

Stream 15. Technology, Innovation and Supply Chain Management
Competitive Session

**Challenges in forecasting uncertain product demand in supply chain: A
systematic literature review**

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Challenges in forecasting uncertain product demand in supply chain: A systematic literature review

ABSTRACT: *Forecasting for uncertain product demand in supply chain is challenging and statistical models alone cannot overcome the challenges faced. Our overall objective is to explore the challenges faced in forecasting uncertain product demand and examine extant literature by synthesizing the results of studies that have empirically investigated this complex phenomenon. We performed a Systematic Literature Review (SLR) following the well-known guidelines of the evidence-based paradigm which resulted in selecting 66 empirical studies. Our results are presented into two categories of internal and external challenges: 24 of the 66 studies express internal challenges, whilst 13 studies report external challenges, and 8 studies cover both internal and external challenges. We also present significant gaps identified in the research literature.*

Keywords: Information systems, Operations management, Supply chain management

Supply chains are known to be large, complex and often unpredictable as they include four essential functions: sales, distribution, production, and procurement (Arshinder, Kanda, & Deshmukh, 2008). Operational management of supply chains requires methods and tools to enable organisations to better understand how unexpected disruptions occur and what impacts they will have on the flow of goods to meet customer demands (Qi, Huo, Wang, & Yeung, 2017). Supply chain visibility provides opportunities for managers not only to plan efficiently but also to react appropriately to the accurate information (Ali, Babai, Boylan, & Syntetos, 2017). Traditionally supply chains had a ‘make-to-stock’ paradigm which in many cases have been replaced by ‘make-to-order’ where the final part of manufacturing a product is performed after a customer order is received. This make-to-order model is particularly suited in organisations that produce customised products. Organisations need to decide on the number of components they source or stock keeping units (SKU) they manufacture before the customer demands it in the next sales. This problem is known as *uncertain demand forecast* and has widely been studied in economics and supply chain management (Kempf, Keskinocak, & Uzsoy, 2018). Supply chain management involves the sales and operations planning process (S&OP) which lies at the strategic and tactical level within an organisation. The S&OP involves a combination of people, process and

technology (Noroozi & Wikner, 2017). S&OP is defined as ‘a process to develop tactical plans that provide management the ability to strategically direct its businesses to achieve competitive advantage on a continuous basis by integrating customer-focused marketing plans for new and existing products with management of supply chain’ (Richard E. Crandall 2018, p.149). Several authors (e.g. (Grimson & Pyke, 2007; Noroozi & Wikner, 2017; Oliva & Watson, 2011; Wallace, 2008) have suggested that there are five formal steps that are performed, shown in Figure 1 (Wagner, Ullrich, & Transchel, 2014).

Insert Figure 1 about here

Several papers have been published on the design and methodology approach of S&OP (e.g. (Belalia & Ghaiti, 2016; Jesper & Patrik, 2017; Kjellsdotter, Iskra, Anna, C., & Riikka, 2015; Wagner et al., 2014). Based on these studies, it is suggested that S&OP is not a ‘one-size-fits-all’ process and that there is a need to consider the internal company context, external company context and the specific industry to address the unique S&OP problem (Jesper & Patrik, 2017). In the supply chain context there are integration issues that impact the S&OP process. Integration can be considered both vertical and horizontal, where vertical integration refers to linking the strategic plan, business plan, financial plan and long term objectives to short-term operational planning, whereas horizontal integration is concerned with the “cross-functional” integration considering both inter- and intra-company's activities (Thomé, Scavarda, Fernandez, & Scavarda, 2012; Thomé, Sousa, & Scavarda do Carmo, 2014). In fact, Lapidé (Grimson & Pyke, 2007) states that traditional S&OP is ‘internally focused and technologically challenged’. The S&OP process is considered to be more about employees participating in the process setup rather than just using a set of models or software (Bower, 2012; Grimson & Pyke, 2007; Petropoulos & Kourentzes, 2014). It is more important to have a well-documented and understood S&OP business process than to have a sophisticated software (Grimson & Pyke, 2007).

The forecasting of product demand is part of the demand planning process which is step two of the five steps in the S&OP process. In the literature, statistical methods, like time series or linear regression (Petropoulos & Kourentzes, 2014), “Fuzzy and grey” (Kahraman, Yavuz, & Kaya, 2010), and “Lumpy demand” (Raj Bendore, 2004), are commonly used to estimate the future demand. There are multiple

reviews (e.g. (Jesper & Patrik, 2017; Noroozi & Wikner, 2017; Thomé et al., 2012; Tuomikangas & Kaipia, 2014) of studies in supply chain management and related concepts, however, they are not adequate in the coverage of forecasting uncertain product demand.

BACKGROUND AND MOTIVATION

Supply chains have been known to create value by transforming and transporting goods and services that satisfy the demand of downstream customers (Carbonneau, Laframboise, & Vahidov, 2008); There are many factors in the supply chain that can affect the performance of fulfilling customer demand. Understanding customer demand is one factor that is crucial for sales forecasting and for efficient demand planning in industry (Armstrong, 1994; Louly, Dolgui, & Hnaien, 2008). The accurate replenishment of products during a specific period may be impossible for some products due to the uncertain demand (Kitaeva, Stepanova, Zhukovskaya, & Jakubowska, 2016). There are three major types of uncertainty that arise in this context: uncertainty of the demand forecast, uncertainty in external process and uncertainty in internal supply process (Keskinocak & Uzsoy, 2011). There has been significant research on forecasting demand in the supply chain, ranging from the early work on Croston's influential article (Croston, 1972) which for many years has been neglected but in the last 15 years has seen 245 citations (Scopus accessed May 17, 2018), to the adaptations of Croston's method such as Syntetos-Boylan Approximation (SBA) in 2001 (Syntetos & Boylan, 2001). Alternative approaches have been proposed such as Bootstrapping the use of statistical models such as Auto-Regressive Moving Average (ARMA), Discrete ARMA (DARMA) model and integer-valued ARMA (INARMA). Considerable amount of forecasting literature has focused on forecasting methods but evaluation of forecasting uncertain demand by systematic literature reviews empirically tested is scarce, for example the work of Berbain (Berbain, Bourbonnais, & Vallin, 2011) and Syntetos (Syntetos, Babai, Boylan, Kolassa, & Nikolopoulos, 2016). None of the previously conducted reviews are following the EBSE guidelines (Kitchenham, Budgen, & Brereton, 2015). An SLR based on these guidelines follows a rigorous and reliable procedure for search and selection of the sample studies in review. It is a methodical and thorough process of collecting and

collating acceptable quality published empirical studies based on a rigorous protocol to reduce bias and provide transparency to the process. This review process is formally documented and hence repeatable. With this gap in mind, our systematic literature review (SLR) is conducted, one which is exploratory in nature. We looked in more detail at previous work in the area of forecasting product demand in order to develop our research question that would be worthwhile pursuing in an empirical context in the area of supply chain. We were interested to find all the empirical papers published most recently that have investigated and evaluated forecasting uncertain product demand in supply chain. During the planning phase of our SLR, we used the following research question for data extractions:

What are the challenges faced by firms in forecasting uncertain product demand in supply chain?

This paper aims to provide, through a study of extant literature, a focus on the challenges of forecasting uncertain product demand in supply chain. We present a SLR of 66 empirical studies selected within the period 2007–2017. Following the guidelines provided by the Evidence Based Software Engineering (EBSE) (Kitchenham et al., 2015) and the supply chain management (SCM) paradigm (Durach, Kembro, & Wieland, 2017). We opted for the EBSE guidelines to conduct our SLR. The SCM guidelines were not found to be suitable to conduct this study as it assumed knowledge had already been acquired of the research problem in order to develop the initial theoretical framework. Our objective for was to explore and analyse the diverse literature to investigate and increase our knowledge of the challenges faced in forecasting uncertain product demand within the S&OP process and present our findings in supply chain.

METHODOLOGY

EBSE guidelines propose three main phases of SLR (Kitchenham et al., 2015), planning, execution, and reporting and disseminating results. During the planning phase we developed a formal SLR protocol for conducting our SLR. The protocol contained the details of our search strategy guided by the research question, inclusion/exclusion criteria, quality assessment criteria, data extraction strategy, and data synthesis and analysis guidelines. The protocol was tested for evaluating the completeness of our search string, and correctness of our inclusion/ exclusion criteria and data extraction strategy. The protocol was also sent to one external reviewer considered as expert in SLR. Minor recommended changes from the

reviewer related to the research questions were incorporated. During the execution the steps of the protocol were further refined. The planning phase of our review include the two key search strategies – primary and secondary including study selection criteria quality assessment and data extraction.

Primary search strategy

Our primary search strategy had the following steps;

- (1) Derived the major search terms from the research questions.
- (2) Conducted a pilot search using our major terms on Google scholar to identify relevant terms, synonyms and alternative spellings that are used in published literature.
- (3) Derived our search string using Boolean AND/OR operators with our major and alternative terms.
- (4) Selecting relevant A and A* ranking journals and conference proceedings (based on Australian CORE ranking, core.edu.au), grounded in empirical research for searching.
- (5) Citations and abstracts of the results were retrieved and managed using Endnote.

From our research question, we identified the following four major terms to be used for our search process: (1) Forecasting, (2) Product, (3) Demand, and (4) Supply Chain depicted in Table 1.

Insert Table 1 about here

From the major search terms, we identified alternative terms and formulated the following search string.

((‘Forecast*’ OR ‘Predict*’) AND (‘Product*’ OR ‘SKU’ OR ‘Stock Keeping Unit’) AND (‘Demand’ OR ‘Availability’ OR ‘Sales’ OR ‘Stochastic’ OR ‘Noisy’ OR ‘Unknown’ OR ‘Uncertain’) AND (‘Supply Chain’ OR ‘Procurement’ OR ‘Inventory’ OR ‘Order*’, OR ‘Planning’))

The search string was customized for the different online journals used according to the online interface requirements while we kept the logical order of the search consistent. For the primary searches the third author who is considered expert in SCM supplied a list of top ranked SCM Journals. We also applied a limit on the year during this primary search process. We posed the limit between 2007 and 2017 to ensure we capture the most recent works and challenges on forecasting demand in supply chain.

Study selection criteria

Once we obtained all the results using our derived search string, we applied the selection criteria (suggested by the EBSE guidelines available in the appendix), to filter out any irrelevant studies. The studies we were interested in were empirical studies that investigate forecasting uncertain demand in the supply chain and provided answers to our research question. For any differences we had in selecting the appropriate literature the decision of second author (Supervisor) was considered final. The study selection process was carried out in the following two steps:

Step 1: The results from the search were screened to filter papers from any of the following categories;

- Totally irrelevant papers that retrieved due to a poor search execution by search engines.
- All papers that were published before 2007

Step 2: From the papers retrieved in step 1, we further evaluated them to exclude studies that were:

- Not following an empirical research method
- Papers that had a simulation methodology and were not using real dataset from industry
- Literature Reviews, PhD or Masters Theses
- Duplicate studies
- Not relevant to the supply chain.

Secondary search strategy

We devised a secondary search strategy to ensure that we do not miss any of the relevant studies by performing the following two steps.

Step 1: Based on the retrieved and selected results, we scanned and reviewed all references that were cited greater than four times in our included studies. Using this snowballing approach, twelve articles were identified and added. The selected studies were applied with the same inclusion/exclusion criteria. However, in the screening process they were found to be published prior to 2007 and had not provided any new and noteworthy insights that were not included in the selected studies of the last 10 years.

Step 2: Furthermore, from the papers selected we checked the publication profiles of four authors who were cited in our selected studies 10 or more times for their work on forecasting uncertain demand. The authors include: Fildes, R, Syntetos, A. A, Gardner, E. S, and, Cachon, G.P. We scanned all their

published papers (from 2007 onwards) and those that were eligible for consideration were treated with the same two step selection criteria. At the end of the two step secondary search strategy, duplicate papers were discarded and the remaining 14 studies were selected and included in the final list.

Quality assessment

The quality of the selected studies was evaluated based on the research method they have adopted as well as the quality of the data used. Overall, we performed a three-stage quality assessment as follows:

1. Quality of the study – Our objective was to find empirical studies investigating forecasting uncertain product demand to answer our research question. Therefore, the studies that had utilised poorly described research methods or had not used data from industry were filtered out. We reused the quality assessment checklist developed using EBSE guidelines. Appendix B provides the Quality Assessment Checklist that we used for evaluating the papers. The checklist evaluates the studies based on their strength of reporting the details of the empirical method design and execution. The first author (student) applied the quality checklist on the selected studies with discussion and feedback from the second author (supervisor). The quality assessment was not used for scoring or ranking but rather to filter out low quality publications. All the papers that scored more than 50% were included in our review.

2. Quality of the publication outlet – For evaluating the quality of the outlet where the papers have been published, we utilized the ABDC (Australian Business Deans Council) ranking of 2016 (www.abdc.edu.au/master-journal-list.php). ABDC is committed to review and ensure the quality list rankings of journals. The outlets where the selected papers were published may not necessarily indicate the quality of the paper itself. To ensure the quality of the included papers, we already have assessed them through the quality checklist as described above and provided in Appendix B.

3. Assessment of the impact of the paper – To assess the impact of the published papers, we checked their citations through Google Scholar.

Data extraction

Based on our research protocol a spreadsheet was used to extract three types of data; Publication details, Context description, and Findings.

1. Publication details (title, authors, journal information, number of citations of, year of publication).
2. Context description (research method, industry of empirical data, and geographical location).
3. Findings (challenges faced in forecasting unknown demand).

SYSTEMATIC LITERATURE REVIEW EXECUTION

By performing a search on Google scholar using our major terms, we retrieved a total of 303 papers. The papers were scanned for key terms and any relevant new terms were derived. The keyword terms were used to produce a keyword search string. By executing the search string on specific resources, we retried a total of 338 papers in our primary search. Irrelevant papers were filtered out at step 3 of the SLR process depicted in figure 2. We were left with 178 relevant papers. After screening the papers from step 4 where we read the full paper and removed any which did not present an empirical research methodology. A decision was also made that any paper which used simulation with random data did not meet the selection criteria and was excluded. Out of 178 relevant papers, 54 remained, and 2 were excluded based on their low quality when evaluated against our quality assessment checklist (Appendix B). We were left with 52 empirical studies (Appendix A). We then performed step 5 of our SLR process, this included two steps. The first step was to complete a snowball scan on all the references in our selected studies. We retrieved 12 papers, however when applying our study selection criteria, no papers were found to be appropriate. The second step in the selection criteria was checking the profile of highly cited authors and retrieving the relevant papers. We retrieved a further 14 studies that were relevant and not included in our primary search results. After this step we ended up with a total of 66 papers for our final inclusion (Appendix A). Figure 2 presents the whole SLR execution process taken.

Insert Figure 2 about here

Table 2 presents a summary of the finally selected studies.

Insert Table 2 about here

RESULTS

In this section we describe the quality characteristics extracted from the 66 empirical studies.

Quality attributes

Out of the 66 studies, 49 studies are from A* ranked journals, which indicates we have an overall high-quality set of result. All the papers that have been included in our review were those that contained sufficient information about the research method used and hence they scored above 50% in the quality assessment checklist provided in Appendix B. Another measure that was used to assess the quality of publications that we used is the impact they have had on the relevant research community. The number of citations to a paper is considered as an indicator for a good impact. In our results 21 papers had over 50 citations and S11 and S33 had over 150 citations.

Insert Figure 3 about here

Research Methodologies

Our collection of the 66 empirical studies contains 37 experiments, 14 case studies and 15 surveys. Out of 66 studies, 35 used a statistical method. From 2008 to 2017 there is an average of 3 studies using a mathematical method and most are of very high quality and are published in A* ranked journals.

Insert Figure 4 about here

Data Sources

Figure 5 shows the number of empirical papers against conferences/journals for our resulting studies.

Insert Figure 5 about here

It is important to note that 49 of the included studies (22 from Journal of Production Economics, 17 from European journal of Operational research and 8 from Journal of Operations management), are published in the highest ranked outlets with highest impact factors for many years. Our collection of papers covers a wide range of geographic locations. One third of the 66 studies are from the UK.

Insert Figure 6 about here

Challenges faced in forecasting uncertain product demand

The challenges identified are divided into two categories namely, internal and external challenges. In Table 3 we present the factors given in the studies that are considered to be causing internal challenges along with their frequency from our studies. Internal challenges are found to be within an organisations’ internal environment which is made up of employees, management, communication and culture.

Insert Table 3 about here

The external challenges relate to outside factors that can impact an organisation in its ability to forecast demand as presented in Table 4.

Insert Table 4 about here

Looking at the overall results out of the 66 studies, 24 studies express internal challenges faced in forecasting uncertain product demand and they make 83% of the results, whilst 13 papers are reporting external challenges only. From the 37 studies, 8 studies cover both internal and external challenges. We further categorized these two categories of challenges incrementally creating several dimensions. Dimensions are generally categorical data and can also be called a variable (Nickerson, Varshney, & Muntermann, 2013). In this paper we define our dimension as our category which describes the characteristics about the challenges faced in forecasting uncertain product demand. We created 6 dimensions for internal challenges and 5 for external, there was only one common dimension between the two which is “technology”. To give a more comprehensive picture of the results obtained, the frequencies are further mapped against the forecasting challenge adopted to obtain these results. In our SLR we found that many challenges in forecasting demand still exist today, the most prominent problem identified by the internal category are product related and for external it is the environment. Figure 7 shows the percentages of the studies selected that have challenges in these categories.

Insert Figure 7 about here

The most frequent challenge occurring in the product category is the product price changing which impacts the ability to accurately forecast demand. Within the environment category the highest frequent challenge occurring is the seasonality which affects customer purchasing habits and the demand of products. Overall the highest challenge mentioned in the studies is judgmental adjustments which causes bias and reduces the forecast accuracy. Several studies (Fildes & Goodwin, 2007; Fildes, Goodwin, Lawrence, & Nikolopoulos, 2009; Syntetos, Kholidasari, & Naim, 2016) have attempted to address this challenge by asking managers to justify their adjustments which has shown to discourage adjustments made without a factual basis. The comparison of previous judgmental adjustment performance has also

been used in several studies (Fildes & Goodwin, 2007; Franses & Legerstee, 2013; Goodwin, Fildes, Lawrence, & Nikolopoulos, 2007) to try and improve accuracy by allowing forecasters to review previous results of their adjustment to help them understand the demand forecast.

It is important to note that these categories are not all mutually exclusive, where some are overlapping such as in the internal environment, marketing overlaps with operations. The creation of promotions by marketing can impact inventory in operations which creates a strain on uncertain product demand forecasting. The overlaps between these challenges can be due to a lack of vertical or horizontal integration in a firm. There are also external challenges which overlap such as government policy and lead times. The change in government policy may increase lead times of importing products and lead to challenges in forecasting. The identified internal and external challenges inform future researchers of the factors that need be considered in the field. Several of the categories should be given priority for future research such as the product, management and communication for internal challenges and environment and culture for external challenges as they make up most of the challenges in the selected studies.

CONCLUSION

In this paper, we have presented a systematic review of 66 scholarly works that deal with forecasting uncertain product demand in supply chain. Our SLR has painted a rich picture of the complex practices by including many internal and external organisation factors that play their role in the challenges of forecasting demand. Our SLR enabled us to organise and structure these challenges into related themes and identify the most frequent challenges discovered in the literature of the last decade. Our rigorous analysis of the results enabled us to develop a categorized list of internal and external factors that impact forecast accuracy. This list would be able to assist practitioners in their understanding of all the issues related to the design of more effective strategies for forecasting in supply chain domain. Furthermore, the results of our SLR will inform practitioners about various aspects of the internal/external organisation challenges faced and how they can be mitigated.

FUTURE WORK

The main focus of our SLR was to explore forecasting uncertain product demand in supply chain and we found that there is an extremely large body of research literature both empirical and non-empirical available on this topic. However, while analysing the included studies to answer our research question we found some gaps in the empirical literature. Following is a list of concepts that are not explored well within the current empirical literature that provides convincing evidence for open research areas:

1. Judgmental adjustment is the largest contributing factor to the identified challenges. Its aim is to alter and improve the statistical output to make it closer to the actual value. (Petropoulos, Fildes, & Goodwin, 2016). Improving this crucial part of forecasting for uncertain product demand needs to be further explored
2. The combination of solutions such as the use of statistical models, judgmental adjustments and information sharing which mitigate the challenges of forecasting uncertain demand in the literature is not empirically investigated and measured.

We were expecting to find more papers on the problems faced in forecasting uncertain product demand in the literature, but our search results show majority of the work has been done only in the operations and management research community and published mostly in operations management journals.

We are using the findings of this SLR to analyze the results of our own ongoing research on forecasting uncertain product demand. We are currently analyzing a large amount of qualitative data collected from a set of 18 interviews in a very large manufacturing company in Australia. Our preliminary results indicate that there are many challenges faced apart from choosing the most appropriate forecasting technique. Our findings will assist in the future work of developing forecasting models that consider the challenges faced internally within a firm as well as its external environment. This is again a rich area for future research that seems to have been somehow neglected.

Tables and Figures

Table 1 Search Terms and their synonyms.

(1) Forecasting	(2) Product	(3) Demand	(4) Supply Chain
Forecasting;	Product; Products;	Demand;	Supply Chain;
Forecast;	Stock Keeping Unit;	Availability;	Planning;
Predicting;	SKU;	Sales;	Procurement;
Predict;		Stochastic;	Inventory;
		Unknown;	Order; Orders;
		Noisy;	
		Uncertain;	

Table 2 Summary of final selection.

Search	Total number of Studies	Studies
Primary searches	52	S1 -S49, (S64 - S66)
Secondary searches	14	S50 - S63
Total	66	

Table 3 Internal Challenges identified from studies selected.

	Category	Forecasting Challenge	Description	Extracted from the following studies	Freq (N= 66)
Internal	Technology	Fragmented information technology	Sales forecasting information resides on multiple systems maintained by different functional areas, or, in the worst case, by an employee in a personal program on a desktop computer. Fragmented IT resources requires manual intervention that in turn introduces errors in the which degrades the data integrity.	S06, S66	2

	Difficulties analysing information being shared	The lack of capability to analyse information between systems leads to problems in forecast accuracy.	S46, S66	2
	Changes in technology	The changes in technology creates new trends which influence and impact forecast demand.	S50	1
Product	Product price change	The continuous change in the price of products makes the forecasting of the focal product demand difficult and to establish a base demand.	S10, S11, S18, S50, S55	5
	New product introduction	The demand forecasts of new products cannot be based on historical data as it is nonexistent.	S16, S64	2
	Substitute product introduction	The creation of substitute products creates a vacuum of accurately forecasting the demand of the product being substituted.	S19, S50, S64	3
	Product customization	The unforeseen demand for the different variations available for products to be customised make forecasting harder.	S05, S19, S34, S64	4
	Large product range	Product variety is an important characteristic of an organisation however it prevents reliable forecasts and limits visibility of future demand.	S18, S22, S34, S64	4
	Short product lifecycle	The stage at which the product is in its lifecycle adds challenges in knowing the true demand.	S49, S51, S55, S64	4
Marketing	Promotions and advertising activity	Promotions, campaigns and advertising aim to modify customer behaviour. The change in behaviour makes forecasting algorithms inadequate for forecasting since they are based on previous demand patterns.	S11, S18, S50, S51, S52, S55, S62	7

Management	Senior management influence	Senior management may simply ignore the system generated forecast and create their own forecasts or adjust forecasts without consulting the forecasters.	S06, S12, S50	3
	Political influence	Adjustments to the forecast may not be achievable as it may be motivated by political factors such as pressure from executive management.	S06, S50, S60, S61	4
	Management agility	Lack of leadership styles and the ability to adapt the business to the changing business environment impacts the demand forecast.	S03, S06, S46	3
Communication	Judgmental adjustment	The change in forecast by a judgmental adjustment may bring optimism bias or an overreaction to recent signals in the demand.	S11, S12, S31, S44, S50, S51, S60, S61, S62	9
	Communication	Forecasters may have difficulties in articulating what judgmental adjustment needs to be made because of the tacit knowledge involved.	S03, S06, S11	3
Operations	Safety stock	Not having a sense of how much is too much of safety stock.	S22, S66	2
	Inaccurate estimates on inventory level	A lack of estimates on inventory information about total or remaining stock creates challenges in understanding the supply and demand.	S66	1
	Too many forecast techniques	Forecasters tend to 'cycle' between forecasting methods often returning several times to methods that they had already investigated.	S61	1

Table 4 External Challenges identified from studies selected

	Category	Forecasting Challenge	Description	Extracted from the following studies	Freq (N= 66)
External	Culture	trust	Abuse of power between manufacturers and suppliers leads to mistrust which causes a lack of communication and sharing of information.	S32, S40, S59, S64, S66	5
		Exaggeration of demand forecast	Forecasters exaggerate demand to ensure that suppliers give them priority.	S32, S40, S50, S60	4
	Environment	Weather	Unforeseeable natural conditions like bushfires or floods adds additional challenges in forecasting demand.	S50, S66	2
		Holidays	Local or international holidays can impact supplies or demand orders.	S50	1
		Strikes	Industrial strikes at any point of the supply chain impact the demand forecast.	S50	1
		International crisis	An international crisis such as an act of war or civil unrest can adversely impact the forecast.	S50	1
		Change in Government policy / regulation	Changes in policy which impact import/exports can impact a demand forecast or the change in regulation for a product or service.	S50, S66	2
		Unique events	Major events such as the Olympic games can have an impact on the demand forecast.	S50, S55	2

		Seasonality	This refers to a portion of demand fluctuation that occurs by a repeating pattern and cannot be accounted as the base demand.	S14, S29, S34, S64, S66	5
	Suppliers	Lead times	Long or change in lead times of components or products from suppliers can impact on meeting the forecast.	S22, S64, S66	3
		Loss of key players i.e. supplier, manufacturer	The liquidation of a competitor, supplier or manufacturer.	S64	1
	Technology	Social media	The use of social media can have an unseen effect on the forecast demand due to a negative/positive attention.	S64	1
	Competitors	Competitor activities	Competitors promotions, new product launch or product price change can impact the demand forecast.	S18, S50, S55, S64	4

Figure 1 S&OP Process

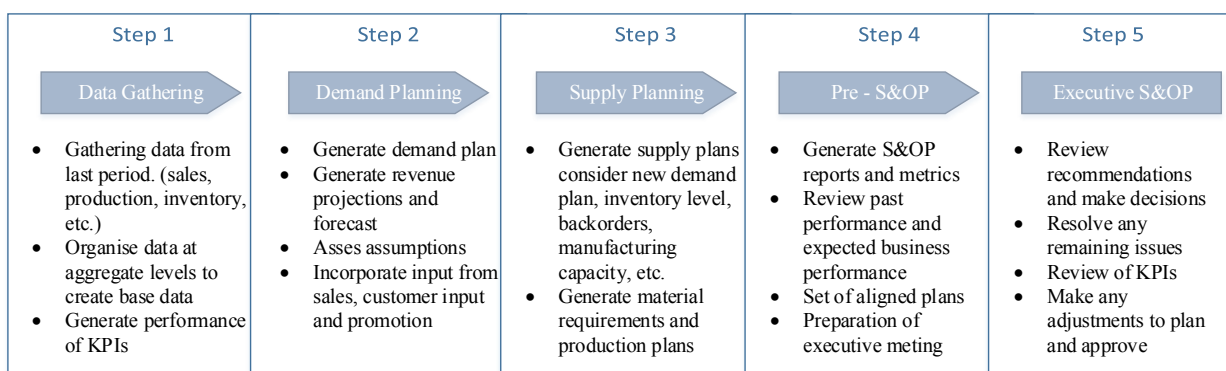


Figure 2 Systematic literature review process executed

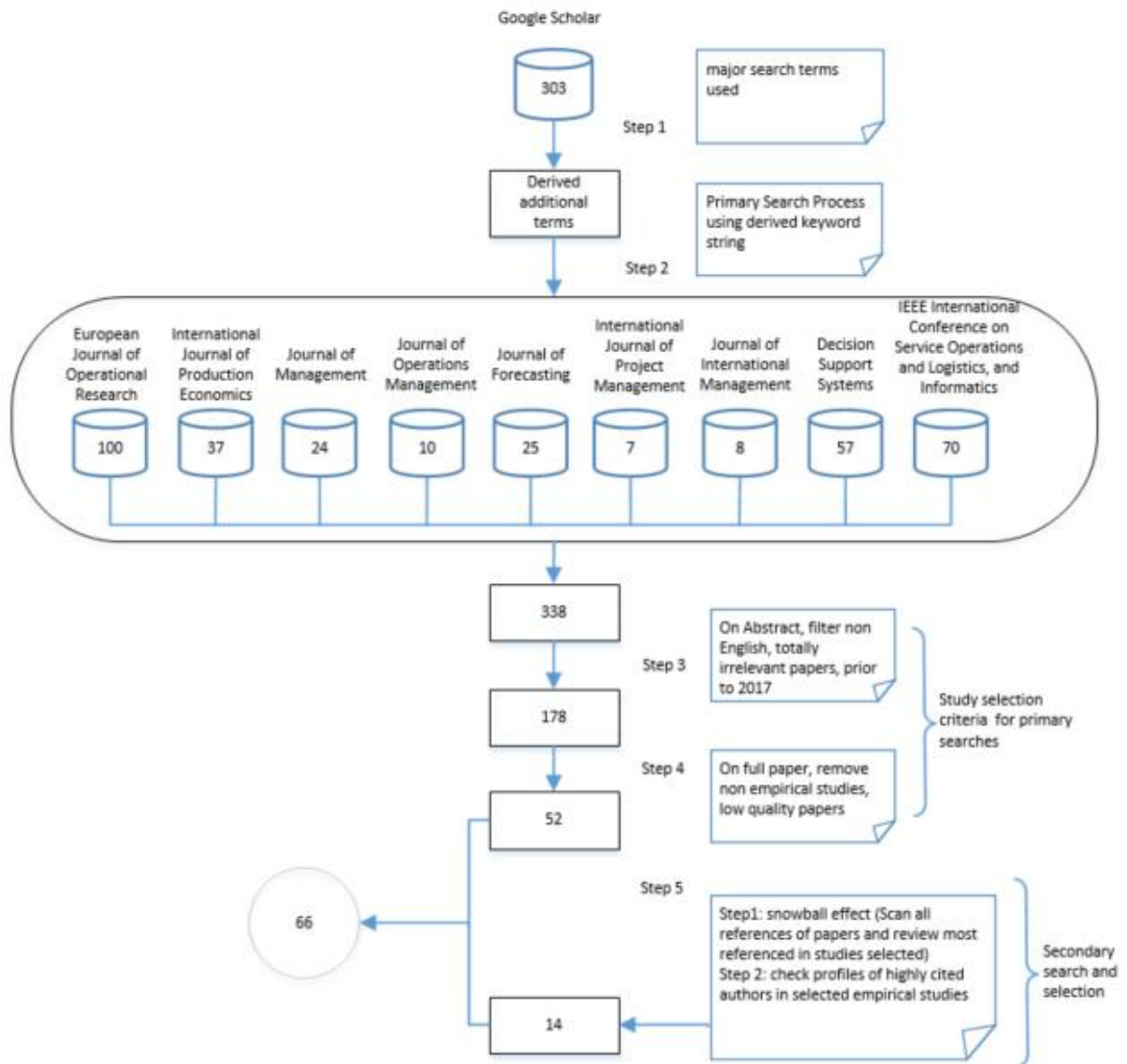


Figure 3 Citation count for resultant studies from Google scholar (as of 5th March 2018)

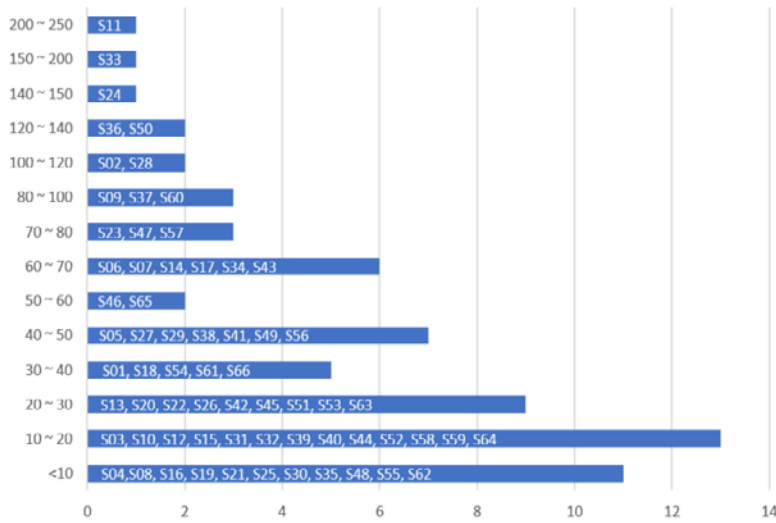


Figure 4 Research methodologies used in resultant studies

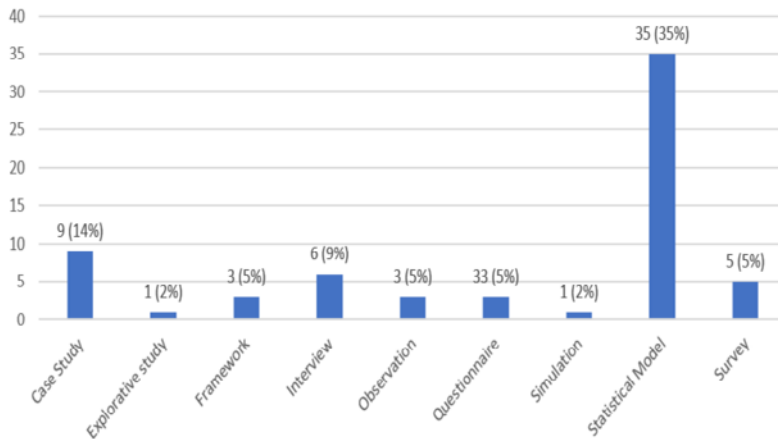


Figure 5 Publication outlet of resultant studies

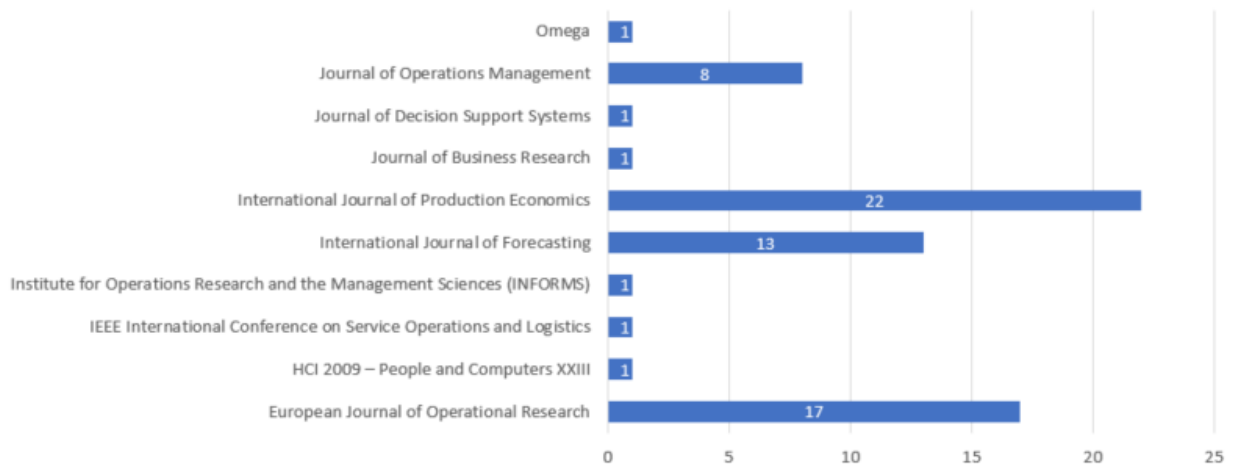


Figure 6 Primary geographic location of resultant studies

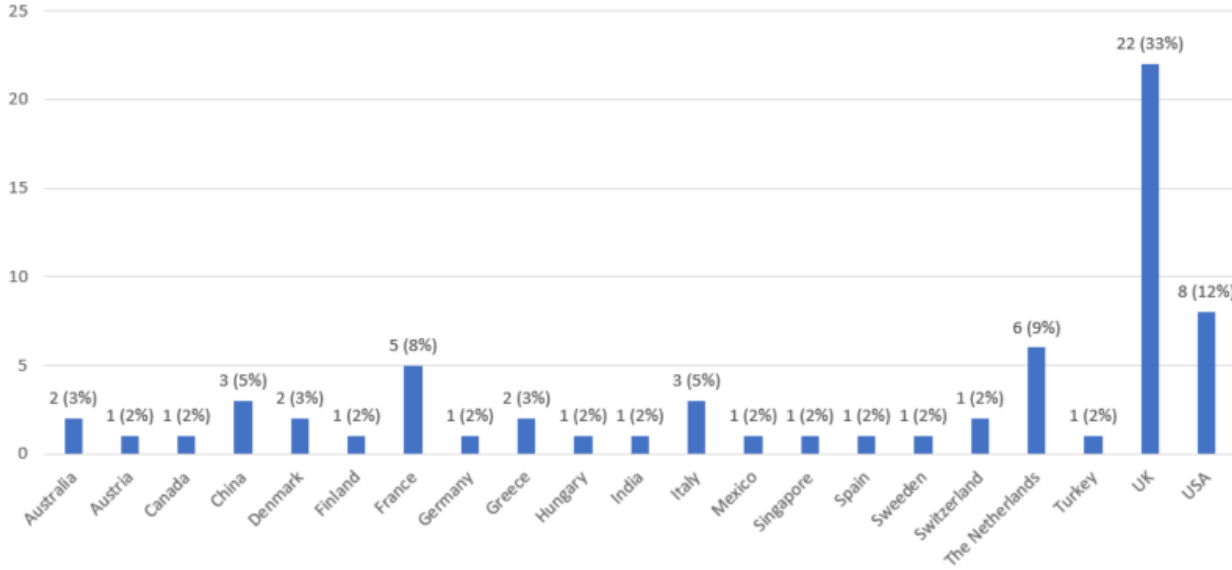
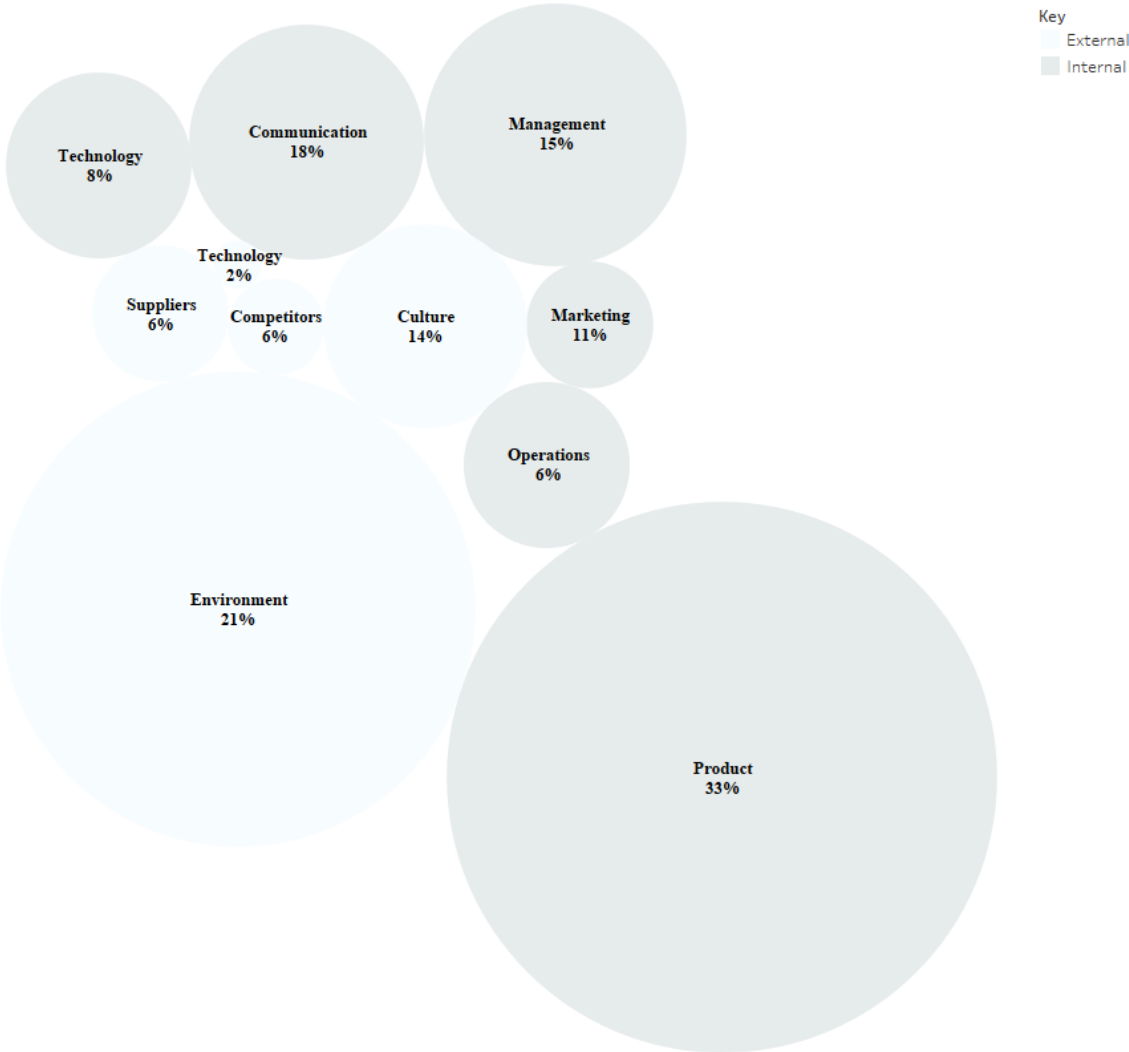


Figure 7 Percentage of studies selected in each category



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Appendix A. Included empirical studies

No	Paper Reference
S01	Ali, M. M., et al. (2012). "Forecast errors and inventory performance under forecast information sharing." <i>International Journal of Forecasting</i> 28(4): 830-841.
S02	Baker, P. (2008). "The design and operation of distribution centres within agile supply chains." <i>International Journal of Production Economics</i> 111(1): 27-41.
S03	Brusset, X. (2016). "Does supply chain visibility enhance agility?" <i>International Journal of Production Economics</i> 171: 46-59.
S04	Chao, G. H. (2013). "Production and availability policies through the Markov Decision Process and myopic methods for contractual and selective orders." <i>European Journal of Operational Research</i> 225(3): 383-392.
S05	Chen-Ritzo, C. H., et al. (2010). "Sales and operations planning in systems with order configuration uncertainty." <i>European Journal of Operational Research</i> 205(3): 604-614.
S06	Davis, D. F. and J. T. Mentzer (2007). "Organizational factors in sales forecasting management." <i>International Journal of Forecasting</i> 23(3): 475-495.
S07	De Vries, J. (2011). "The shaping of inventory systems in health services: A stakeholder analysis." <i>International Journal of Production Economics</i> 133(1): 60-69.
S08	Demeter, K. (2014). "Operating internationally - The impact on operational performance improvement." <i>International Journal of Production Economics</i> 149: 172-182.
S09	Nenes, G., et al. (2010). "Inventory management of multiple items with irregular demand: A case study." <i>European Journal of Operational Research</i> 205(2): 313-324.
S10	Duan, Y., et al. (2015). "Bullwhip effect under substitute products." <i>Journal of Operations Management</i> 36: 75-89.
S11	Fildes, R., et al. (2009). "Effective forecasting and judgmental adjustments: an empirical evaluation and strategies for improvement in supply-chain planning." <i>International Journal of Forecasting</i> 25(1): 3-23.
S12	Franses, P. H. and R. Legerstee (2013). "Do statistical forecasting models for SKU-level data benefit from including past expert knowledge?" <i>International Journal of Forecasting</i> 29(1): 80-87.
S13	Govindan, K. (2015). "The optimal replenishment policy for time-varying stochastic demand under vendor managed inventory." <i>European Journal of Operational Research</i> 242(2): 402-423.
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S15	Hansen, K. R. N. and M. Grunow (2015). "Planning operations before market launch for balancing time-to-market and risks in pharmaceutical supply chains." <i>International Journal of Production Economics</i> 161: 129-139.
S16	Hartzel, K. S. and C. A. Wood (2017). "Factors that affect the improvement of demand forecast accuracy through point-of-sale reporting." <i>European Journal of Operational Research</i> 260(1): 171-182.
S17	Hemmelmayr, V., et al. (2010). "Vendor managed inventory for environments with stochastic product usage." <i>European Journal of Operational Research</i> 202(3): 686-695.
S18	Huang, T., et al. (2014). "The value of competitive information in forecasting FMCG retail product sales and the variable selection problem." <i>European Journal of Operational Research</i> 237(2): 738-748.

- S19 Kaipia, R., et al. (2017). "Information sharing for sales and operations planning: Contextualized solutions and mechanisms." *Journal of Operations Management* 52: 15-29.
- S20 Kalchschmidt, M. (2012). "Best practices in demand forecasting: Tests of universalistic, contingency and configurational theories." *International Journal of Production Economics* 140(2): 782-793.
- S21 Krishnan, T. V., et al. (2011). "Modeling the demand and supply in a new B2B-upstream market using a knowledge updating process." *International Journal of Forecasting* 27(4): 1160-1177.
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Appendix B

The scoring on the quality assessment checklist was based on three possible answers to the questions; yes = 1, partial = 0.5 and no = 0. If any of the criteria was not applicable on any study then it was excluded from evaluation. The studies that scored less than 50% in the quality assessment were excluded as they were not providing adequate information on the studies research methodology.

Generic Assessment

Q1	Are the aims clearly stated?	Yes/No
Q2	Are the study participants or observational units adequately described?	Yes/No/Partial
Q3	Was the study design appropriate with respect to research aim?	Yes/No/Partial
Q4	Are the data collection methods adequately described?	Yes/No/Partial
Q5	Is the statistical methods used to analyze the data properly described and referenced?	Yes/No
Q6	Are the statistical methods justified by the author?	Yes/No
Q7	Are negative findings presented?	Yes/No/Partial
Q8	Are all the study questions answered?	Yes/No
Q9	Do the researchers explain future implications?	Yes/No

Survey

Q1	Was the denominator (i.e. the population size) reported?	Yes/No
Q2	Did the author justify sample size?	Yes/No
Q3	Is the sample representative of the population to which the results will generalize?	Yes/No
Q4	Have “drop outs” introduced biasness on result limitation?	Yes/No/Partial

Experiment

Q1	Were treatments randomly allocated?	Yes/No
Q2	If there is a control group, are participants similar to the treatment group participants in terms of variables that may affect study outcomes?	Yes/No
Q3	Could lack of blinding introduce bias?	Yes/No
Q4	Are the variables used in the study adequately measured (i.e. are the variables likely to be valid and reliable)?	Yes/No

Case Study

Q1	Is case study context defined?	Yes/No
Q2	Are sufficient raw data presented to provide understanding of the case?	Yes/No
Q3	Is the case study based on theory and linked to existing literature?	Yes/No
Q4	Are ethical issues addressed properly (personal intentions, integrity issues, consent, review board approval)?	Yes/No
Q5	Is a clear Chain of evidence established from observations to conclusions?	Yes/No/Partial