



HAL
open science

Understanding Supply Chain Visibility Through Experts' Perspective: A Delphi Based Approach

Tarun Kumar Agrawal, Ravi Kalaiarasan, Jan Olhager, Magnus Wiktorsson

► **To cite this version:**

Tarun Kumar Agrawal, Ravi Kalaiarasan, Jan Olhager, Magnus Wiktorsson. Understanding Supply Chain Visibility Through Experts' Perspective: A Delphi Based Approach. IFIP International Conference on Advances in Production Management Systems (APMS), Sep 2021, Nantes, France. pp.189-196, 10.1007/978-3-030-85910-7_20 . hal-03806487

HAL Id: hal-03806487

<https://inria.hal.science/hal-03806487v1>

Submitted on 7 Oct 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License



This document is the original author manuscript of a paper submitted to an IFIP conference proceedings or other IFIP publication by Springer Nature. As such, there may be some differences in the official published version of the paper. Such differences, if any, are usually due to reformatting during preparation for publication or minor corrections made by the author(s) during final proofreading of the publication manuscript.

Understanding supply chain visibility through experts' perspective: A Delphi based approach

Tarun Kumar Agrawal¹✉ [0000-0003-4408-3656], Ravi Kalaiarasan¹[0000-0002-5005-9639], Jan Olhager³[0000-0002-0175-1557], Magnus Wiktorsson¹[0000-0001-7935-8811]

¹Department of Sustainable Production Development,
KTH Royal Institute of Technology, Södertälje, Sweden

²Department of Industrial Management and Logistics,
Lund University, Lund, Sweden

tkag@kth.se; tarunagraw@gmail.com

Abstract. Visibility in production logistics and across the supply chain has become a key concern for organizations. Its need has been further emphasized due to the current COVID 19 crisis. Organizations find it challenging to prepare the internal logistics and supply chain, and quickly respond to such unexpected events, due to low visibility. Against this backdrop, the paper, which is a work-in-progress, systematically documents different factors influencing supply chain visibility and crucial information that should be collected and shared among supply chain partners for better visibility. A Delphi analysis is being conducted with twenty-six supply chain experts from various globally recognized enterprises with manufacturing units located worldwide. The study starts with a short open-ended questionnaire to collect a comprehensive list of antecedents, drivers, barriers, effects, and visibility information based on the qualitative response from the experts. The preliminary results from the first round of the Delphi analysis indicate that risk management, environmental sustainability, and supply chain control are some of the key drivers. Lack of IT infrastructure and maturity are some of the barriers, integrated systems, and technology maturity are among the key antecedents and gaining planning capability and better customer service are some of the positive effects of supply chain visibility as per the experts' opinion. In addition, information related to planning, supplier location, and deviation are among the crucial ones that require the collection and sharing for better supply chain visibility. This research study is among the few that empirically explores factors influencing supply chain visibility and generates new insights as to why the barriers can be difficult to overcome in complex supply chain settings.

Keywords: Supply chain, Visibility, Delphi analysis.

1 Introduction

Supply chain visibility (SCV) refers to “management efforts to gather information about operations upstream and downstream in their supply chains” [1]. A simplified conceptualization of SCV – including external and internal visibility – is demonstrated

in Figure 1. Internal visibility management refers to the gathering and sharing of information within a business's processes. It includes all the methods, procedures, and elements needed to collect, record, and share data. Internal tracking takes place when goods or raw materials are received, processed internally, and then the product is delivered to third parties. It involves an intra-site real-time visualization system for material management including dynamic synchronization, takt, and resource planning. External visibility, on the other hand, refers to the product outside of a business entity, in the entire supply chain, and concerns dynamic status and prediction of supply network status among companies and countries. For external SCV to be effective, it relies on the existence and appropriate design of internal visibility of each entity [2].

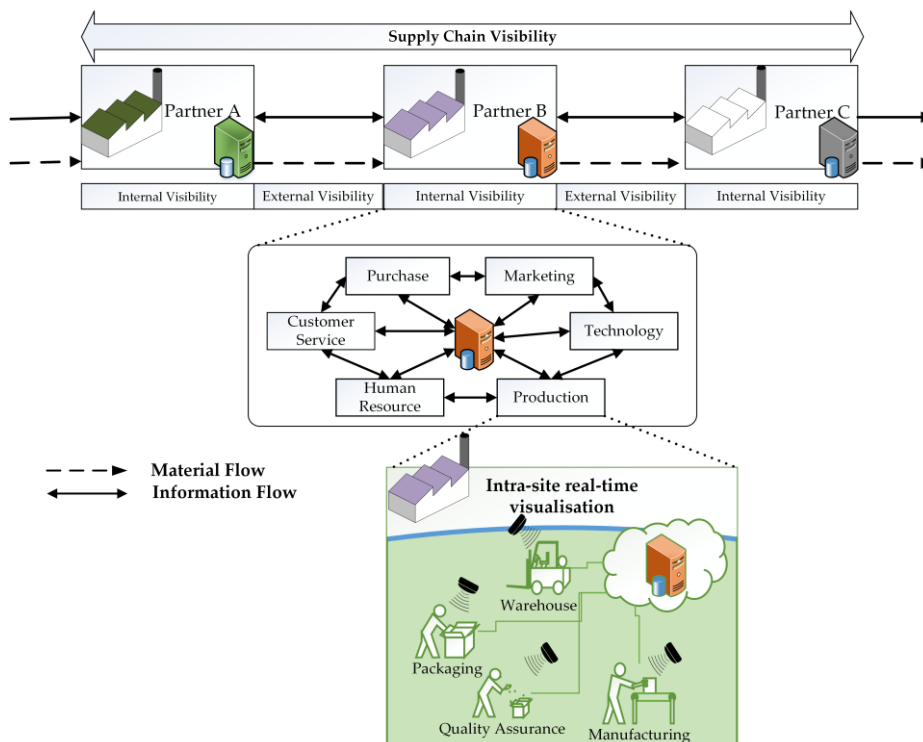


Fig. 1. A simplified conceptualization of Supply Chain Visibility (SCV)

Presently, owing to low SCV, firms are facing numerous challenges and risk those results in huge losses [3]. One of the major risks currently faced by supply chains across the globe is the event risk - for instance, COVID-19 virus - resulting in a long-term disruption in supply chains. These unexpected events lead to material shortages, delay in deliveries, a decrease in productivity, and fall in revenue for manufacturing companies across the globe [3]. Organizations find it challenging to prepare the internal logistics and supply chain, and quickly respond to such unexpected events, due to low inter and intra-site visibility [5]. Due to low SCV, partners usually act upon incomplete

information that results in wrong forecasts and the Bullwhip effect. Additionally, because of low SCV focal firms find it difficult to efficiently monitor all the involved actors. As a result, the focal firms are at supply chain sustainability risk, and any sustainability-related violation on part of irresponsible suppliers reflects on the focal firm, leading to reputational loss, financial losses due to costly legal obligations, and negative publicity [6].

Besides risks, the current supply chains are facing challenges due to low visibility in internal production processes. Collecting and sharing real-time data related to the order process, inventory, delivery, and potential supply chain disruptions is still not a well-adopted practice in production units [7]. Parts of the department work independently and do not share crucial information. This makes the whole production process quite opaque and even a small issue leads to huge disturbance. In addition to this, there is a significant demand for transparency and product traceability from customers, assuring ethical practices and sustainable sourcing [8].

Hence, visibility in production logistics and across supply chains has become a key concern for organizations all over the globe. Significant research has been done in past to analyze the state of visibility in different supply chains and exploring new digital technology tools that can enhance visibility throughout the supply chain [9, 10]. It is also observed that though SCV encompasses both internal and external visibility, the concept of visibility and factors influencing its implementation are mostly explored and analyzed in the context of external supply chain - involving buyer-supplier interaction and information asymmetry in the network. It is also evident that most of the studies collect these factors using secondary data through a review of literature, for instance [2]. In the past, little attention has been paid to practitioners' views on SCV, especially after the introduction and wide acceptance of disruptive technologies like blockchain, artificial intelligence, etc.

To bridge this gap, the current study adopts a Delphi-based approach to understand practitioners' views on SCV, the factors influencing its implementation, and crucial information requiring collection in sharing for SCV. It is among the few that empirically explores and rank the barrier, drivers, and antecedents for SCV through a multi-stage analysis that is iterated until a common consensus is reached among the experts. The study is a work-in-progress and describes the first round of Delphi analysis, the results of the full study will be communicated through a journal article in few months.

2 Methodology

2.1 Delphi-based approach

Delphi was developed at Rand Corporation in 1968 and since then it is a well-established methodology followed in various literature to explore and attain consensus on multifaceted and multidisciplinary issues [11]. It is a systematic approach where a group of experts – having extensive experience on the topic under study – communicates and interacts anonymously in multiple rounds. Responses from each Delphi round forms the basis for the input to the following round in terms of the aggregate response from the group, and the respondents can reflect on and change their response. Such an

approach helps to avoid adverse effects related to dominating personalities, interpersonal biases, defensive attitudes, and unproductive disagreements [12]. The rounds continue until a saturation point is reached. A Delphi study creates opportunities to gain valuable insights from practicing managers and is suitable for exploratory theory building [13]. In the past, Delphi-based approaches have been adopted in various research studies for needs assessments, policy development, and forecasting [11, 13]. In supply chain management, applications of the Delphi approach are found in studies investigating factors influencing decision-making; see e.g. [8, 14, 15].

2.2 Expert selection

We followed the general guidelines for Delphi studies [13, 14] for setting up an appropriate panel to ensure the validity of the results. The experts should have extensive experience and knowledge related to the specific issue under study. We invited senior supply chain executives from large and medium-sized industrial firms, operating from northern Europe, with global supply chains and manufacturing locations across the globe. These experts were primarily drawn from, or recommended by, industry contacts and research partners. All invited executives had at least ten years of experience in global SCM. Overall, 34 SCM practitioners were invited, and 26 agreed to participate in the Delphi expert panel. They represent a variety of industries: Aerospace, automotive, fast-moving consumer goods, food and beverage, forest & garden equipment, furniture, heat transfer, heavy industrial goods, optoelectronics, packaging, steel, and telecommunication. The number of participants (26) is in the recommended range for Delphi studies. The panel should include at least 20 respondents to reduce potential individual biases, and larger groups than 30 tend to generate few additional insights and might limit the exploration of insights that emerge [8, 11].

2.3 First round

The first round consists of four open-ended questions: (i) "Please describe in your own words what supply chain visibility means to you, your company, and your supply chains. Please provide examples." The first question helps us to understand the experts' definition of SCV and the effects SCV can have on a company's internal and external logistics processes. (ii) "Why is supply chain visibility important to your company and your supply chains?" The second question helps us to understand the potential outcome of implementing SCV. (iii) "What factors affect visibility of your supply chains and how?", The third question on other hand helps us to understand the inputs for implementing SCV, for instance, the potential the drivers, barrier and challenges (iv) "Is there anything else that you think is important in the context of supply chain visibility that you would like to add?" This fourth question helps to understand possible contingencies. Experts were given three week times to respond and they could choose to respond directly on the mail or through attached word documents. Reminders were sent after every week and full contact details of the researchers were provided in case the experts had any query. The responses were analyzed individually by the four researchers (one

Ph.D. student, one postdoc and two professors), to identify potential themes and categories. Coding was compared and in most cases, there was full agreement among the researchers. Differences in interpretations were thoroughly reexamined and resolved jointly.

3 Results and Discussions

In the first round, we identified five categories within the responses: drivers, barriers, antecedents, effects, and information. Furthermore, effects could be divided into two sub-categories: capabilities, and performance effects, while information was sub-divided into three: (i) market and products, (ii) internal, and (iii) supply. The specific factors in each category are listed in Table 1.

Table 1. Factors influencing SCV and list of crucial information

Factors		
<i>Drivers</i>	<i>Barriers</i>	
Risk management	IT infrastructure (lack of ...)	
Environmental sustainability	IT maturity (lack of ...)	
SC control	Standardization (lack of ...)	
Managing deviations	Organizational culture (e.g. silos, conflict of interest)	
Customer service	Risks with sharing sensitive information (IPR)	
Transparency	Information sharing (lack of willingness)	
Operational excellence	IT competence (lack of ...)	
Decision-making support	SC competence (lack of ...)	
	SC complexity	
	Factors	
<i>Antecedents</i>	<i>Effects: Capabilities</i>	<i>Effects: Performance</i>
Integrated systems	Planning capability	Customer service
Technology maturity	Decision-making support	Profitability
Information sharing	Advanced analytics capability	Environmental impact
Standardization	Predictive capability	Cost
Inter-organizational collaboration	Risk management	Lead time
Trust	Traceability	
Data quality	SC Control	
	Forecasting	
	Information	
<i>Market & product</i>	<i>Internal</i>	<i>Supply</i>
Demand	Production plans	Purchasing plans
Forecasts	Inventory levels	Supply
Orders	Capacity	Supplier location
Deliveries	Lead times	Supplier capabilities
Deviations	Safety stocks	Track and trace

Customer service
Country of origin
Product in use information

3.1 Drivers

According to the experts, one of the main driving forces for SCV is risk management and mitigating risk. As one of the experts mentioned in describing the importance of SCV: “To know and understand the full value chain gives you the possibility to make proactive initiatives instead of reactive. Increasing importance of Supply Chain Risk Management, given recent years development with trade barriers, pandemic, natural disasters, etc.” Controlling supply chain operations, transparency, and decision-making support are among other mentioned drivers.

3.2 Barriers

Many of the experts state that the main barriers of SCV are lack of IT infrastructure and maturity. One of the experts highlighted it by mentioning: “If visibility means being able to ‘see’ the supplier's supply chain, or my order's position against plan in it, then that possibility is today greatly affected by existing IT systems that are rarely / never created for visualization in this dimension”. Lack of standardization is another crucial factor restricting the adaptation of SCV systems. As the product traverse through stages of the global supply chain standardization becomes a crucial element especially for effective data sharing and technology integration. IPR and fear of losing information advantage (willingness to share information) are some of the other mentioned barriers.

3.3 Antecedents

As per the experts, integration of systems and technology maturity level are some of the prerequisites or enablers for SCV. One of the experts mentioned: “The amount of different systems that drive the supply chains and how easy/difficult it is to load/share data from these systems and the level of integration between these systems. The level of integration between our systems and our suppliers’ and customers’ systems”. Among other factors, quality of data, trust, and collaboration are some of the other antecedents for SCV. One expert mentioned: “The degree of visibility affects our ability to plan and collaborate effectively, and our ability to detect trends and changes in the supply chain at an early stage. This, in turn, affects our ability to grow profitably and our ability to build trust and loyalty with our partners and customers”.

3.4 Effects

Some of the effects concerning capabilities are better planning, informed decision-making, advanced analytics and predictive analysis. As one expert state: “part of visibility in supply chains is about making information about demand, capacity, order volume

and inventory development visible by creating better processes for demand planning, capacity planning, phasing in and phasing out, etc. Much of this visibility is about making the information visible internally within the company and that everyone functions share the same information in order to make better decisions about the material supply.” Traceability is another major effect for which the experts mentioned: “we see with increased Supply Chain Visibility we can secure traceability and chain of custody, certification schemes of raw material for instance.” On the other hand, some of the mentioned major performance-based effects of SCV are better customer service, profitability, and decreased lead-time. As per an expert through SCV, the involved actors can get “the ability to see what our customers are asking for (volumes of different products), but also to have a picture of our suppliers' ability to meet our needs.”

3.5 Information

Finally, we also identified from the responses, various information that the experts perceive crucial for SCV. This information is worth capturing and sharing among actors through a common database, to get desired effects of SCV. One of the experts mentioned, “Visibility is also about having the same information as your partners in the SC at the same time. It is also about having good tooling to visualize forecasts, plans and orders. A good BI tool with the same information is key to analyze the current status and the future. Common SC master data is important.” Some of the crucial information are those regarding demand, forecast, planning, inventory, purchase. As per one expert: “part of visibility in supply chains is about making information about demand, capacity, order volume and inventory development visible by creating better processes for demand planning, capacity planning, phasing in and phasing out, etc. Another dimension of visibility in supply chains is about making information available/visible internally within the company and to other stakeholders in the supply chain, e.g. suppliers, carriers, etc.”

4 Conclusions

The study presents the initial results of a Delphi analysis with the aim to understand SCV from practitioners' perspectives. It systematically explores different drivers, barriers, effects, antecedents, and crucial information for SCV. It was found that risk management, environmental sustainability, and supply chain control are some of the key drivers, lack of IT infrastructure and maturity are some of the barriers, integrated systems and technology maturity are among the key antecedents and gaining planning capability and better customer service are some of the positive effects of supply chain visibility as per the experts' opinion. In addition, information related to planning, supplier location, and deviation are among the crucial ones that require collection and sharing for better supply chain visibility. To the best of our knowledge, this research study is among the few that empirically explores factors influencing supply chain visibility and generates new insights as to why the barriers can be difficult to overcome in com-

plex supply chain settings. It also lay the foundation for the development for technological solutions, by providing the required inputs for development of decision support systems (DSS) that can enhance visibility in the supply chain.

Abovementioned, the study is work-in-progress and presents only the results from the first Delphi round. In the subsequent rounds, the experts will revisit the aggregate results, rank the factors and information on basis of their experience –while providing commentary inputs explaining their choices. This process will be repeated until consensus and the full analysis results are available, it would be also meaningful to approach the SCV problem predictively/prescriptively not just descriptively (understand why). Finally, a workshop will be organized with experts, towards the end of the Delphi, around June 2021, to share the findings and collect additional commentary inputs to understand why the top-ranked factors are so important. We expect to have a full paper ready by August 2021.

Acknowledgement

We gratefully acknowledge the funding from Produktion2030 and Vinnova for this research, as part of the research project Production Logistic Visibility (LOVIS).

References

1. Sodhi, M.S., Tang, C.S.: Research Opportunities in Supply Chain Transparency. *Production and Operations Management*. 28, 2946–2959 (2019).
2. Somapa, S., Cools, M., Dullaert, W.: Characterizing supply chain visibility – a literature review. *The International Journal of Logistics Management*. 29, 308–339 (2018).
3. Yu, M.-C., Goh, M.: A multi-objective approach to supply chain visibility and risk. *European Journal of Operational Research*. 233, 125–130 (2014).
4. Caridi, M., Crippa, L., Perego, A., Sianesi, A., Tumino, A.: Do virtuality and complexity affect supply chain visibility? *International Journal of Production Economics*. 127, 372–383 (2010).
5. Srinivasan, R., Swink, M.: An Investigation of Visibility and Flexibility as Complements to Supply Chain Analytics: An Organizational Information Processing Theory Perspective. *Production and Operations Management*. 27, 1849–1867 (2018).
6. Kalaiarasan, R., Olhager, J., Wiktorsson, M., Jeong, Y.: Production Logistics Visibility – perspectives, principles and prospects. Presented at the Swedish Production Symposium , Jönköping, Sweden October (2020).
7. Bregman, R., Peng, D.X., Chin, W.: The effect of controversial global sourcing practices on the ethical judgments and intentions of U.S. consumers. *Journal of Operations Management*. 36, 229–243 (2015).
8. Agrawal, T.K., Pal, R.: Traceability in Textile and Clothing Supply Chains: Classifying Implementation Factors and Information Sets via Delphi Study. *Sustainability*. 11, 1698 (2019).
9. Cao, X., Li, T., Wang, Q.: RFID-based multi-attribute logistics information processing and anomaly mining in production logistics. *International Journal of Production Research*. 57, 5453–5466 (2019).

10. Pfahl, L., Moxham, C.: Achieving sustained competitive advantage by integrating ECR, RFID and visibility in retail supply chains: a conceptual framework. *Production Planning & Control*. 25, 548–571 (2014).
11. Ogden, J.A., Petersen, K.J., Carter, J.R., Monczka, R.M.: Supply Management Strategies for the Future: A Delphi Study. *Journal of Supply Chain Management*. 41, 29–48 (2005).
12. Lummus *, R.R., Vokurka, R.J., Duclos, L.K.: Delphi study on supply chain flexibility. *International Journal of Production Research*. 43, 2687–2708 (2005).
13. Melnyk, S.A., Lummus, R.R., Vokurka, R.J., Burns, L.J., Sandor, J.: Mapping the future of supply chain management: a Delphi study. *International Journal of Production Research*. 47, 4629–4653 (2009).
14. Kembro, J., Näslund, D., Olhager, J.: Information sharing across multiple supply chain tiers: A Delphi study on antecedents. *International Journal of Production Economics*. 193, 77–86 (2017).
15. Hassan, M., Ali, M., Aktas, E., Alkayid, K.: Factors affecting selection decision of auto-identification technology in warehouse management: an international Delphi study. *Production Planning & Control*. 26, 1025–1049 (2015).