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Upstream supply chain visibility and complexity effect on focal company's sustainable performance: Indian manufacturers' perspective

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Abstract Understanding supply chain sustainability performance is increasingly important for supply chain researchers and managers. Literature has considered supply chain sustainability and the antecedents of performance from a triple bottom line (economic, social, and environmental) perspective. However, the role of supply chain visibility and product complexity contingency in achieving sustainable supply chain performance has not been explored in depth. To address this gap, this study utilizes a contingent resource-based view theory perspective to understand the role of product complexity in shaping the relationship between upstream supply chain visibility (resources and capabilities) and the social, environmental,

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and economic performance dimensions. We develop and test a theoretical model using survey data gathered from 312 Indian manufacturing organizations. Our findings indicate that supply chain visibility has significant influence on social and environmental performance under the moderation effect of product complexity. Finally, we have outlined our research limitations and further research opportunities.

Keywords Sustainable supply chain · Supply chain performance · Contingent resource based view · Connectivity · Information sharing · Visibility · Product complexity · Factor analysis · Regression analysis

1 Introduction

Sustainable supply chain management (SSCM) remains a key management perspective that affects supply chain performance (Marshall et al. 2015; Jabbour et al. 2012, 2015; Brandenburg and Rebs 2015; Fahimnia et al. 2017). In a recent study, Kumar et al. (2016) defined sustainable supply chain as the integration of environmental, social and economic aspects in the supply chain. Despite the increased attention from both academia and industry, achieving sustainable supply chain performance remains a challenge. While characteristics such as tighter coupling, increased complexities, reduced inventory levels, outsourcing, and ever-greater geographic dispersion have helped firms to reduce their supply chain costs, they have created greater vulnerabilities in the form of rapid change in climate and social–economic disparities (Hall and Matos 2010; Bode et al. 2011; Kaur and Singh 2016). Failures in implementing supply chain sustainability have occurred in the past; for instance, the fire in one of the leading suppliers of Wal-Mart, a Bangladesh garment factory, where more than 1130 people died (The Guardian 2013), due to a lack of proper understanding of sustainable supply chain design. Thus, many organizations, including Nestle, ITC, Unilever, Toyota and others are seriously paying attention to their upstream suppliers to create sustainable supply chains to generate profit for the organizations while reducing environmental impacts and improving the quality of working life of their employees.

Wu and Pagell (2011) argue that in sustainable supply chains, organizations need to consider and address the uncertainty that surrounds environmental decisions (Song et al. 2016), the environmental issues due to the number of entities in the chain, and the interconnectedness of supply chain and ecological systems due to lack of *visibility* in the supply chain network. Supply chain visibility has been noted as an important organizational capability (see Barratt and Oke 2007; Juttner and Maklan 2011; Brandon-Jones et al. 2014). It may improve coordination between supply chain partners (Arshinder et al. 2008; Carter and Rogers 2008; Kannan et al. 2014; Lehoux et al. 2014; Maghsoudi and Pazirandeh 2016; Akhavan and Beckmann 2017), information sharing (Mabert and Venkataramanan 1998) and performance, by reducing the negative consequences of distortions (Lee et al. 2000). Furthermore, supply chain visibility allows organizations to be more agile (Christopher 2000) and creates strategic value (Wei and Wang 2010).

Barratt and Oke (2007) regard information sharing as an antecedent of supply chain visibility. Holcomb et al. (2011) argue that supply chain visibility relies on shared data and information, whereas Brandon-Jones et al. (2014) argue that supply chain connectivity and information sharing are the immediate antecedents of supply chain visibility. In this study 'supply chain connectivity' relates to the technological infrastructure to share information among supply chain network partners (Zhu and Kraemer 2002) and "information sharing" relates to the nature, speed, and quality of information being shared (Cao and Zhang 2011; Brandon-Jones et al. 2014). Both form the basis of supply chain visibility.

Francis (2008) argues that supply chain visibility is often misunderstood. Barratt and Oke (2007) have noted that prior research has failed to delineate between information sharing and supply chain visibility. Cao and Zhang (2011) argue that information sharing is predominantly concerned with the quality and relevance of the information provided and hence is an intangible resource. Visibility, on the other hand is a broader capability whereby material, funds and information flows are captured, and renders the supply chain more transparent at a given time (Braunscheidel and Suresh 2009). Transparency is important for building confidence among partners (Christopher and Lee 2004) and leads to improved coordination and resource sharing (Maghsoudi and Pazirandeh 2016) for better performance. In this paper, we consider upstream supply chain visibility in terms of connectivity and information sharing as a key capability to implement sustainability aspects in a supply chain. However, the broad empirical evidence for its effects still appears largely absent from the literature. To address this gap, we pose two questions. The first one is: *What are the effects of the information connectivity and information sharing on supply chain visibility?*

We examine the conditions under which the supply chain visibility is effective in sustainable supply chains (Sousa and Voss 2008; Boyd et al. 2012). We look into complexity, which has been increasingly recognized as one of the key areas of managerial concern (see Choi and Krause 2006; Eckstein et al. 2015; Pérez Mesa and Gómez 2015; Aitken et al. 2016) and a critical factor moderating various performance relationships (Jacobs 2013). In this context, we argue that complexity is one of the factors of uncertainty which may enhance or hamper the effectiveness of the supply chain visibility (Caridi et al. 2010b). Caridi et al. (2010a, b) have attempted to explain how virtuality and complexity impact upon supply chain visibility using contingency theory. Building on Bozarth et al. (2009), we view supply chain complexity from the perspective of focal firm, and thus following the arguments of scholars (see Bozarth et al. 2009; Blome et al. 2013; Eckstein et al. 2015) we limit our focus on product complexity, which stems from the customization, intricacy, and the variety of the firm products. Product complexity is driven by number of factors including remanufacturing and product life-cycle (see Debo et al. 2005, 2006; Geyer et al. 2007); the latter is critical is critical for sustainable product development (Trotta 2010) and sustainable supply chain design (Gupta and Palsule-Desai 2011). However, research focusing on the effects of product complexity on sustainable supply chain design is still underdeveloped. Thus, our second research question is: *What are the effects of the product complexity on the relationship between supply chain visibility and social performance/ environmental performance/economic performance?*

Our research is informed by contingency theory (Donaldson 2001; Sousa and Voss 2008; Bozarth et al. 2009; Boyd et al. 2012; Eckstein et al. 2015) and in particular contingent resource based view theory (CRBV) (Brush and Artz 1999). Contingency theory and CRBV help us understand the contextual aspects and contingencies related to *how* and *why* organizations can implement sustainability aspects in the supply chains. Barney (1991), proposing the resource based view (RBV), focused on the role of resources and capabilities in assisting organizations achieve competitive advantage, while contingent RBV suggests that the competitive advantage may be contingent on certain conditions. Brandon-Jones et al. (2014) have argued that specific conditions have a significant effect on the impact of resource bundling and capability building. Sirmon et al. (2007) argued in favor of a dynamic resource model to address environmental uncertainty; observed heterogeneity in the final outcome under similar initial conditions may be due to choices made related to structuring, bundling and leveraging of the resources. Therefore, based on the literature we argue that resources and capabilities which are possessed by the organization—in this case supply chain connectivity and supply chain information sharing (together referred to as "supply chain visibility")—may impact on supply chain sustainability performance (economic, social, and environmental) under the contingency of product complexity (Bozarth et al. 2009; Jacobs 2013; Eckstein et al. 2015).

Our contribution to the operations and supply chain management literature is as follows. Firstly, building on Wu and Pagell (2011) and Lai et al. (2015) we investigate the impact of bundling resources to build supply chain visibility and its influence on supply chain sustainability performance. We argue that by building visibility in the supply chain, the sustainable supply chain performance can be improved significantly. We therefore address the suggestion of scholars to further investigate sustainability performance and visibility (Wu and Pagell 2011). Secondly, we investigate the contingent role of product complexity in achieving sustainability performance through supply chain visibility. We argue that product complexity influences the impact of visibility on social performance, environmental performance and economic performance, extending thereby previous studies (e.g. Barratt and Oke 2007; Holcomb et al. 2011; Brandon-Jones et al. 2014). Thirdly, we examine the contingency of product complexity based on the CRBV logic (Brush and Artz 1999). We therefore extend earlier studies (e.g. Barratt and Oke 2007; Holcomb et al. 2011; Brandon-Jones et al. 2014; Eckstein et al. 2015) by grounding our model in CRBV to explain this complex phenomenon. Finally, we add evidence and insight to the study of supply chain visibility and its influence on supply chain sustainability performance from the Indian context. In this vein we provide a better understanding of the sustainable supply chains in BRICs than existing literature (Jabbour et al. 2012; Kannan et al. 2014; Gunasekaran et al. 2014; Dubey et al. 2015; Mani et al. 2016).

The remainder of the paper is structured as follows. Next, we introduce our theoretical model and research hypotheses. We then present our research design and methodology. Then follows our data analysis and the discussion of our results in light of the literature. Finally, we provide the limitations of our work and future research directions.

2 Theoretical framework and hypotheses development

2.1 Theoretical framing

This paper adopts the contingent RBV perspective (Brush and Artz 1999). The RBV asserts that an organization can achieve competitive advantage by creating bundles based on the combination of resources and /or capabilities (Rumelt 1984; Barney 1991). Barratt and Oke (2007) argue that supply chain connectivity and information sharing have the potential to generate competitive advantage, if the resources or capabilities have the attributes of being valuable, rare, inimitable, and non-substitutable (Barney 1991). Resources, per Barney (1991) can be broadly categorized as 'physical capital', 'human capital', and 'organizational capital'. Grant (1991) extends these resource types to include 'financial capital', 'technological capital', and 'reputational capital'. In a later study, Größler and Grübner (2006) argue that resources may be 'tangible', such as infrastructure, or 'intangible', such as information sharing. Bundling resources with specific practices and skill sets has also been highlighted as necessary for building capabilities (Sirmon et al. 2007).

The RBV has attracted significant attention from the operations and supply chain management community (Hitt et al. 2016). Brandon-Jones et al. (2014) argue, however, that in the operations and supply chain management field there are still limited studies discussing the *bundling* of capabilities and resources. Bundling resources and capabilities can have a significant impact on performance (see Zhu and Kraemer 2002; Ravichandran and Lertwongsatien 2005). Zhu and Kraemer (2002) suggest that bundling IT infrastructure (resources) and information sharing through e-commerce (capability) leads to improved performance. Ravichandran and Lertwongsatien (2005) further investigate how information systems (resources) and capabilities influence organizational performance. In a recent study, Golini et al. (2014) use RBV to discuss how capability building (i.e. site competence) can improve social and environmental performance in the supply chains.

Despite the popularity of RBV, critics suggest that RBV suffers from context insensitivity (Ling-Yee 2007; Brandon-Jones et al. 2014). To address this criticism we follow Brush and Artz (1999) who propose the contingent RBV. Grötsch et al. (2013) argue that contingency theory can provide insights on how to utilize resources along with unique capabilities to achieve better outcomes in different situations. Eckstein et al. (2015) argue that contingency theory involves identifying and matching context settings with firm settings (Hambrick 1983), whereas Donaldson (2001) notes that contingency theory assumes the nature of the firm's internal and external task environments. Hence, contingency theory argues that firms should adapt structures and processes to achieve a desired fit with the environment to achieve better performance (Donaldson 2001; Brandon-Jones et al. 2014; Eckstein et al. 2015). However, the contingent perspectives of RBV are underdeveloped in the literature (Brandon-Jones et al. 2014).

In this paper our focus is on sustainable supply chains where contingency theory addresses how internal and external conditions can guide those dealing with products within a sustainable supply chain network. Aragon-Correa and Sharma (2003) argue that contingent RBV may offer better insights by categorizing resources and capabilities of an organization based on certain internal and external contingencies. These, per Sirmon and Hitt (2009) may differentiate organizations in terms of the use of resources for the achievement of competitive advantage.

Zhu et al. (2008) argue that industry has three task environments: uncertainty, complexity and munificence, which have significant influence on managers' decisions. Pressure from stakeholders may force an organization to adopt proactive strategies such as environmental and social sustainability. Supply uncertainty, however, may not influence proactive strategies due to tendency of the organization to minimize the need due to scarce managerial resources (Carter and Rogers 2008), whereas less complexity may trigger proactive strategies such as environmental sustainability or social sustainability in comparison to more complex organizations. Hence, we consider product complexity as a contingency variable.

2.2 Hypotheses development

We argue, following the CRBV perspective, that supply chain connectivity and information sharing can build capabilities which can further enhance sustainable supply chain performance under the contingent effects of firm size, product complexity, and time (see Fig. 1). We see supply chain connectivity as mainly a technology issue. Furthermore, we define supply chain visibility as an organizational capability that enables supply chains to be more transparent in terms of demand and inventory levels. The supply chain visibility construct is visualized as a multidimensional second-order reflective construct of supply chain connectivity and information sharing, which in turn are conceptualized as first-order reflective constructs.

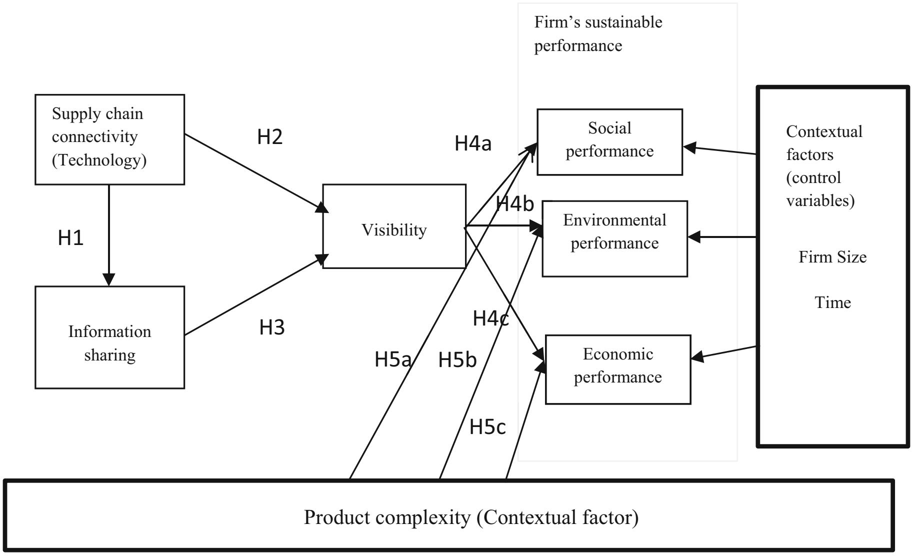

Fig. 1 Hypothesized relationships

2.2.1 Hierarchical model specification

Following Wetzels et al. (2009) arguments, our theoretical framework was specified as hierarchical model, representing the relationships between the indicators, sub-dimensions, and higher-order constructs. Hence, we have developed a three-order reflective model (see Fig. 1).

2.2.2 Hypotheses

Impacts of supply chain connectivity on information sharing Following RBV, resources are combined to create capabilities (Grant 1991). We argue that supply chain connectivity and information sharing can be combined to create visibility in a supply chain network (see, Sirmon et al. 2007; Brandon-Jones et al. 2014). Premkumar and King (1994) argue that information sharing is an intangible resource that focuses on the flow of information. In a later study, Zhou and Benton (2007) argue that the value of information sharing depends upon the information quality. Brandon-Jones et al. (2014) note that information quality, accessibility, accuracy, and the relevance of the information depend upon the IT infrastructure. Hence, based on Cao and Zhang (2011) we argue that IT infrastructure is a tangible resource that plays a significant role in information sharing. Furthermore, following the literature (Zhu and Kraemer 2002; Fawcett et al. 2007) IT infrastructure or support technology can be referred to as 'supply chain connectivity'. Fawcett et al. (2011) define supply chain connectivity as the ability of organizations to gather and share information using information and communication technologies (ICTs).

Hence, we can hypothesize:

H1: Upstream supply chain connectivity has a positive impact on information sharing.

Impacts of supply chain connectivity on visibility We have argued based on RBV that strategic resources and capabilities can generate competitive advantage (see also Barney 1991). Supply chain connectivity is an important resource for the development of capabilities within the supply chain (see Zhu and Kraemer 2002; Wu et al. 2006; Brandon-Jones et al. 2014). Brandon-Jones et al. (2014) note that supply chain connectivity facilitates supply chain visibility. Hence based on RBV logic we conceptualize that supply chain connectivity and information sharing jointly form a capability, and we argue that supply chain connectivity is a prerequisite for building the capability of supply chain visibility. Therefore, we hypothesize:

H2: Upstream supply chain connectivity has a positive impact on upstream supply chain visibility.

Impacts of information sharing on visibility Lee and Whang (2000) note that the sharing of information related to inventory, sales, demand forecast, order status and production schedule using advanced information technology plays a significant role in the evolution of the supply chain. Christopher and Lee (2004) note that the sharing of appropriate and timely information among players in supply chains may improve visibility. In a later study, Brandon-Jones et al. (2014) argue that information sharing is an intangible resource, "while supply chain visibility is seen as a broader capability whereby material and information flows are captured" (p. 59). Sezen (2008) study the relationship of information sharing to performance, arguing that information sharing leads to improved performance, whereas Barratt and Oke (2007) suggested that information sharing is an antecedent of supply chain visibility that leads to performance. Therefore,

H3: Information sharing has a positive impact on upstream supply chain visibility.

Impacts of supply chain visibility on sustainable supply chain performance Francis (2008), in an extensive review of supply chain visibility, argues for its importance and relationship to supply chain performance while urging researchers to do further research on the subject. Barratt and Oke (2007) further note that visibility in a supply chain has positive impacts on inventory level, product availability, flexibility, responsiveness and quality. Caridi et al. (2010a) undertake extensive research on visibility and its impact on supply chain performance measures. They note that supply chain visibility impacts positively on total distribution costs, inventory level, service level, generic firm performance, delivery performance, product availability, flexibility, responsiveness and quality issues. Wu and Pagell (2011) discuss supply chain visibility as being vital to environmental decision making. However, so far researchers have not discussed the impact of visibility on social aspects and on the overall sustainable firm performance. Given that when referring to sustainability, the performance of a firm needs to be measured in terms of the triple bottom line (see Elkington 1999; Kleindorfer et al. 2005; Pagell and Wu 2009; Wu and Pagell 2011), that is, economic, social, and environmental aspects, we argue that supply chain visibility may have positive impacts on social performance, environmental performance and firm performance. Therefore:

H4a: Upstream supply chain visibility has a positive impact on social performance.
H4b: Upstream supply chain visibility has a positive impact on environmental performance.
H4c: Upstream supply chain visibility has a positive impact on economic performance.

Moderating role of product complexity Jacobs (2013) argues that product complexity is a significant concern for managers and can undermine operational performance if not managed well; if managed well it could be used for gaining competitive advantage. Product complexity has received increasing attention from various scholars (see Bozarth et al. 2009; Jacobs 2013; Eckstein et al. 2015; Caniato and Größler 2015), however the role of product complexity on firm sustainable performance is still underdeveloped. Eckstein et al. (2015) attempt to test the moderating effect of product complexity on the relationship between supply chain agility and adaptability on organizational performance. Even though there are mixed views in the literature regarding the role of product complexity (see Fisher et al. 1999; Closs et al. 2010), we argue that product complexity may moderate sustainable supply chain performance, and hence in our study we investigate the moderating role of product complexity on sustainable supply chain performance. Therefore,

H5a: Product complexity positively moderates the effect of upstream supply chain visibility on social performance;
H5b: Product complexity positively moderates the effect of upstream supply chain visibility on environmental performance;
H5c: Product complexity positively moderates the effect of upstream supply chain visibility on economic performance.

3 Research design

3.1 Construct operationalization

To test our research hypotheses, we used the survey method. A survey questionnaire was developed by identifying appropriate measures from our extensive literature review. The scales were pre-tested and modified using an expert panel comprising industry practitioners and academics. The five industry experts whom we selected had over fifteen years of experience in the supply chain management field and are members of APICS, ISM and CILT UK. The academics were selected based on their related research works published in the highly-ranked (ABS 4* and ABS 3*) journals listed by the Financial Times and the Chartered Association of Business Schools (2015). The finalized questionnaire includes reflective constructs and their measures as discussed next and shown in "Appendix 1". We have measured each item on a five-point Likert scale with anchors ranging from strongly disagree (1) to strongly agree (5).

3.1.1 Supply chain connectivity

We measured supply chain connectivity using a scale by Fawcett et al. (2011) further modified using Brandon–Jones et al.'s (2014) scale. The three-item construct (see "Appendix 1") examines the extent to which the use of ICTs facilitates quality information exchange in the supply chain.

3.1.2 Information sharing

We measured information sharing using Brandon–Jones et al.'s (2014) five measures scale, developed by Cao and Zhang (2011). The five-item construct (see "Appendix 1") assesses the extent of relevant, timely, accurate and complete information sharing occurring between suppliers, manufacturers, logistic service providers and dealers.

3.1.3 Supply chain visibility

We used Brandon–Jones et al.'s (2014) two-item construct, grounded in Braunscheidel and Suresh (2009). The two-item construct (see "Appendix 1") examines the extent to which inventory and demand levels are visible throughout the supply chain.

3.1.4 Product complexity

We measure product complexity using Eckstein et al.'s (2015) three-item construct (see "Appendix 1"). This construct examines the extent to which product complexity is well managed to improve the sustainable supply chain performance.

3.1.5 Social performance

We used Hutchins and Sutherland's (2008) twelve-item construct (see "Appendix 1"). It examines the extent to which labor equity, health related issues, education, and housing security related issues are addressed without compromising with quality, profit, and environment.

3.1.6 Environmental performance

We used Zhu and Sarkis' (2004) six-item construct that examines the extent to which the negative consequences of supply chain activities on the environment are reduced (see "Appendix 1").

3.1.7 Economic performance

We used Zhu and Sarkis' (2004) five-item construct (see "Appendix 1") that examines the extent of reduced costs due to waste and injuries. We measured each item on a five point Likert scale with anchors ranging from strongly disagree (1) to strongly agree (5).

3.1.8 Statistical controls

To fully account for the differences among organizations, we included firm size and time as control variables. To measure firm size, we used 'number of employees' and 'revenue' (Liang et al. 2007). Finally, we included 'time' since the adoption of sustainable practices in supply chains is a dynamic process and misalignments which might have existed initially due to poor coordination may have been resolved to a certain extent. Thus, this variable takes into account the learning effect (Liang et al. 2007).

3.2 Data collection

In this study the unit of analysis employed was at the level of manufacturing plant and its constituent upstream suppliers. Prior research has indicated that this analysis provided a detailed understanding of supply chain network design (see Brandon-Jones et al. 2014; c.f. Bozarth et al. 2009). We utilized a cross-sectional e-mail survey of a sample of Indian manufacturing companies drawn from the Confederation of Indian Industries (CII) database and further validated using a database provided by Dun & Bradstreet. Eighteen hundred respondents were selected from the CII database situated across India. The title of the respondents sought was

Table 1 Sample profile (N = 312)

	Count	Percent
Industry code (NIC)		
16 (Wood and products of wood)	18	5.77
17 (Manufacture of paper and paper products)	23	7.37
19 (Manufacture of coke and refined petroleum products)	28	8.97
20 (Manufacture of chemicals and chemical products)	67	21.47
22 (Manufacture of rubber and rubber products)	82	26.28
25 (Manufacture of fabricated metal products, except machinery and equipment)	94	30.13
Number of employees		
Less than 100	48	15.38
101–500	70	22.44
501–1000	100	32.05
1000 or more	94	30.13
Annual Sales (US$)		
150 million and above	93	29.81
More than 100 million and less than 150 million	150	48.08
Less than 100 million	69	22.12
Position of the respondent		
Director	42	13.46
Vice-president	98	31.41
General manager	172	55.13

primarily Vice President or Director of Supply Chain Management, Logistics Management, or Materials Management (see Table 1).

In an effort to increase the response rate we followed Dillman's tailored design test method with new internet and mixed mode guidelines (see Dillman 2011). Survey questionnaires were e-mailed to the 1800 respondents. Each survey questionnaire included a cover letter in which the purpose of the study was explained. After two weeks, we had received 160 usable responses. We sent further reminders via e-mail and followed up by phone. After three weeks, we had received a further 152 usable responses. Hence, we received a total of 312 usable responses, which represents 17.33% (312/1800 = 17.33%). In comparison to similar studies in operations and supply chain management (see Braunscheidel and Suresh 2009; Eckstein et al. 2015; Lai et al. 2015), our sample size is sufficient for a hypotheses test.

To test for non-response bias, we followed the steps by Armstrong and Overton (1977). We compared the responses of early and late waves of returned survey based on assumption that the opinions of the late respondents are representative of the opinions of the non-respondents (see Armstrong and Overton 1977; Lambert and Harrington 1990). However, Fawcett et al. (2014) noted that comparing early to late respondents may not be a strong test of nonresponse bias. Hence, we also adopted alternative techniques (see Fawcett et al. 2014) and compared the demographics of the late respondents via a Dun & Bradstreet database and further followed up by making a phone call to increase the confidence level of the late respondents. The *t* tests yielded no statistically significant differences between early-wave (160 responses) and late-wave (152 responses), suggesting that non-response bias was not a problem.

The final sample consisted of 42 directors (13.46%), 98 vice-presidents (31.41%) and 172 general managers (55.13%). The respondents primarily worked for medium to large firms with 30% of the respondents working for large firms with more than 1000 employees and a gross income of more than US $150 million. The respondents are evenly distributed among the six NIC codes selected.

4 Data analysis and results

Before evaluating reliability and validity of the constructs and their measures, the indicators were tested for constant variance, existence of outliers, and normality. We used plots of residuals by predicted values and statistics of skewness and kurtosis. The maximum absolute values of skewness and kurtosis of the indicators in the remaining dataset were found to be 1.53 and 4.75, respectively. These values were well within the limits recommended by Curran et al. (1996) which suggest skewness <2, kurtosis <7. Finally, neither the plots nor the statistics indicated any significant deviance from the assumptions.

4.1 Measurement model

We used the co-variance based method (AMOS 19.0) for conducting data analysis. We conducted confirmatory factor analysis (CFA) to estimate the measurement properties of the multi-item constructs (see Fig. 1). All factor loadings were more than the commonly accepted 0.5 standard of Hair et al. (2006). The model revealed a good fit to the data. Based on the recommendations of various researchers (see Bentler and Bonett 1980; Hair et al. 2006; Hooper et al. 2008) we obtained the following fit indices: χ^2/degrees of freedom = 179; goodness of fit [GFI] = 0.98; adjusted goodness of fit [AGFI] = 0.96; Bentler and Bonnet's normed fit index [NFI] = 0.97; Bentler comparative fit index [CFI] = 0.99; root mean square residual [RMSR] = 0.04; root mean square error of approximation [RMSEA] = 0.05. We further followed a series of procedures (see Fornell and Larcker 1981; Hair et al. 2006; Li et al. 2016) to assess convergent and discriminant validity. In support of convergent validity, we observed that all the factor loadings were significant and greater than 0.5; scale composite reliability (SCR) greater than 0.7 and average variance extracted (AVE) greater than 0.5 (see Table 2).

Discriminant validity was next assessed, via both inter-correlations and AVE comparisons. The construct inter-correlations were between −1 and 1, and all the squared inter-correlations were less than the AVE estimates for either construct in pairing, supporting discriminant validity (see Table 3).

4.2 Common method bias (CMB)

Podsakoff et al. (2003) noted that in all self-reported data, there is a potential for common biases resulting from multiple sources such as consistency motif and social desirability. Following Podsakoff and Organ (1986), we requested our respondents not to estimate environmental performance and economic performance related questions purely based on memory. Instead we requested our respondents to get this information from documents maintained by the organizations. Secondly, we performed statistical analyses to assess the severity of

Table 2 Confirmatory factor analysis

Construct	Indicator	Factor loading	Variance	Error	SCR	AVE
Supply chain connectivity (SCC)	SC1 (current information systems)	0.74	0.54	0.46	0.82	0.60
	SC2 (information applications)	0.80	0.64	0.36		
	SC3 (adequate information systems linkage)	0.78	0.60	0.40		
Information sharing (IS)	IS1 (relevant information)	0.59	0.35	0.65	0.91	0.71
	IS2 (timely information)	0.88	0.77	0.23		
	IS3 (accurate information)	0.88	0.77	0.23		
	IS4 (confidential information)	0.97	0.95	0.05		
Supply chain visibility (SCV)	SCV1 (Inventory levels)	0.90	0.82	0.18	0.90	0.82
	SCV2 (demand levels)	0.90	0.82	0.18		
Product complexity (PC)	PC1 (diverse add-ons)	0.91	0.83	0.17	0.95	0.87
	PC2 (high number of components)	0.90	0.82	0.18		
	PC3 (new product variants)	0.98	0.96	0.04		
Social performance (SP)	SP1 (gender equality)	0.69	0.47	0.53	0.93	0.59
	SP3 (poverty reduction)	0.80	0.64	0.36		
	SP4 (nutritional status)	0.85	0.73	0.27		
	SP5 (sanitation)	0.81	0.66	0.34		
	SP6 (safe drinking water)	0.87	0.76	0.24		
	SP7 (health care delivery)	0.95	0.91	0.09		
	SP9 (proper residence)	0.56	0.31	0.69		
	SP10 (transport facility)	0.61	0.37	0.63		
	SP11 (living conditions)	0.69	0.48	0.52		
Environmental performance (EP)	EP1 (reduction of air emission)	0.87	0.76	0.24	0.92	0.67
	EP2 (reduction of waste water)	0.68	0.46	0.54		
	EP3 (reduction of solid waste)	0.89	0.79	0.21		
	EP4 (reduction of consumption for hazardous harmful toxic materials)	0.85	0.73	0.27		

Table 2 continued

Construct	Indicator	Factor loading	Variance	Error	SCR	AVE
	EP5 (reduction of frequency of environmental accidents)	0.81	0.65	0.35		
	EP6 (improve enterprises environmental situations)	0.79	0.63	0.37		
Economic performance (ECOP)	ECOP1 (decrease in materials purchasing cost)	0.94	0.87	0.13	0.97	0.88
	ECOP2 (decrease of cost for energy consumption)	0.95	0.91	0.09		
	ECOP3 (decrease in fee for waste treatment)	0.94	0.88	0.12		
	ECOP4 (decrease of fee for waste discharge)	0.93	0.87	0.13		
	ECOP5 (decrease of fine for environmental accidents)	0.94	0.88	0.12		

Table 3 Inter-correlations of constructs

	SCC	IS	SCV	PC	SP	EP	ECOP
SCC	**0.77***						
IS	0.16	**0.84***					
SCV	0.20	0.50	**0.91***				
PC	−0.19	−0.05	−0.12	**0.93***			
SP	0.22	0.33	0.40	0.04	**0.77***		
EP	−0.05	0.22	0.09	0.27	0.04	**0.82***	
ECOP	0.36	0.05	0.13	−0.18	0.00	0.03	**0.94***

* Square root of AVE

common method bias by performing the Harmon one-factor test (Podsakoff and Organ 1986; Liang et al. 2007) on seven constructs in our theoretical model (Fig. 1). The result suggests that all the seven constructs are present and the maximum co-variance explained by one factor is 14.8% (see "Appendix 2"), indicating that CMB is not likely to impact upon our study.

4.3 Hypothesis testing

We have tested our research hypotheses using multiple regression analysis (see Zailani et al. 2012) with hierarchical moderation tests applied as necessary based on prior studies (see Brandon-Jones et al. 2014; Eckstein et al. 2015; Dubey and Gunasekaran 2015). We tested for multi-collinearity of the interaction terms (see Aiken et al. 1991; Chen and Paulraj 2004; Eckstein et al. 2015). The multi-collinearity was tested by calculating variance inflation

Table 4 Supply chain visibility and supply chain information sharing regression results

Variable	DV=IS		DV=SCV	
	β	t value	B	t value
Control				
Firm size	−0.064	−1.46	−0.026	−0.381
Main effects				
SCC	0.787	14.975	0.218	2.965
IS			0.684	10.064
Model summary				
R^2	0.528		0.619	
Adj R^2	0.523		0.613	
Model F	112.283		108.312	

factors (VIF). The calculated values for each regression coefficient were from 1.00 to 3.45, significantly lower than the recommended threshold of 10 (Hair et al. 2006).

Table 4 summarizes the results for hypotheses H1–H3. Addressing H1 we found that supply chain connectivity (SCC) is positively linked with information sharing (IS) ($\beta = 0.787$; t =14.975). The result obtained is found to be consistent with prior studies (Barratt and Oke 2007; Brandon-Jones et al. 2014). The control variable ‘firm size’ does not have a significant effect on the model ($\beta = -0.064$; $t = -1.46$). We therefore interpret the results that the supply chain connectivity helps significantly in information sharing. The size of the firm has very little to do in supply chain connectivity-information sharing relationship.

Addressing H2 and H3, we find that the results support both hypotheses (see Table 4). H2 ($\beta = 0.218$; $t = 2.965$), indicates that supply chain connectivity (SCV) has a positive impact on upstream supply chain visibility and H3 ($\beta = 0.684$; $t = 10.064$) indicates that information sharing (IS) has a positive impact on upstream supply chain visibility (SCV). Thus, our results are consistent with the findings of Brandon-Jones et al. (2014). The role of information sharing on supply chain visibility further support the results by Lai et al. (2015) in the context of Hong Kong firms. Based on the regression analyses (see Table 4), H1–H3 are supported. Hence, we can argue that resources (supply chain connectivity and information sharing) are important for creating visibility in a sustainable supply chain network.

H4 and its sub-hypotheses (H4a, H4b and H4c) were tested using hierarchical moderated multiple regression. Specifically, three models, for social performance (SP), environmental performance (EP) and economic performance (ECOP) as dependent variables, were tested.

Addressing H4a–H4c, we find (see Table 5) that H4a ($\beta = 0.387$; $t = 8.463$) and H4b ($\beta = 0.258$; $t = 3.18$) are supported. Our findings support the view of Wu and Pagell (2011) regarding the role of visibility in upstream supply chains. Our interpretation for the results is that extra effort to improve supply chain visibility may help to enhance social and environmental performance. However, the visibility seems to have no significant influence on the economic performance (H4c: $\beta = 0.106$; $t = 1.312$). Surprisingly, this hypothesis was not supported which runs contrary to many findings. This study supports Holcomb et al.’s (2011) findings which noted mixed results in context to impact of visibility on firm performance. However, Holcomb et al. (2011) focused on the role of culture to differentiate between North American and European markets, whereas in our study we have not consid-

Table 5 Firm sustainable performance hierarchical moderated regression results

Variable	DV=SP		DV=EP		DV=ECOP	
	B	t value	β	t value	β	t value
Control						
Firm size	0.008	0.064	0.013	0.085	0.152	0.833
Main effects						
SCV	0.387	8.463	0.258	3.18	0.106	1.312
PC	0.086	0.392	0.045	0.336	0.109	1.634
Interaction effects						
SCV*PC	0.012	3.734	0.718	14.79	0.014	2.368
Model summary						
R^2	0.315		0.56		0.024	
Adj R^2	0.313		0.552		0.014	
Model F	136.99		63.411		2.448	

ered country culture or organizational culture. Furthermore, literature suggest that visibility in terms of inventory and demand may hinder coordination due to behavioral uncertainty (Kwon and Suh 2004), and that trust and commitment play an important role in reducing opportunistic behavior (Morgan and Hunt 1994). Nevertheless, no data on trust, commitment and behavioral uncertainty was collected in our survey. Finally, we also cannot ignore data related issues which may have influence on weak beta values. The current study utilizes cross-sectional data gathered using a pre-tested instrument. Guide and Ketokivi (2015) in their recent editorial note have compiled some interesting observations which leads us to reflect upon weak beta values. The beta co-efficient is found to be insignificant in our case which may be due to problem of endogeneity and CMB. Although we have undertaken necessary statistical tests to ensure that the endogeneity problem and CMB do not have major influence, we admit that the problem of endogeneity and CMB cannot be eliminated. The endogeneity problem may lead to asymptotic bias in parameter estimation (Guide and Ketokivi 2015).

Next addressing H5a–H5c, we find (Table 5) product complexity (PC) has positive moderating effects on social performance (SP) ($\beta = 0.012$; $t = 3.734$), environmental performance (EP) ($\beta = 0.718$; $t = 14.79$) and economic performance (ECOP) ($\beta = 0.014$; $t = 2.368$). Our interpretation of this result is that the product complexity can become an effective moderator between SCV and sustainable supply chain performance. This result suggests that the effort of the firm to develop supply chain visibility capability is generally justified as it leads to improved performance, in both complex and simple product environments. Supply chain visibility is more effective under high product complexity than under low complexity and may help the firm to handle complex product environments, resulting into better social and environmental performance. This result is consistent with prior research findings (see Kekre and Srinivasan 1990; Quelch and Kenny 1994), implying trade-offs for managers between sales growth through added product complexity and enhanced operational efficiency through product rationalization. Trading-off between product complexity and operational efficiency may help to strike a balance between social, environmental and economic benefits of the firm.

5 Discussion

5.1 Theoretical contributions

Our study makes three contributions to the sustainable supply chain literature. Firstly, the paper investigates the interplay of resources on building supply chain visibility to achieve sustainability performance. Especially in developing countries, organizations are under constant pressure from government or regulatory bodies to design sustainable supply chains. The achievement of sustainability performance has been a major concern, often attributed to lack of visibility (Wu and Pagell 2011) and complexity (Caridi et al. 2010b). Nevertheless, no matter if the effect of strategic sources and capabilities on visibility is well discussed in the operations and supply chain management literature (see Barratt and Oke 2014; Brandon-Jones et al. 2014), what is less understood is how supply chain visibility impacts on economic, social and environmental sustainability. To address this gap and based on prior studies (see Barratt and Oke 2007; Brandon-Jones et al. 2014) we proposed a theoretical model that conceptualizes supply chain connectivity and information sharing as bundled resources that build supply chain visibility as a capability under the contingent effect of product complexity to explain sustainable performance (conceptualized as economic, social, and environmental performance). By examining the direct effect of bundling of resources (i.e. supply chain connectivity and information sharing) on supply chain visibility, we argue the bundling of resources (i.e. supply chain connectivity and information sharing) improves supply chain visibility (capability) and impacts positively on social and environmental performance. We therefore elaborate on the arguments by Wu and Pagell (2011) and Lai et al. (2015) to further investigate the role of supply chain visibility in sustainable supply chains.

Secondly, the role of contingencies and product complexity in achieving sustainability performance through supply chain visibility is not well understood. In the past, scholars have attempted to study the impact of product complexity on the relationship between internal and external knowledge transfers and supply chain flexibility and role of product complexity on supply chain agility and supply chain adaptability. However, to our best of the knowledge, the role of product complexity on supply chain visibility and sustainability performance is still less well understood. To address this gap, we examine the moderating effect of product complexity on the influence of supply chain visibility on environmental performance, economic performance and social performance. We argue based on existing literature that product complexity can influence the impact of the visibility on social performance, environmental performance and economic performance. We therefore extend some earlier studies (e.g. Barratt and Oke 2007; Holcomb et al. 2011; Brandon-Jones et al. 2014); by investigating product complexity as a contingent variable we offer an interesting insight to our understanding related to supply chain visibility.

We investigate the contingency of product complexity in achieving sustainability performance using the CRBV logic (Brush and Artz 1999) that revolves around the bundling of strategic resources and /or capabilities (Barney 1991) to generate competitive advantage under contingencies. We therefore extend earlier studies (e.g. Barratt and Oke 2007; Holcomb et al. 2011; Brandon-Jones et al. 2014) and Eckstein et al.'s (2015) study on the moderating effect of product complexity on supply chain designs, focusing on visibility and sustainability performance, and we ground our model in CRBV to explain this complex phenomenon. We believe product complexity as a contingent variable offers an interesting insight which furthers our understanding related to supply chain visibility and sustainability performance.

Finally, we contribute to the study of supply chain visibility and its influence on supply chain sustainability performance in the Indian context. We provide a better understanding of the sustainable supply chains in BRICs extending the existing literature (Jabbour et al. 2012; Kannan et al. 2014; Gunasekaran et al. 2014; Dubey et al. 2015; Mani et al. 2016).

5.2 Managerial implications

This study offers several useful implications for supply chain managers. Firstly, our study demonstrates that investments in supply chain visibility capabilities may generate different results depending on contingent factors. For organizations operating within a complex environment (for examples, one having huge product variation), the social and environmental benefits increase with investments in supply chain visibility capability. Our results further assist managers who face a constant trade-off between profit, responsibility towards society and environmental related decisions. It has been noted in prior research that an increase in product lines may boost sales growth due to increased customer satisfaction. However, this may lead to increase in obsolete inventory due to decrease in product life cycle and increase in globalization. In most cases organizations fail to strike a balance between sales and commitment towards society and environment. Hence, our study results indicate that exploitation of product complexity may help reduce negative effects of supply chain on environment, improve the living standard of the employees, and create better living conditions and improve profit margin. However, an important point to be noted is that the benefits are comparatively slower, and thus in the long term the proper management of product complexity may be good for supply chain sustainability. Our suggestions are based on data which we gathered using a pre-tested questionnaire. Presumably, it is in the best interest for companies to exploit connectivity and information sharing to generate supply chain visibility to achieve sustainable performance. Therefore, supply chain visibility under the moderation effect of product complexity may help organization to achieve their sustainability goals.

5.3 Limitations and future research directions

Our research has the following limitations. Firstly, following the arguments by Ketokivi and Guide (2015), we argue that CMB may be an issue influencing our results. However, though following Podsakoff et al. (2003), we performed their suggested statistical test to minimize the influence of CMB but the CMB cannot be completely eliminated. Thus, to address CMB beside Harman's single-factor test, the data should be gathered from multiple informants from each single unit.

Secondly, the use of survey data may limit the scope of research (Markman and Krause 2014). Therefore we propose the use of alternative methods, including, for instance, the use of qualitative methods in conjunction with quantitative methods (see Eisenhardt 1989; Beach et al. 2001; Pagell and Wu 2009; Barratt et al. 2011; Childe 2011) to address those questions which may not be answered using a single method (Boyer and Swink 2008; Tang et al. 2016).

Thirdly, our theorizing is heavily driven by the contingent resource based view/theory. We believe the current study can be extended using the natural resource based view (Hart 1995) to examine sustainable supply chain performance. Further studies could also aim at understanding the pressures behind the managerial decisions on information sharing and connectivity, visibility, and performance, and to this extend institutional theory could be used (Kauppi 2013). Oliver (1997) argued that resource-based view has not looked beyond the properties and resource markets to explain enduring firm heterogeneity. It has not examined the social context within which resource selection decisions are embedded (e.g., firm traditions, network ties, regulatory pressures) and how this context might affect sustainable firm differences. Hence in this context integrating institutional theory with CRBV may help to understand how regulatory pressures can influence the resource selection decision.

Finally, we have noted, based on Holcomb et al. (2011), that country culture or organizational culture may have an important role to play on degree of effectiveness of supply chain visibility and performance. Hence, it may be interesting to investigate in the future the role of organizational culture on supply chain visibility and its influence on sustainable performance measures. Furthermore, the role of opportunistic behavior may be influencing supply chain visibility and could be empirically examined in the future.

6 Conclusion

The current study focused on the impact of product complexity on supply chain visibility and sustainability performance. We grounded our theoretical framework in CRBV to explain how bundling resources and capability under the contingent effect of product complexity can influence sustainable performance. We tested our research hypotheses and its sub-hypotheses using data gathered from 312 Indian organizations.

We found that supply chain visibility has a positive direct impact on environmental and social performance. Furthermore, we noted that under the moderating effect of product complexity, supply chain visibility has a positive impact on environmental, social and economic performance. However, the weak beta values suggest that further research should utilise longitudinal data. We realise that gathering longitudinal data is highly challenging. Hence, we cannot ignore the importance of survey based research but to ensure that endogeneity and CMB should not contaminate the results, the researchers need to further tighten their research design as per recent debates.

Similarly, our results on the moderation effect of product complexity further suggest that product complexity is still one of the major concerns within Indian organizations which is no doubt reflected in companies across the globe. Hence it is recommended that product complexity should be exploited to achieve better results of supply chain visibility on sustainable performance. We believe that we have provided food for thought to those researchers and practitioners who would like to study further the role of supply chain visibility in supply chain sustainability performance.

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Appendix 1

Construct	Indicator	Item
Supply chain connectivity (SCC)	SC1	Current information systems satisfy supply chain communication requirements
	SC2	Information applications are highly integrated within the firm and supply chain
	SC3	Adequate information systems linkages exist with supply chain partners

Construct	Indicator	Item
Information sharing (IS)	IS1	Our organization exchanges relevant information with the partners
	IS2	Our organization exchanges timely information with the partners
	IS3	Our organization exchanges accurate information with partners
	IS4	Our organization exchanges confidential information with partners
	IS5	Our organization exchanges confidential information with partners
Supply chain visibility (SCV)	SCV1	Inventory levels are visible throughout the supply chain
	SCV2	Demand levels are visible throughout the supply chain
Product complexity (PC)	PC1	We offer our customers diverse add-ons and the option of production individualization
	PC2	Our product consists of a high number of components
	PC3	We frequently offer new product variants
Social performance (SP)	SP1	Our organization believes in gender equality
	SP2	Our organization pays significant attention to the mortality rate of the daily wage workers children
	SP3	Our organization believes in poverty reduction
	SP4	Our organization pays significant attention to the nutritional status of the meal served in the canteen
	SP5	Our organization pays significant attention to the sanitation at work place, offices and lavatories
	SP6	Our organization ensures adequate safe drinking water facility
	SP7	Our organization pays significant attention to effective health care delivery
	SP9	Our organization helps to find proper residence for employees
	SP10	Our organization provides adequate transport facility from residence to the work-place
	SP11	Our organization pays significant attention to the living conditions of the employees
Environmental performance (EP)	EP1	Our organization has adopted adequate measures for reduction of air emissions
	EP2	Our organization has adopted adequate measures for re-cycling waste water
	EP3	Our organization has adopted adequate measures to prevent discharge of solid waste
	EP4	Our organization has adopted adequate measures to prevent consumption of hazardous harmful toxic materials
	EP5	Our organization has adopted adequate measures to reduce the frequency of environmental accidents
	EP6	Our organization has made a significant effort to improve an enterprise's environmental situation
Economic performance (ECOP)	ECOP1	Decrease of cost for materials purchasing
	ECOP2	Decrease of cost for energy consumption
	ECOP3	Decrease of fee for waste treatment
	ECOP4	Decrease of fee for waste discharge
	ECOP5	Decrease of fine for environmental accidents

Appendix 2: Exploratory factor analysis

	ECOP	PC	SCV	IS	SP	SC	EP	
SC1						0.74		
SC2						0.80		
SC3						0.78		
IS1				0.59				
IS2				0.88				
IS3				0.88				
IS4				0.97				
IS5								
SCV1			0.90					
SCV2			0.90					
PC1		0.91						
PC2		0.90						
PC3		0.98						
SP1					0.69			
SP3					0.80			
SP4					0.85			
SP5					0.81			
SP6					0.87			
SP7					0.95			
SP9					0.56			
SP10					0.61			
SP11					0.69			
SP12								
EP1							0.87	
EP2							0.68	
EP3							0.89	
EP4							0.85	
EP5							0.81	
EP6							0.79	
ECOP1	0.94							
ECOP2	0.95							
ECOP3	0.94							
ECOP4	0.93							
ECOP5	0.94							
	4.42	2.60	1.63	2.84	5.33	1.79	4.02	22.64
	12.29	7.23	4.54	7.90	14.81	4.96	11.18	

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