



Dairy farmers face a number of interesting questions, starting with: Could my cows produce more milk?

Markov chains and dairy farming in Croatia

Collaboration of Department of Mathematics University of Osijek and Farmeron produces promising results for production efficiency.

By Nenad Suvak,
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Since its founding in 1992, the Croatian Operational Research Society (CRORS) has aimed to motivate its members and other researchers to develop new methods of operations research (O.R.), as well as to implement those methods in business practice. Many projects of applying O.R. methods in Croatian companies have been conducted in production, supply chain, sales, transport and other areas. Croatian researchers traditionally exchange their ideas and experience at the International Conference on Operational Research (KOI), organized by CRORS every other year. One example of successful implementation of O.R. methods is the collaboration of mathematicians from the Department of Mathematics, University of Osijek, with the software company Farmeron Ltd. Based in Osijek, Croatia, Farmeron develops information systems for dairy farms.

With the world's population expected to grow to more than 9 billion by 2050, all of us should be concerned about food sources and the way our food is produced. According to Farmeron, a cloud-based business IT solution provider for running agricultural enterprises, the next big revolution in agriculture won't come from new tractors or fertilizers. Rather, it will come from radical improvements in production efficiency – driven by data. The same goes for the world of dairy and cattle farming.

In this new environment, dairy and cattle farmers face a number of interesting questions: Could my cows produce more? Are we looking at the transformation of the dairy business model? How would increasing the cow conception rate affect my business? What if the price of corn goes up a dollar? How will my operation project out 18 months? Or three years? What if I get cows to eat another pound of dry matter? Is benchmarking against other farms valuable?

All of these questions – and many more – can be answered with the help of O.R. and analytical software tools that shift the focus from herd management to improving the odds of a dairy farm business succeeding in times of change.

Collaborations between academia and the business world often generate smart problem-solving solutions. Kruno Strazanac, head of technical support at Farmeron and a former graduate student in the Department of Mathematics at the University of Osijek, turned to the university's math department for help when presented with some practical, real-world problems. As a result of the discussions, the group came up with the idea of applying Markov chains in order to minimize the expected cost at dairy farms. That, in turn, led to collaboration on a scientific paper, "Markov decision processes in minimization of expected costs," co-authored by Strazanac, along with Marija Rukav, Nenad Suvak and Zoran Tomljanovic from the Department of Mathematics at the University of Osijek. The paper was first presented at the KOI 2014 conference, and an extended version of the paper was later published in the *Croatian Operational Research Review* journal (Vol. 5, No. 2).

The project deals with a specific problem that appears on dairy cow farms – the possibility of lowering the expected cost in milk production. The model the team developed provides a solid foundation that needs an upgrade with specific domain knowledge from a veterinarian and a nutritionist in order to be implemented as a decision tool in solving problems at farms. Farm activities such as animal feeding, medical treatment,



Figure 1: Productivity, efficiency and profitability chart analysis in Farmeron's software.

breeding and milk production generate huge amount of data that make it possible to apply optimization and non-optimization models aimed at increasing farm efficiency.

Looking forward, similar collaborations could be used to address such related topics as:

- optimization of livestock feeding;
- time series analysis of food prices and milk production;
- assessing the optimal time for removing an animal from a farm;
- analysis of influence of feed's nutritional value on the quantity, quality and income;
- analysis of influence of food optimization and food quality on the frequency of illness on the farms,
- analysis of statistically significant differences in productivity in case of different feeding procedures; and
- simulations of herd growth.

Together with other software companies in the Slavonia region that joined together in a non-profit association called "Osijek Software City," the employers of Farmeron contribute actively as guest lecturers on software programming at the University of Osijek. Given the impor-

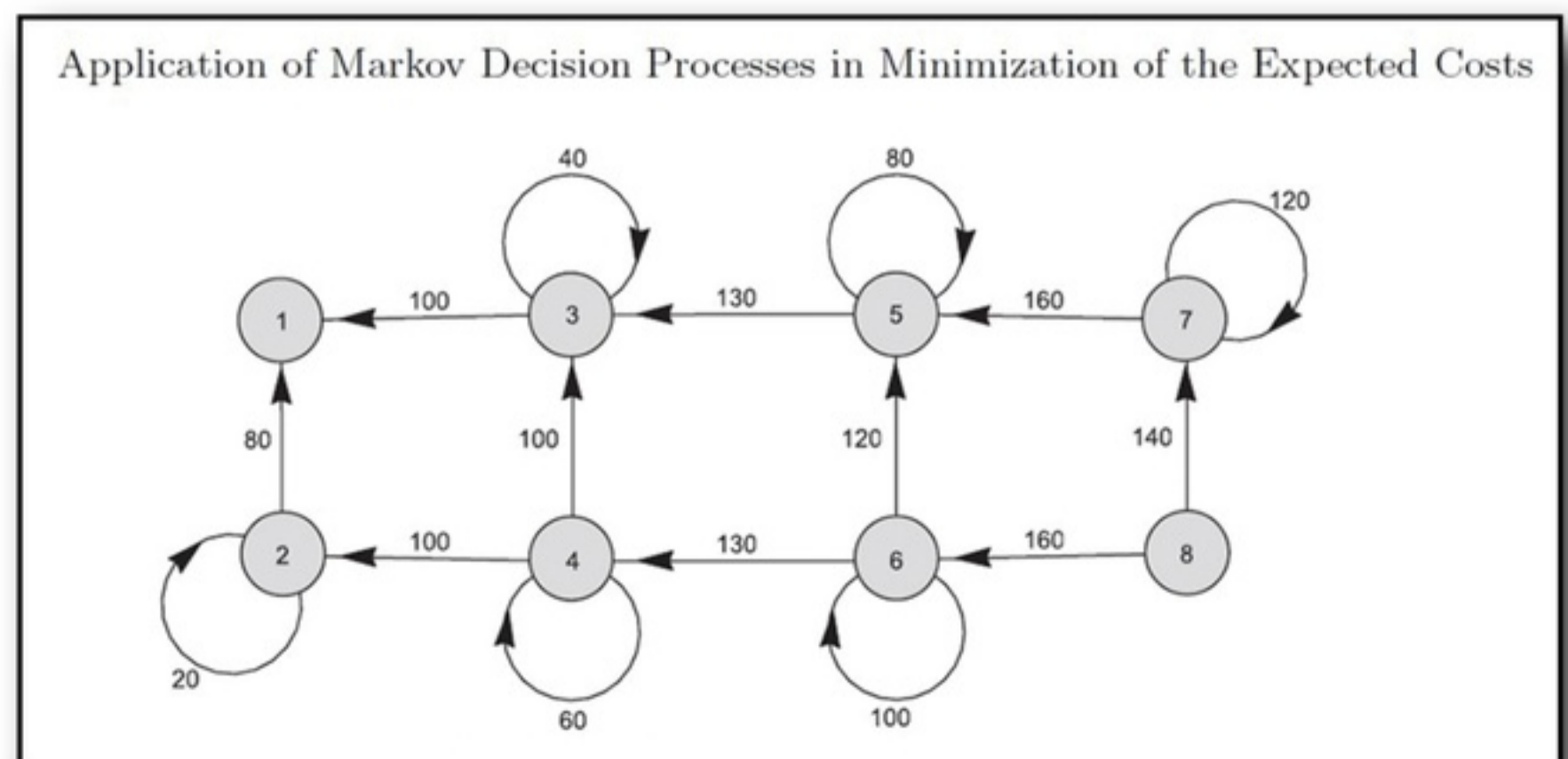


Figure 2: The scheme of decision costs.



Dairy farming

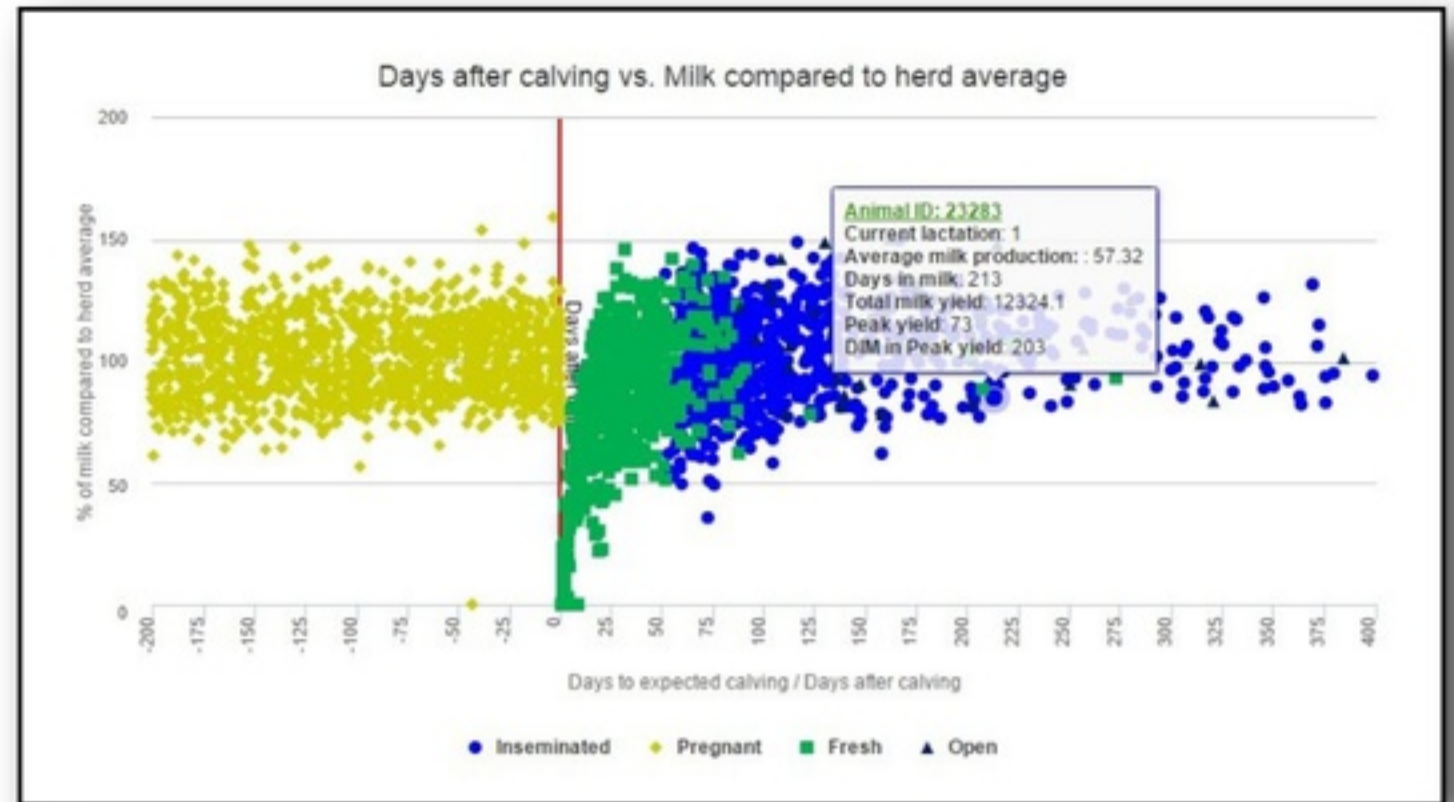
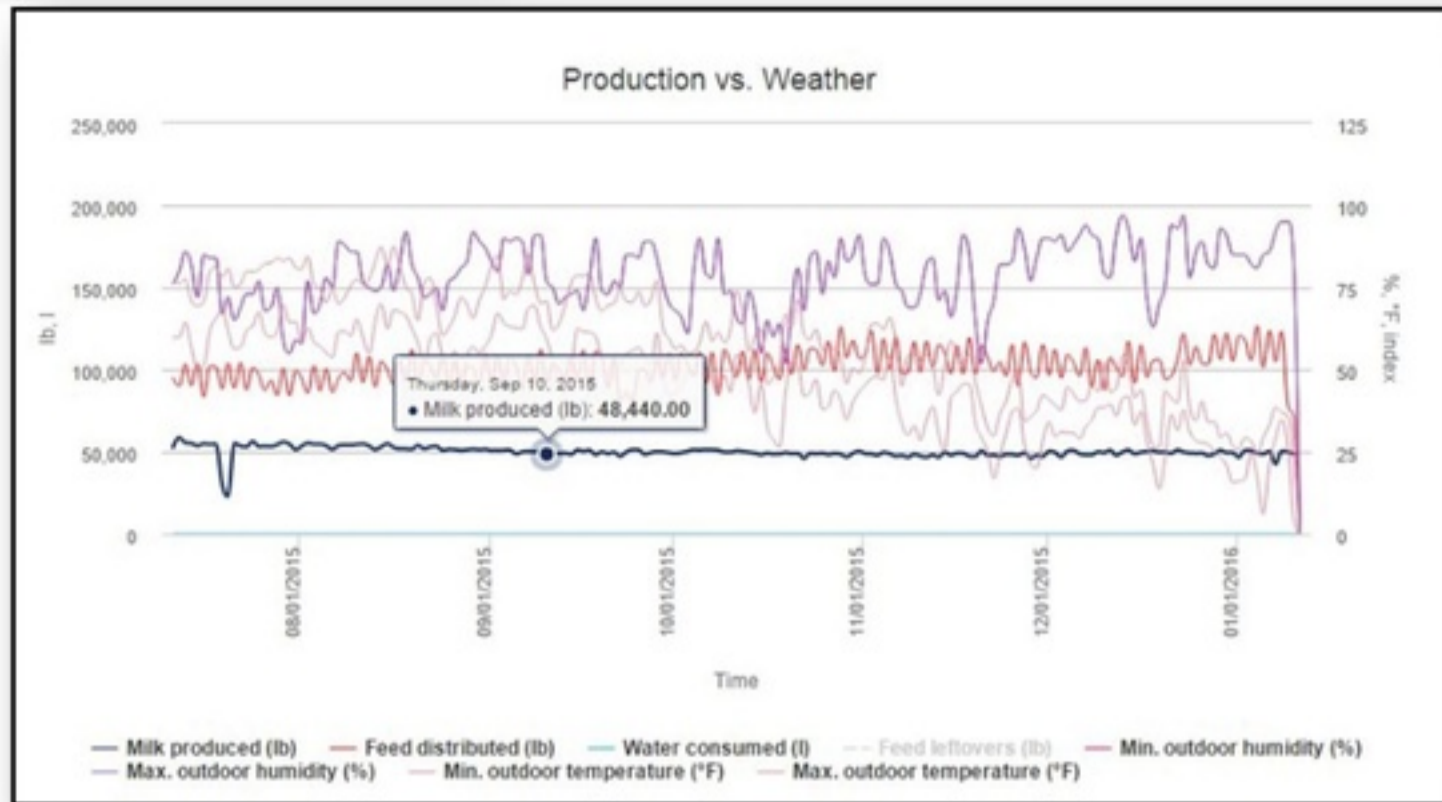


Figure 3: Analysis of production and weather conditions data in Farmeron's software.

Figure 4: Days after calving vs. milk compared to herd average.

tance of scientific research for the growth of the economy, Farmeron continues its collaboration with scientific institutions throughout Croatia, as well as with the University of California-Davis and The Ohio State University in the United States. Besides investigating Markov chains, the company plans to test and implement more O.R. methods in its software to increase the efficiency of farm management and agricultural development in general. **ORMS**

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