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Predicting long and short term milk supply change in the Irish dairy industry

Key external stakeholders:
Dairy Processors, dairy farmers, ORNUA

Practical implications for stakeholders:

- Models can be used to help the decision making process around milk supply prediction when;
  - The models are accurate
  - They are easy to use to all end users
  - Provide useful information to the all end users
- The models developed in this project are being implemented across the dairy industry through deployment at individual processor level and within the ICBF framework
- The models developed have been used by a large number of dairy suppliers to help with the planning process for milk supply agreements with the individual processors as well as helping to plan milk output from their farms

Main results:

- A mechanistic milk prediction model was developed and deployed within the Dairy Industry to increase the accuracy of milk prediction with a one to three year time frame.
- Farmer engagement with the model was very strong with virtually all Dairygold farmers using the model over a three period and a very large number of Glanbia farmers engaging with the overall process.
- A nonlinear auto-regressive model with exogenous input, a static artificial neural network, and a multiple linear regression model were developed using 3 year historical milk-production research data.
- The models predicted the total daily herd milk yield over a full season using a 305-day forecast horizon, 50 day forecast horizon, 30 day forecast horizon and 10 day forecast horizon with a Root Mean Square Error (RMSE) of <12%.
- The non linear auto-regressive models which included exogenous input were capable of increasing the prediction accuracy as the modelling horizon shortened 12% to 10.7%.
- The multiple linear regression models were not capable of increasing the prediction accuracy as the modelling horizon shortened 10.62% to 10.54%.

Opportunity / Benefit:

While there has been a considerable amount of research carried out around milk supply profiles and lactation curves there has been very little research carried out predicting long term trends and short term fluctuations in milk supply in Ireland or Internationally. While it is expected that predicting short term fluctuations in milk supply with accuracy will prove difficult the overall industry benefit would be large if successful. This study focused on the effect of variation in the amount of AI usage, number of heifer's calves born, and culling rates on long term trends in cow numbers. Long term trends in cow numbers were used to predict long term changes in overall milk supply, while short term fluctuations in milk production were

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modelled using dynamic modelling approaches, taking into account short term fluctuations in for example weather as it effects milk output.

Collaborating Institutions:

Teagasc project team: Dr. Laurence Shalloo
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External collaborators: Liam O Flaherty (Dairygold),
John Fitzgerald (Glanbia),
Mike Lynch and Sean Coughlin (ICBF),
Michael Murphy (CIT),
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1. Project background:

While it can be expected that milk output will increase as a result of increases in cow numbers, the nature of that increase is more difficult to predict. National reductions in milk production in 2009/2010 were largely driven by a poor milk price as well as difficult climatic conditions. There was a significant recovery in milk output in 2010/2011 with an increase in milk output of 10.6% and dramatic increases in milk output between 2010 and 2016. These fluctuations in output create a situation where it is difficult to plan around milk processing, product port folios, the creation increased processing capacities as well as sourcing markets for this product. Realistic model projections both within season and between season help facilitate better planning around the dairy industry in the form of service providers, milk transport, milk processing and marketing, but also help farmers with financial planning and budgeting on farm. The seasonal nature of milk supply in the Irish dairy industry is highly reliant on grass growth, weather conditions and calving date with regard to milk supply profiles and total milk supply. As a result predicting milk supply based on these many variables can be difficult. An added complexity in the past around the overall process relates to milk quotas. While increased cow numbers could normally be expected to result in increased milk output, milk quota management upto 2015 has distorted the overall natural supply of milk. The benefits of models capable of predicting milk supply greatly adds to the planning process across the dairy industry as a whole.

2. Questions addressed by the project:

- Develop three separate models capable of predicting milk supply
  - Overall changes in milk supply brought about by changes in cow numbers, lactation length, level of feeding, etc.
  - Milk supply profile at herd level based on calving date, peak milk yield etc.
  - Short term milk supply fluctuation as result of changes in weather and grass growth
- Develop a decision support tool that can be used by the dairy industry based on the key components identified that effect milk supply

3. The experimental studies:

A model was developed which incorporated national statistics and their relationship with overall national milk production. The key driver of increased milk output in Ireland will be increased cow numbers and changes in milk yield. The model was used to predict cow numbers based on historic culling levels, calving's and the number of animals that were born that subsequently enter the dairy herd. The relationship between factors such as climate, milk price, feed price etc were tested. A mechanism to make longer term projections based on calving's and numbers of in calf heifers available to enter the dairy herd were included in the model. Numerous lactation profile models have been developed and used both in Ireland and internationally in the past. These include for example algebraic models developed by Wood (1967) and the SLAC lactation curves developed by O Lori and Galesloot (1999). While these curves form the basis of the expected milk supply profiles in the future, all of these models have been developed at individual cow level and not at herd levels. The availability of individual cow information will be limited when trying to ascertain herd level projections and therefore herd milk supply profiles were developed. A model was developed to predict short term milk supply fluctuations based on changes driven by changes in climatic conditions. Historical milk supply data was combined with data around weather, cow numbers and milk price to train the models and the subsequent projections were tested based on a proportion of the data not used to train the models. Outputs from these model components were integrated within decision support tools and were deployed at ICBF and at individual milk processors.

4. Main results:

- Models were developed and deployed within milk processors and within the ICBF framework.

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- Models were used by many farmers around their planning for increased milk production. This allowed the farmer to provide more informed predictions within the milk supply agreement and it allowed the milk processor to make more informed decisions around the plans for increased milk production and it also provided more information to help in the marketing of Irish dairy product.
- The short term dynamic models developed in this project facilitated the development of a larger project in this space which involved a collaboration between TSSG, Teagasc, CIT, ICBF, Dairygold and Glanbia around the development of an ICT based platform for milk supply prediction within the overall dairy industry, which was funded by Enterprise Ireland

5. Opportunity/Benefit:

This project will help increase the profitability of the Irish Dairy Industry by creating more focused strategic expansion of processing capacity at processor level based on the expected increased milk production. Both short term, long trends and fluctuation in supply affect the optimum product port folios and planning carried out at processor level. The model developed in this study strives to help the dairy industry with planning post quota. It is expected that this project will result in increased returns for dairy products based on better planning as well as more timely and profitable investment in processing capacity, that will create a closer sync between demand and requirement for processing capacity.

6. Dissemination:

Main publications:

Murphy, M. D.; O'Mahony, M. J.; Shalloo, L.; French, P.; Upton, J. (2014). Comparison of modelling techniques for milk-production forecasting. Journal of Dairy Science 97 6 3352-3363

Zhang F. Murphy M.D., Shalloo L., Ruelle E., Upton J. (2017) An automatic configuration and optimization system for milk production forecasting. Computers and Electronics in Agriculture 128 100-111

Zhang F. Murphy M.D., Shalloo L., Ruelle E., Upton J. Effect of Parity Weighting on Milk Production Forecast Models. Journal of Dairy Science (Submitted)

National conferences and seminars

The outputs from this research formed parts of teaching that was delivered to the Dairy Degree students when based in Teagasc Moorepark.

Open days:

Presented at Moorepark Opendays

Industry consultation

This project involved extensive collaboration with the dairy industry including Dairygold and Glanbia as well as with ICBF. The models developed were deployed at processor level and within the ICBF platform in order for farmers to interact with them to advance the milk prediction.

Farmer discussion groups

Results were presented and discussed at many farmer discussion groups and seminars. Both Dairygold and Glanbia worked with their farmer producers using the models to develop accurate milk supply predictions.

7. Compiled by: Dr Laurence Shalloo

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