ACCOUNTING FOR SUSTAINABILITY IN SUPPLY CHAIN VISIBILITY ASSESSMENT

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ABSTRACT

Supply chains strive to improve their visibility levels. For a supply chain, visibility is ability to see clearly from one end of the supply chain to another whilst sharing information across the chain. Visibility performance is achieved principally through improved integration of quality information, coordination of supply chain relationships, bullwhip effect reduction, and enhancement of technological and management capabilities. These factors are important in supply chain visibility assessments. With the increasing need for supply chains to be sustainable, it is imperative that sustainability associated factors are accounted for in supply chain visibility assessments. Accounting for sustainability in the assessment requires integration of factors associated with compliance of green practices embracing environmental, social and economic considerations across products and services life cycle. This paper examines ways of consolidating assessments of supply chain visibility by accounting for sustainability. Following a review of related work, an analysis of sustainability measures in supply chain visibility assessment methods is presented. An integration of a notion of green absorption capacity in supply chain visibility assessments is then suggested and the associated benefits is discussed.

Keywords: visibility, assessment, sustainability, Supply chains

1. INTRODUCTION

Globalisation has created the need for supply chain organisations to consider their contribution to the future of the people and planet as key for achieving long-term success (Bubicz, Barbosa-Póvoa and Carvalho, 2019). Hence sustainable supply chains have emerged embracing the integration of economic, social and environmental considerations in their practices. There is a need for organisations to change their focus from a firm level to a supply chain level while synchronising their organisational goals with the sustainability goals. In many cases, the possibilities are overrated and overshadowed by complexities such as high cost, lack of standardisation and technologies.

Visibility is important for sustainable supply chains. Visibility is the ability of the supply chain to see clearly from one end to another whilst sharing information across the chain. Visibility performance is achieved principally through improved integration of quality information, coordination of supply chain relationships, bullwhip effect reduction, and enhancement of

technological and management capabilities.

As the need for visibility becomes an essential criterion for the successful management of sustainable supply chain, there is the need to be able to account for sustainability in the assessment of the visibility levels associated with the chain. There currently exists methods for assessing visibility of supply chains such as …. . It is important to extend the supply chain visibility narrative into the context of sustainable supply chains. The focus of this paper is in exploring an approach to visibility assessment for sustainable supply chain. This is done primarily through the notion of green absorption capacity.

The remainder of this paper contains four sections. Section 2 contains a background to sustainable supply chains. This is followed in Section 3 by a literature review on existing measures of supply chain visibility. Green absorptive capacity in the context of sustainable supply chains is introduced in Section 4 with mentions of how it can feature in measures of visibility in sustainable supply chains. The paper ends in Section 5 with conclusions and highlight of future work.

2. SUSTAINABLE SUPPLY CHAIN

The term sustainability represents a concept which is focused on creating a system that is restorative by intention (Antikainen and Valkokari 2016). Recent advances have shown a massive adoption of this concept especially in supply chain management (Seuring et al., 2008 and Easton, 2011; Berke and Satir, 2011; Grzybowska 2012). This comes as a result of the increasingly globalisation of supply chains which creates a vacuum for risk and opportunities (Silvestre, 2016). Supply chains are realising that adopting sustainable practices and acting responsibly are essential due to the risk and cost associated with not do so. The quest for sustainable practices usually comes from stakeholders and pressure groups such as government policies, laws, regulations and new sustainability approaches by competitors (Karimi and Rahim, 2015). Also, supply chains pursue sustainable practices because they tend to identify untapped opportunities within the system which may improve and offer long-term value to the stakeholders (Eccles, Ioannou and Serafeim, 2014). According to Silvestre (2016), a proactive approach to these risks and opportunities would put such companies in a privileged position thereby adding to its competitive advantage and overall performance.

Traditionally, supply chains tend to adopt the open loop approach. In a classical open loop approach the emphasis is on forward flow with little or no emphasis on reverse operations. Moreover, in open loop systems, organizations and resources within the chain typically operate as separate functional units more like silos. Moreover, as a result of sustainability thinking, the current trend is to establish closed loop supply chains enabling companies to circle back into their value chains products that previously would have been discarded.

In contrast to the open loop approach, the closed loop approach not only helps minimise waste but also supports sustainability with tremendous benefit for the environment, a justification for the move towards sustainable supply chains. There are success stories. For example, Dell are committed to reusing 10% of their discarded parts in new products (Wolk-Lewanowicz *et al.*, 2017). The big and influential move of Apple to closed loop supply chains has also been well reported (Apple, 2018).

Sustainable supply Chains (SSC) refer to the management of product and information flow while considering their natural environment, society and economic performance throughout their lifecycle in a supply chain (Carter and Easton, 2011). This aims at providing long-term value for the stakeholders by achieving a balance within the triple bottom line of Social, environmental and economic dimensions (Tseng *et al.*, 2018). To achieve a coherent sustainable supply chain that is

effective and efficient, digitisation of the chain is important. According to Schrauf and Berttram (2016), digitization of supply chain means the integration of smart technologies into the supply chains. These smart technologies would enable the chains to react to disruptions and anticipate them, thereby improving the transparency and visibility among the supply chain stakeholders.

3. MEASURING VISIBILITY IN SUPPLY CHAINS

In ascertaining the value of visibility in supply chains, numerous studies have been conducted to define supply chain visibility (SCV) and propose different measures. Some studies have used benchmarking to measure and identify visibility gaps and found it useful for understanding the impact of visibility in a supply chain (Caridi, Perego and Tumino, 2013). Some other measures such as grading system, obtained using questionnaires/surveys or case studies were also found relevant. In addition are mathematical techniques which focused on the quality and quantity of the information shared among supply chain partners (Lee and Rim, 2016). A set of studies defined visibility as the ability to share or access information across the supply chain (Lamming et al. 2002; Sridharan and Simatupang 2005) and proposed a collaboration index to measure the visibility level. Another set of studies proposed measures for supply chain visibility by considering the quality and quantity of the information shared (Barratt and Oke 2007; Caridi et al. 2010b).

Caridi et al. (2010b) explored the various dimensions of visibility (accuracy, timeliness) and their relationships to supply chain performance and proposed a quantitative model to measure visibility. SCV was measured according to the amount and quality of useful information that could be exchanged when compared to the total information that is available between nodes in a supply chain. A value assessment method proposed by (Caridi et al., 2014) to improve business performance uses cause and effect mapping and linked the data in the information to key performance index (KPI).

A reliable measure of the level of supply chain visibility will help in identifying the vulnerable parts of the supply chain's visibility and provide an insight into how the improvement of supply chain visibility would impact on the overall performance of the system. Table 1 summaries various measures of visibility which have been proposed in the literature.

Table 1. Example measures of visibility in supply chain.

Authors	The characteristics of information used	Research Methods	Techniques used	
			Qualitative / Quantitative	Visibility Measure
(Choy *et al.*, 2007)	Usability, usefulness	Case study	Qualitative	Integrated Logistics Information Management System (ILIMS) adopting Radio Frequency Identification (RFID)
(Barratt and Oke, 2007)	Accuracy, freshness, quantity, trust, usefulness, usability	Case study	Qualitative	Resource based theory
(Caridi *et al.*, 2010)	Accuracy, freshness, quantity	Case study	Quantitative	Visibility Index
(Barratt and Barratt, 2011)	Accuracy, timeliness	Case study	Qualitative	Resource based theory

(Roy, 2011)	Accuracy, quantity	Multiple Case study	Qualitative	Supply chain mapping
(Klievink *et al.*, 2012)	Timeliness, accuracy	Case study	Qualitative	The Data Pipeline concept using the piggybacking principle and system-based approach
(Caridi, Perego and Tumino, 2013)	Accuracy, freshness, quantity,	Case study	Quantitative	Visibility Index Geometric mean of collected quantity and quality judgements
(Almeida *et al.*, 2013)	Accuracy, freshness	Case study	Qualitative	Traceability
(Brandon-Jones *et al.*, 2014)	Accuracy, freshness, quantity.	Survey	Quantitative	Structural equation modelling
(Caridi *et al.*, 2014)	Accuracy, freshness, quantity	Case study	Quantitative and Qualitative	A value assessment model
(Lee and Rim, 2016)	Quantity, accuracy, and freshness,	Simulation/Modelling	Quantitative	Process Capability Model
(Maghsoudi and Pazirandeh, 2016)	Accuracy, freshness, quantity, trust, usefulness, usability	Survey	Quantitative	Structural equation modelling-partial least square
(Pruksasri *et al.*, 2016)	Accuracy, Quality	Case study	Qualitative	The data Pipeline Model
(Papert, Rimpler and Pflaum, 2016)	Accuracy, Timeliness	Multiple Case study	Qualitative	Automatic Identification Technologies
(Silva *et al.*, 2017)	Timeliness, quantity	Simulation/Modelling	Quantitative	Artificial Neural Networks
(Somapa, Cools and Dullaert, 2018)	Accessibility, Quality and usefulness	Systematic Literature Review	Qualitative	Process oriented approach
(Messina, Barros and Soares, 2018)	Quantity and Quality (Timeliness and Accuracy)	Simulation/Modelling	Quantitative	Visibility Metric

Table 1 indicates that the approaches used in measuring visibility are either qualitative or quantitative. The analysis of the results revealed three main considerations namely; the characteristics of shared information used in the studies, the techniques used and the interpretation of the measures. A variety of techniques have been used, for example, Pruksasri et al., (2016) and Klievink et al., (2012) used data pipeline model while Lee and Rim, (2016) used a process capability modelling approach.

Predominantly the focus has been on the different types of information firms need to exchange across the supply chain measured by the characteristics of the information. Examples of the types of information covered are: Stock level, supplier/customer order, available capacity, market changes, third party logistics etc (Messina, Barros and Soares, 2018). In order to develop the correlation amongst the various types of information mentioned above, only the accessible information types are typically considered. The characteristics of the accessible information generally cited in supply chain literature are shown in Table 2.

Table 2. Analysis showing characteristics of the accessible information.

Characteristics of the accessible information	Meaning	Reference	No of times used
Accuracy	The degree to which the result of a measurement, or specification conforms to the correct value or a standard	(Lee and Rim, 2016), (Caridi et al., 2014), (Papert, Rimpler and Pflaum, 2016), (Pruksasri et al., 2016), (Maghsoudi and Pazirandeh, 2016), (Almeida, Silva and Ferreira, 2013), (Klievink et al., 2012), (Roy, 2011), (Barratt and Barratt, 2011), (Caridi et al., 2010), (Barratt and Oke, 2007), (Caridi, Perego and Tumino, 2013).	12
Freshness	The quality of being new or different.	(Lee and Rim, 2016), (Caridi et al., 2014), (Maghsoudi and Pazirandeh, 2016), (Almeida, Silva and Ferreira, 2013), (Caridi et al., 2010), (Barratt and Oke, 2007), (Caridi, Perego and Tumino, 2013).	7
Quantity	A value or component that may be expressed in numbers	(Lee and Rim, 2016), (Caridi et al., 2014),) Maghsoudi and Pazirandeh, 2016), (Caridi, Perego and Tumino, 2013), (Roy, 2011), (Caridi et al., 2010), (Barratt and Oke, 2007).	7
Trust	Firm belief in the reliability, truth.	(Maghsoudi and Pazirandeh, 2016), (Barratt and Oke, 2007).	2
Timeliness	The fact or quality of being done or occurring at a favourable or useful time	(Papert, Rimpler and Pflaum, 2016), (Klievink et al., 2012), (Barratt and Barratt, 2011).	3
Quality	The standard of something measured against other things.	(Pruksasri et al., 2016), (Caridi, Perego and Tumino, 2013).	2
Usability	The degree to which a something can be used by specified users to achieve quantified objectives.	(Maghsoudi and Pazirandeh, 2016), (Barratt and Oke, 2007), (Choy et al., 2007).	3
Usefulness	The quality or fact of being useful	(Maghsoudi and Pazirandeh, 2016), (Barratt and Oke, 2007), (Choy et al., 2007).	3

Table 2 shows the characteristics of the accessible information. It revealed that most authors concentrate on a few of these characteristics when developing their visibility assessment metrics. The most common of these are quality, accuracy and timeliness (Caridi *et al.*, 2014). Although not explicit in Table 1, the measures of visibility are commonly scaler measures. A key influencing factor of information sharing in the context of supply chain visibility, recognised in the literature, is linkages, both external and internal linkages (Barratt and Oke, 2007). Linkages are connections created by firms with critical entities of their supply chain in order to manage the flow of demand and supply inputs (Barratt and Barratt, 2011).

For measures of supply chain visibility, it can be inferred that the focal point in the context of the three pillars of sustainability is the economy as expressed in Figure 1 below.
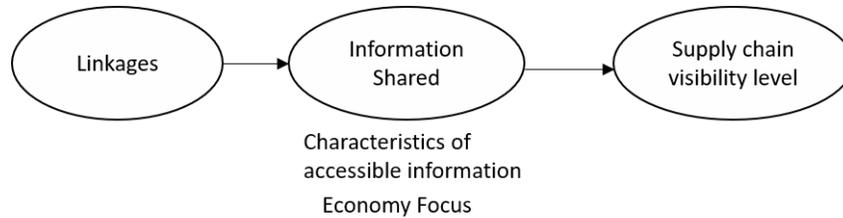
Figure 1. Assessment model for supply chain visibility

4. GREEN ABSORPTIVE CAPACITY

In a dynamic and turbulent business environment, knowledge represents a capability which acts as a key factor for the development of an organisation's supply chain that creates value, develops and sustains competitive advantages (Camisón and Forés 2010). An inward-looking approach to organizations that depend solely on their knowledge or their own resources appears not to be enough as they need to possess knowledge from different sources and fields (Murovec and Prodan 2009). To be able to absorb information from all kinds of sources, extensive acquaintance with the relevant field is necessary for an organisation to even be aware of such existing knowledge and technological development. To understand and implement ideas and concepts of others, organisations must have the competencies that enable them to understand, decode, assimilate and utilize these ideas (Zhang *et al.*, 2015).

Absorptive capacity represents the "*capability of an organisation to recognise the value of new external information, assimilate it and apply it to commercial ends*" (Cohen and Levinthal 1990). In this paper, it is the ability of the focal company to absorb knowledge and information on its supply chain processes (upstream and downstream). From the extant literature, the concept of absorptive capacity is composed of two distinctive hypotheses (Camisón and Forés 2010). The first is its ability to value and assimilate external knowledge (Cohen and Levinthal 1990), and the other is the ability to transform, exploit and use the knowledge to commercial ends (Cohen and Levinthal 1990; Liu et al. 2009). The concept of absorptive capacity used in this paper highlights both hypotheses. The first component of recognising the value and assimilating external knowledge and information means the sharing of usable information through the supply chain. However, this does not guaranty the usage or application of such knowledge unless if it is of mutual benefit to the recipients. The second component of transforming and using such knowledge means the ability to transform or apply the new knowledge to commercial ends. The adoption of both hypotheses stretches beyond individual firms' operations in that it also includes their direct and indirect stakeholders (Busse *et al.*, 2017). Stakeholders inclusion brings substantial pressure and would increase the awareness for sustainability in supply chains, pushing firms to be more transparent in their practices and to adopt sustainability-related goals. Amongst such practices is the green absorptive capacity.

The green absorptive capacity relates to an organisational capability to obtain, integrate, convert, utilize and apply environmental knowledge for commercial use (Chen *et al.*, 2015). In the context of sustainable supply chains, this can be inferred to the ability of a company to apply its existing resources and knowledge to renew and create its organisational capabilities to respond to the dynamic market as it relates to the environment, economy and society (Savita, Dominic and Ramayah, 2014). The capability derived from the integration of green absorptive capacity into the firm can be considered as a critical determinant of competitive advantage. This is to say the more firms use their knowledge as it relates to environment, society and the economy, the better they can deal with issues involving green technology, climate change, waste reduction and variations in the

market. An extension of the assessment model of Figure 1 for supply chain visibility that incorporates green absorption capacity can account for sustainability in measures of sustainable supply visibility as illustrated in Figure 2 below.
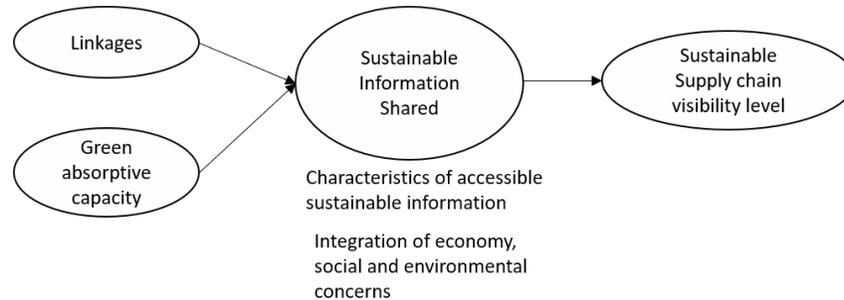

Figure 2. Assessment model for sustainable supply chain visibility

5. CONCLUSION

Visibility is widely acknowledged to be central to supply chain performance. Studies have shown that the most common approach in assessing visibility in supply chains are quantitative or qualitative in nature, however within the context of sustainable supply chain, there is a need for a consensus approach. This research also highlighted the importance of the characteristics of the shared information as a catalyst for assessing the supply chain visibility levels. It is proposed in this work that a model that incorporates green absorptive capacity through a sustainable information sharing network would help in assessing visibility levels of a sustainable supply chain. Future work would entail developing a computational model for visibility that includes green absorption capacity.

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