Decision support tool for replacement heifer management: A strategy comparison

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Abstract
The objective of this paper is to introduce and illustrate the application EkonMOD milk, the decision support tool concept for dairy farm managements. The purpose of this simple web-based application is to assist dairy farms managers to better understand the dynamics of the dairy herd structure and to improve economically sensible decision-making abilities in Slovak conditions. The application firstly helps dairy farmers to calculate the potential production and economic impact of different scenarios at the farm-level, in the terms of alternative what-if analyses comparison. Secondly, it takes into account the farm specific characteristics, unique limitations or weaknesses. The versatility of the core application offers potential use in numerous areas including optimal replacement heifer management or feeding strategies evaluation. When heifers calve at ages greater than optimum, larger inventories of heifers must be maintained in the young female bovine herd. Increasing the age at calving also increases the generation interval, delaying the introduction of genetically superior replacements in the herd. If the annual replacement rate of first lactation cow in the EkonMOD milk tool is set to 35%, and 25 % for remaining stages of lactations in a 300 head herd, a minimum of 170 heifers are needed in the pool, assuming a 4% attrition factor for stillbirths, 100 % dairy cow natality, 5 % mortality of calves. With selection of calves indicator set to 4 %, 50 % ratio of heifers born, heifer selection at 20 %, culled cows that die before disposal set to the value of 20 %, approximately 64 pregnant heifers are needed. For every one month increase in the age at calving over 24 months, the replacement inventory numbers are increasing at a rate of 4.7% in this model. This figure takes into account the inventory of heifers from birth until calving.

Keywords: age at first calving, replacement heifers, culling rate, decision tool

JEL Classification: Q120

Introduction
A major cost for dairy operations is obtaining a sufficient supply of healthy heifers needed for replacements. The majority of milk producers prefer raising future dairy cows on their own, instead of purchasing replacements. The second alternative may become attractive for some producers, especially in the case of external herd expansion or reorganization of dairy unit according to the farm management decision. Selecting the most efficient source of replacement heifers has important implications for optimal resource management, profitability and sustainability of dairy operation, when reflecting the global milk price volatility, ongoing structural changes and geographical relocation in the most productive regions at both, European union and world level. Key factors to consider when determining an optimal herd replacement strategy include financial market indicators, feed costs, labor costs, reproductive rates and specific limitations and business plans of a unique dairy operation. Evaluation of all inputs and outputs relevant to the raising process, with respect to the biological nature of the production and environmental restrictions, can help to determine the optimal rearing strategy and consequent breeding goals. Considering these circumstances will determine the difference between profit and loss in selected period of time. Therefore, producers must be flexible and able to modify herd replacement strategies as needed to
take advantage of changing conditions. One of the biggest expenses incurred on the dairy is replacement heifer rearing. The feeding costs during this nonproductive life represent the fixed costs for dairy operation and may account for up to 20% of the total farm expenses (Bailey et al.) Feeding schemes for dairy cattle should be specifically formulated for weight gains during strategic time periods of development, but over-feeding prior to puberty can be detrimental to milk production. In addition to this, the average weight is more critical than age at calving in relation to milk production, therefore replacement heifers can be adequately developed to calve at 24 months, while decreasing expenses and increasing profits (Bailey et al.). Another important management agenda connected to profitability is feed costs optimization. Feed is generally the greatest expense for milk production. With volatility in feed and milk markets, income over feed cost (IOFC) is a more advantageous measure of profit than simply feed cost per cow (Buza, 2014). Optimal feeding strategies related to the unique herd specification represent the key role in efficient and profitable dairy operations. In this paper we reflect on our experiences in developing and delivering management decision tool for dairy farmers in Slovak conditions.

Data and Methods

The application EkonMOD milk, the decision support tool concept for dairy farm managements is used to evaluate the economic consequences of different on-farm strategies. The selected module Number of heifers needed for replacement was developed to raise the awareness about replacement heifer rearing costs and it is used in this paper as a tool to evaluate specific economic and production parameters of a user specified dairy operation. EkonMOD milk is developed in SAP Business Objects Dashboards (version 4.1) and was developed by National agricultural and food centre in Nitra. The core of the application consists of a main Microsoft Excel input and output worksheet, containing basic algorithms and formulas for computing selected farm specific economic and performance outputs. The interactive dashboards are used to illustrate the impact dynamics of the changed variables and they represent the visual add-on to the Excel core application. The tool combines inputs and transforms them into information source - output for farmer by operative construction of economic a production model from individual farm data. The concept builds on user friendly format, with no extra timely demands on farm management. The most of the inputs to the model are easily inserted by sliding bars and filters. The application consists of specific modules focusing on selected key processes on dairy farm. It has a web-page interface to the users, with an idea to spread this approach on all types of animal production present in Slovakia. No input model data would be archived or maintained by the administrator of the dedicated EkonMOD milk tool web page. Once downloaded, no internet connection is needed to running various what-if scenarios against. The idea of constructing this application arises from detailed and long run cooperation with dairy farms in Slovakia, focusing on economic a production analysis, guidance and consultancy. The previous data mining showed a significant difference in dairy operations in terms of scale and number of production units within one single dairy operation. Different husbandry systems, management techniques and number of other individual characteristics connected to the region of production, types of ownership and crop production are present, as well. Development of the tool that can be easily fitted to any dairy farm is being debated with farmers continuously. Number of heifers needed for replacement will be calculated by EkonMOD milk using several herd specific metrics: culling rate indicator (CR) for first lactation cows set to 35%, and 25% for remaining stages of lactations in a 300 head herd (H), a minimum of 170 heifers are needed in the pool, assuming a 4% attrition factor for stillbirths (SB), 100%
dairy cow natality (N), 5% mortality of calves (M). With selection of calves indicator (CS) set to 4%, 50% ratio of heifers born (HB), heifer selection (HS) at 20%, culled cows (CC) that die before disposal set to the value of 20%, average age at first calving (AFC) 24 months. Average culling rate (ACR) reflects culling rates on first and next lactations. Herd size (H) include first stage lactating cows as well as cows on next lactations. First, heifers needed in replacement pool (HN) are determined by the formula (1), containing the number of heifer from birth till calving in two year period. Finally, deficit or surplus heifer annually to maintain constant herd size (HA) are quantified by formula (3).

\[
(H \times ACR) \times 2 \times \text{AFC/24} \quad (1)
\]

\[
H \times \text{SB} \times M \times CS \times HB \times HS \quad (2)
\]

\[
HP - (HN/2) \quad (3)
\]

If this metrics and ratios remain consistent, after one year’s time they would have 20 heifers more than what they would need as replacements. This gives them options to increase herd numbers, change culling schemes, or sell surplus heifers on the market. The application offer a graphical interpretation of this formulas and allow to change input variable in the terms of possible or planned on-farm scenarios.

**Results and Discussion**

Economic efficiency of dairy cattle husbandry depends on the timely and proper utilization of biological fixed assets, namely cows (Genchev and Angelova, 1984). With this regard, the replacement heifer program is particularly important, and its primary goal is to breed these animals at an early age with optimal body weight to achieve easy calving with minimum investments (Fricke, 2004). Dairy farmers face a complex dilemma in minimizing costs associated with rearing heifers while ensuring or enhancing lifetime economic productivity. Decisions about heifer management interact with underlying biological aspects of growth, thereby influencing future profitability of the herd (Mourits et al., 1999). A basic approach to reduce costs is to shorten the nonproductive period of dairy heifers, which can be accomplished by breeding heifers earlier to reduce the age at first calving (AFC; Abeni et al., 2000; Daniels, 2010). Many studies suggest that the optimal AFC is ≤24 mo (Mourits et al., 1999; Gabler and Heinrichs, 2003; Shamay et al., 2005; Stevenson et al., 2008). However, most of those researchers based their conclusions on milk production rather than whole economic measurements. Ettema and Santos (2004) found that only 2.7% of US Holstein dairy farms achieved the recommended targets of AFC ≤24 with liveweights ≥560 kg. The tendency for additional returns from higher number of newborn calves was also confirmed in sheep by Bonev and Kostadinova (2011). Fricke (2003, 2004) proved that the delay in age at first calving in heifers generated additional costs from higher culling rate, dystocia, and metabolic disturbances. According to the author, the optimum age at first calving of heifers was 24 months. Calving heifers at an older age has many disadvantages other than increasing their nonproductive life and delaying potential milk income. When heifers calve at ages greater than 24 to 25 months, larger inventories or numbers of heifers must be maintained in the heifer herd. Increasing the age at calving also increases the generation interval, delaying the introduction of genetically superior replacements in the herd (Bailey et al.). If the annual replacement rate of first
lactation cow in EkonMOD milk toll in Figure 1 is set to 35%, and 25% for remaining stages of lactations in a 300 head herd, a minimum of 170 heifers in the pool, assuming a 4% attrition factor for stillbirths, 100% dairy cow natality, 5% mortality of calves. With selection of calves indicator set to 4%, 50% ratio of heifers born, heifer selection at 20%, culled cows that die before disposal set to the value of 20% and average age at first calving (AFC) 24 months, proximately 64 pregnant heifers are needed (Figure 2). When calving is delayed to an age greater than 24 months, heifers are accumulating in the replacement pool. For every one month increase in the age at calving over 24 months, the replacement inventory numbers are increasing at a rate of 4.7% in this model. This figure takes into account the inventory of heifers from birth through calving. Therefore, if a herd is calving 28 month old heifers with an average culling rate of first lactation cows 35% and remaining cows in herd with 25%, the number of replacement heifers on the farm is now increased from 170 to 199 heifers (Table 1). This equates to 29 additional heifers or an increase of 17% in the total number of heifers consuming feed, labor, fuel, facilities, and management. The tables below demonstrate the increase in heifers needed at various culling rates (Table 2) and the relationship between the culling rate, age at first calving, and increasing heifer inventory (Table 3). Calving older heifers is subtracting dollars from profitability. Producers should raise only the number of replacement heifers needed, unless the additional heifers will be marketed (Bailey et al.).

**Figure 1: EkonMOD milk model calibration**

![EkonMOD milk screenshot](image)

Source: EkonMOD milk screenshot, inputs inserted by author

**Table 1: Increased number of heifers needed in replacement pool for each age at calving**

<table>
<thead>
<tr>
<th>Number of Cows in Herd</th>
<th>24 months</th>
<th>26 months</th>
<th>28 months</th>
<th>30 months</th>
<th>32 months</th>
<th>35 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>300 cows</td>
<td>170</td>
<td>185</td>
<td>199</td>
<td>213</td>
<td>227</td>
<td>249</td>
</tr>
</tbody>
</table>

Source: Table adapted from Bailey et al., own calculations
Note: Total heifer inventory numbers for varying herd sizes at a 35% replacement per year for first lactation cows and 25% replacement per year for cows at remaining lactation stages. Other rearing parameters are taken from the following assumption: 4% stillbirths, 100% dairy cow natality, 5% mortality of calves, selection of calves 4%, 50% ratio of heifers born, heifer selection 20%, culled cows that die before disposal 20%.

Table 2: Total number of heifers needed per 300 cows for various herd culling rates

<table>
<thead>
<tr>
<th>Culling Rate</th>
<th>Heifers Needed in Replacement Pool</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>151</td>
</tr>
<tr>
<td>33</td>
<td>155</td>
</tr>
<tr>
<td>35</td>
<td>159</td>
</tr>
<tr>
<td>37</td>
<td>163</td>
</tr>
<tr>
<td>40</td>
<td>167</td>
</tr>
</tbody>
</table>

Source: Table adapted from Bailey et al., own calculations

Note: Calving at 24 Months of Age. Other rearing parameters are taken from the following assumption: 4% stillbirths, 100% dairy cow natality, 5% mortality of calves, selection of calves 4%, 50% ratio of heifers born, heifer selection 20%, culled cows that die before disposal 20%.

Table 3 Total heifers needed* in replacement pool

<table>
<thead>
<tr>
<th>Culling Rate</th>
<th>(Increase in heifer pool numbers over 24 month calving age *)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>161 (41^) = 202*</td>
</tr>
<tr>
<td>33</td>
<td>167 (42^) = 209*</td>
</tr>
<tr>
<td>35</td>
<td>171 (43^) = 214*</td>
</tr>
<tr>
<td>37</td>
<td>175 (45^) = 220*</td>
</tr>
<tr>
<td>40</td>
<td>181 (46^) = 227*</td>
</tr>
</tbody>
</table>

Source: Table adapted from Bailey et al., own calculations

Note: Increase in heifer replacement numbers for various culling rates in 300 cow herd: First calf heifers calving at 30 months.

The current research indicates an average cost to raise a heifer 1824 € (Michaličková et al.) A herd of 300 lactating cows with a culling rate of 35% will need to calve 88 heifers per 12 months. If the average calving age is 30 months, the increase in expenses is approximately 540 € per heifer for those 6 months over goal. This transforms to 47,520 € loss per year in extra labor, feed and fuel. An additional loss in calving heifers at more than 24 months of age is the increase in heifer inventory numbers (Table 2). If producer A is calving heifers at 24 months of age per 300 cows and producer B is calving at 30 months of age, producer B will have additional heifers in his replacement pool to meet the same culling rate as producer A. The higher AFC accumulates the heifers in inventory. For each additional month over goal of 24 months, 4.7% more heifers are needed in replacement inventory in this model. If producer A needs 171 heifers in his heifer inventory for a 24 month turnover of heifers (from born to calving). Producer B, to meet the same culling rate, will need 214 heifers on his farm. These 43 additional heifers are unnecessarily consuming feed and management (Table 3). Returns from this period down to 24 months could also represent generated income. If the age at first calving is reduced from 30 down to 24 months, the dairy could expect these additional heifers for potential sale, growth, or culling pressure on the lactating herd. This scenario means that in the first two years heifer development is emphasized, expenses in feed and management are decreased by 47,520 € per year, and 53,750 € worth of
heifers are sold, bringing the total potential income for those two years to 101,270 € (Table 4). Dairymen should not anticipate reducing the age to calving in several months, as experience indicates that it takes at least 18 to 24 months to decrease age at calving to a goal of 24 months (Bailey et al.)

**Figure 2: EkonMOD milk result dashboard**

Table 4: Economic impact of changed input variables

<table>
<thead>
<tr>
<th>Form for estimating heifer rearing economics for a 300 cow herd:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of raising a heifer to 24 months of age = <strong>1900€</strong></td>
</tr>
<tr>
<td>Cost per Month over 24 months in additional expenses = <strong>90€</strong></td>
</tr>
<tr>
<td>Herd at 35% culling rate</td>
</tr>
<tr>
<td>Herd calving heifers at 30 months</td>
</tr>
<tr>
<td>6 months over goal of 24 months</td>
</tr>
<tr>
<td>6 months X <strong>90 €</strong> = <strong>540€</strong> per heifer per year</td>
</tr>
<tr>
<td>Calving <strong>88</strong> heifers in 12 months @ <strong>540 €</strong> additional cost = <strong>47,520 €</strong></td>
</tr>
<tr>
<td>Transition to reduce age at calving to 24 months of age</td>
</tr>
<tr>
<td>Reduced to <strong>24</strong> month age at first calving would need less heifers</td>
</tr>
<tr>
<td>See Table 1 (reduce inventory from 213 to 170 heifers or 43 heifers over 2 years) heifers selling for <strong>1250 €</strong></td>
</tr>
<tr>
<td><strong>1250 €</strong> X <strong>43</strong> Extra or surplus heifers first and second year = <strong>53,750 €</strong> total over 2 year transition period</td>
</tr>
</tbody>
</table>

Source: Form adapted from Bailey et al., own calculations
Note: **One time transition recovery of income decreasing from 30 Months to 24 Month. Typically accomplished over a 2 year period of time**

**Conclusion**

The objective of increasing competitiveness and sustainability of dairy farms depends on operative adjusting to the global trends, adapting best practice resource management, calculating price volatility of inputs and outputs and reaching the full production potential of animals with respect to the welfare standards. Detailed analysis of all these factors on day-to-day basis, including possible or considerable situations, represents the key role in every efficiently operating dairy farm management. Keeping the decision making data up to date requires a complex view and understanding the dynamics within the processes and recourses on specific farm. EkonMOD milk demonstrates the effects of changed input variables on heifer replacements requirements based on economic analysis. By indicating the cost of the delay in breeding heifers, the figure provides another evaluation tool for the economics of heifer development. This project gave involved researchers an improved insight in the requirements in the field. Numbers of requests from the dairy farmers have been implemented into the EkonMOD milk tool. The requirement for the model calibration to fit various herd types was communicated with various professionals and specialists.
in dairy economics. These experiences are vital for future research and development activities in the field of dairy production in Slovakia.

References


