

Stream 15: Technology, Innovation and Supply Chain Management

Competitive Session

**Expanding Sales and Operations Planning using Sentiment Analysis:
Demand and Sales clarity from social media**

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ABSTRACT

We outline the use of sentiment analysis as a tool for demand planning in sales and operations planning (S&OP). First, we explain how S&OP functions and the reliance on cooperation or collaboration with other firms to gain information. We introduce sentiment analysis and show its value in determining marketplace-changes which feed into supply chains. We show how sentiment analysis supports data acquisition independent of other firms in the supply chain; incorporated into S&OP, these data can support preparation for changing requirements. While demonstrated in marketing, this concept remains unproven in supply chain research. We believe this is the first assertion and examination of how sentiment analysis can support effective S&OP but further empirical research is required to validate this concept.

Keywords: Supply Chain Management, Sentiment Analysis, Business Analytics, Sales & Operations Planning

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Supply chains consist of activities fragmented over multiple companies in an attempt to create value in items and deliver these to the right customer and right place at the right time (Coyle, Langley, Novack, & Gibson, 2011; Fisher, 1997; Lee, 2004). Materials flow along the chain and are progressively transformed into products that a given firm believes customers want to buy. At the consumer-facing end, information about desires and market tastes can be collected, analysed, and transmitted back along the supply chain. In many cases the firms positioned upstream (i.e., closer to the source of materials than the consumer) will never fully understand, comprehend, or have full visibility of what is happening in the marketplace. Thus, their perception of 'what is going on' will come largely through other information flows in the supply chain and may be driven by purchase orders from customers, which may be used as a proxy for demand. However, using information this

way may also lead to the phenomenon of demand amplification, or the bullwhip effect (Lee, Padmanabhan, & Wang, 1997).

To overcome these challenges and to enable better internal planning and supply chain coordination, firms seek to gain greater visibility over operations throughout the supply chain. This often occurs through methods such as sharing point-of-sale (POS) information; sharing product movements captured with barcode scanning or radio frequency identification (RFID) tag reading; use of consignment stocks; vendor managed inventory (VMI); collaborative planning, forecasting, and replenishment (CPFR); just-in-time II (JIT II); sharing data using electronic data interchange (EDI); or other e-messaging systems and protocols (Wood, Reiners, & Pahl, in press). All of these data may be included in demand planning decisions in the sales and operations planning (S&OP) process as firms seek to ensure they have suitable capacity and inventory available to meet demand.

While these processes are well-understood, the mechanisms used to provide the information are all based on a key premise: that other information is available from cooperative or collaborative partners along the supply chain. We seek to understand how firms can break from this premise and engage in similar activities, but without the prerequisite of assumed cooperation of supply chain partners. We outline the use of ‘sentiment analysis’, sometimes referred to as ‘opinion mining’ (Pang & Lee, 2008; Tsytarau & Palpanas, 2012; Wood, Reiners, & Srivastava, in press), as a method that can be incorporated into S&OP to achieve this outcome.

This manuscript is laid out as follows. First, we review literature relating to demand sensing, demand planning, and the S&OP process. We then review literature on the use of sentiment analysis to understand market-based shifts in concerns that generate sales. We then outline how this approach can be employed by a focal firm that does not need to cooperatively or collaboratively engage with others in the supply chain to gain value from this approach in improving their S&OP process. Finally, we present the contribution that sentiment analysis can make to the S&OP process and outline areas where further research is required.

LITERATURE REVIEW

While senior management levels plan in broad strokes with highly aggregated data and operational execution works at an extremely detailed, day-to-day, level; the S&OP, or aggregate planning, process bridges these with plans at the tactical level (mid-range time horizon) plans that support the overall strategic plan of the organisation (Dougherty & Gray, 2006; Wallace & Stahl, 2008). Aggregate planning is performed for product families or groups of products (rather than for individual sales-keeping units [SKUs]) and contains plans for sales, production, and targeted inventory levels and backlogs (Figure 1). S&OP manages these aggregated ‘volumes’ of capacity and demand in product families and the mix between these groups. It balances overall rates of production, aggregated inventories, and matches these to sales rates. When the volumes have been established and agreed on in advance, other planning problems may disappear. This is the ‘big picture’ and provides an answer to questions of: how much, when, how, and at what rate. This level feeds into the master production schedule used at the execution level. It allows firms to avoid some problems through improved articulation of the gap between supply and demand earlier, providing more time to adjust and accommodate changes as required. The repetitive and iterative monthly S&OP is comprised of:

- **Data gathering** and demand reviews on a weekly basis to ensure accuracy and timeliness of data.
- **Demand planning** where the sales team reviews and updates data to generate new forecasts. Sources of demand and variability are analysed; customer service is monitored.
- **Supply planning** relates to evaluating the ability to meet demand using a mix of capacity and inventory positioning.
- **Pre-S&OP meeting** is the initial attempt to align the supply and demand plans while evaluating the overall financial impact. Exceptions are noted and alternatives are developed.
- **Full S&OP meeting** presents validated alternatives to senior decision-makers.

----- Insert Figure 1 about here -----

----- Insert Figure 2 about here -----

Demand planning focuses on likely future demand and the outcomes are derived primarily from statistical analysis of past sales and received orders and may be supplemented with judgemental

or qualitative analysis. Sales staff can aggregate the promotional plans and requirements for large customers, providing an overview of the evolving dynamics of orders and anticipated likely sales. Present and future sales for key product families or categories are forecasted. Firms following a make-to-stock (MTS) approach may draw primarily on forecasts while those following a make-to-order (MTO) approach may rely more heavily on customer intentions.

A basic principle of supply chain management is that information should be shared along the supply chain, with great emphasis being placed on information pertaining to 'how much' and 'where' demand would be. A simple supply chain (Figure 2) indicates the delays in transmitting information along the supply chain between a change in the market-based demand (point A at time t), the perception of demand by the retailer (at point B, time $t+1$), and the factory perception of a change in purchase orders (point C, $t+4$). The factory interprets purchase orders (*not* demand from the marketplace) a long time after an original change in demand in the marketplace; this has been identified as a primary cause of the bullwhip effect or demand amplification (Lee, Padmanabhan, & Whang, 1997). Approaches to combat the bullwhip effect have attempted to improve sharing data on inventory levels, forecasts, anticipated promotions or campaigns, or even point of sale (POS) data or stock movements captured using either RFID tags or barcode scanning. Capturing and sharing information on every product movement could result in the ultimate level of transparency, with full disclosure and availability of this information over the supply chain. In years gone by, much market-based information was possessed and used solely by the retailer to forecast and place replenishment orders from their suppliers. Now, however, many other firms along the supply chain are increasingly seeing value to be extracted from 'demand sensing' technologies (Folinas & Rabi, 2012). Such a "demand-driven approach ensures that supply and demand align as closely as possible, compensating for forecasts that are often incorrect without incurring excess costs. Building on this, implementing a Demand Sensing solution is a key backbone to becoming demand-driven, and the benefits in doing so are quite significant" (Folinas & Rabi, 2012, p. 260) for most organisations.

Most approaches adopted today in supply chains emphasise a dyadic information sharing arrangement to increase visibility and transparency. These approaches have been largely driven by requirements at the retail end of the supply chain, as large and dominant retailers seek to use supply

chain management as an approach to reduce costs and improve transparency or to improve product availability. These approaches include JIT II, CPFR, and VMI. Other approaches are driven by technology changes, including EDI, e-messaging systems, and information sharing between enterprise resource planning (ERP) systems using established standards (Wood, Reiners, & Pahl, in press).

It has become increasingly commonplace for ERP systems to facilitate communication and transfer of data between firms along the supply chain. These approaches can provide 'a window' into a firm's database and information, allowing a supplier to potentially see what the firm sees in a way that cuts the 'fog' between the supplier and the marketplace, and may even provide access to POS data (depending on where in the supply chain the firms are located).

Suppliers may embed their own employees at a customer site to manage inventory and the resulting orders in JIT II systems (Dixon, 1997). This can also accommodate the full management of inventory in a consignment stock or VMI approach to plan for availability of the product over two firms to reduce supply chain costs, with full responsibility taken by the supplier/vendor for ensuring that cost and service level targets are met (Disney & Towill, 2003).

Visibility over two levels of the supply chain can be enhanced using CPFR by improving the long-term forecast quality, raising planning decisions in a way that can reduce inventory levels while boosting service levels in a dyadic coupling (Nyman, 2012). Joint determination of purchase orders allows the supplier to prepare for anticipated changes in demand, based on the customer's anticipation/evaluation of the market. In-built continuous improvement processes between the firms lead to convergence on solutions over time.

These approaches all improve visibility over the supply chain by collaborating with firms in the supply chain. POS data must be shared by acquiescent retailers; customers must be happy with the staff at their site in JIT II; trading partners must use compatible systems or integrate 'communication modules' to trade data with each other; CPFR by definition begins with 'C' for collaboration. Thus, all these supply chain approaches require cooperation with partners and management of the relationships over time, presenting a not inconsiderable investment of resources. The question becomes: what happens if our partners' are unwilling to collaborate? What happens if the relationships are too manifold for us to manage at a low-cost of resources?

The rise of social media and Web 2.0 has created a wealth of new data which is widely available. These data are created by users and consumers, relating to products and services that they consume, possibly reviews, opinions, suggestion, likes, and not-likes. This data is freely available and represents the aggregated 'marketplace' opinion; if a firm is able to use these data wisely using approaches like sentiment analysis, they may have insight into the marketplace dynamics without reliance on supply chain partners.

Sentiment Analysis

For sentiment analysis to prove valuable in supply chain management two key relationships must hold. First, consumer behaviour must be connected to social media posts and sentiment analysis must be useful in predicting behaviour based on social media posts. Second, consumer behaviour must be connected to sales.

There is strong and compelling evidence emerging that social media can predict social behaviour (Abbasi, Chai, Liu, & Sagoo, 2012). Social behaviour can often be connected to sales to consumers. Sentiment analysis tools have been successfully applied to marketing functions in firms selling direct to consumers. This has been demonstrated where Web 2.0 opinions and reviews from consumers have been used to accurately predict sales and revenues (O'Leary, 2011; Qin, 2011; S. Yu & Kak, 2012; X. Yu, Liu, Huang, & An, 2012). Qin (2011) demonstrates that there is stronger evidence that the comments on blogs are causally connected to revenue; thus, understanding changes in the social media can help us anticipate changes in revenue. Such use of analytics is accepted as part of a current shift in improving business operations (Woodward, 2012; Zitnik, 2012).

As sentiment analysis can be used to predict sales and revenues to a consumer market the approach should be a useful process to improve S&OP for firms distant to the consumer market; i.e., those firms further upstream with less access to direct data relating to market activities. Here, sentiment analysis can predict sales/revenue changes in the consumer marketplace, allowing upstream firms to evaluate future changes in supply requirements and may help to prevent the bullwhip effect (Wood, Reiners, & Srivastava, in press).

The analysis of these natural-language-based data differs from the forms of statistical data analysis that most supply chain managers will be more familiar with and which underlie traditional tools such as statistical process control (SPC) and quality control approaches (think of the ‘sigma’ in six sigma quality control processes.). Instead, it falls under the category of ‘natural language processing’ (NLP) and rather than analysing numeric data to discover patterns, it attempts to discern the meaning of words, based on the words, their orders, and the context that they are used in, passing through several phases. The general analytic methods used in NLP take one of several main forms:

1. **Latent semantic analysis** assumes a hidden meaning that is not immediately apparent in the text. Analysis occurs using word occurrence data and correlation matrix-based approaches; transformations are used to uncover the most crucial terms and concepts that have been encoded into the text and how related these are to other terms (Landauer, 2007).
2. **Concept-based indexing** creates a network of semantic meanings based on the document. The relationships between concepts are measured and weighed to understand the importance of given concepts within the network of semantic relatedness displayed within the text (Boese, Reiners, & Wood, 2014).
3. **Formal concept analysis** relies on lattice theory and partially ordered sets. Context is determined and defined using tuples (i.e., a set of entities, attributes, and the binary relationships that occur between these) to create an ontology or collection arranged hierarchically to determine shared meaning in the document (Wille, 2009).

While analysis of the meaning of words is important, sentiment analysis needs to understand the ‘sentiment’ component – the emotional meaning and judgement behind those words (Montoyo, Martínez-Barco, & Balahur, 2012). This is comprised of three constituent tasks: (1) subjectivity classification, (2) sentiment classification, and (3) extraction of data concerning the ‘opinion holder’ or the ‘object/feature’ that is commented on. The process is independent of the level of analysis, or granularity (Kumar & Sebastian, 2012); a particular product may be analysed at the ‘item’ level (i.e., evaluation of opinions about a particular brand of motor vehicle) or at the ‘feature’ level (e.g., opinions regarding a new feature on a motor vehicle, such as seat warmers in an entry-level car).

Whether for an opinion holder or a feature/object (Kumar & Sebastian, 2012), first **subjectivity classification** follows semantic analysis; the meaning of text is used to separate the components that are of interest in the analysis: the subjective opinions or opinionated statements. This creates the subset that then undergoes **sentiment classification** where measurement is made of how positive or favourable a given comment is (Madison et al., 2012), allowing distinctions between positive and negative responses to be made. This separation may be based on a scale with multiple levels of strength (e.g., extremely positive, neutral, or somewhat negative) or it may simply be binary (i.e., either positive or negative). Finally, object/feature extraction seeks to connect the comments to a particular object/feature of interest, allowing analysis of how popular this may be (and, by extension, whether it may be worth including in other products in the future). At other points, opinion-holder extraction connects information about the utterer of the comment to sentiment; this is valuable in understanding nuances of the market segment that may be making these judgements on the product.

Such analysis is not without challenges and drawbacks, however. Research shows that evaluation of sentiment is fraught with difficulty. This is not limited to automated analysis using NLP approaches; even humans can struggle to interpret the subjective meaning of comments correctly. By way of example, a comment that may challenge both automated- or human-based analysis may be “Great stuff [Laptop Brand Name] – having the battery go flat so quickly is helpful!” Such sarcasm can be easily conveyed and understood with voice tonality, yet this nuance is lost due to the low-fidelity nature of text. While a simple analysis of the word ‘great’ and ‘helpful’ in the comment may indicate positivity; the idiomatic ‘go flat’ may not be picked up as a negative element. A human may pick up on the sarcasm and rate this as a ‘negative comment’ but automated sentiment analysis may instead evaluate it as ‘positive’.

If these comments are correctly evaluated as being negative, along with other comments including “battery life in new [Laptop Brand Name] computer is cra*p - returning the product”; “[Laptop Brand Name] battery only lasts 3 hours, no good. iPad is much better”; and “New [Laptop Brand Name] laptop battery drains too quickly when I’m out of office so it is no good for me”, then it is likely that sales will not likely be as high as anticipated. Such a sentiment analysis process allows the change in market-based sentiment to be analysed at a given point in time, with changes tracked to

determine the swell of market-based demand that will translate into sales at the market-facing end of the supply chain and which will, over time, translate into orders along the supply chain. If a large number of similar comments were made on social media, it is likely that this would precede a drop in sales, as consumers researching the product are dissuaded from purchasing the item following the warnings and stories that they hear from other, existing, users. In contrast, however, where a product exceeds expectations and there is significant positive discussion about the item or particular features, these will be in greater demand, pushing up sales in the market.

We therefore assert that while this technique has not been applied in supply chain management before, the successful experiences in marketing and consumer-facing firms indicates that the approach of sentiment analysis has value in understanding shifts in opinion within the market that can be used to evaluate sales in the market. A firm that is located farther upstream from the consumer can evaluate sentiment in the social media and, thereby, judge and forecast sales in that marketplace.

THE ROLE OF SENTIMENT ANALYSIS IN S&OP

The 'demand planning' process within S&OP can be enhanced using sentiment analysis as an aid to understanding the upcoming demand in the near future. Traditionally, this was done with reference to qualitative market analysis and sales orders. Increasingly, new approaches to business analytics extends the capabilities of the firm to go further, in this case, using sentiment analysis to understand changes in consumer sentiment and feeling towards products in the marketplace, which will translate directly into sales.

Sentiment analysis can prove to be a bellwether or a canary in the mine; early changes in the marketplace can be sensed before these are even translated into sales of consumer-oriented products, let alone before the information is transmitted along the supply chain. It has been postulated that the use of sentiment analysis may help prevent the bullwhip effect (Wood, Reiners, & Srivastava, in press). Divergences between behaviours along the supply chain and market-based demand can also be analysed using sentiment analysis as a leading indicator of sales. If orders from a customer company are moving in the opposite direction to that suggested by marketplace sentiment, further analysis is clearly required and the customer may be contacted for further information. If sales orders are

increasing while market-demand is decreasing, then a focal firm runs the risk of over-producing and having too much inventory in the supply chain (costly, as it will lead to write-offs later). Contrariwise, decreasing sales orders in the face of increasing market place demand may prompt further expansion of production in advance of the sales orders from a customer firm, enabling improved responsiveness, or the ability to appropriate position inventory in the supply chain to better manage fluctuations in demand. These are substantial challenges for firms.

RIM is the maker of the Blackberry mobile phone and new Playbook tablet. In late 2011, RIM made a \$485m USD write-down on their Playbook tablet inventory with the total value of inventory climbing to \$1b USD. Using sentiment analysis as input into their S&OP decisions may have led to a proactive reduction in inventory in advance, or a reduction in capacity allocated to particular products, in response to lukewarm market-based sentiment concerning the products. Similarly, in 2001 Cisco's write-off of \$2.25b USD of inventory was a response to accumulation of significant inventory volumes that were not matched by demand.

Example S&OP Using Sentiment Analysis – a Hypothetical Example

ABC is a component manufacturer of electronics products and supplies components to an electronics contract manufacturer, who supplies ComputerBrand (Figure 3). A few months back ComputerBrand (a major computer retailer and the main customer of the electronic contract manufacturer) launched a new flagship product that was supposed to revitalise their product line: the 'NewProduct' tablet computer. Next week, ABC has their monthly S&OP meeting scheduled; however, ABC's Supply Chain Manager is perplexed by the number of purchase orders he is getting from ABC's customer (the electronics contract manufacturer). He is not sure whether this new tablet computer is well accepted by the consumers and so to get an overview of consumers' sentiments he asks his analyst to log into <http://www.sentiment140.com> and <http://www.opinioncrawl.com> to informally evaluate what consumers and reviewers are noting about the NewProduct tablet. (These particular tools are 'broad' and user friendly so that the Analyst does not need to evaluate or connect terms and words to the positivity of sentiment expressed; the software manages this process.) Such tools evaluate the emotions/sentiments that are being expressed about NewProduct. The analyst

observes that during the pre-release marketing there was significant excitement expressed by consumers; yet, when the product became available and sales started there was a sudden drop in positivity of sentiment, connected to the consumer dissatisfaction with the device where various elements of performance failed to meet their expectations. During the monthly S&OP meeting the analyst notes that positive sentiment about the NewProduct tablet is relatively weak, in contrast with the expectations that this product would revitalise ComputerBrand's fortunes. Meanwhile, purchase orders are still coming the electronics contract manufacturer (the firm appears positive about the success of NewProduct). ABC can decide during their S&OP meeting to commence reduction of supply of the component in anticipation of a significant drop in demand in the near future. ABC's allocation of capacity to these components can be reduced; simultaneously, alternate customers can be identified who may be able to absorb some of the available supply in the near future if demand conditions change dramatically. This enables ABC to balance supply with expectation of a drop in demand in the near future, as indicated by the rapid drop in positivity to the products that one of the corporate customer manufactures.

----- Insert Figure 3 about here -----

Using sentiment analysis, therefore, occurs within the on-going data gathering and monthly demand planning process. We suggest that incorporation of sentiment analysis can serve in two main ways. First, where partner-based changes in demand information are not available, sentiment analysis can be used as a method for a firm to independently (of others in the supply chain) assess marketplace changes in sentiment and thus prepare for future changes in demand. In this way it can build into the regular demand planning processes. Second, divergences can be detected between forecasts of partner-based changes in demand and the sentiment-analysis-derived changes in the marketplace; these divergences require further investigation and can 'tighten' estimates made in this process.

CONCLUSIONS

We have demonstrated some of the challenges of the S&OP process in firms as they seek to balance supply and demand factors in planning processes. These approaches can be supported by tools such as EDI, e-messaging, JIT II, VMI, consignment stocks, CPFR, and sharing stock movements or

POS data. However, these approaches all require significant reliance on others in the supply chain. We have presented sentiment analysis as a solution that allows a firm to understand market-place demand changes without reliance on other firms downstream. This allows independent evaluation and monitoring of likely changes in sales before they are manifested as orders along the supply chain.

Challenges and future research

Several key challenges are still apparent and these should motivate future research. First, the technical challenge of correctly evaluating the meaning and sentiment of comments is an area of active and on-going research. Second, the impact of the 'distance' between a focal firm using this approach and the market is not clear. Whether sentiment analysis is as useful for a raw material extractor (i.e., distant from consumers) as it is for a firm that assembles finished goods (i.e., close to the consumer) is still an open question. Furthermore, where a firm has only a portion of their output going into certain markets, the consolidation and 'sense-making' of various sentiment analyses may be diluted. Finally, not all firms have identified where their output makes its way into the consumer market or which brands use it. Thus, it will be difficult for them to use sentiment analysis in S&OP. This paper outlines the possible value that can be derived using sentiment analysis but this value remains unproven and non-validated. Empirically, it would be necessary to identify and work with a firm that experiences regular sudden surges or drops in consumer purchases of their products or product families. Sentiment analysis can be used by the researchers to understand the swings in consumer sentiment which can then be correlated with the changing patterns of purchase orders along the supply chain that our partner firm experiences. Several firms could be partnered with in different industries, showing that the concept may be generalisable to other situations, including the service sector. Concurrently, simulation modelling of supply chain and sentiment analysis activities can be used to demonstrate that changes in sentiment can be incorporated into supply management processes in a way that a given firm's financial or operational performance is improved. The concepts may also prove valuable in service supply chains which are important as the service sector is dominant in developed economies and is becoming increasingly important in developing economies (Chesbrough & Spohrer, 2006); e.g., in China it accounts for approximately 40% of GDP (Lin, Zhou, Levine, &

Fridley, 2008). We opted to evaluate opportunities in manufacturing supply chains as there is a clear flow of products which we believe makes the concept easier to conceptualise for readers. Further research will evaluate the efficacy and validity of these concepts as applied to service supply chains.

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Figure 1 The Sales and Operations Planning process in the context of various types of business planning. Adapted from Figure 2-1 in Wallace & Stahl (2008).



Figure 2. A simple supply chain showing a delay in information transmission along the supply chain and different types of information.

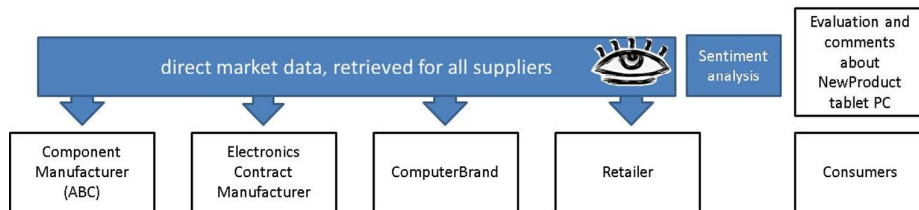


Figure 3. Sentiment analysis used by ABC to determine that a product is failing in the marketplace and feeding this information directly into S&OP to reduce the allocation of 'supply' to this product.