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# A Design Theory for Supply Chain Visibility in the age of Big Data

Jerrel Leung
*The Chinese University of Hong Kong*, jerrelleung@baf.cuhk.edu.hk

Sung-Chi Chu
*The Chinese University of Hong Kong*, scchu@baf.cuhk.edu.hk

Waiman Cheung
*The Chinese University of Hong Kong*, wcheung@cuhk.edu.hk

# A Design Theory for Supply Chain Visibility in the age of Big Data

*Completed Research Paper*

**Jerrel Leung**
Chinese University of Hong Kong
Hong Kong
jerrelleung@baf.cuhk.edu.hk

**Sung-Chi Chu**
Chinese University of Hong Kong
Hong Kong
scchu@baf.cuhk.edu.hk

**Waiman Cheung**
Chinese University of Hong Kong
Hong Kong
wcheung@cuhk.edu.hk

## Abstract

*Existing literature has extensively discussed that supply chain visibility (SCV) can help to improve supply chain performance. Yet there is no sound approach available to effectively operationalize SCV. We posit that information sharing alone is not decisive for SCV, as SCV is context sensitive. On one side, there is the generator role that shares information. However, we posit that there is also the utilizer role, which aims to solve specific management problems. This study documents three knowledge moments in the search for SCV in the age of big data. The first knowledge moment is of a nomothetic science, where we define SCV from a utilizer and generator perspective. The second knowledge moment is of a nomothetic design, where we developed an ISDT and proposed five design principles. Finally, the third knowledge moment is of an ideographic design, where we described an actual implementation in an actual garment supply chain.*

**Keywords:** Supply Chain Visibility, Design Theory, Secondary Design, Big Data, IoT

## Introduction

Existing literature has extensively discussed that supply chain visibility (SCV) can help to improve supply chain performance. Although SCV is important in supply chain management, we still lack a way of systematically realizing it (Feki et al. 2013; Baratt and Baratt 2011). The diverse interpretation of SCV may have led to the difficulties in operationalizing SCV. Many studies suggest that information sharing and relational ties are imperative in SCV. However, we posit that information sharing and relational ties are only the necessary conditions, but are not always sufficient to gain an effective SCV. The advent of big data further pushes for more information sharing and the existing SCV view may not suffice. We argue that there is a need to reconsider SCV with big data in mind and propose a design theory to catalyze SCV operationalization.

We can observe that SCV and information sharing, in general, involves at least two parties, the one offering the information and the one consuming the information. Existing literature mostly focuses on the prior party, which suggests that sharing more information is beneficial to create a more effective SCV. However, the literature on the latter has been less explored. The advent of big data will undoubtingly cause more information being shared, but more information may not always lead to more effective SCV, e.g. information overload. We therefore posit that the information that is shared should fit the contextual needs of the consuming party. We call this the duality of SCV. For instance, the number of product returns at the retail shops does not concern the warehouse manager, but may be indicative of quality issues or design flaws to the production manager.

Supply chains currently lack guidance to operationalize SCV. We aim to develop an information system design theory, which can help supply chains to develop artifacts and gain a more effective SCV with big data in mind. The aforementioned discussion suggests that SCV is context specific to the SCV consumer and therefore cannot be predefined. We leverage on the secondary design concept, which allows the artifact users to define the ultimate system design. For instance, the primary design of Facebook is a platform, which allows users to share information with friends. The secondary design of Facebook is how the users can generate content. We argue that our secondary design does not fall in the existing secondary design of context and functionalities. We posit that it is based on the secondary design of the participatory role, e.g. information offerer and information consumer.

This study describes three knowledge moments in our quest for SCV. The first knowledge moment is of a nomothetic science, where we define SCV from the SCV duality perspective and with big data in mind. Secondly, we propose a nomothetic design, which is a design theory on SCV and aims to propel future research and SCV artifacts. Finally, we describe an ideographic design, where we illustrate how SCV is operationalized in an actual garment supply chain.

## Literature Review: Supply Chain Visibility and IoT

### *Supply Chain Visibility*

Existing literature often associates SCV with superior supply chain performance. For instance, recent studies have suggested that SCV can improve supply chain performance and reduce supply chain cost. Indeed literature suggests that SCV is beneficial to supply chain performance, but yet studies often interpret SCV differently (Roh et al. 2009; Wei and Wang 2010). For instance, Roh et al. (2009) defined SCV as "*the firm's ability to track the flow of goods, inventory, and information in the supply chain in a timely manner*". We concur with this definition, but the definition suggests that the material flow and other information need to be shared. However, what the other data consist of is difficult to define and depends on the supply chain needs. Therefore, further research to identify the other data is required. Consequently, there is no systematic way for supply chains to gain an effective SCV.

We agree with findings from social science, where visibility is suggested to consist of minimally two roles: one role that sees and one role that is being seen. The role that is being seen offers information to the role that sees (Brighenti 2010). Current literature often focuses on the role that is being seen, which suggests that more information sharing and closer relationships can lead to more effective SCV (Wang and Wei 2007; Williams et al. 2013). However, as suggested in the social science literature, the value of SCV is judged by the role that sees. Although, the role that sees is less explored, several studies do attempt to identify the necessary information for specific supply chain parties (Baratt and Baratt 2011; Shih et al. 2012). We call the roles that sees and the roles that is being seen the duality of SCV. The literature is currently missing an overarching view that covers both roles.

Albeit SCV has been extensively discussed, it remains difficult to operationalize (Enslow 2006). Literature lacks compelling cases for practitioners to leverage on, in order to operationalize SCV. There is an urging need for a SCV guideline. We posit that the SCOR (Supply Chain Operations Reference) model can be utilized as the bases for this guideline. SCOR is a widely accepted standard by the industry to chart supply chains, to benchmark supply chains, and to provide current best practices (Lockamy and MccorMack 2004; Huan et al. 2004). More importantly, SCOR suggests information flow of a supply chain per business process. This can help to potentially identify contextual information needs in the supply chain.

### *Big Data*

Big data can be simply described as very large datasets (Malik 2013). Datasets in big data are often created by different sources. However, literature in big data suggests that it goes beyond the huge Volume of data. Literature suggests that big data also entails a wide Variety of data, e.g. pictures and other unstructured data, the rapid Velocity of data that is generated on a daily basis, and the Veracity of data that questions the trustworthiness of data that is not generated by the organization itself (Jagadish et al. 2014). Volume, Velocity, Variety, and Veracity are also known as the 4Vs of big data. The 4Vs make existing data analysis techniques insufficient to deal with big data. Literature proposed the following three types of analytics for big data: descriptive analytics tries to describe what is currently happening, predictive analytics discover explanatory and predictive patterns, and prescriptive analytics aims to suggest actions to alter current events (Delen and Demirkan 2013).

IoT is currently one of the most prevalent forms of big data in supply chain management. Current IoT implementations in supply chains mainly leverage on Radio Frequency Identification (RFID) technology. Various studies suggested that IoT can automate processes and lead to operational benefits (Qiu 2007; Heim et al. 2009; Heo et al. 2011). However, using IoT for SCV is suggested to be even more effective (Delen et al. 2007; Wang et al. 2010; Leung et al. 2014). Even though, IoT has been documented to be an effective technology in supply chains, a recent study showed that managers have a keen interest in IoT, but yet only 6% of the respondents have used some form of RFID (Leimeister et al. 2009). Therefore, we suggest that IoT should be further explored, as literature has discussed the great potentials, but yet has seen limited usage.

IoT will surely exponentially increase the amount of data that the role that is being seen can share with supply chain partners. However, making sense out of the massive data will become increasingly difficult for the role that sees, due to information overload and the 4Vs of big data. We believe that there is a necessity to reevaluate SCV with big data.

### *Information System Design Theory*

This study suggests utilizing Information System Design Theory (ISDT) to operationalize SCV. ISDT does not intend to describe, explain, or predict natural and behavioral phenomena, as in natural sciences, but ISDT intends to introduce IT artifacts to alter the natural and behavioral (Gregor 2006). ISDT is a research mindset that rigorously solves a class of relevant real world problems, with the goals to advance the cumulative body of knowledge (Walls et al. 1992). ISDT involves a design process, which can bring various contributions throughout different knowledge moments (Baskerville 2015)

For SCV, we particularly look into secondary ISDT. ISDT in general focuses on the primary design, which discusses the design and features of an artifact. Secondary ISDT, on the other hand, concerns the user engagement in a secondary design process to define the functions and content, e.g. users generated content in Wikipedia, Twitter, and Facebook (Germonprez et al. 2011). Germonprez et al. (2011) discussed that secondary ISDT must consider the planned-emergent and participation-reification dualities for functional and contextual secondary designs. However, we advocate that the SCV duality is neither a form of functional nor contextual secondary design, it is rather a secondary design based on the participatory role (of the role that sees and the role that is being seen). Since the content and functionality of the SCV would depend on the contextual needs of the role that sees.

## Nomothetic Science – A Novel SCV Conceptualization

Literature suggests that SCV is a major driving force towards the competitiveness of supply chains, yet literature does not clearly discuss how SCV can be achieved. We abductively discover that tighter relationships and more information sharing alone do not always lead to improved SCV, as suggested by existing literature. Managers face different supply chain problems on a daily basis and need SCV that fit the particular contextual situation to make well-informed decisions. It is indeed true that having more information can more likely address the managers' contextual problems on hand, but offering the right information in the vast amount of (big) data can be difficult. We advocate that there is a need to provide the right information to the right person at the right time. We call this the duality characteristic of SCV, where SCV always involves two parties, the SCV generator (role is being seen) and the SCV utilizer (role that sees), as shown in Figure 1. The SCV generator is a role where data owners share information with supply chain partners. The SCV utilizer role makes use of the supply chain information to make well-informed decisions.

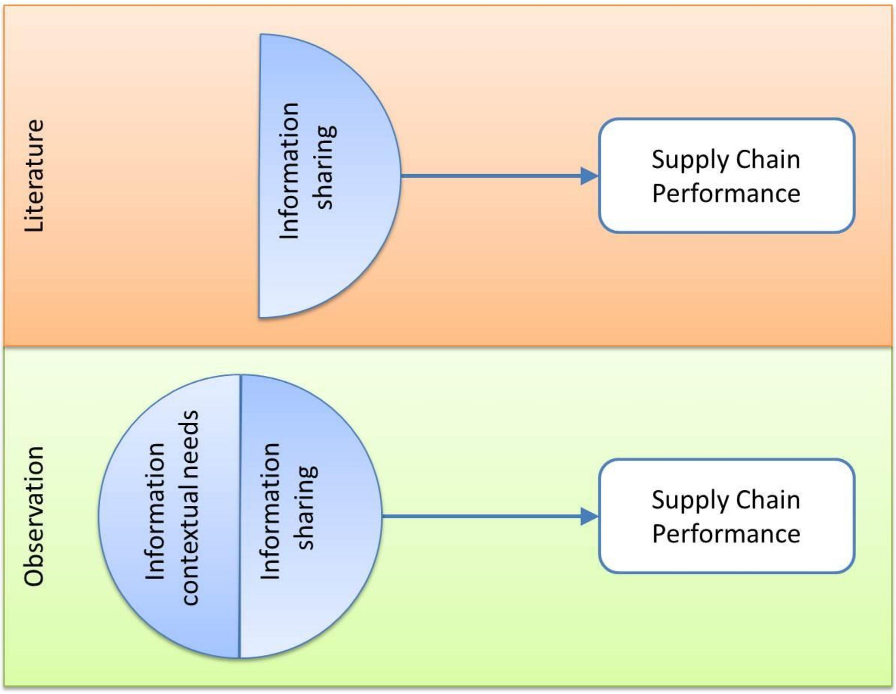


**Figure 1. SCV Duality of Generator and Utilizer**

Big Data will further increase data of the SCV generators. These types of data are often not pre-defined, making it difficult for SCV generators to gauge whether the data is useful to the SCV utilizers. Moreover, the vast amount of data will make manually constructing a context sensitive SCV even more difficult for the SCV utilizers. The 4Vs of Big Data will upset the traditional way of analyzing data and usher for the need of a new analytics in the age of Big Data. IoT is the most prominent technologies in terms of Big Data for supply chains. IoT can automatically record the material flow, without human intervention and thus reducing the chance of error. The volume of data increases dramatically with Big Data, as IoT generates vast amount of sensor readings and social media provide numerous behavioral data. Social media data is especially useful to gauge the consumer sentiment, which enables supply chains to understand consumer behavior even when they have not purchased products or services from the supply chain. Furthermore, Big Data increases the velocity of SCV with real-time updates of IoT events. These two Big Data characteristics significantly help the SCV generators to capture and share supply chain information, but will also challenge the existing ways of SCV generators to collect and share supply chain data, see Figure 2. Variety and Veracity, on the other hand, introduces new elements for the SCV utilizers to analyze supply chain data. The variety of data types that different IoT data brings can be discerning. Traditional supply chain data typically entails transactional documents, e.g. purchase orders and production orders, and are typically stored in text and numbers. Big Data, on the other hand, is often unstructured and involves various data types, which can bring new opportunities to analyze new data, but also makes traditional analysis methods inadequate. Big Data often involves data generated by parties outside the supply chain, which questions the data veracity. For instance, data that is offered by vertical and especially by the horizontal supply chain partners may not always be as accurate as own generated data. Therefore, care must be taken how to make use of data generated by external partners.

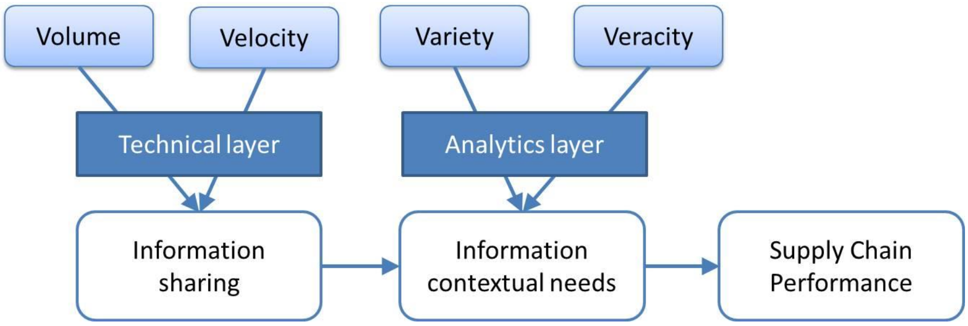


**Figure 2. Big Data Considerations in SCV**

In conclusion, the nomothetic science knowledge moment is an abductive knowledge discovery process, which introduces the novel SCV duality concept in the age of Big Data and explores how Big Data characteristics affect SCV from the generators and utilizers perspective. The novel conceptualization of SCV will form the basis of (grounded) kernel theory for the next phase.

## Nomothetic Design – Information System Design Theory for SCV

In this phase we attempt to operationalize the SCV duality by inductively deriving a comprehensive ISDT for SCV, which leverages on Big Data with the aim to provide useful analytics. The operationalization can help to further propel research and implementations, as the current literature lacks compelling business cases and concrete frameworks to guide how SCV can be realized.

The purpose and scope of this study is to develop an ISDT to guide artifact development for SCV in the age of big data. ISDT is an established research methodology in the information system field, which has the benefit that design artifacts can be developed as rigorous as other scientific research counterparts. Partly, this is due to that designs must be intrinsically linked to kernel theories. More specifically, we deal with a secondary ISDT. The primary design will utilize Supply Chain Operations Reference (SCOR) model and the SCV duality as the kernel theory to form the foundational basis of the artifact. The SCV duality suggests that the ISDT has two main constructs, namely the generator and the utilizer. The secondary design attempts to propose a method that allows the generator role to effectively offer information that is required by the contextual needs of the utilizer's role. The nature of the secondary design makes the design by default mutable to satisfy the SCV contextual needs. We propose the following design principles for the SCV *generator* and SCV *utilizer*:

### *SCV Generator*

*Design principle 1: Identify data requirements*

SCOR can be used as the basis to develop the primary design of the artifact. The secondary design allows the system to be customized to any user, e.g. SCOR level 1 analysis to determine which supply chain partners will be within the scope. Moreover, SCOR has the ability to pinpoint which business processes can affect which KPIs. Conversely, supply chains can identify which KPIs they want to improve and SCOR can subsequently pinpoint potential business processes that will positively affect the KPIs. This design principle can suggest how to re-engineer the business process to improve supply chain performance and it can also suggest what information to capture at the respective business process (Leung et al. 2013). Pivotal transactional documents can be identified, which are used to communicate along the supply chain. For instance, purchase orders could be used to link information shared between manufacturers and raw material suppliers.

*Design principle 2: Enable data sources*

Data collection will not necessarily be limited to transactional data, but may also include external (big) data. Each supply chain will have different data requirements and the secondary design allows the generators to determine the data made available. These data resources may be based on operational IoT data or even behavioral social media data. Different data sources will require different ways to collect them. For instance, SCOR model can suggest which business processes to IoT-enable, based on the KPI improvement requirements from Design Principle 1. IoT has the advantage that it can augment periodic transaction data with real-time updates. It is therefore imperative to gain access to the relevant social media. Social media data is an effective way to gauge the sentiment of consumers towards the supply chain.

### *SCV Utilizer*

*Design principle 3: Realize descriptive SCV analytics*

Descriptive SCV analytics is commonly practiced and describe what is currently happening in the supply chain (Delen and Demirkan 2013). However, the suggested SCV duality discusses that the provided SCV is based on the contextual needs of the SCV utilizer and can often not be defined beforehand. We therefore argue along the same spirit as cloud computing that context sensitive SCV can be self-helped by the SCV utilizer. In other words, the secondary design allows the SCV utilizer to define his/her own context sensitive SCV. We use SCOR to guide the SCV construction, in a similar fashion as proposed by Leung et al. (2013). This allows the SCV utilizer to select the relevant information and view what is happening in the supply chain.

*Design principle 4: Facilitate predictive SCV analytics*

Predictive analytics require more advanced analysis to discover explanatory and predictive patterns, compared to descriptive analytics (Delen and Demirkan 2013). For this type of SCV analytics operational IoT data take the center stage and needs to be used in conjunction with transactional data. IoT sensory data can real-time monitor supply chain operations and can determine whether it can meet the planned transactional completion dates. Managers can set targeted SCOR KPIs, which can be real-time monitored by the artifact. This type of secondary design allows users to be only notified with relevant contextual data alerts.

*Design principle 5: Enable prescriptive SCV analytics*

In prescriptive analytics behavioral data becomes imperative (Chen et al. 2012). The largely unstructured data requires novel techniques to make sense out of behavioral data. However, behavioral data can bring many insights including and not limited to: customer sentiment, customer shopping behavior, and customer satisfaction. Secondary design can allow users to define scenarios in which the artifact can prescribe the optimal course. We suggest that this can only be done with accurate transactional, real-time operational data and likely behavioral data.

The nomothetic design knowledge moment describes how we induce design principles to address the SCV duality. Design principles are commonly recognized outcomes in ISDT studies. Moreover, we further explore secondary ISDT and extend existing literature by suggesting a secondary design based on the participatory user role.

## Ideographic Design – An Instantiation of the SCV Duality

In this knowledge moment we test the validity of proposed ISDT for SCV duality and demonstrate the relevancy of the SCV duality. This is currently a daunting problem in ISDT, as design artifacts are often developed in lab environments and may not be applicable in practice. We validate the proposed SCV concept and design theory through an instantiation.

### *ActiveWear Case*

For the instantiation we approached an end-to-end garment supply chain. We will call the supply chain ActiveWear, as the supply chain requested not to disclose its identity. The ActiveWear brand owner operates four different menswear brands and their respective supply chains. Each brand has its own supply chain manager, yet they share most facilities, which include Fabrics Warehouse (FW), Parts Factory (PF), Garments Factory (GF) and Garments Warehouse (GW). Each brand has its own retail outlets in Hong Kong, Macau and China. An overall view of the supply chain is shown in Figure 3.

We conducted several rounds of interviews with each individual supply chain partners to find out the visibility needs. Afterwards, we held brainstorm sessions with representatives from all supply chain partners to identify the major concerns of the management. The interviews suggest that information sharing among supply chain partners is not commonly practiced. This forms a stumping block, as a delay at one of the supply chain partners can escalate to other downstream supply chain partners. The lack of information sharing was mainly due to that it is not a common practice and that the information systems were not interoperable. For instance, the parts factory mainly manages its operations with paper work and computer spreadsheets, the garment factory uses an Enterprise Resource Planning (ERP) system to keep track of its progress, the garment warehouse uses a Warehouse Management System (WMS) to manage the incoming and outgoing products, and the retailers use a Point of Sales (POS) to track their sales. Most information sharing occurs by placing orders with adjacent supply chain partners. Although the ActiveWear supply chain partners jointly produce menswear, they operate like independent organizations and are hesitant to share information for the sake of trade secrecy. Obviously, supply chain partners will ask for the production status of their partners, but this is only done on a periodic basis. For instance, the garments factory needs to monitor the parts factory in order to prevent interruptions, but only does this once at the end of each day.

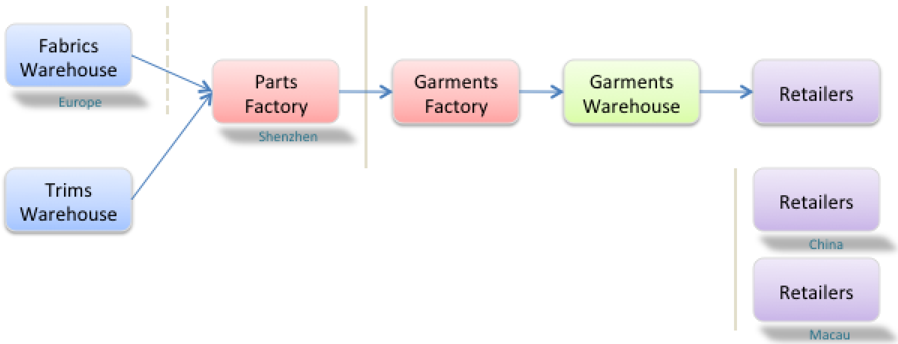


**Figure 3. ActiveWear Supply Chain Configuration**

Through several brainstorming sessions with the management we discovered that the supply chain's raw material management often causes production delays. The Parts Factory needs to know when and which fabrics will arrive at the factory. However, in reality the Parts Factory only knows that fabrics have been received when the daily delivery truck arrives. Production Orders are often received before the fabrics arrive. The production process obviously involves scheduling various operations, yet factory production cannot just follow the Production Orders as fabrics are often not in place when Production Orders are scheduled to start. This causes major concerns to the brand owner, as the garment industry is fashion sensitive and being able to adjust to the customer demands is pivotal.

## ***The SCV instantiation***

In this section we share our experiences of our previous project where we developed a SCV platform for the aforementioned garment supply chain. We followed the design principles derived of the proposed ISDT and the instantiation also serves to validate the ISDT design principles. Guided by the design principles we developed an artifact, which could systematically define which information to capture and share for the SCV generator and offer highly context sensitive SCV for the SCV utilizers.

*Design principle 1: Identify data requirements*

We first conducted several rounds of interviews and brainstorm sessions with the participants of the ActiveWear supply chain. The intention was not only to investigate in problems of each individual supply chain partner, but rather problems that affected the entire supply chain performance were discussed. Afterwards, we conducted on-site visits to better understand the supply chain business processes. We used SCOR to describe the supply chain and detailed it to a SCOR level 3, where the process elements flow was documented. Subsequently, we presented the SCOR charts and identified several potential supply chain issues. We held another session to discuss the SCOR charts and identify which SCOR KPIs needed to improve. The ActiveWear supply chain suggested that Order Fulfilment Cycle Time (OFCT) would be the top concern. Currently, a full cycle from design to selling garments in the retail store takes 18 months. Reducing the OFCT could drastically help the supply chain to faster bring products to the market and become more agile.

*Design principle 2: Enable data sources*

We then further detailed the SCOR charts to a level 4, where both the process and information flow were documented. The SCOR charts revealed that the existing information flow mainly is based on four documents, namely Purchase Order, Production Order, Production Packing List, and Transfer

Order. A further analysis investigated the necessary information to calculate the OFCT KPI and also revealed the information that is lacking to do so. We systematically used IoT technologies to automatically capture the missing information and to automate various labor-intensive processes. A data schema was defined based on the organizational data and IoT data. The underlying IoT data flow infrastructure was design and tested. For example, we would consider whether data was captured by mobile RFID readers or stationary RFID readers.

*Design principle 3: Realize descriptive SCV analytics*

We went back to the ActiveWear supply chain with the hope to articulate the required information that would suit the contextual needs of each individual supply chain party. However, the supply chain parties had difficulties to describe the information needs and suggested that the required information is often ad-hoc depending on the management decision on hand. We therefore approached the descriptive SCV analytics as a secondary design, where we did not specify the SCV for them, but rather let the users define the SCV for themselves. In order to do so, we arranged all available data according to the SCOR business processes and the available data per business process. The user could drag and drop the required information and build their own context sensitive SCV, which could depict a particular SCV view in real-time. An example of such SCV building is shown in Figure 4.

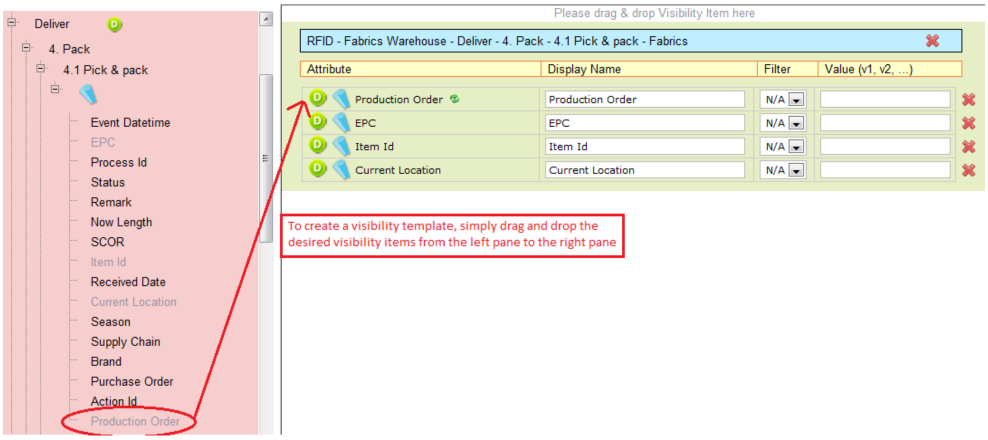


**Figure 4. SCV creation**

*Design principle 4: Facilitate predictive SCV analytics*

Other than viewing the current situation in real-time, as in the descriptive SCV analytics, we also attempted to develop predictive SCV analytics. For predictive analytics we used SCOR KPIs to guide the development. The SCOR model has the benefit that the defined KPIs can be measured through the business processes. We therefore not only enabled the data sources for the OFCT KPI, but we also enabled data sources for other SCOR KPIs, such as Perfect Order Fulfilment (POF). The users could set the desired KPI level, e.g. number of days for OFCT and a percentage for POF. The enabled data sources allow SCV generators to offer information in real-time. Once a KPI falls below the defined threshold, a notification can be given to the SCV utilizer. The SCV utilizers can then investigate and identify the culprits that caused the KPI to deviate.

The artifact that was developed served as a pilot system and ActiveWear used the system for approximately 6 months. The instantiation shows that we were only able to deliver descriptive and predictive analytics. The project duration unfortunately did not allow us to develop prescriptive analytics. However, we believe that we could implement machine learning techniques, which could identify patterns that lead to KPI changes. Based on these patterns the artifact could for instance prescribe certain actions. For instance, the system could detect that the POF KPI is starting to decrease, due to quality problems caused by a particular business process. The system could then suggest certain actions or alert the SCV utilizer to take actions for that particular business process.

| | Operational benefits | | Tactical benefits |
|---|---|---|---|
| SC party | Receive | Stock take | |
| Fabrics WH | Double capacity | Enable – 10 mins | Manage materials over two sites |
| Parts supplier | Verify vs. count | Enable – 20 mins | Ensure material availability per PO |
| Garments Fact. | Save 94% time | - | Monitor parts supplier progress |
| Garments WH | Save 83% time | Save 93% time | Enable more advanced WH planning |
| Retailer | Verify vs. count | Save 94% time | Prevent out-of-stock situations |
| Strategic Benefits can be developed from SC visibility and change the supply chain configuration from<br>Make-to-stock → Make-to-order | | | |

**Table 1. IT artifact benefits for ActiveWear Supply Chain**

ActiveWear was in general quite satisfied with the results of the artifact. In the 6 months ActiveWear perceived operational, tactical and strategic benefits, see Table 1. One of the main goals was to turn the supply chain more agile. However, this could not be achieved in a mere 6 months pilot. However, the operational and tactical benefits showed that the OFCT for several key business processes has been drastically reduced and ActiveWear is seriously exploring whether the supply chain can change from a Make-To-Stock strategy to a Make-To-Order strategy. In general ActiveWear was satisfied with the results and is investigating whether it is feasible to further refine the artifact and turn it into a full production system.

Conclusively, the ideographic design knowledge moment first intends to validate the SCV duality concept and design theory against an end-to-end actual garment supply chain. Moreover, the instantiation also functions as an example to illustrate which technologies can be utilized to operationalize SCV.

## Discussions and Conclusions

Scholars and practitioners in general agree that SCV is beneficial to supply chain performance. Although, many have a presumption of a SCV definition, we often still lack a well-defined common understanding of SCV and how it can be applied in practice. Numerous studies associate more data with more effective SCV. However, we argue that this is not always the case. We differentiate between the role that is being seen and the role that sees. The role that is being seen refers to the data owner, which we call generator, who shares information with their partners, which is a prerequisite for realizing SCV. The role that sees refers to the one interpreting the available SCV, which we call utilizer. We argue that interpreting SCV is context specific, e.g. a retailer may appreciate point of sales data, but this may only be of little use to a factory production manager.

This study documented three knowledge moments in the search for SCV in the age of big data. The first knowledge moment is of a nomothetic science, where we tried to define SCV from a utilizer and generator perspective. Current literature mostly addresses SCV from the generator perspective and we warrant that further research is needed from the utilizer perspective. The second knowledge moment is of a nomothetic design, were we developed an ISDT for SCV. We proposed five design principles, which allow generators to provide the information that is needed and where utilizers can develop personalized SCV dependent on the contextual needs. Finally, the third knowledge moment is of an ideographic design, where we described an actual implementation of the SCV duality concept in an actual garment supply chain. The instantiation also serves as a validation for the ISDT.

Do note that the case study mainly looked into IoT, and specifically RFID, to represent big data and care must be taken to extend our findings to other types of big data, e.g. social media. However, IoT can currently be considered as one of the most prominent technologies that generate big data in supply chains. Moreover, the SCV duality instantiation has only been implemented in one supply chain and caution need to be taken not to overgeneralize the findings. Although, we did use the SCOR model to guide the framework, which allows the framework to be easily adapted to other supply chains. Moreover, in this study we only considered SCV that are required for a specific supply chain party and future studies could investigate how collaborative decision making would affect the SCV duality concept. This study is an initial attempt to further elucidate and articulate SCV. We understand that the quest towards SCV is an iterative process and further research is greatly encouraged.

## Acknowledgements

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