Economics - Part 1:

Economics of PRRSV

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Introduction

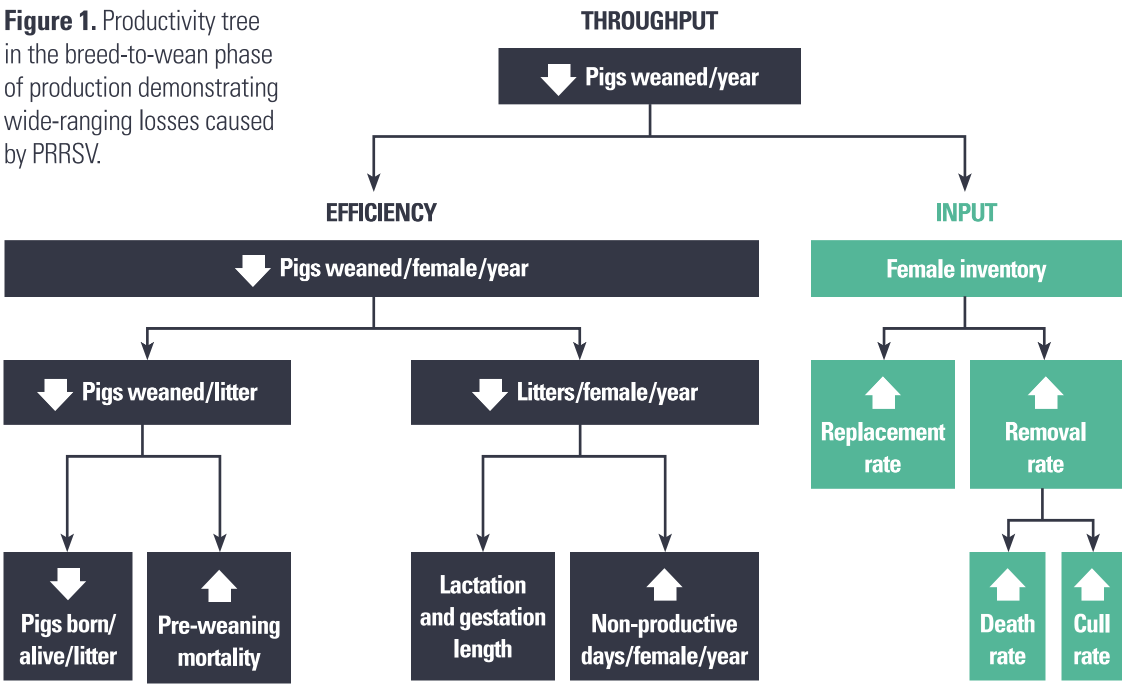
Economic losses caused by porcine reproductive and respiratory syndrome virus (PRRSV) reduce the profitability of individual producers and diminish the global competitiveness of countries in which it is endemic resulting in lower exports, higher imports or both. Understanding and quantifying the economic losses caused by PRRSV is important for making informed decisions about how many resources to spend to reduce those losses. At the national level, that means making informed decisions about how many resources to devote to research and development to advance understanding of the virus and the disease it causes and to develop innovations to combat the virus. For individual producers, it means making informed decisions about how much time, money and effort should be spent on vaccines, biosecurity, antimicrobials and other animal health interventions to reduce the losses associated with PRRSV.

Economic losses caused by PRRSV

Lost productivity is the most significant economic loss associated with PRRSV. One of the reasons PRRSV is so costly is that it causes disease and productivity losses in all phases of production. In the breed-to-wean phase of production, PRRSV results in fewer pigs weaned, and those that are weaned are of lower quality. The losses arise from pregnancy losses, especially late-term abortions, failure to conceive, stillborns, mummies and pre-weaning mortality (Zimmerman *et al.*, 2012). The wide-ranging impact in the breed-to-wean phase of production is demonstrated with the productivity tree in Figure 1. In the wean-to-market phase of production, losses include higher mortality, slower growth and poorer conversion of feed to weight gain. Depending on the availability of space in the wean-to-market phase, slower growth may result in more pigs sold as culls, less pork being sold at a lower average price, due to higher discounts for light weight carcasses, or higher facility costs.

Another reason productivity and economic losses caused by PRRSV are so severe is that the losses extend well beyond the acute phase of outbreaks. Using statistical process control (SPC) in 58 breeding herds that experienced outbreaks, Linhares reported that the median time to baseline production, defined using statistical process control methods to represent time to recover to the number of pigs weaned per week that herds had prior to the outbreak, was 16.5 weeks ranging from 0 to 29 weeks (Linhares *et al.*, 2014). The time to baseline production, in the same study, was associated with whether sows in the herd were vaccinated with a modified live PRRSV (MLV)

Figure 1. Productivity tree in the breed-to-wean phase of production demonstrating wide-ranging losses caused by PRRSV.



Derald Holtkamp (2018)

vaccine or inoculated with live virus from the same herd to establish uniform immunity in the herd. When MLV was used, the median time to baseline production was 10 weeks compared to 21 weeks when live virus was used.

Other economic losses associated with PRRSV include:

Antimicrobials and vaccines
- Increased use of antimicrobials occurs because PRRSV alters immune function in the pig leading to increased susceptibility to secondary bacterial infections
- Increased use of vaccines to control or eliminate PRRSV and other bacterial and viral co-infections

Veterinary services and diagnostic testing
- To develop and execute control or elimination strategies

Biosecurity
- In countries where PRRSV is endemic, investments in biosecurity are frequently made primarily for PRRSV
- Money spent on biosecurity efforts to exclude pathogens may result in benefits for multiple pathogens

Labor
- To execute control and elimination strategies

Another, sometimes overlooked, source of losses due to PRRSV is increased variation. Variation in the number of pigs weaned can lead to a disruption in pig flow resulting in extended times to place a batch of pigs or comingling of pigs from multiple sow farms. In cases where pigs are produced under a production contract, penalties in the contract for delivering too many or too few pigs may also be triggered. Variation in the weight of pigs weaned and average daily gain in the wean-to-market phase may lead to fewer pigs sold at target market weights resulting in higher discounts or lower premiums for lighter carcasses and fewer pigs sold at optimal prices. If facilities are available to allow pigs at the lower end of the weight distribution extra time to grow, losses from selling pigs at lighter weights may be offset but higher facility costs result.

Economic losses due to PRRSV

Estimates of losses due to PRRSV are scarce and results for those that have been done are variable. Estimates made in the last 10 years for several countries in Europe and North America are reported in Table 1. Estimates made for the various countries are for different phases of production and different periods for which losses were estimated and, therefore, are not directly comparable. The losses estimated include the value of lost production in every study. In the Netherlands study, other losses, including higher treatment

Table 1. Recent estimates of economic losses due to PRRSV.

Country	Losses in herds affected by PRRSV (US$)	Type of analysis and number and type of herds included in the analysis	Phases of production and period for which losses were estimated
Netherlands (Nieuwenhuis, *et al.*, 2012)	• $70 to 447[1] per sow $88 in commercial herds[2]	• Longitudinal comparisons (pre versus post) • Estimate for 9 (7 commercial) herds that had outbreaks	• Losses during acute phase of outbreak only • Sow or sow and nursery phase
Denmark (Danish Pig Research Centre, 2012)	• $38 / sow[3]	• Longitudinal comparisons (pre versus post) • Estimate for 6 herds that had outbreaks	• Losses during acute phase of outbreak only • Sow herd only
Denmark (Danish Pig Research Centre, 2012)	• No significant difference	• Cohort comparisons • Estimate for PRRSV positive and negative farms; 510 farms in 2010 and 451 in 2011	• Annual • Sow herd and growing pigs
France (Normand *et al.*, 2014)	• $20 to 74 / sow[2]	• Cohort comparisons • Estimate for 22 PRRSV negative, PRRSV positive stable and positive unstable farms in 2007	• Annual • Sow herd and growing pigs
Canada (Morin *et al.*, 2014)	• $59 / sow space - sow herd plus • $32 / pig space - growing pigs[4]	• Cohort comparisons • Estimate for 78 sow farms, 658 batches of nursery pigs and 720 batches of finishing pigs in 2010 to 2012	• Annual • Sow herd and growing pigs
US (Holtkamp *et al.*, 2013)	• $52 to 143 / sow – sow herd plus • $2.06 to $3.90 / pig – growing pigs	• Cohort comparisons • Estimate for PRRSV negative, provisional negative, positive stable and positive unstable farms; 80 sow farms and 639 batches of pigs in 2006 to 2010	• Annual • Sow herd and growing pigs

[1] Reported loss includes value of lost gilt sales in genetic nucleus herds.
[2] Results were reported in Euros and converted to US$ using an exchange rate of 1.18 US$/€
[3] Results were reported in DKK and converted to US$ using an exchange rate of 0.16 US$/DKK
[4] Results were reported in CA$ and converted to US$ using an exchange rate of 0.81 US$/CA$

costs and lost gilt sales in genetic nucleus herds were also included. Roughly, the combined impact from breed-to-market in commercial herds, ranged from $0 in Denmark to over $200 per year in the most affected herds in the US. Estimates for countries in South America and Asia have not been published.

Economic losses at the national level

Losses due to PRRSV at the national level were estimated in the Canadian and US studies reported in Table 1 by extrapolating estimated losses at the herd level to the national level. The losses for Canada were estimated to range from US$94 (C$ 116) to US$177 (C$ 219) million per year, depending on the percentage of Canadian production sites assumed positive for PRRSV. In the US, the national losses were estimated to be US$664 million per year. Of those, 45% (US$302 million) were due to losses in the breed-to-wean phase of production and 55% (US$362 million) due to losses in the wean-to-market phase.

Estimated losses attributed to PRRSV at the national level are a function of four factors:

1. Distribution of breeding females and growing pigs in PRRSV affected and PRRSV unaffected herds

Herds that are PRRSV negative or where the virus has been successfully eliminated may be considered unaffected by PRRSV. PRRSV affected breeding herds may be impacted differently according to their PRRSV status and outbreak history. Therefore, it is important to make some effort to categorize PRRSV affected breeding herds accordingly. In a country, the distribution of breeding females in PRRSV affected and unaffected herds at a point in time may be measured as the percentage of females in unaffected and defined categories of affected herds. The distribution is affected by the incidence of PRRS outbreaks and efforts made to control or eliminate the virus from herds. In a country, the distribution of growing pigs marketed annually from PRRSV affected and unaffected batches is measured as the percentage of pigs in unaffected and defined categories of affected batches. PRRSV unaffected batches of pigs are those that remain negative from birth-to-market. PRRSV affected batches of pigs may be impacted differently according to when they are infected. The percentage of pigs that are infected with PRRSV prior to weaning will be determined by the PRRSV status of the breeding herd from which they were weaned. For batches of pigs that are negative at weaning, some will remain negative while others will become infected prior to marketing.

2. Productivity of breeding herds and growing pigs in PRRSV affected herds relative to PRRSV unaffected herds

Productivity in breeding herds affected by PRRSV, may be compared to unaffected herds to assess the impact of PRRSV on key production outcomes. Productivity in batches of pigs affected by PRRSV may be compared to the productivity of unaffected batches of pigs to assess the impact of PRRSV on key production outcomes in growing pigs.

3. Pig prices and feed prices

In general, the value of lost productivity is highest when market pig prices are high, input prices and costs are low and raising pigs is highly profitable. Intuitively, as the profitability of raising pigs increases, the value of every pig or unit of pork lost due to PRRSV also increases. Consequently, the value of lost productivity due to PRRSV will increase when raising pigs is highly profitable, independent of how effectively producers and veterinarians are managing PRRSV.

4. Size of the national herd

The value of lost productivity for an entire country may be estimated by extrapolating breeding female and pig level estimates for the value of lost productivity due to PRRSV to all breeding females and pigs raised annually in the country. The bigger the national herd, the greater the losses. Independent of how effectively producers and veterinarians are managing PRRSV, the value of lost productivity due to PRRSV may increase solely because the size of the national breeding herd and the number of pigs raised increased.

The National Pork Board (NPB) funded the US study in Table 1. In 2014, the NPB developed a strategic plan that identified several goals to drive sustainable production. For PRRS, the following goal was established: "By 2020, the NPB will deploy tools and programs to decrease the annual economic impact of PRRS by 20 percent, as adjusted for inflation and measured against the 2012 ["2010 study"] PRRS economic impact baseline study." To monitor progress toward that goal, the NPB funded semi-annual updates of the estimated value of lost productivity in the US swine herd attributable to PRRSV.

For the updates, the four factors that impact the value of lost productivity due to PRRSV at the national level, described above, were monitored (Holtkamp *et al.*, 2017). The contribution of each factor to changes in the value of lost productivity due to PRRSV was assessed independently, by fixing values for all other factors at the levels estimated for the 2010 study, to elucidate why the impact of PRRSV was changing. The cumulative effect of changes in all factors was also estimated to determine the overall impact on the value of lost productivity due to PRRSV. For the purpose of monitoring progress toward the NPB's goal of reducing the impact of PRRSV, changes in the prices and costs as well as the size of the national herd, factors that were not directly influenced by producer and veterinary efforts to manage PRRSV, were fixed at the values used for the 2010 study.

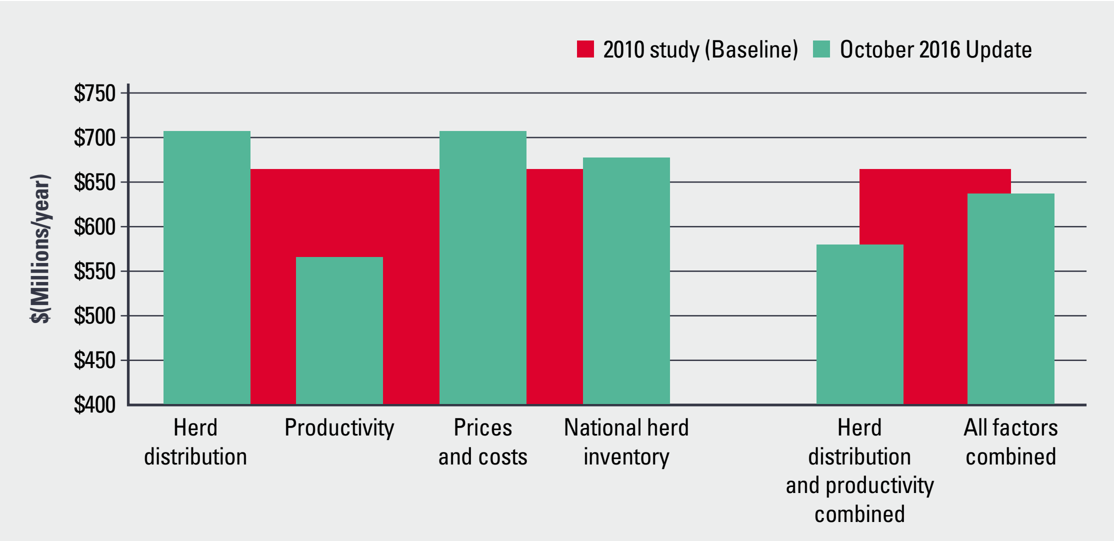
In the most recent update, done for a 5-year period ending in October of 2016, changes in the distribution of PRRSV affected and unaffected herds, prices, and the size of the national herd contributed to an increase in the value of lost productivity due to PRRSV compared to those estimated in the 2010 study (Figure 2). On the other hand, productivity losses in breeding herds in PRRSV affected herds relative to PRRSV unaffected herds has declined, suggesting that producers were doing a better job of managing PRRSV in affected herds, contributing to a decrease in the value of lost productivity due to PRRSV. The incidence of PRRS outbreaks has decreased since the 2010 study which contributed to a significant increase in breeding herds that are PRRS virus positive but have not had an outbreak for at least 12 months. However, a shift favoring control of PRRSV over elimination in breeding herds also occurred since 2010 reducing the percentage of breeding herds that are unaffected by PRRSV. The net effect of these shifts in the distribution of herds was to increase the value of lost productivity due to PRRSV. Since 2010, the size of the national herd has increased and market pig and feed prices resulted in higher profits and, therefore, higher value for production losses caused by PRRSV. The value of lost productivity in the US for all factors combined has declined by $25.7 million to $638.1 million annually (Figure 2). However, when adjusted for changes in market hog and feed prices as well as the size of the national herd, the value of lost productivity declined by $83.3 million to $580.6 million annually.

Economic losses at the herd level

Productivity losses associated with PRRSV depend on the severity of disease caused by the virus. At the herd level, the clinical severity and impact on production is highly variable, from almost no impact to very high losses. Genetic differences in viruses contribute to significant differences in the pathogenicity of the virus and severity of disease (Mengeling *et al.*, 1998). Other factors that may contribute to the severity of clinical outcomes include the genetics of the pig, size of the herd, type of housing and management practices. Therefore, estimates of the production and economic impact of PRRSV on individual herds must be made locally to make informed decision about how much time, money and effort should be spent on vaccines, biosecurity, antimicrobials and other animal health interventions to reduce the losses associated with PRRSV.

Estimating the economic value of production losses attributed to PRRSV involves calculating how costs, revenues and profit change as productivity changes. One approach is to use rules-of-thumb such as; a one percent reduction in wean-to-market mortality is worth $2 per pig marketed. However, rules-of-thumb fail to capture how the value of mortality varies as market hog and feed prices change. A better approach is to use budgeting models. Budgeting models are composed of equations that use entered data; including key productivity indicators, space and flow parameters, output prices and input prices to calculate costs, revenues and profit. Budgeting models are accessible online, such as the economic simulators available through MSD Animal Health. The models, which allow the user to enter farms specific data to compare multiple scenarios, are available through the ResPig® Management System (http://www.respig.com/) and ReproPig® Management System (http://www.repropig.com). A PRRS Economic Simulator

Figure 2. Contribution of each factor to changes in the value of lost productivity due to PRRSV, the cumulative effect of changes in all factors and the cumulative effect of changes in the herd distribution and productivity since the 2010 study.



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(http://test1.007.msd-animal-health.com/Simulator/Index) is also available through MSD Animal Health. The PRRS Economic Simulator combines an epidemiological model, used to estimate annual farm-level losses due to PRRS virus, and a budgeting model to estimate the economic value of those losses. The simulator also estimates the expected reduction in losses when various interventions are applied. The epidemiological model is a stochastic model, which means that a distribution of losses around the average is defined in the model. For each intervention included in the simulator, the expected value of the reduction in losses over 5 years is estimated.

Budgeting models can also be built using spreadsheet programs such as Microsoft Excel®. An example of a simple model built in Excel is shown in Figure 3 (see next page). Cells with a yellow background contain values that are entered. Cells without a yellow background contain formulas that are shown in the last column for the Baseline.

In the example in Figure 3, the value of a reduction in litters farrowed per female per year from 2.29 to 2.25; a reduction in pigs born alive per litter farrowed from 12 to 11.5 and an increase in pre-wean mortality from 12 to 15 percent was estimated. The value of the productivity losses, measured as a loss of profit were US$94,608 for the 1,000 sow herd modelled at the weaned pig price, feed prices and other costs entered into the model.

As the swine industry has consolidated, the stakes involved in making animal health decisions has increased dramatically. A single decision to vaccinate may now be made for millions of pigs. As the stakes have risen, quantifying the economic losses caused by PRRSV is increasingly important for making informed decision about how many resources to spend to reduce those losses. The stakes are just too high to rely on educated guesses and clinical experience alone.

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Figure 3. Example budgeting model for the breed-to-wean phase of production

	Baseline	Scenario	Change from baseline	Formula
Productivity				
Breeding female inventory	1,000	1,000	0	
Litters farrowed/female/year	2.29	2.25	-0.04	
Pigs born alive/litter farrowed	12.00	11.50	-0.50	
Pigs born alive/year	27,480	25,875	-1,605	=B2xB3xB4
Pre-wean mortality (% of pigs born alive)	12.0%	15.0%	3.0%	
Pigs weaned weaned/litter farrowed	10.56	9.78	-0.79	=B4x(1-B6)
Pigs weaned/female/year	24.18	21.99	-2.19	=B3xB8
Revenue				
Value of weaned pig ($/pig)	$45.00	$45.00	$0.00	
Revenue ($/year)	$1,088,208	$989,719	-$98,489	=B19xB$2
Costs				
Fixed costs ($/year)	$408,267	$408,267	$0	
Variable costs				
Breeding herd feed cost/female ($/breeding female/year)	$242.54	$242.54	$0.00	
Annual breeding herd feed cost ($/year)	$242,540	$242,540	$0	=B19xB$2
Creep feed cost/pig ($/pig weaned)	$0.48	$0.48	$0.00	
Annual cost of creep feed ($/year)	$11,608	$10,557	($1,051)	=B22xB9
Annual animal health cost for breeding females ($/breeding female/year)	$25.00	$25.00	$0.00	
Annual animal health cost for breeding females ($/year)	$25,000	$25,000	$0	=B25xB$2
Annual animal health cost for piglets at farrowing ($/pig born alive)	$0.40	$0.40	$0.00	
Annual animal health cost for piglets at farrowing ($/pig year)	$10,992	$10,350	($642)	=B27xB5
Annual animal health cost for piglets at weaning ($/pig weaned)	$1.00	$1.00	$0.00	
Annual animal health cost for piglets at weaning ($/year)	$24,182	$21,994	($2,189)	=B29XB9
Semen, royalties and breeding supplies ($/breeding female)	$25.00	$25.00	$0.00	
Annual breeding cost ($/year)	$25,000	$25,000	$0	=B32xB$2
Wages and benefits ($/hour)	$15.00	$15.00	$0.00	
Hours of labor and management required/breeding female (hours/breeding female)	12.0	12.0	0.0	
Annual labor and management cost ($/year)	$180,000	$180,000	$0	=B36xB35xB2
Other non-feed variable cost ($/breeding female/year)	$100.00	$100.00	$0.00	
Annual other non-feed variable ($/year)	$1000,000	$1000,000	$0	=B39xB$2
Total costs	$1,027,589	1,023,707	-$3,881	=B16+B20+B23+B26+B28+B30+B33+B37+B40
Total costs ($/breeding female/year)	$1,028	$1,024	-$4	=B42/B2
Total costs ($/pig weaned)	$42.49	$46.55	$4.05	=B42/B9
Net profit ($/year)	$60,619	-$33,989	-$94,608	=B13-B42
Net profit ($/breeding female/year)	$60.62	-$33.99	-$94.61	= B46/B2
Net profit ($/pig weaned)	$2.51	-$1.55	-$4.05	=B46/B9

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