Robert Peels

Lehman Wave shakes the Chemical industry

ROBERT PEELS*, MAXIMILIANO UDENIO, JAN C. FRANSOO, SJAAK GRIFFIOEN

*Corresponding author

DSM NeoResins+, Sluisweg 12, 5145 PE, Waalwijk, Netherlands

ABSTRACT: End markets such as Construction in 2009 went down 15 percent compared to 2007. This article will provide an explanation why the sales volume of upstream suppliers to Construction markets first went down 30-50 percent, and then recovered to around original levels, and then went down again. Royal DSM together with a group of scientists from Eindhoven University of Technology have investigated this effect based on the hypothesis that de-stocking in the long value chains of the chemical industry is the cause of a significant part of the decline, and that de-stocking has been triggered by the collapse of Lehman Brothers mid September 2008. It is further based on the hypothesis that the supply chains act elastically to a strong impulse, thus creating wave-like effects.

RESULTS OF THE INVESTIGATION OF DSM IN THE SUPPLY CHAIN FOR PAINT

Following a dramatic decrease in sales in the last few months of 2008 at DSM Neoresins+, one of the resin units of DSM, the idea started to arise that this decrease might be due to inventory effects. At that time, actual sales of product in the end markets, such as construction and retail, did not show any substantial decline. To investigate this, however, information on the downstream supply chain of Neoresins+ and the inventory developments in that supply chain was necessary. In January 2009 there was no reliable public information available on inventories and sales, therefore, initiated by DSM NeoResins+, a series of 50 telephone interviews was conducted under distributors, paint producers, job coaters, part producers, OEM, and retailers in a variety of markets. We asked about actual sales, inventory levels, and changes in inventory policies. The results are shown in table 1.

This picture was later confirmed in various other investigations, including a survey with the newspaper *Brabants Dagblad* and in many quarterly reports. We also found that the supply chain between a Coating resin producer and the end-customer could be as long as "250 days' sales", meaning that it takes 250 days for a molecule to travel from DSM's warehouse to the final consumer. Finally, the survey showed that practically all companies decided to de-stock, with percentages between 10 and 20 percent, which was later confirmed by various other sources. Note that a 10-20 percent reduction of a 250 day value chain means a loss of sale of 25-50 days.

Our conclusion at this stage was that indeed the strong decline in our sales was caused by cumulative de-stocking by the companies downstream from us.

Level in supply chain		*Percentage decline*
Upstream	Resin production	30%
	Paint production	20%
	Parts production	15%
	OEM	8%
Downstream	Retailer	Fairly stable

Table 1. The sales decrease at companies upstream was higher than the sales decrease at companies downstream.

BUILDING A MODEL TO QUANTIFY THE LEHMAN WAVE

The complex combination of strong stock decisions, a declining end market demand, multiple layers and lead times, and dynamic responses by the decision makers in the supply chain makes it impossible for a human to accurately predict the development of sales demand. A computer simulation model is needed and DSM and researchers at Eindhoven University of Technology started in January 2009 to build one.

There are two types of de-stocking, *active de-stocking* and *reactive de-stocking*. Active de-stocking is a conscious management decision to increase efficiency by setting sharper stock targets, for instance reducing the stock target from 30 days sales coverage to 25 days of sales coverage. Reactive de-stocking is the response by supply chain planners to reduce stock levels if sales levels go down. If actual sales decline, most planners will reduce their sales forecast. For instance, if the sales forecast is reduced from 1000 to 900 units, and having 25 days of inventory coverage, inventory targets will decline from 25,000 to 22,500. Both de-stocking actions interact and combine. In the model, active de-stocking constitutes a 10% decrease in the desired inventory coverage (expressed in weeks). In addition, we estimated the average inventory coverage and the lead times for each step in the supply chain.

We have captured this in a system dynamics model, which is a simulation model in which all the interactive decisions can be depicted. The structure for the model is based on the Beer Distribution Game, which was developed in the 70ies by MIT as a demonstration game for supply chain managers. The basic building block of the model is one echelon or one company, which has raw material buying, finished product stock, sales, sales forecasting, desired stock levels and the interrelations between them. Using this single echelon model as a building block, we constructed a complete, simplified supply chain of 5 steps: resin, paint, OEM, construction companies, end market.

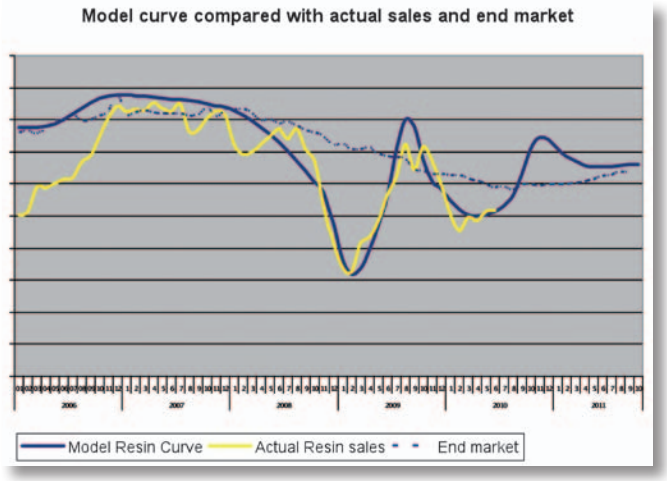

Figure 1. Model forecast (blue) and actual sales curve (yellow) in a segment supplying resin for industrial paint for the construction market (dotted line), based on construction market realizations issued by Eurostat in October 2009 and forecasts issued by Euroconstruct in December 2008, updated in June 2009. In the model all players in the supply chain reduce their desired inventory coverage by 10 percent per October 1, 2008. The yellow curve shows the actual DSM sales uptill June 2010, 3-month moving average, corrected for seasonality.

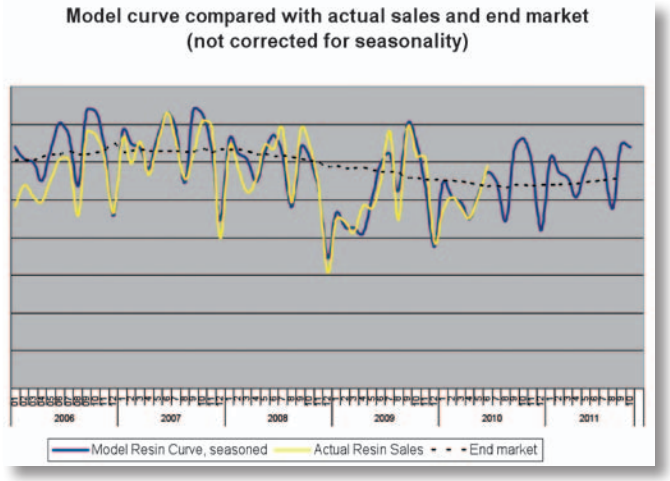

Figure 2. Same Model Forecast (blue) as in Figure 1, multiplied with monthly seasonality for this segment, and same actual sales curve (yellow) in the same segment as in Figure 1, until June 2010, not taking the 3-months moving average and not correcting for seasonality.

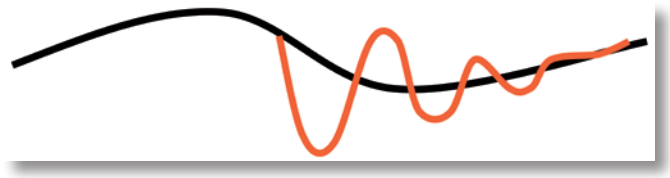

Figure 3. Lehman wave (red) with a wavelength between 12 and 16 months on top of the longer term economic wave (black), with a wavelength of 5 to 10 years.

The first curves (not shown) were already generated in January 2009, proved quite reliable and had the same phasing as the curves shown in Figure 1.

Note that the model accurately forecasts and explains the timing of the trough in February, the recovery of the sales curve in November 2009 and the second trough in Q2 2010. The position of the troughs and peaks is actually very robust to many of the parameters in the system, and is primarily a result of the structure of the chain and the de-stocking decision. Furthermore, the depth of the trough and the height of the peak, which are primarily dependent on the amount of de-stocking and the decline in the end market, have also been forecasted quite well. The curve for Paint looks similar, but the amplitude is not as large.

Figure 2 shows even more than Figure 1 that the forecast accuracy of the model can be surprisingly good. It has to be added that this high accuracy has not been reached in all investigated segments, but in general the model was reliable. The yellow line in Figure 2 is what most business managers will see if they look at their sales, which explains why most companies do not immediately discern the Lehman wave. If you take the seasonality out of your sales curve, and if you are multiple steps away from your end market, you might see the same Lehman wave.

Due to all lead times it takes some time before the actual inventory level reaches the desired lower inventory level. Once this has been reached, orders will start to increase again. This pattern interacts with patterns in end market sales. As a consequence, forecasts will be updated upward and as a result restocking will take place. In line with the terminology used above, we will denote this as *reactive restocking* and this will lead to increased inventories, and thus will cause an upward peak.

Figure 3 summarizes the insight of our work. The model is able to predict reality to a certain extent because the economy as a whole is riding on a strong secondary wave on top of the normal economic cycle. This secondary wave is caused by the bankruptcy of Lehman Brothers; therefore we have named it the Lehman wave. It is a wave because the value chain system is elastic: all companies constantly strive to keep their optimal equilibrium, but due to delay factors are always overshooting. The Lehman wave is dampened, because all companies take time to respond to changes in demand. Like any other wave, the Lehman wave has a wavelength, which is determined by the medium in which it oscillates, thus by the parameters of the supply chain. The amplitude of the Lehman wave is determined by the force of the pulse that caused it.

So immediately after the Lehman wave had been triggered, its course was determined. The system dynamics model acts as an algorithm that accurately describes and predicts the Lehman wave.

WHAT DID DSM DO WITH THESE INSIGHTS?

For DSM NeoResins+ these insights were the basis for our approach of the crisis. In October 2008, after the decline started, we started re-organizing our non-core business, while leaving our core segments intact and ensuring that all key personnel were kept on board. Being a business unit of Netherlands-based Life Sciences and Materials Sciences company Royal DSM N.V., our Innovation program as well as our investment programs were approved by the board, in line with the company's approach of "Staying the Course" during the economic downturn.

We opened two new resin factories during the crisis, which gave us extra capacity of which we are benefiting greatly now demand has picked up. The insight from the Lehman wave was included in the Sales & Operations Planning (S&OP) process as a second source of info next to the currently rather unreliable sales forecasts.

In January 2009 it was decided to close one plant and reduce some product lines. The rest of possible crisis measures were postponed in the hope that business would recover as predicted by the model.

In April 2009 we started in advance of market pick-up to partially rebuild the stocks which had been reduced the previous 6 months. When we found in July-September 2009 that sales indeed recovered completely as forecasted by the model, the implementation of other measures was put further on hold. In January 2010, we started preparing ourselves for the forecasted "second dip" in our sales. The model forecasted that it would not be as deep as in 2009, but still profound.

The timing of the dips and peaks is a little different for each market segment, thus one model curve cannot be taken as representative for the whole business.

We saw this crisis as a once-in-a-life time opportunity to improve market position and aim at a leadership position. In line with the overall strategy of Royal DSM, we believe that companies with long term vision and cash reserves, companies that stay the course, are in the best position to emerge from the crisis stronger.

Further, we believe it is essential for companies to really know their end markets and to have an understanding of the general stockpiling in the industry. Finally, a relatively simple system dynamics tool seems to help to fairly accurately predict sales cycles.

The model has been of great value as it has predicted our running sales with >98 percent accuracy. One level deeper it provided us data per country (as Spain for example was more hit by the construction crisis than for example Germany). By introducing the seasonality as in Figure 2 we have been able to forecast extremely accurate in volume per month and therefore we have enabled our manufacturing units to manufacture and supply for these construction related segments more effectively at minimal working capital impact.

Using the monthly sales levels as predicted in the model we have now for the first time built a budget for 2011 based on reason, as we have found that the model not only can predict a Lehman wave in a crisis situation, but also can be used as input for statistical forecasting. Based on the half yearly updated numbers from – in this case – EuroConstruct we are able to update the full model and recalibrate our forecast accordingly.

In discussion with customers this tool has proven itself as well. In the -artificial- upturn we have been able to warn for too much optimism and vice versa, thereby also helping our customers to manage their purchasing levels more effectively.

As an extra example we can state that from July until October 2010 we saw an increase in sales level indicating a faster recovery than the model predicted; deeper investigation indicated that due to raw material shortages our customers had started to build up extra stock, which resulted in an artificially higher demand. Having understood this we are now preparing for when the raw material situation will improve and supply is getting back to normal. This will mean that the pre-buying volumes will be taken out again, resulting in small artificial dip again.

CONCLUSION

Most companies with a stable market share will expect their sales to change in line with their end market, but we have shown that due to the Lehman wave a company can sell alternating much less and much more than its end market. In this Lehman wave the sales volumes for resins are in a roller coaster of decline, growth, decline and now growth again, before it will slowly settle on the new end market level. For many other supply chains these effects are similar, but the timing of the troughs and peaks depends on the structure of the supply chain, so needs to be investigated separately. The Lehman wave shows that synchronous stock effects can have a profound influence on a company's sales levels and thereby on the economy as a whole. Macro economics should take this into account.

The Lehman model has made it possible to significantly improve predictability and reliability both in- and externally.