Development of a methodology for the standardized economic assessment of SoundTalks for detection and response to a swine outbreak of a detectable respiratory disease outbreak in swine

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Abstract

To quantify the financial value for variable time horizons a standardized economic index (SEI) was developed, including a cost-to-operate (CTO) with a weighted depreciation across a 12.8-year time horizon to demonstrate long-term value consistency at monthly intervals. Major diet ingredient costs, animal market prices (including slaughter plant value matrix), and monthly inflation data for adjustments to some diet components and preparation/delivery fees were included. Where analytic time frames include projected future periods; available futures contract prices for feedstuffs, pork prices and projected monthly inflation data are used. Technology economic effect differences are calculated using a SEI based on a partial budget model. The SEI is a function of animal performance measures, historical feed ingredient costs, animal market prices and the technology CTO. Animal performance measures utilized in the SEI are average daily gain (ADG), feed conversion rate (FCR), average daily feed (ADF), mortality, and individual animal treatments. Historical monthly market prices and feed ingredient costs are obtained for the most recent 12.8-year time period. In addition to hardware installation costs, a weighted hardware lifespan is determined to calculate the depreciation cost for the CTO value. Cost and price data obtained from various global markets is standardized to a base currency using historical exchange rates of relevance to the currency to the analysis recipient, e.g., dollars, euros, RMB or other currencies. To account for the time-value of money and enable more direct comparison of aggregate time-series data, monthly cost data is adjusted for the corresponding monthly inflation rate.

Keywords: respiratory health, mycoplasma, PRRS, cough, economic modeling, benefit-cost ratio

Introduction

Respiratory disease outbreaks continue to be a major pig production problem, impacting antibiotic use, welfare, productivity and profitability (Lopes et al, 2019). While it should be expected that earlier detection and treatment of respiratory disease outbreaks would reduce the negative impact of respiratory disease on pig productivity and financial performance, both earlier detection and earlier intervention (treatment) can be problematic.

Where caregivers are relatively inexperienced the onset of clinical respiratory episodes can be missed until the clinical symptoms increases to more obvious levels over a period of days. Even in situations where experienced and skilled caregivers are overseeing growing pig production sites, these caregivers are not present in the barns continuously and around the clock, also reducing the opportunity for the earliest possible detection of the onset of an episode of clinical disease. Further, important to both of the preceding scenarios, once the onset of an episode of clinical respiratory disease is detected, the interval between detection and executing an appropriate (optimal) intervention response will determine the response as measured by pig and financial performance measures. If the intervention response lags detection, even an intervention of optimal composition progressively and increasingly loses its effectiveness.

SoundTalks (ST) is an audio-based technology that continuously identifies and quantifies respiratory problems in pigs, generating alerts (yellow warnings, red alarms) when respiratory outbreak onset is detected. These alerts have enabled triggering earlier caregiver awareness than caregiver observations alone (Polson et al., 2018). However, further research is needed to quantify the economic impact of this technology.

The objective of this study was to evaluate the post-detection-plus-intervention performance and economic differences resulting from earlier detection of the onset of a clinically detectable respiratory disease episode measured by SoundTalks immediately followed by optimal intervention.

Materials and methods

Disease challenge study

Pigs used for this study were sourced from a PRRS virus negative and *Mycoplasma hyopneumoniae* negative breeding herd. All study pigs were vaccinated with a porcine circovirus type 2 (PCV2) and *Mycoplasma hyopneumoniae* vaccine at weaning (i.e., three weeks of age). Eleven-week-old pigs (n=1655) were allocated to 72 pens targeting 23 pigs per pen across two rooms.

There were three SoundTalks monitor devices per room (airspace), with one ST monitor device covering each of three zones per room. Each ST monitor device was placed two meters above slat-level over the middle of the center alleyway in the center of each designated zone. Each designated zone included 12 pens (six pens on each side of the center alleyway). In between each SoundTalks monitor zone there were two pens intentionally left empty on each side of the alleyway to create an audio buffer "dead-space" between zones to minimize the probability of coughs being detected by multiple SoundTalks monitors in adjacent zones.

Each of the 72 study pens containing 23 pigs. Of the 23 pigs per pen, three randomly selected pigs (13%, 3/23) were designated as seeder pigs and directly challenged at 12 weeks of age (9 weeks post-weaning) for two consecutive days with a virulent wild-type *Mycoplasma hyopneumoniae* (MHPwt) and then challenged seven days later with a virulent wild-type PRRS virus (PRRSwt, RFLP type 1-7-4). The remaining 20 non-directly-challenged pigs per pen were considered contact-exposed pigs over the course of the study period.

Continuous sensor data was recorded at the zone level (e.g., audio, temperature, humidity) and pen level (e.g., water use, temperature). Performance was measured at both the individual pig and pen levels. Individual pigs were weighed at the beginning of the study and every four weeks through the end of the study. Feed disappearance was recorded weekly for every pen. Daily individual pig treatments and mortality were also recorded. Pig carcass weights and the processing plant carcass discount-premium matrix were obtained.

There were three study groups, defined as: SoundTalks (ST) alert day zero (G0), day 5 (G5) and day 10 (G10). Alert day 0 was defined as the day that the first ST yellow/red alerts were reported post-challenge. All pigs received the same treatment protocol – differentiated only by the date the treatment protocol was started. Group ST-G0 received the intervention beginning the day of the first actionable SoundTalks alert. Subsequently, groups ST-G5 and ST-G10 received the same intervention at ST alert day 0 + 5days and ST alert day 0 + 10 days, respectively.

To represent the impact of a more natural (contact) exposure and infection dynamic under routine operational conditions, performance data for contact challenged pigs that did not experience exceptional handling (e.g., did not experience individual snaring, bleeding, tracheal catheterization) were used for the standardized economic analysis.

Standardized economic analysis

Economic differences among treatment groups were calculated using a "Standardized Economic Index" (SEI) approach based on a partial budget spreadsheet model. The SEI is a function of finished pig performance measures, historical feed ingredient costs, historical market pig prices, historical inflation rates, processing plant carcass discount-premium grid and the calculated cost-to-operate (CTO) of the technology being evaluated.

CTO is a function of the initial technology purchase and installation costs (materials, labor) depreciated over the weighted estimated life-span of the technology hardware plus any recurring costs (software subscriptions, electrical power consumption costs). Charges for the technology (inclusive of installation and recurring costs) are accrued daily by and assigned to a group of pigs from the time they enter the technology-enabled facility (site-barn-room) until the last pig of that group is sold and the site is emptied. This cost is expressed as a cost per pig sold (or cost per unit of sold weight). One nuanced caveat with the CTO cost accrual by a group of pigs would be accounting for the daily depreciation and recurring costs during the interval between the last pig of a prior group exiting the site until the first pig of the subsequent group enters the site. A logical way to account for this period would be to estimate the inter-group (close-to-place) interval and assign that cost to either the group that just previously closed out or to the new group subsequently starting on feed.

Pig performance measures utilized in the SEI were average daily gain (ADG), feed conversion rate (FCR), average daily feed (ADF), mortality, and individual pig treatment cost. Historical monthly market prices and feed ingredient costs were obtained for a roughly 31 year period from January 1992 through October 2022 (USDA Quick Stats, USDA-NASS). Historical monthly inflation rates were also obtained and used to adjust non-protein and non-energy feed cost components (US Inflation Calculator, Coin News Media Group). The most recent 12.8 year (154 month) time period (January 2010 through October 2022) was used as the focus of the economic analysis using the most current data available. In addition to hardware installation costs (labor and materials), a weighted SoundTalks hardware lifespan of 48 months was used to calculate the hardware cost on a per pig marketed basis for inclusion in the CTO.

A sensitivity analysis was conducted by constructing a 3 x 3 table (nine combinations) where the X-axis was pig live market price (USD per kg live body weight) and the Y-axis was diet cost per metric ton (USD per 1000 Kg complete diet). The pig price middle value was the calculated average of the 154 historical monthly market price values from January 2010 through October 2022 (12.8 years). The pig price lower and higher sensitivity matrix values used were calculated as the 99% lower control limit (LCL) and 99% upper control limit (UCL) from the 154 months of historical data for the same period.

The diet cost per metric ton middle value was the calculated average of the 154 historical monthly cost values from January 2010 through October 2022 for:

- Number two yellow corn as the primary dietary energy source
- 44% soybean meal as the primary dietary protein source

Non-energy and non-protein ingredient cost estimated were obtained (Tokach, *personal communication*) and were adjusted across the 12.8 year period using monthly US inflation rate (i.e. Consumer Price Index (CPI)) data. The fee for finished diet preparation and delivery (GMD) was obtained (Hoek, *personal communication*) and was also adjusted across the 12.8 year period using monthly US inflation rate data. Typical grower-finisher pig diet formulations were obtained (Tokach, *personal communication*), and utilized the aforementioned ingredient and GMD costs to calculate an average diet cost per metric ton representing the 154 month period. The diet cost lower and higher sensitivity matrix values used were calculated as the 99%

lower control limit (LCL) and 99% upper control limit (UCL) from the 154 months of historical data for the same period.

Results

Disease challenge study

After the seeder pig dual challenge (*Mycoplasma hyopneumoniae* followed by PRRS virus), two respiratory outbreaks caused by swine A influenza virus (IAV-S) were documented during the study period. All pigs and pens were treated according to the study design.

Contact-challenged pigs from G0 had 12.7 and 20.4 grams higher ADG compared to those from G5 and G10 respectively. Similarly, contact-challenged pigs from G0 had a 23.4% and 10.1% decrease in individual treatments when compared to G5 and G10 respectively. Contact-challenged pigs from G0 had a 0.26% higher and 1.22% lower percent mortality compared to those from G5 and G10 respectively. All production variables were introduced into the SEI model.

Standardized economic analysis

Throughout the 154-month period from January 2010 through October 2022, based on a CTO of USD $0.254/pig marketed (inclusive of installation, hardware, and software subscription for a 4800 head grow-finish site) the mean monthly B:C ratio was 6.51, ranging from 3.89 to 11.28. The B:C Ratio (G0 vs G5) exceeded 2:1 for 154 of 154 (100%) months and exceeded 4:1 for 153 of 154 (99.4%) months. For the same 154-month period, the 48-month rolling B:C Ratio (G0 vs G5) ranged from 4.91 to 7.45, exceeding both 2:1 and 4:1 for 154 of 154 (100%) intervals.

When a higher CTO of USD $0.303/pig marketed (inclusive of installation, hardware and software subscription for a smaller single barn 1200 head grow-finish site) is used for the same 154 month period, the mean monthly B:C ratio (G0 vs G5) was 5.47, ranging from 3.27 to 9.47. The B:C Ratio (G0 vs G5) exceeded 2:1 for 154 of 154 (100%) months, and exceeded 4:1 for 138 of 154 (89.6%) months. For the same 154-month period, the 48 month rolling B:C Ratio (G0 vs G5) ranged from 4.13 to 6.26, exceeding both 2:1 and 4:1 for 154 of 154 (100%) intervals.

For the sensitivity analysis of the nine combinations of pig market price and diet cost (based on the 99% confidence limits), the middle market price ($1.322/kg) and diet cost ($55.14/1000kg) generated a benefit:cost estimate of 4.17 where a denominator cost of $0.254 for SoundTalks was used, reflecting the technology and installation cost per pig marketed for a 4800 head grow-finish site. As would be expected, the lowest benefit:cost (3.79) occurred where the market price was lower ($1.269/kg) and the diet cost was higher ($270.77/1000kg), and the highest benefit:cost (4.55) occurs where the market price was higher ($1.376/kg) and the diet cost was lower ($239.52/1000kg).

When a denominator cost of $0.303 was used (reflecting the cost per pig marketed for a single-barn 1200 head grow-finish site), the middle market price ($1.322/kg) and diet cost ($255.14/1000kg) generated a benefit:cost estimate of 3.50, with the lowest benefit:cost (3.18) occuring where the market price was lower ($1.269/kg) and the diet cost was higher ($270.77/1000kg), and the highest benefit:cost (3.82) occuring where the market price was higher ($1.376/kg) and the diet cost was lower ($239.52/1000kg).

Discussion and conclusions

The results of this study and the standardized economic analysis suggests that there can be a consistent and long-term favorable economic impact based on aggregate performance differences using a technology that enables earlier detection and treatment intervention.

Earlier alerts of the onset of clinical disease episodes, in and of themselves, do not have a direct positive impact on the course of disease in affected pigs. Alerts can only provide the producer the opportunity to take the most appropriate action to mitigate and resolve the developing clinical disease episode, i.e., knowledge requires informed action to generate value. As soon as meaningful alerts are observed, only immediate and optimal interventions taken by the pig producer will enable capturing the value potential enabled by any detection technology that provides early alerts of disease episode onset.

An obvious advantage of evaluating the benefit:cost using actual historical pig/pork market prices and major feed input costs instead of a traditional analysis using more subjective, artificially constructed market price and input cost combinations is that financial impact can be evaluated based on real (and realistic) combinations of cost inputs that reflect prior experience as well as current conditions. To account for expected and emerging market conditions, further development of the SEI method will include incorporation of forecasting based on available futures contracts for pork and the major feed ingredients as well as the ability to generate stochastic output distributions and confidence limits around future projected time series.

Partial budgeting and related decision analysis methods applied to agriculture and livestock production have been described and used for many decades (Boehlje and Eidman, 1984) and have been long applied to pig/pork production (Polson, 1989). Partial budgeting is a relatively frequently used method for deterministic economic analysis (Polson et al, 1992; Polson et al, 1993; Dee et al, 1996; Dee et al, 1997; Holck and Polson, 2003; Nathues et al, 2017) and is also used, albeit less frequently, as a method for stochastic economic analysis (Jerlstrom et al, 2022). However, the authors are not aware of the use of the partial budgeting method utilizing a continuous time series and inflation adjusted input costs (e.g., feed), a depreciation-based cost-to-operate, as well as a time series of revenue data in this standardized approach. Several enhancements of the SEI method are in-process and planned but are beyond the scope of this study and paper.

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