Supply chain dynamics have major impact on course of credit crisis.

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Abstract

Dynamics in the Supply Chain have had a major effect on the sales curve experienced by many companies during the credit crisis. Operations Management models are strong in capturing this dynamic behavior, for instance by providing a good understanding of the bullwhip effect. In this paper we show how Operations Management insights have contributed towards understanding the sales curves in the credit crisis and the substantial effect of destocking. We also argue that the OM insights on these "Lehman Waves" could help better understand the roller coaster of the overall economy and hence that OM models could contribute to getting a more reliable economic outlook.

1. Introduction

In the popular economics press and in multiple blogs on the web, economists and journalists are having a fierce debate about the poor quality of macroeconomic forecasts. First of all, this relates to the question why all (mainstream) economic models have not foreseen the sharp economic downturn of 2009. Second, this relates to the rapid recovery observed in the fall of 2009. And more recently, the discussion is on whether there is going to be a "double dip" (W-shaped) recession or not. During economic crises, GDP and world trade figures show huge variations from quarter to quarter. In general, the models used by economists to predict world trade and other economic indicators have difficulty in capturing the dynamics of cycles.

Taking an operations management perspective on the development of the crisis may help us to improve the quality of the economic forecasts. A variable that plays a key role is inventory. In economic models, inventory may be taken into account to correct for differences in production and demand at an aggregate level. However, these models do not take into account the supply chain effect that inventory management generally causes, and which is know to us as the bullwhip effect (Forrester, 1961, and Lee *et al.* 1997). During times of crisis, inventory surpluses and shortages may differ considerably across different levels of the supply chain and hence cause substantial fluctuations in sales. In this OM Forum contribution, we will argue that inventory, carefully disentangled across the supply chain, may explain the sharp drop and sharp recovery of the overall sales volume during the credit crisis. Moreover, based on common supply chain dynamics, we do expect a "double dip". We realize that our detailed observations are based on a few specific supply chains during this crisis, supplemented by some macro-economic indicators. Nevertheless, we conclude that our insights provide a potential basis for enriching macro-economic models with insights from supply chain management.

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2. Some observations during the credit crisis.

Until the summer of 2008, credit was abundantly available. Following a slumbering problem with mortgages in the United States, by the middle of 2008 the credit crisis started to make headlines. Both attention and impact peaks in September 2008 with the bankruptcy of Lehman Brothers. The collapse of this bank caused a shockwave throughout the (financial) world, and in some cases even panic. Both consumer and producer confidence dropped and consumers were hesitant to spend money, especially on large purchases. As a result, the automotive market went down sharply; other consumer markets dropped considerably less.

The credit crisis also resulted in a stronger focus on cash for all companies. The actual availability of credit decreased, and moreover – and probably even more important – the expectation that credit availability would further decrease became stronger. This resulted in a strong reduction in investments and capital expenditure, as well as cost reductions. In turn, this resulted in a decline of the B2B markets, and this decline was stronger than that in the consumer markets. It also made companies eager to reduce their operating working capital, which they did mainly by reducing stocks. Many companies decided more or less instantaneously after September 15, 2008, to reduce their inventories. We have denoted this cumulative effect as the *Lehman Wave* (Peels *et al.*, 2009) and this has also received coverage in the financial press (Steen, 2009).

One of the business units of Royal DSM, a Life Sciences and Materials Sciences company headquartered in the Netherlands, is a producer of specialty resins for the coating industry. Like many other companies, this business unit saw a strong decline in its sales in the fourth quarter of 2008. Based on the knowledge that it has very long supply chains, the unit's management drafted the hypothesis that it was destocking that caused the strong dip in demand for industrial products, and that this destocking was triggered by the bankruptcy of Lehman Brothers on September 15, 2008. It is fair to assume that the supply chain between this business unit and the end-customer could be as long as 250 days' sales. This means that it takes at least 250 days for a molecule to travel from DSM's warehouse to the final consumer, most of which is spent sitting in inventory. To give an example: if such a 250-day supply chain decides to reduce its stocks by 12%, an amount of stock equal to 30 days of sales (a whole month) is taken out of the chain, which for this DSM unit can result in either a business standstill for a whole month or a 33% decline during three months. Such a decrease does not take into account any dynamic behavior that may occur as a result of companies observing such substantial declines in sales, and which will further amplify the response. It is well-know from the literature (e.g., Forrester (1961), Sterman (1989), and Lee et al. (1997), Croson and Donohue (2006)), that decision makers typically overreact to short term sales information by erroneously updating their forecasts and by underestimating cumulative supply chain effects.

Extensive and simultaneous de-stocking throughout the supply chain has detrimental effects on this chain, especially for companies that are positioned upstream, such as DSM's resins business unit. However, extensive de-stocking will at some moment need to lead to restocking, as in many end markets consumer sales dropped only marginally compared to the losses amounting to dozens of percentage points that were reported in typical upstream industries such as the chemical industry.

It may be argued that due to aggregation this effect is no longer visible at the level of an entire economy. Chen and Lee (2010) argue that this aggregation could be a potential cause why Cachon *et al.* (2007) were unable to discover a bullwhip effect in aggregate economic data. However, in this credit crisis the initial response of companies was triggered *simultaneously*, effectively causing a composite bullwhip. Figure 1 shows US retail and US manufacturing sales between January 2007 and July 2009.
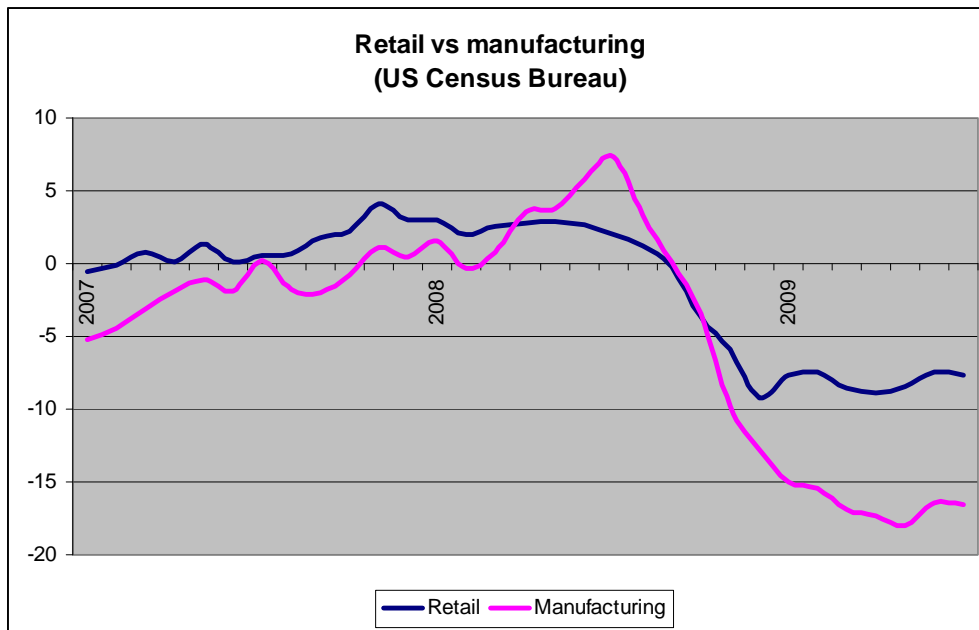
Figure 1. US retail and manufacturing sales (Source: US Census, downloaded 27 October 2009; seasonally adjusted, average of 2008 = 0)

The data in Figure 1 clearly shows that while retail sales dropped about 12% from September 2008 to the deepest point during the crisis, manufacturing sales dropped almost 30% in that period. The shapes of the curves are also different, with manufacturing sales showing a steeper decline extending over a prolonged period. These data therefore suggest that the effect that we observed in the resin/paint supply chain may also occur at the level of an entire economy. Obviously, more extensive study will be needed to investigate this and this could therefore form a strong basis for a joint operations management / economics research agenda.

3. Modeling the Lehman Wave

In order to contribute towards economic forecasting, however, we also need to be able to forecast the dynamics beyond after-the-fact observation and explanation. In particular, it is important to be able to model the moment at which the gradient changes from negative to positive. As we know from supply chain theory, the change to a positive gradient (increase in orders) typically leads to an overreaction in the supply chain, and therefore a later change from a positive gradient to (again) a negative gradient may also address the omnipresent question whether this recession is V-shaped or W-shaped.

Taking again the resins/paint supply chain as an example, our results (Peels *et al.*, 2009) indicate that forecasting at the supply chain level is very well possible and shows an excellent fit. In order to produce the forecasts, we have built a system dynamics model based on the logic of the beer distribution game (Sterman, 2000) and applied this within DSM to a number of business units and market segments. The decision making behavior that we modeled assumed that decisions makers update their desired stock level (base stock level) dynamically based on their demand forecast. Furthermore, we assumed that the demand forecast is dynamically updated using a moving average of sales of the two months prior to the forecast being made. Also, we modeled a supply chain wide simultaneous reduction of inventory on 1 October 2008. Based on a field survey of the supply chain, we estimated this average reduction at 10%. Finally, the regular delays in the supply chain were

modeled, such as lead time delays and delays for information processing. The latter ones are typically related to planning frequencies that may not be aligned across the supply chain.

An example of one of the market segments at Royal DSM is included in Figure 2.
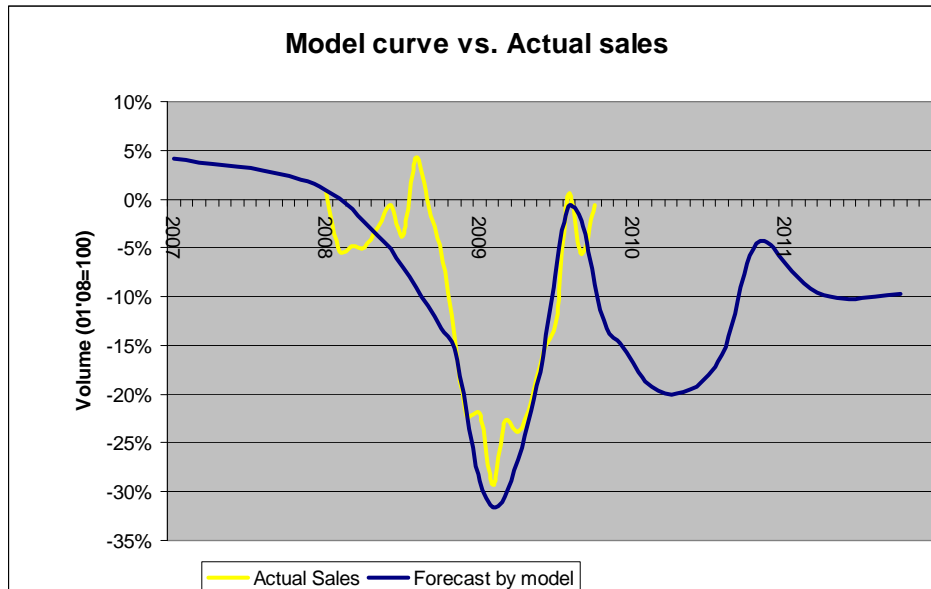

Figure 2. Modeled and actual sales curves in segment 2 supplying to construction market, based on construction market realizations issued by Eurostat in October 2009 and based on construction market forecasts issued by Euroconstruct in June 2009[†].

Figure 2 shows a market segment, which supplies into a part of the construction market. The blue line shows our sales forecast and the yellow line shows the actual sales. The forecast for the end market (European construction) is a gradual decline from the middle of 2008 to almost -10% in the middle of 2010. This and similar results for other segments and other business units of DSM show a high reliability of the forecasts. The most crucial value of the forecast for the company is the prediction in time, i.e., when is the dip at its lowest and when is the subsequent peak at its highest. This turns out to be fairly robust to the various modeling assumptions. Once the structure of the supply chain with its delays (especially lead times) is well-estimated, the frequency of the cycle turns out to be quite robust for other variables. Second, it is important to have a good estimate of the depth of the dips and height of the peaks. This is very much dependent on the estimate of the total inventory taken out of the supply chain and the quality of the forecast of the end market demand. Hence, this is more difficult to calibrate. Careful monitoring as the crisis progresses however provides very important information. For instance, once the first dip has been observed, it can be calculated with the model how much inventory has been taken out. Furthermore, once new end market forecasts become available, they can immediately be inserted into the model.

It is clear from our findings that supply chain theory and associated models can assist the management of companies to direct their company effectively through an economic crisis. It can provide a strong impetus to position supply chain management high on the management agenda. Based on these models, companies can improve the quality of their decision making on important crisis measures, such as:
- inventory reductions and inventory building
- lay-offs and re-hirings

[†] Note that data for the last quarter of 2010 cannot be shared at this stage due to reasons of confidentiality as DSM is a publicly listed company.

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- factory closures and re-openings

Furthermore, if commodity products are involved, this can also provide useful information for when to conduct extra buying of commodities.

4. Opportunities for improving economic outlooks

As mentioned above, the results of the model are fairly robust to parameter choice. For economic outlook modeling, especially estimating the moments that the gradient changes from negative to positive and the reverse is important. The length of the cycle is the same for the companies across the supply chain. While they are not completely in phase, at the aggregation level of quarters (three-month periods), the estimates are also robust. These empirical and experimental findings provide a good basis to understand the dynamics in the supply chain. These insights and models from the Operations Management discipline may hence be used for constructing aggregate economic outlooks. Obviously, this will require substantial research but it is a clear example of how operations management can contribute to the development of the economics research discipline. While the OM models may be strong in capturing the dynamics, they would need to be complemented by econometric models that capture the aggregate effects of sales and inventory.

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