow one to accurately assess the impact of these assumptions on the outcome of the partial budget analysis. Sensitivity analysis investigates the effect on overall profitability when one parameter (such as hog price) is varied over a possible range at values while holding the rest of the variables in the analysis constant. Sensitivity analysis thus allows one to explore the robustness of a partial budget outcome—i.e., it allows you to determine how sensitive the results of partial budgets are to the assumptions that go into the analysis. In this example, we performed sensitivity analysis on both parameters directly affected by the planned intervention (PW/MF/Y, N-F F:G), and those factors that can vary independently of the intervention (interest rate and market price) (Figure 1). The lines in Figure 1 with the steepest slopes (PW/MF/Y, N-F F:G) show that relatively small changes in the values chosen for these variables have the largest impact on the projected profitability.

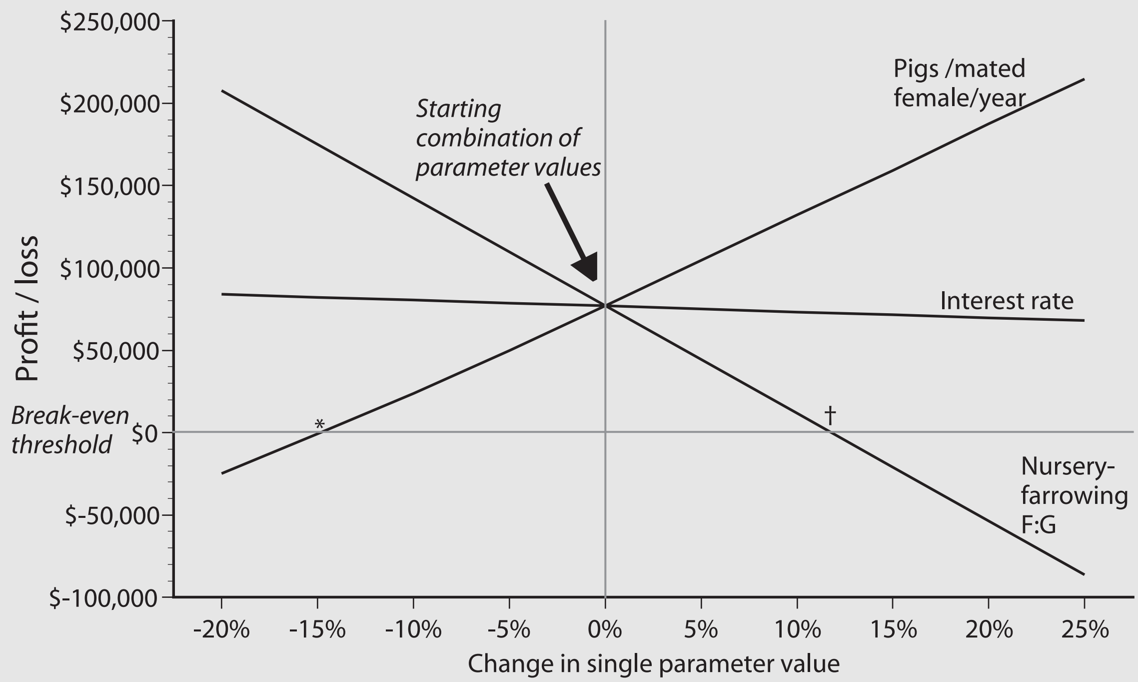
Threshold analysis

A particularly useful variant of sensitivity analysis is threshold analysis. Threshold analysis can address the question of "what is the minimum or maximum level for a particular parameter that will make the planned intervention profitable?" Advanced spreadsheet users may perform this operation by setting the net benefit to zero and solving for each variable of interest in turn. The points in Figure 1 where the lines cross the zero point on the x axis denote the break-even value for that parameter: i.e., the level for a given parameter at which the planned intervention results in neither a profit or a loss (net benefit = 0).

Discussion

Inspection of the increased expense items in this hypothetical intervention indicate that increased feed costs and increased market sales dwarfed other categories of increase or decrease in this example. In our model, the net benefit was most sensitive to market price ($/cwt). Market price has a direct impact on market hog revenues, which was the single largest item in the partial budget. Pigs per mated female per year determines how many pigs are finished per year and thus, not surprisingly, played a major role in predicted total market hog revenues in

Figure 1



Sensitivity analysis for nursery–farrowing F:G, interest rate, and pigs/mated female/year

*,† If pigs/mated female/year is reduced by approximately 15% of its initial value or if nursery–farrowing F:G is increased by approximately 12%, , the change in profit or loss will approach or pass the break-even threshold, making the decision or intervention unprofitable.

our model.

Anticipated profitability will be very sensitive to small changes in values for "big ticket items," such as the components of planned feed expenses (price, quantity) and expected market sales (price/cwt, market weight, premiums). Because these values can have a dramatic impact on the potential profitability of an intervention, great care should be taken in obtaining estimates for these variables, and sensitivity analysis should be carried out over a reasonable range of settings. Conversely, the bottom line is less sensitive to values of components at smaller dollar values, such as interest rate (Figure 1). Thus, "ballpark" estimates for these parameters may be adequate for this and other models.

It is important to keep in mind that our hypothetical example assumed a debt-free situation. Rarely, however, is this the case. The solvency (ratio of debt:equity[1]) of an operation is an important factor in considering the advisability of implementing any management intervention (e.g., implementing SEW and doubling the size of the breeding herd). Lender tolerance for higher debt:equity ratios also varies considerably. Although partial budgets are an important first step in determining the profitability of an intervention, additional means of determining the feasibility of an intervention are necessary. Partial budgeting does not calculate solvency as defined by debt:equity ratio. Solvency and liquidity before, during, and after an intervention should be determined before an intervention is undertaken.

Amortized construction costs (ACC) and interest rate had a minimal impact on profitability in this hypothetical model. For the debt-averse producer, the temptation might be to minimize borrowing in order to minimize interest and principal payments. In doing so, this type of producer may forgo labor-saving investments hoping to increase profitability by decreasing capital expenses. Our partial budget analysis indicates that, at least in some situations, this course of action may in fact decrease profitability. Producers that follow this course may spend too much time completing laborious tasks and would therefore be unable to invest the necessary time to maximize productivity and efficiency in the reproductive herd and the finishing barn. Greater opportunities might be lost if N-F F:G and P/MF/Y suffer than could be realized by decreasing ACC or interest costs.

Producers who undertake leveraged interventions should be aware of the consequences of prolonged periods of low market prices. Risk reduction strategies, such as hedging or contract sales, should be implemented to insure profitability and maintain solvency if low market prices are likely. Risk reduction strategies for N-F F:G should include feed purchasing strategies that reduce overall feed costs as well as management and production strategies that reduce the amount of feed required to produce lean gain. Risk reduction strategies are not necessary for every intervention and should be used at the discretion of the individual producer. Additionally, production and management strategies that maximize P/MF/Y are also necessary to ensure profitability.

Implications

- Partial budgets quickly estimate performance differences and subsequent changes in profitability that result from an intervention by using historical information and projected intervention performance levels.
- Reliability of the analysis is dependent on the reliability of the input estimations.
- Sensitivity analysis allows producers to visualize the effects on profitability if input performance parameters are varied.
- Partial budgeting does not determine liquidity, or the capacity to generate cash to pay debt.

References

1. Boehlje MD, Eidman VR. *Farm Management.* New York, New York: Wiley and Sons. 1984.

2. Wittum TE, Dewey CE. Partial budget analysis of sow *Escherichia coli* vaccination. *Swine Health Prod.* 1996; 4:9–13.

3. Lane DM, Rendleman CM, Ott SL. Using partial budgets to analyze selected management practices associated with reduced preweaning mortality. *Swine Health Prod.* 1997;3:95–102.

4. *Hogs and Pigs Report.* ISDA-NASS. December 18, 1995.

5. Koketsu Y. Influence of feed intake and other factors on lactational and postweaning reproductive performance of sows. 1994. University of Minnesota. PhD Thesis.

6. Drum SD, Walker RD, Marsh WE, Mellencamp MM, King VL. Growth performance of segregated early-weaned versus conventionally weaned pigs through finishing. *Swine Health Prod.* 1998; 6:203–210.