Sales forecasting in times of crises at DSM

Technische Universiteit
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eSCF Operations Practices:
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European Supply Chain Forum

Sales forecasting in times of crises at DSM

Where innovation starts

Responding to the Lehman Wave

Sales forecasting and Supply Management during the Credit Crisis

Concise summary of this best practice

A system dynamics model has been developed in order predict demand development throughout the supply chain in times of crises. Good insights by using this type of modeling enable managers to make the right decisions and to gain competitive advantage out of the crisis. Using a system dynamics model described in this best practice, DSM was able to predict its sales with astonishing accuracy, and came stronger out of the crisis.

Key terms

Cumulative de-stocking, synchronized de-stocking, bullwhip, improvement of sales forecast to enhance S&OP process.

Relevant for

Companies with a desire to improve supply chain visibility; Companies who want to understand the impact of their end markets; Companies with a desire to understand their supply chain dynamics.

Panic takes over

Shortly after the bankruptcy of Lehman Brothers, in October 2008, a strong dip in the manufacturing industry was visible. The crisis in the US housing market crash had turned into a credit crisis, and the bankruptcy of Lehman caused a shockwave of panic throughout the international business community. Both consumers and producers lost confidence and the sales of large purchases dropped sharply. Many companies focused on cash by cutting costs, by reducing working capital in inventories and investments, and by delaying their purchases. This makes forecasting an extremely difficult job. Often, companies use Sales or Sales and Operation Planning (S&OP) departments to make accurate forecast based on historical data, current sales and customer information. However, historical data do not provide any solution, customers also do not know what to expect, and S&OP managers basically remain clueless. In the rampant times of panic after the collapse of Lehman, traditional forecast processes become totally unreliable.

The panic will not disappear but accumulate, unless more sophisticated methods are developed to understand the real situation. This is exactly what the management of DSM NeoResins+ did. Together with Eindhoven University of Technology, DSM focused on modeling the dynamics within the supply chain to forecast the future sales upstream. This is the story of DSM's research on the bullwhip effect.

The sudden drop of global sales

DSM NeoResins+, one of the business units of Royal DSM in the Netherlands, produces specialty resins for the coating industry. These resins are a typical raw material positioned upstream in the supply chain, which means there are approximately 5 companies (echelons) downstream before DSM's products reach the end-consumer (see Figure 1). Therefore, it takes at least 250 days for DSM's resins to arrive at the final customer.

figure 1

A simplification of the echelons in the supply chain of DSM NeoResins+.

In the fourth quarter of 2008, DSM NeoResins+ observed a strong dip in sales. Figure 2 shows this sales decline for a specific segment[1] of DSM, supplying to the construction market, shortly after the collapse of Lehman. It can be seen that sales dropped heavily especially in the three months after the collapse of Lehman, obviously causing tremendous uncertainty in boardrooms and production floors. Will the decline of sales continue? What will be the sales next year? Do we have to close our factories? Will I lose my job over this? Or will demand be picking up soon?

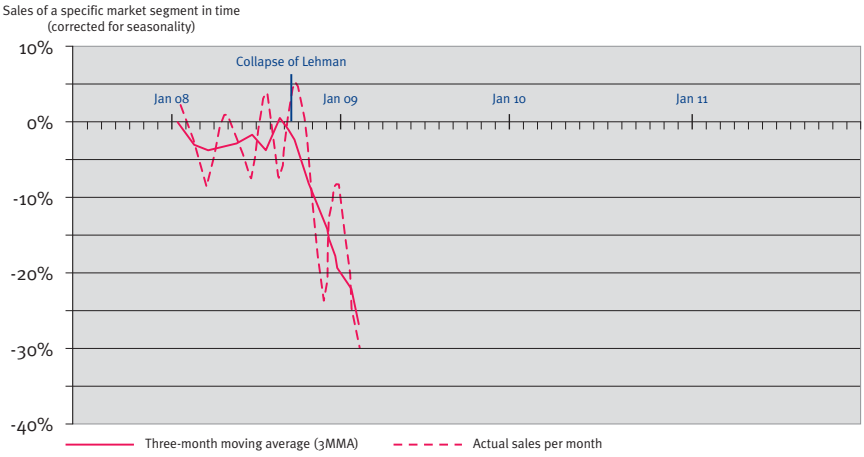


figure 2

The decrease of sales (adopted from Peels et al., 2009). The dashed line is the actual sales and the solid line is the three-month moving average (3MMA) for this specific segment, corrected for seasonal impact by taking the difference with 2007. Such results are devastating for any company.

To protect the company and her employees, the management of DSM NeoResins+ decided in January 2009 to reorganize only non-core businesses and to cut overhead and expenses. *All core segments remained in tact for as long as possible*. DSM realized that it is very hard to find highly trained people and all engineers and other knowledge bearers were kept on board. Also sales and marketing departments were not touched. Moreover, it was also decided that innovation and investments projects should be continued. For the time being, further closures of factories and larger lay-offs were postponed in the hope that everything would pick-up soon.

[1] It should be noted that each segment is only a tiny fraction of DSM's total business. Many of DSM's business segments do not see these effects because the chain is too short or there is no de-stocking. Hence DSM does not view these curves as an actual reliable forecast of total business development for DSM (Peels et al., 2009).

But everything remained uncertain. What happened? The panic came out-of-the-blue. Surely, there was a financial crisis, but the end-markets were still selling more or less at pre-crisis levels. Large retailers in the Netherlands presented 1 % sales growth, and the GDP remained relatively stable across many countries. The consumer sales only dropped marginally compared to the dozens of percent points losses that were reported in upstream industries. How was it possible that DSM's resins sales declined by more than 30 %?

The bullwhip effect

The management hypothesized that this strong decline was caused by extensive and simultaneous de-stocking downstream in the supply chain, triggered by the bankruptcy of Lehman on September the 15th of 2008. Active de-stocking is a conscious decision to lower stocks, intended to free cash from inventory investments. Extensive and simultaneous de-stocking through the supply chain has detrimental effects on the supply chain, especially for companies that are positioned upstream, such as DSM NeoResins+, because the impact amplifies by each preceding company. This is the well-known supply chain bullwhip, where the variation in demand is higher upstream than downstream. This means, if all downstream companies decide to reduce their stocks by 10 %, a cumulative effect would take place and large amount of sales would be taken out of the chain. For DSM this can result in the lost of sales for one month, or a 33 % decline during three months.

The management decided to investigate this. However, this is not straightforward: there was no reliable public information available on inventories and sales across the different levels of the supply chain, and like most companies, DSM only collects sales information from their immediate customers for S&OP purposes. Not for supply chain decisions. Thus, a new way to obtain information was required.

An unusual quest to understand downstream decision policies

For this project, DSM conducted an explorative study to investigate the behavior of the decision makers of the companies downstream. In January 2009, a series of telephone interviews were conducted to better understand the sales development in the supply chain further downstream. They contacted their customers, and the customers of their customer, etc, all the way down to retail.

From the empirical evidence collected during these phone calls, DSM concluded that inventories were depleted across the resin supply chain after the liquidation of the Lehman Brothers. Furthermore, it was concluded that during the financial crisis of 2008-2009, the sales decrease at companies further upstream was higher

than the sales decrease further downstream. Hence, the results clearly support the existence of the bullwhip effect[2]. Because this was the first time a phenomenon like this has been described in the literature and because it had been triggered by the bankruptcy of Lehman Brothers, they dubbed this special type of cumulative bullwhip the **Lehman Wave.**

Thus, the series of simultaneous inventory reductions (destocking) could have caused the substantial declines in sales more upstream. So far, so good. However, destocking has to lead to re-stocking, to refill the chain. The question is when will the customers start restocking, and therefore the study was extended. The management of DSM NeoResins+ desired to create to simulation tool that explicitly models the relationship between de-stocking and sales decline. Let's try to model the Lehman Wave.

The dynamic model

Sales are per definition the result of ordering decisions at all echelons downstream in the supply chain. To study the Lehman Wave, the ordering decisions at the various supply chain echelons have to be modeled. Per supply chain echelon, two types of de-stocking are taken into account:

1. The conscious management decision to decrease the desired inventory level, to increase efficiency and to free cash. When multiple downstream companies actively decrease the desired inventory coverage of demand (in times of crises), the supply chains deplete. This can lead to a cumulative effect throughout the chain. In a supply chain with multiple echelons, this can lead to 20-60 days lost of sales upstream. This is called active de-stocking.
2. The action to decrease stock levels when sales go down: When demand decreases, supply chain planners update their forecasts. Since the desired inventory level is the product of the desired inventory coverage and the forecasted demand, a decrease in the forecast will lead to a decrease of stock. This response is delayed over time, and thus its effects also come with a delay. This is called re-active de-stocking.

Thus, the decision makers in the supply chain influence other decision makers. To simulate the resulting behavior of the decision makers across the supply chain, the interaction between the various decisions and decision makers should be taken into account. Modeling the interaction between the various echelons

[2] For more recent discussions of the bullwhip literature, please see Lee et al. (1997) or Fransoo and Wouters (2000).

requires sophisticated methods. Seemingly simple systems can display puzzling effects when the interaction is taken into account. System dynamics is a methodology to simulate and study the behavior of complex systems over a time period. It deals with multiple feedback loops and time-delays, using stocks and flows, which affect the entire system. These elements help describe how these individual entities interact. This makes systems dynamics an appropriate method to understand the behavior of the entire supply chain.
Per echelon, the model requires information on the lead-time and on the base stock policy that gear sales decisions.

- Although the placement of the order can be done in seconds, the actual products movements can take much more time. Therefore, there is a feedback loop in terms of actual supply rate over time. Due to the delay for delivering products, **the lead-times**, it takes some time before the desired inventory levels are reached[3]. This interacts with stock levels and backlogs, and eventually leads to increase of orders caused by the moving average and the forecast updates. This interaction determines the course of the Lehman Wave.
- In the model, it is assumed that all ordering decisions are based on the **base stock policy**, i.e. the decision makers order products to reach a desired inventory level. The desired inventory level is updated to reflect the desired coverage of expected demand. Therefore, the expected demand is modeled using the three-month-moving-average method, using the realized demand.

The decision-making process within an echelon is rather simplified, however the model is fairly robust. Moreover, the required parameters are based on actual estimates of the supply chain, obtained via the telephone interviews.
Furthermore, the dynamic model requires two additional input variables that influence the entire chain:

- The **de-stocking strength of the inventory reduction decision after the pulse**. The model includes that all players downstream in the supply chain decided to reduce their desired inventory coverage by 10 %. Thus, the model simulates a desired synchronous active de-stocking of 10 %, in each echelon, after the collapse of Lehman.
- The **end-market demand** (realized and forecasted). The model uses the forecast of some crucial end-markets. The end-market data are based on the Euroconstruct prediction. In December 2008 they predicted that the market in 2009 would decline by 10 % and recover in 2010.

[3] Dynamic modeling takes this delay into account. The combination between feedback loops and delays in time is one of the strengths of this modeling method.

At the end of January 2009, the model was working according to expectations. At this time, the sales had declined by more than 35 % in the specific business segment. Let's see what it predicts...

The Lehman Wave

In February 2009, the researchers of Eindhoven University of Technology modeled the Lehman Wave for the specific product segment (see the blue line in Figure 3). The results are rather stunning. The model decreases almost parallel with the actual sales[4]! Interestingly, the model predicts a fast recovery in 2009, followed by a second decline in 2010, and an upward peak in 2011.

The next question is how this curve is influenced by the different parameters. The results from these tests are interesting: namely, immediately after the Lehman Wave had been triggered, its course was determined by the cumulative de-stocking decisions. Firstly, the position of the through is very robust to many of the parameters of the system, and is primarily a result of the structure and the decision making behavior in the supply chain. The amplitude of the wave is much larger upstream than downstream, in accordance with the bullwhip effect and due to the accumulation of the effects of the de-stocking decisions in the various echelons. The course of the Lehman Wave is dampened due to the fact that companies take time to respond and because each company tries to go back to equilibrium. Secondly, the depth of the trough is dependent on the length of the chain, the decline in sales of the end market and the force of the pulse that caused the wave. Further downstream in the supply chain, there is less cumulative active destocking and less reactive destocking due to forecast updating.

The further upstream in the supply chain, the less its sales decline can be explained by a sales decline in the end-market, and the more it is due to destocking along the supply chain. Thirdly, the wavelength is primarily dependent on the lead-times within the supply chain, which are known. In other words, most parameters are known from the phone call survey along the supply chain! It turned out that the behavior of the curve was very robust and thus very reliable!

The upward peak of the model, caused by re-stocking in 2011, is delayed by the lead-times within the chain. For the same reason, there is the second dip in 2010.

4 Note that the system dynamics model has not been fitted to any actual sales data.

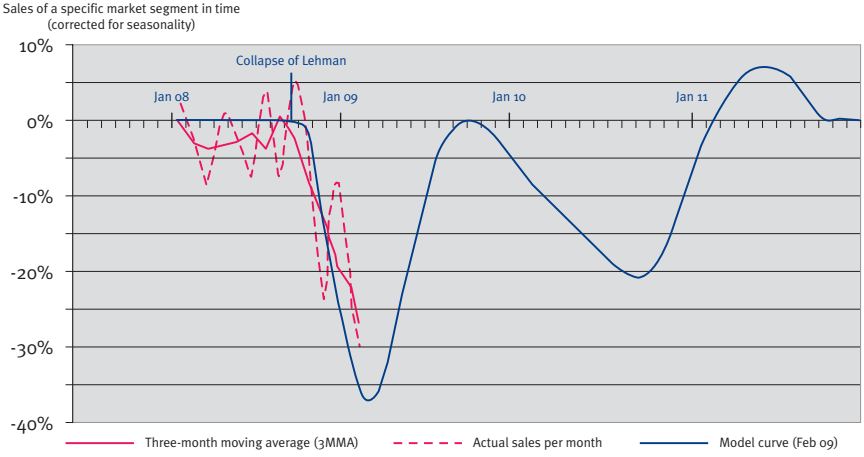


figure 3

In February 2009, the obtained model suggested that sales should be picking up soon. Would this be an appropriate forecast?

The Managerial decisions based on this model

Based on this model, the management of DSM decided, despite the heavy financial losses and the widespread panic, that the innovation and investment programs should be continued. Also closures of factories and dismissal of staff were postponed in the hope that business would recover as predicted. Actually, in March 2009 DSM opened a new factory, providing a large additional capacity for one of the critical product lines.

From April to October, the sales recovered in a comparable fashion predicted by the model (see Figure 4). It can be seen that the realized sales in Q2 and Q3 follow the prediction alarmingly well! Through is predicted accurately in terms of depth and timing, and the recovery came out in a comparable fashion!

The model has been tested on different segments of DSM, and it appeared that the peak was often forecasted correctly, in terms of both position and depth. This shows that the system dynamic model is able to accurately describe the course of the Lehman wave, and this validates the model. Moreover, it also provides evidence that most companies in the chain of DSM have indeed reduced their inventories after the collapse of Lehman. This is what an inventory reduction of 10 % can cause.

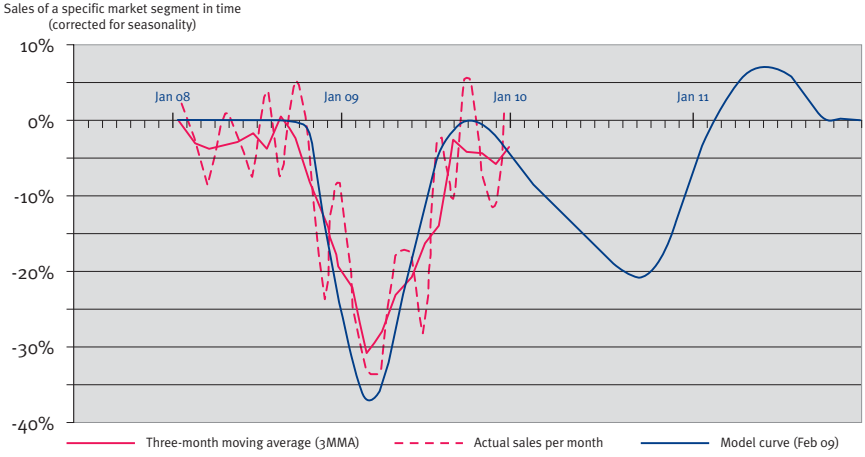


figure 4

The model predicts the sales with a stunning accuracy.

Due to these improved sales, further and more severe cost reductions were finally now permanently put on hold. The global crisis caused a downturn that could not be avoided. DSM was able to boost the production and DSM was impacted less than the competition. And most importantly, DSM NeoResins+ had retained their employees and knowledge bearers.

As DSM reports in the end of 2009: "*Based on the model, DSM started in advance of market pick-up to re-build the stocks which had been reduced in the previous months. When demand picked up, we benefited greatly from the abundant capacity. […] The resulting stock position was not good enough to prevent all supply problems in the second half of the year, but the problems would have been much larger if we had not started so early. For some crucial products, we covered the anticipated higher demand a year in advance and therefore could benefit from price as well as availability during the initial phase of market pick-up. […] We saw this crisis as a once-in-a-life-time opportunity to improve market position and take a leadership position. In line with the overall strategy of Royal DSM, we believed that companies with long term vision and cash reserves, companies who stay the course, are in the best position to come stronger out of the crisis. In a preliminary benchmark study, we found that we have indeed done relatively well*".

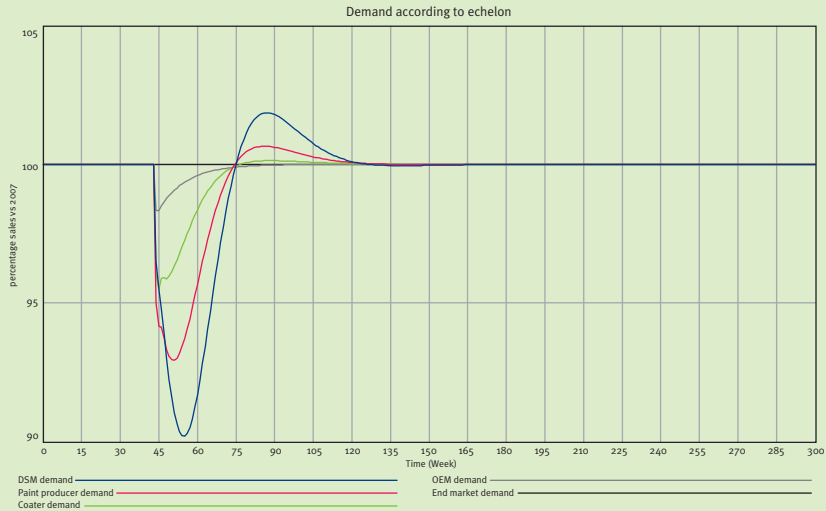
Conclusions

This research of DSM and the TU/e beautifully shows the combination of logical sense and dynamic modeling can provide the necessary insight to make extremely difficult decisions. The model can explain the complete sales pattern across a number of business units upstream in the supply chain.

Part of the beauty of this research is that it uses information and decision parameters from multiple downstream echelons to create a more sophisticated sales forecast. It is well-known that downstream echelons drive your future demand. The lack of research into modeling this is stunning.

Since the summer of 2009, the modeling effort at DSM has been extended to other business units. The executive board has mandated that more extensive work to build comprehensive models to deal with future dynamics and economics cycles. In the future, the insights from the Lehman Wave will be included in the S&OP processes at DSM. This makes the Lehman Wave research at DSM a true supply chain best practice!

The functionality of the model



Sales level in a sample run of the 5-echelon resin supply chain under stable end market demand and a single inventory decrease across all supply chain echelons.

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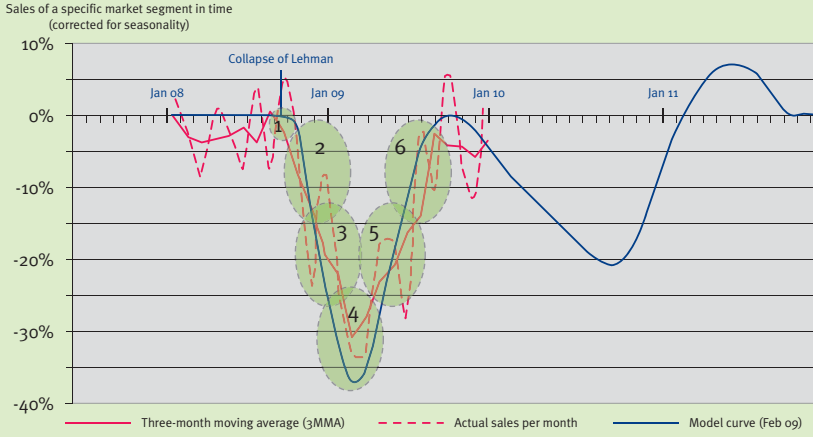
Recommended actions

1. Sudden decline of trust; don't overreact, but communicate across the supply chain
2. Rapidly cut costs and plan scenario's
3. Don't close factories, but prepare for a rapid expansion, and start building inventories of raw materials
4. Execution; build inventory of end-products
5. Sell and expand; gain market share
6. Feel and anticipate the next macro-economic sentiments.

At all times, don't fire crucial employees, don't cut innovation, nor stop marketing communication.



These are the recommendations on how managers can act to gain competitive advantage out of the crisis by using this type of modeling.

Colofon

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Editorial

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