On modelling the price of beef and salmon using a fully dynamic approach

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This study explains the food market mechanisms and derives price function curves for beef and salmon. The price mechanism model, is part of the WORLD6 model, which has been developed for global commodities like metals and materials (Sverdrup et al, 2014a,b; Sverdrup et al, 2015; Sverdrup et al, 2017a,b,c,d). The model has now been adapted for food and makes price endogenous to the integrated system dynamics models for industrial and food supply dynamics. The market mechanism has a number of feedback loops and especially the interplay between market amount, price, demand and profits that drive production and supply has been studied. The mechanism is included in the VALUMICS model for integrated supply-, decision- and value-chains in the food supply system. For the global system, the VALUMICS model will be integrated in the WORLD6 model. The model was preliminary tested on the global level for bulk world market supply of grain and coffee, without involving whole supply chains. The tests show that the obtained price functions follow a pattern earlier discovered for metals and materials. Price curves were determined for beef and salmon.

The objective is to use an integrated model food supply chains, the associated value chains and the coupled decisions on a global, regional and business-to-business scales. In order to be able to model prices endogenously in the VALUMICS model as a result of market and supply chain dynamics, a number of fundamental aspects must be explored and analyzed. The model system will be used to assess the long-term supply sustainability of these systems with respect to environmental sustainability and including climate change impacts, efficiency and resilience. Provocative scenarios will be explored to assess what it takes to disrupt the system.

Supply chains of a simple generic physical product flow from a primary producer to the consumer, through a processor and a retailer, is simple to represent on a company to company basis (business scale). A system with many agents and markets is analysed on a larger scale. When working with a supply chain on a business scale the individual orders and product flows can easily be tracked, but the price used in the transactions between agents is not determined on this scale. Market dynamics and the associated price generation takes place on a larger scale so in this simple example such mechanisms are neglected and the focus is purely on the physical flow of products and orders.

The project's aim is to take the next step and introduce market- and pricing dynamics. This is done by moving up from the company-to-company scale to a more aggregated scale and add markets between agents. In these markets the price of products is generated dynamically according to the laws of supply and demand. The market model applied in the VALUMICS and SIMRESS (WORLD6 models) is a free market model. Describing price like this does lead to price predictive capabilities and the price histories can be reconstructed (Sverdrup et al, 2014a,b; Sverdrup et al, 2015; Sverdrup et al, 2017a,b,c,d).

The main distinction between modeling a market driven supply system with multiple agents and a simple business scale company-to-company system lies in the scale. By introducing multiple agents in each section of the market (primary producers, processors etc.) we are able to dynamically generate price with market dynamics. In a simple company-to-company model the price cannot be generated within the model as price determination takes place on a larger scale and would therefore need to be fed into the model in the absence of a market. When the market dynamics are introduced the model no longer keeps track of individual orders and order backlogs which are replaced by aggregated demand and shortages in the market.

Figure 1 shows a partial causal loop diagram needed to understand how profits drive production, investment and supply and how price limits demand. This part of the VALUMICS model generates market price inside the model and eliminates the need for externally supplying guessed price curves.

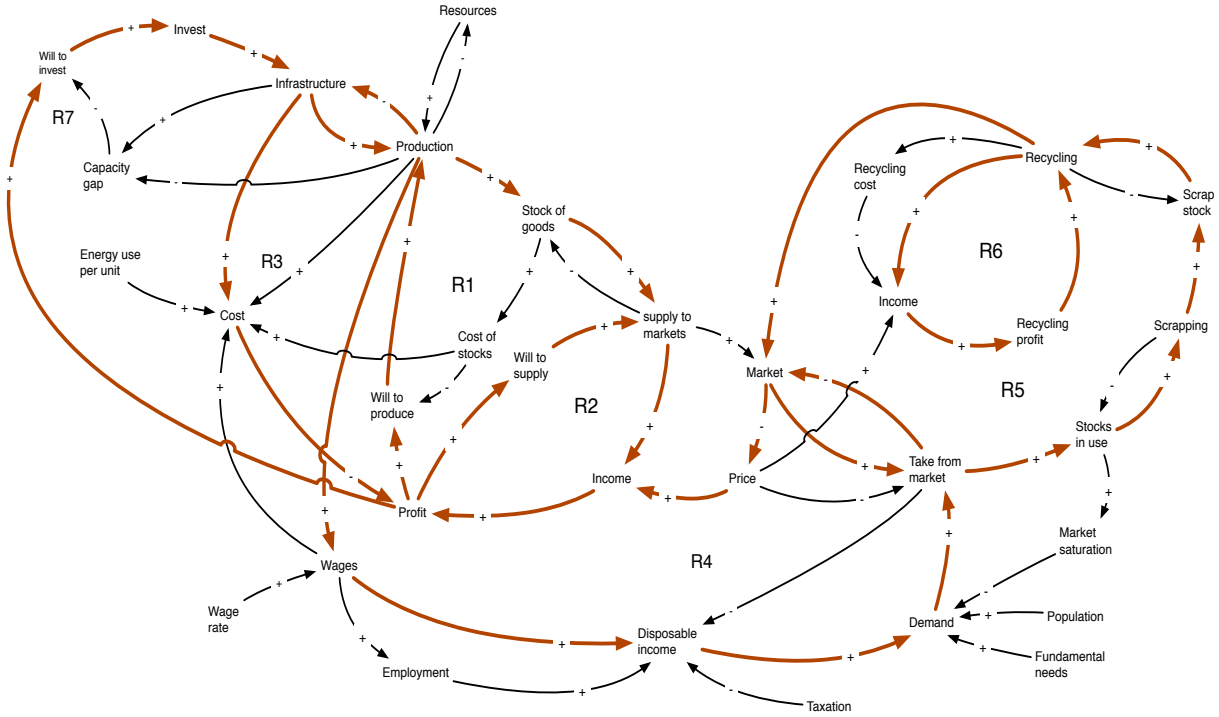
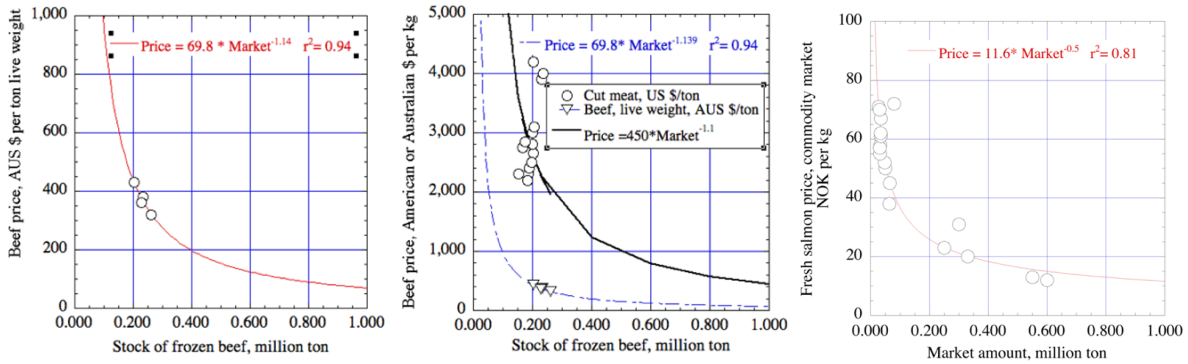


Figure 1. The causal loop diagram showing the market mechanisms and their effect on extraction, supply, demand and actual delivery from the market.

Figure 2 present some demonstrations of the model results for salmon and beef. Figure 2a and b shows the obtained price curve for beef and Figure 3c shows the obtained price curve for fresh Atlantic Salmon, based on reasonably certain market amount estimations.



(a) *(b)* *(c)*

Figure 2. Some of the obtained price curves for beef are presented in a) and b) and the obtained price curve for fresh Atlantic Salmon, NOK per kg is presented in c).

It was possible to determine the market price mechanism curves for fresh salmon, and reasonable proxies for beef, that can be tested in the VALUMICS and WORLD6 models. A methodological way was found and we will when proper data is available, be ready to make the requested parameterization of the supply chain models. The results presented here are methodological and the quantitative results are preliminary. We conclude that with better data, a better parameterization will be possible.

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