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Stakeholder-driven modelling the impact of animal profile and market conditions on optimal delivery weight in growing-finishing pig production

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ABSTRACT

Pig delivery weight optimisation (PDWO) has been studied extensively and has resulted in several optimisation models. A previous participatory analysis of the problem has revealed that existing models are too complex and might therefore be under-valorised. Farmers desire a simple but reliable model based on available farm data to learn about the problem. A spreadsheet simulation model was therefore developed based on empirical animal performance models. The present study aims at conceptualising a stakeholder-driven model concerning PDWO that should provide insights into four key questions: I) how do the driving forces behind the optimisation determine the optima, II) what is the dependency of the optimal delivery weight on market conditions, III) how do the opportunity costs due to suboptimal delivery evolve, in addition to the mere optimisation results and IV) what is the effect of differences in animal performance profile, in terms of growth, feed intake and average carcass quality on the optimal delivery results? The results generated by the simulation model generally align with those generated using more sophisticated modelling approaches in previous studies. Our results indicate that the animal's growth and feed intake profile can more importantly affect the location of the optima, the stability of the optima and economic importance of delivery weight optimisation compared to market conditions. Moreover, the effect of market conditions on the optimisation was dependent on the animal profile, which determines the flatness of the payoff curve per pig. The possible flat payoff curves imply that the benefits of accurate PDWO can be limited and that some error margin in decisions on PDWO can be exploited. Moreover, this finding illustrates and corroborates the increased benefit of a shift in technology, i.e. an improved animal performance, compared to striving for the optimum on the production function of an inferior technology. Using this simplified model, farmers can investigate the flatness of their farm-specific payoff curve and the stability of their farm-specific optima. That information may help them to determine the appropriateness of a robust decision-supportive rule about optimal delivery weight on their farm.

1. Introduction

In order to improve their enterprise's profitability, pig producers strive for improved efficiency of production through optimisation of their management. Optimisation of slaughter management (decisions on slaughter weight and timing of slaughter) has been the subject of many studies. This subject is explored indirectly in studies focusing on the determination of the correct decision rule for profit maximisation per unit of time from batch production (Heady et al., 1976; Kawaguchi and Kennedy, 1989) as well as directly in studies exploring the integrated optimisation of feeding and slaughter decisions (Boland et al., 1993; Chavas et al., 1985; Jolly et al., 1980; Niemi, 2006; Niemi et al., 2010) and studies on the optimisation of delivery strategies for heterogeneous herd (Boys et al., 2007; Kristensen et al., 2012; Kure, 1997).

Despite the wealth of insights generated in those studies, the industry is again requesting investigations into the optimal delivery weight problem. This renewed interest can have a two-fold reason: I) a dynamic and spatially situated decision context and a changing production process and II) a lack of practical valorisation of existing insights. First, the context and production of pigs has changed. Pricing schemes and market conditions can differ between different regions and have changed over time, which may imply a need for updated delivery weight information. Genotypes have also been improved by genetic selection and alternatives for surgical castrated males, i.e. intact and GnRH-vaccinated males, are increasingly applied as a response to

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welfare concerns. These societal concerns on animal welfare and abatement of the ecological impact of pig production lead to increases in cost of production (Sørensen et al., 2006). In addition, globalization and liberalisation of markets has increased the level of competition in pig production, which puts pressure on the profitability. As a consequence, farmers may perceive an increased need for optimisation to safeguard their profitability. The second explanation for the renewed interest in pig delivery weight optimisation (PDWO) might be the incomplete valorisation of existing research insights in practice. This is also described as the implementation gap that decision support systems based on complex but accurate models often face (McCown et al., 2009). This incomplete valorisation may be related to the approach to handle the delivery weight problem. Researchers' strategy has been to examine the total complexity inherent to the optimisation problem and then attempt to capture it fully in a model that does not always align with the way the farm managers experience the problem. Moreover, these models often require data that are unavailable on-farms. As such, some theoretical control variables cannot be fully controlled: because this requires complete, accurate and timely information and most farmers cannot yet collect or manage all of that data (Black, 2014).

In a participatory decision problem analysis dedicated to the optimisation of pig delivery weights, Leen et al. (2017a) investigated how stakeholders from the industry perceived this problem, what they considered as control variables and what they desired from model-based support. Although stakeholders acknowledged that PDWO is affected by a complex multitude of factors and processes, as identified in scientific literature, they requested to focus only on a set of basic factors to develop a straightforward simple simulation model. Moreover, they explicitly asked to refocus from routine and accurate decision support to enable the farmers to learn from basic key insights on PDWO, obtained with the simulation model. An example of complexity that was left out under impulse of the stakeholders is the integrated optimisation of feeding and slaughter decisions which assume that growth rate and carcass quality can be fully controlled. In practice, however, farm managers usually have incomplete control over carcass quality and growth rate, since precision livestock farming is not yet current practice on most farms. Additionally, there are no affordable on-farm estimation protocols for the parameters needed in mechanistic growth models, such as: maximal protein deposition, maintenance energy requirements and partitioning energy available for growth over protein and fat deposition (Schinckel and De Lange, 1996).

The present study seeks answers to several related questions: What can be learned if the delivery weight optimisation problem is approached starting from the way the farm managers experience the problem? Which insights into the delivery weight optimisation would be obtained and would they align with those of previous studies? To which extent can the optimisation model be simplified while still providing meaningful insights for the farm manager? In this study we build upon the participatory decision problem analysis by Leen et al. (2017a), in which the need was defined for a straightforward PDWO model to support learning instead of routine decision support. The present study aims at conceptualising a stakeholder-driven model concerning PDWO that should provide insights into four key questions: I) how do the driving forces behind the optimisation determine the optima, II) what is the dependency of the optimal delivery weight on market conditions, III) how do the opportunity costs due to suboptimal delivery evolve, in addition to the mere optimisation results and IV) what is the effect of animal profile and differences in animal performance on the optimal delivery results? The model and its answers to the four questions are presented and the results are compared to those obtained with more complex models to seek confirmation of the produced insights.

2. Materials & methods

2.1. Outcome of the participatory decision problem analysis as a starting point

The aim of the participatory problem analysis was to get a clear understanding of the practical decision context of the delivery weight decision (Leen et al., 2017a). In that process stakeholders were involved in reframing the decision problem, i.e. listing the crucial factors and processes to be modelled and the questions to be answered. This analysis revealed that the consulted stakeholders' priority was not to increase the level of detail and model sophistication to further improve the accuracy of the model's results. Their priority was to get a relatively simple model, enabling the farmer to use the limited amount of available on-farm data to obtain farm-specific insights and learn about key issues in the delivery weight optimisation problem. The model should consider 1) pig prices and the dynamics in carcass weight based premiums and discounts, 2) piglet prices, 3) feed prices, 4) evolution in feed efficiency, 5) evolution in daily growth rate, 6) sex of the pig and 7) flexibility in feeder piglet supply (Leen et al., 2017a). Moreover, the model should consider a context with very limited data collection on production performance indicators (i.e. no on-line weight and feed intake registrations) during pig finishing and a two- or three-phase ad libitum feeding regime with predetermined phase transitions based on purchased compound feed. Furthermore, in the participatory DPA it was agreed with the stakeholders to focus on simulations that provide insight in the strategic and tactical organisation of the pig farm concerning PDWO. The reason is that on these longer term management levels, decisions are made (e.g. facility design and piglet supply scheme), that affect PDWO through the constraints posed on the maximal finishing duration per batch. Moreover, decisions at these long(er) term management levels take more time before they can be remediated (Huirne, 1990).

2.2. Brief overview of the spreadsheet optimisation model

The simulation model was built in Microsoft Excel (version 2016) (Microsoft, Redmond,WA, USA) and requires limited data on animal performance, i.e. growth and feed intake and average carcass quality (see below) and mortality. These data are then used to estimate empirical growth and feed intake curves. Some barn management features are also required, such as the timing of feeding phase transitions and the idle time between two consecutive production cycles. This animal and management information is combined with prices for inputs and outputs to obtain calculations on revenues and costs. The model approaches the decision problem at the tactical level and not on the operational level on which decisions to market pigs are made at a weekly or daily basis. As such the model provides information on the optimal organisation of the farm's production scheme, i.e. number of feeder piglets required over a longer period of at least one to five years. This tactical orientation, assumes the defined animal performance as the average expected performance for the longer time period. Additionally the tactical orientation requires longer term average expected prices for inputs and outputs. In this study five year average prices over the period 2011–2015 in Flanders were used. Pig production is a continuous batch operation, thus optimisation needs to be executed per unit of time and not at batch level. Therefore the opportunity cost of replacement (OCR), i.e. the trade-off between extending a current batch versus starting the next batch should be taken into account (Kawaguchi and Kennedy, 1989). Therefore, fluxes of in- and outputs are calculated per finishing pig place per year for each day in the production cycle.