Environmental scanning, supply chain integration, responsiveness, and operational performance: An integrative framework from an organizational information processing theory perspective

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Abstract

Purpose – It remains unclear how environmental scanning (ES) can generate firm performance through supply chain management (SCM) practices. This study investigates the effects of ES on operational performance through supply chain integration (SCI) and supply chain responsiveness (SCR).

Design/methodology/approach – The scanning–interpretation–action–performance (SIAP) model and organization information processing theory (OIPT) are used to explain the ES–SCI–SCR–performance (S-I-A-P) relationships, which were tested by structural equation modelling of survey data of 329 manufacturing firms in China.

Findings – The results indicate that ES has a significant positive effect on SCI and SCR. SCI is significantly and positively related to SCR. SCR partially mediates the relationship between ES and operational performance, and fully mediates the relationship between SCI and operational performance.

Practical implications – Supply chain managers should collaborate with senior executives to obtain signals from ES activities, as input for building SCI and SCR, and use SCI as a joint interpretation mechanism of ES signals for developing SCR to reap operational advantages in the rapidly changing business environment.

Original/value – Strategic management academics and practitioners have explicitly emphasized the importance of ES in developing strategic plans but are unsure about the role of SCM in creating operational advantages through ES. Using the SIAP model, this study theorizes and demonstrates how SCI and SCR transform signals from ES into operational performance. In doing so a more precise application of OIPT is explicated in the supply chain context.

Keywords Environmental scanning; Supply chain integration; Supply chain responsiveness; Operational performance; China

Paper type Research paper

1. Introduction

The demise of the car company Rover, according to the post mortem case study analysis by Oliver et al. (2008), was caused primarily by a disconnect between the management team and the market. This disconnect was created by a failure to adequately scan the environment and resulted in poor product portfolio choices, missed opportunities to capture innovation, and inefficient production processes that increased product cost. Environmental scanning (ES) is defined as "scanning for information about events and relationships in a company's outside environment, the knowledge of which would assist top management in its task of charting the company's future course of action" (Aguilar, 1967, p. 1). Through ES, senior executives gather signals about competitors' strategies, technological innovations, governmental regulations, customer needs, and supplier conditions (Daft et al., 1988; McGee and Sawyerr, 1994) to ensure business strategy fit (Cousins et al., 2011; Garg et al., 2003; Hambrick, 1981). As a key strategic management concept (e.g., Aguilar, 1967; Hambrick, 1981) ES is regarded as a prerequisite for developing strategic plans (Beal, 2000; Elenkov, 1997; Hambrick, 1981) in dynamic and complex business environments (Hambrick, 1982).

While the strategic management literature emphasizes using ES for information gathering to reduce strategic uncertainty, the links between ES and performance remain little understood. The collapse of Rover in 2005 reminds us of the importance of ES for strategic planning and operational aspects of firms; how signals from ES must be interpreted by members of a supply chain so they can respond appropriately to improve performance. The organizational information processing theory (OIPT) argues that uncertainty necessitates reducing information processing needs and/or increasing information processing capacities (Daft and Lengel, 1986; Galbraith, 1973). As such, approaches to reducing information processing requirements through strategies such as organizational designs, liaisons, boundary spanning roles, and lateral information systems (Galbraith, 1973) have been explored in the Operations Management (OM) literature (Flynn and Flynn, 1999). However, the capacities of the supply chain to process information (interpret) and respond remain unexplored.

This study argues the ES–performance links can be more fully explicated by investigating how firms interpret ES signals and subsequently take supply chain actions. While the strategic management research argues the importance of ES, it lacks an overarching framework to explain how ES generates performance. Toward that end, we introduce a structured framework, the

Scanning–**I**nterpretation–**A**ction–**P**erformance (SIAP) model (Thomas et al., 1993). The SIAP model positions “scanning” (S), e.g., ES, as a critical first step in organizational adaptation to environmental changes (Aguilar, 1967; Ebrahimi, 2000; Hambrick, 1981). The model recognizes the difficulty senior executives have spotting weak signals which may be crucial for generating strategic insights and rapid response (Daft et al., 1988). Strategic uncertainty can be caused by distorted information and push senior executives toward a situation called equivocality (Daft and Macintosh, 1981) wherein different actors use different frames to interpret the same information (Weick, 1979). The value of SIAP model is that once information from the external environment is “interpreted” (I) accurately (Ebrahimi, 2000) it can be transformed into strategic “actions” (A) aligned with the environment to generate “performance” (Beal, 2000; Bourgeois, 1980; Yasai-Ardekani and Nystrom, 1996).

We emphasize it is the quick “action” through supply chain responsiveness (SCR) informed by accurate “interpretation” that helps firms stay ahead of competitors (Fabbe-Costes et al., 2014) and achieve superior performance (Beal, 2000). Early evidence suggests it is the faster response to environmental information than competitors, not signals from ES, that contributes to distinctive advantages (Hambrick, 1982). Moreover, to quickly respond to changes in customer demand (Kim and Lee, 2010) or supply disruption risks, firms must realign supply chain resources with the environment (Ambulker et al., 2015). As such, we argue supply chain integration (SCI) acts as a supply chain information processing and “joint interpretation” mechanism to reduce uncertainty and equivocality and to create shared meanings and goals that can form the basis for SCR. However, empirical research on the roles of supply chain management (SCM) practices in the SIAP model remains scarce. To address these research gaps this study integrates the concept of ES as “scanning”, SCI as “interpretations” of signals from ES to inform SCR as “actions” to create “performance” in the SIAP model.

In summary, this study integrates the strategic management and supply chain management literatures to explain the relationship between ES and performance. While the strategic management literature provides information on “scanning” through ES, applying the SIAP model (Thomas et al., 1993) will explain how ES creates performance through SCI as “joint interpretation” and SCR as “quick action”. The supply chain literature has recently recognized that ES can support responses to disruptions (Ambulker et al., 2015), sensing of regulatory changes (Nair et al., 2016) and sustainability risks (Fabbe-Costes et al., 2014). In the context of firms spending time scanning and learning from the environment (ES) to better respond to disruption risks (SCR), we contribute to the SCM literature by expanding the work of Ambulker et al. (2015) by adding that SCI can act as an interpretation mechanism of ES signals to inform SCR. We also demonstrate that existing supply chain knowledge can inform the strategic management literature and senior executives. For example, we know SCI can support SCR by reducing uncertainty (Danese et al., 2013), support responses to customer demand (Ralston et al., 2015), and increase commitment to a more responsive supply chain through strategic collaboration (Kim and Lee, 2010). The "interpretation" role played by SCI to reduce uncertainty and equivocality and the quick response "actions" by SCR when incorporated into the SIAP model expand the knowledge base by testing an ES–SCI–SCR–performance conceptual model. From a practical perspective, this study reveals how supply chain managers may better exploit ES activities carried out by senior executives by integrating them into the implementation of SCI and SCR strategies.

2. Theoretical background

2.1. Key concepts and literature review

This section clarifies definitions of key concepts: ES, SCI, and SCR, followed by a brief review of the related state-of-the-art literature.

2.1.1. Environmental scanning (ES)

Environmental scanning (ES) involves gathering information about events, trends, and relationships from the external environment as input for the planning of an organization's course of action (Aguilar, 1967). ES absorbs information about emerging issues, situations, and potential pitfalls from the external environment that potentially influence a firm's decision-making process (Albright, 2004). ES also enables firms to identify external competitive, social, economic, and technical issues (Albright, 2004; Aguilar, 1967; Hambrick, 1982; Stoffels, 1994). ES informs the potential influences from external environments and how firms can respond strategically in a timelier and more effective manner (Albright, 2004). ES is viewed as an effective tactic helping firms adapt to the external environment (Albright, 2004; Beal, 2000; Fabbe-Costes et al., 2014). To survive in today's dynamic and competitive marketplace firms must adequately understand and interpret the signals derived from the external environment and systematically identify, gather, analyse, and process external environmental information (Aguilar, 1967; Albright, 2004; Hambrick, 1982; Hough and White, 2004).

Past studies show that ES is often carried out by senior executives or specialized scanning departments (Daft et al., 1998; Daft and Lengel, 1986). Some firms may use employees at different levels to perform scanning tasks, and there is a variety of scope, geographical coverage, and futurity of scanning (Thomas, et al., 1993). The environment can be divided into two layers. The first layer is the task environment which has direct interactions with the firms (e.g., customers, markets, competitors and suppliers) and the second is the general environment which is an outer environment related to social, demographic, and economic sectors (Daft et al., 1998). It remains an ongoing debate whether the two layers (task and general environments) should be scanned in combination or separately (Bourgeois, 1980) and whether the search of environments should be broadened or narrowed (Srinivasan et al., 2011). To improve the validity of our study, we conceptualize ES based on task environment (i.e., customers, markets, competitors and suppliers) since it is where strategic uncertainty is perceived as high (Daft et al., 1988) and it is closely related to SCI and SCR. Given that perceived strategic uncertainty tends to increase scanning frequency (Daft et al., 1998), the measurement of ES also considers whether scanning activities have been routinely carried out.

Though the ES literature provides insight into information gathering for strategic foresight, there are a number of limitations. The literature focuses more on understanding information gathering behaviour (Daft et al., 1988), design of organization structures to reduce information needs and the use of liaison, boundary spanning integrators, and lateral information systems (Galbraith, 1973). Less is known about the interpretation aspect of information processing capacity. While it is important to know what environments to scan and how to spot weak signals (Daft et al., 1988), Hambrick (1982) shows that it is the ability to act on the environmental information that leads to distinct competitive advantage. A similar argument is that know-what (information to scan) and know-how (how to run operations) are equally important for formulating manufacturing strategy (Paiva et al., 2008).

Firms need to clarify what the future may hold especially when the environment is highly uncertain and equivocal. Foresight can be created when business partners interpret the environment together to jointly describe and agree upon what will happen in the future (Cuhl, 2003). Thus, there is a need to better understand joint interpretation activities and their connection to scanning. Moreover, although ES is a key concept in the strategic management literature (e.g., Aguilar, 1967; Hambrick, 1981, 1982) its application and importance in a supply chain context is nascent (Ambulker et al., 2015; Fabbe-Costes et al., 2014). While the supply chain literature focuses on the sharing of operational information (demand, capacity, inventory and supply) with suppliers and customers, the scanning of strategic information related to competitors, markets, wider customer needs, technologies, society, governmental regulations, and politics (Badri et al., 2000; Fabbe-Costes et al., 2011) are not well integrated.

2.1.2. Supply chain integration (SCI)

Supply chain integration (SCI) is generally defined as strategic collaboration among supply chain partners through information sharing and coordination of decisions (Flynn et al., 2010; Wong et al., 2011; Wu et al., 2006; Yu et al., 2017). Academics have long articulated the importance of building a strategic collaboration between a firm and its supply chain partners, but their arguments have generally been from the resource-based and relational views (Bowersox et al., 2003; Flynn et al., 2010; Wu et al., 2006; Yu et al., 2013). The use of OIPT may help better explain the role of SCI in enabling information sharing and alignment as a way to reduce strategic uncertainty. Additionally, SCI can facilitate information processing by coordinating strategic supply chain activities (such as forecasting and planning) with trading partners (Yu et al., 2017, 2018). Such coordination activities, supported by boundary spanning and liaison roles, can reduce strategic uncertainty through face-to-face and group meetings (Daft and Macintosh, 1981).

However, another role of SCI is to reduce equivocality (Daft and Macintosh, 1981). Equivocality restricts goal alignment. Through strategic collaboration and joint interpretation of information (Srinivasan and Swink, 2015; Swink and Schoenherr, 2015; Wong et al., 2011) equivocality can be reduced such that shared schema and goals can be reached (Bowersox et al., 2003; Sheu et al., 2006). By extending the notion of a firm as an information processing system (Daft and Weick, 1984) into the supply chain context, we position SCI as a joint information processing agent reducing uncertainty and equivocality (Daft and Macintosh, 1981). As such, SCI helps align the external operations (Flynn et al., 2010; Kim, 2009; Huo, 2012; Wong et al., 2011) and leverage the resources and knowledge of suppliers and customers (Cao and Zhang, 2011).

Even though SCI can have positive effects on all dimensions of operational performance, these effects are not universal (Danese et al., 2013; Mackelprang et al., 2014; Wong et al., 2011). Since quick response is suited to environments with high uncertainty (Daft et al., 1988), SCI may improve interpretation of ES signals and thus lead to better SCR. There is already some evidence for the positive link between SCI and SCR (Danese et al., 2013; Ralston et al., 2015) serving as a basis for explaining the missing ES–operational performance links.

The present study acknowledges SCI can have different foci, e.g., technology integration and activity integration (Vickery et al., 2013; Wu et al., 2006). While earlier studies conceptualize SCI as a unidimensional meta construct (Vickery et al., 2013; Wu et al., 2006; Yu et al., 2017, 2018), SCI is elsewhere divided into two dimensions – internal and external (Danese et al., 2013). External integration is further divided into customer and supplier integration (Flynn et al., 2010; Jacobs et al., 2007; Swink et al., 2007; Wong et al., 2011). However, the use of different dimensions and scales to measure SCI may be one of the reasons studies of SCI have reached disparate findings (Danese et al., 2013; Mackelprang et al., 2014). The division of SCI into different dimensions has created a new challenge to research. Even though evidence shows internal, supplier, and customer integration can positively affect responses to customer demand (Droge et al., 2012; Ralston et al., 2015; Wong et al., 2011), there is evidence of insignificant effects (see meta-analysis of Mackelprang et al., 2014), varying performance effects of each SCI dimension (Danese et al., 2013; Wong et al., 2011), and interaction effects among SCI dimensions (Flynn et al., 2010). No theory or study, so far, has fully theorized or explained the insignificant, interaction, or varying effects among SCI dimensions.

The focus of this study is not to address the issues arising from the division of SCI into different dimensions, but rather the focus is to understand the roles of SCI in facilitating the effects of ES and SCR on operational performance. Since the conceptualizations of ES and SCR encompass suppliers, customers, markets, and competitors, our theory considers "joint integration" among all of them through SCI as an aggregated construct. Dividing SCI into discrete dimensions would lead to inconsistency in the level of abstraction in our theory (e.g., no division of supplier and customer for ES and SCR, but dividing SCI into internal, supplier and customer). To maintain a parsimonious theoretical model, avoid the potential complex interactions, and varying effects among SCI dimensions, we have chosen to focus on conceptualizing SCI as an aggregated construct.

2.1.3. Supply chain responsiveness (SCR)

Supply chain responsiveness (SCR) is defined as the extent to which a firm along with its supply chain partners responds to changes in the business environment (Williams et al., 2013; Wang and Wei, 2007; Wu et al., 2006; Yu et al., 2018). To survive in a rapidly changing environment firms seek to develop responsive supply chains (Malhotra and Mackelprang, 2012; Williams et al., 2013). SCR entails quickly responding to changing customer/supplier needs and competitor strategies by developing new products/services or adjusting supply chain operations to match the changing markets through strategic collaboration with partners (Kim and Lee, 2010; Lee, 2004; Wu et al., 2006). This conceptualization reflects a supply chain's overall responsiveness to changes in demand and supply (Williams et al., 2013). Thus, SCR comes from not only the firm itself but also its supply chain partners when the entire supply chain is able to effectively respond to demands from each supply chain member and the business environment (Kim et al., 2006; Kim and Lee, 2010; Wu et al., 2006; Yu et al., 2018).

This study acknowledges the possible overlaps in terms of the conceptualizations between SCR and supply chain flexibility and agility. The term responsiveness refers to being quick (speedy) in responding to changing market or customer needs, which can be achieved with any of the following antecedents: short lead time, quick response capability, flexibility, agility, and visibility. The supply chain literature assumes supply chain agility includes both responsiveness and flexibility (Christopher and Peck, 2004; van Hoek et al., 2001) thus indicating a distinction and hierarchy in conceptualizations. Some studies consider a wider scope of SCR by including flexibility and delivery performance as components of the construct (Danese et al., 2013; Droge et al., 2012), which is appropriate as long as the theory considers all these components. We understand our conceptualisation of SCR based on quick response can be viewed as a limitation, but it is also a strength because we strictly adhere to our theoretical domain and we use a unidimensional SCR construct to avoid effect size errors.

Herein, following previous work (Wu et al., 2006; Yu et al., 2018), we focus on overall indicators of responsiveness, e.g., the ability to quickly respond to changes in the needs of market, customer, supplier and strategies of competitors instead of the many possible antecedents such as flexibility, agility, visibility, etc. This approach maintains the unidimensionality of the SCR construct and therefore improves the parsimoniousness of the theoretical model. Since

OIPT considers that environmental uncertainty arises from markets, customers, suppliers, and competitors, we conceptualize ES to reflect this scope of task environment (customer, supplier, competitor, and market) and therefore SCR also represents the ability to quickly respond to changes in the task environment.

2.2. Organizational information processing theory (OIPT)

It has long been recognized that firms must adapt to their business environments to survive and prosper (Hambrick, 1982). The more environmental uncertainty facing a firm, the more information it needs to gather and process to achieve a better performance (Bode et al., 2011). The Organizational Information Processing Theory (OIPT) argues that as uncertainty increases information processing capacity must also increase to fit with the information needs (Daft and Lengel, 1986). OIPT explains organizational behaviour (such as strategy and decision making) by examining the information flows occurring within and across organizational boundaries (Daft and Weick, 1984; Smith et al., 1991). OIPT posits that coping with uncertainty through gathering, processing, and communicating information from the business environment is the main task in organizational design (Daft and Weick, 1984; Gattiker and Goodhue, 2004; Hult et al., 2004; Swink and Schoenherr, 2015). Research has shown organizations need to develop information gathering capability to cope with uncertainty and dynamism in their external business environment (Aguilar, 1967; Albright, 2004; Daft and Lengel, 1986; Hambrick, 1982). Accordingly, we view ES as an information gathering capability.

Uncertainty, as a central concept in OIPT, drives the need for developing an information processing capability (Gattiker and Goodhue, 2004; Goodhue et al., 1992; Smith et al., 1991). OIPT has been applied as a theoretical lens to examine supply chain sustainability (Busse et al., 2017; Fabbe-Costes et al., 2014), SCI (Srinivasan and Swink, 2015; Swink and Schoenherr, 2015; Williams et al., 2013; Wong et al., 2011; Yu et al., 2013), and responses to supply chain disruptions (Bode et al., 2011). SCI acts as the information processing capability in a focal firm and its suppliers/customers to systematically identify, gather, and analyse external environmental information (Bode et al., 2011; Srinivasan and Swink, 2015). Information sharing among supply chain partners (Huo et al., 2014; Williams et al., 2013) can help reduce information needs. To better coordinate and manage material and information flows across the entire supply chain, firms use strategic collaboration (SCI) for gathering, sharing and analysing information regarding upstream, internal and downstream supply chain operations and activities (Hult et al., 2004; Huo et al., 2014; Jacobs et al., 2016; Williams et al., 2013). Thus, SCI can act as an information processing mechanism at a supply chain level, involving several supply chain actors.

OIPT can be used to explain the relationship between SCI and SCR but its explanation is restricted to the ability of SCI to reduce strategic uncertainty through information sharing and alignment with suppliers (Danese et al., 2013). OIPT focuses on linking uncertainty with information needs and information processing capacity and prescribe organizational designs to reduce uncertainty and information needs (Galbraith, 1973). However, OIPT does not focus on the ability to gather and interpret information (such as signals from ES) and how firms incorporate the information into their strategic actions. Thus, OIPT alone cannot fully explain the links between ES and performance.

3. Conceptual framework and research hypotheses

To supplement the OIPT and better explain the roles of SCI and SCR in transforming ES signals into operational performance, this study introduces the scanning–interpretation–action–performance (SIAP) model proposed by Thomas et al. (1993) to the supply chain literature. The model was initially developed to understand how managers and organizations deal with potentially significant information. It is argued that organizations adapt to the environment through three processes: scanning, interpreting, and responding (Milliken, 1990). Similarly, strategic sense-making activities performed by executives often involve reciprocal interaction of information seeking, meaning ascription, and action (Gioia and Chittopeddi, 1991). Thomas et al. (1993) further argue each sense-making process could affect performance.

Scanning involves information gathering through identification of events or issues from the external and internal environments that might affect an organization (Ebrahimi, 2000; Thomas et al., 1993). The SIAP model suggests that “scanning” is a crucial first step in organizational adaptation to the environment through its role as an antecedent to interpretation and action (Aguilar, 1967; Hambrick, 1981; Thomas et al., 1993). Scanning is often performed by top executives who are frequently provided more information than they can process (Mintzberg, 1973). Among this information weak signals, which are crucial for strategic insight, are difficult to identify (Daft et al., 1988). Thus, information specificity is key to scanning effectiveness (Choudhury and Sampler, 1997).

Interpretation involves the development or application of methods for comprehending the meaning of information supporting decisions related to strategic actions (Thomas et al., 1993). At an individual or group level, managers use various schema as information processing mechanisms to interpret and label information (Gioia and Chittipeddi, 1991). During this process managers may categorize incoming information about an object, event, or issue as an "opportunity", "problem" or "threat" (Duncan and Duncan, 1987) which will subsequently effect the level of risk taking, involvement, and commitment associated with a given strategic decision or action (Kahneman and Tversky, 1984). Since there is a need to align across suppliers and customers (Skipworth et al., 2015) with the environment (Beal, 2001; Bourgeois, 1980), we argue focal firms should develop a shared schema with key suppliers and customers by using SCI – defined as strategic collaboration (Flynn et al., 2010; Wong et al., 2011) – as an inter-organizational information processing mechanism.

Action is referred to as strategic changes implemented by organizations adapting to the environment; they can range from minor changes in procedures, to significant changes in product and market strategies, and the redesign of organizational structures (Dutton and Duncan, 1987). Owing to the dependency between a firm and its suppliers and customers, we argue the implementation of supply chain strategies acts as a key organizational action. In practice, organizational actions can be generated based on information gathered from the environment with or without substantial interpretation thereof. However, the lack of an ability to align organizational actions with the environment using information from the environment could lead to compromised performance (Thomas et al., 1993). In the present study, SCR is treated as a strategic action for responding to a changing environment.

Performance is the last component of the SIAP model. Researchers seek to attribute differences in the performance of similar organizations to differences in their ability to carry out the scanning, interpretation, and action activities (Thomas et al., 1993). Since executives often lack a process for assessing the effects of their scanning and interpretation activities, or the associated actions on a performance in practice, an important role of academic researchers is to collect and analyse data about each element of the SIAP model to better inform the practice. One of the issues debated concerns the possible direct and indirect effects of scanning and interpretation processes (Thomas et al., 1993). One stream of literature argues performance depends greatly on a rational thought process, which involves active information processing and systematic sequential execution of the scanning, interpretation, and action processes (Thomas et al., 1993). In contrast, other scholars argue for a less deliberate approach to sense-making (interpretation) and that managers may simply refer to the outcomes of past actions to inform the next action without scanning and/or interpreting information from the environment (Weick, 1979). To interpret the performance implications for organizations, we therefore need a comprehensive understanding of the detailed linkages among scanning, interpretation, action, and performance (Daft et al., 1988).

Figure 1 illustrates a proposed conceptual model to link ES, SCI, SCR, and performance following the SIAP model (Thomas et al., 1993). We chose operational performance as the "P" in the SIAP model. Operational performance is a composite measure of volume flexibility, delivery performance, inventory cost and product quality (e.g., Flynn et al., 2010; Huo et al., 2014). It is commonly used in the strategy literature to explain effects of ES (Thomas et al., 1993). It could be indirectly affected by SCI (Flynn et al., 2010; Swink et al., 2007) and ES (Thomas et al., 1993). Demonstrating the effects of SCI and SCR on operational performance helps justify the strategic value of such SCM practices in supporting the efforts by executives to capitalize on weak signals. Six hypotheses (H1-H6) are developed to accommodate all possible direct and indirect paths.

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3.1. The role of ES

ES serves as the "S" and first sequence in the SIAP model (Thomas et al., 1993). ES can provide information about changes to supply and/or demand and thus serves as a prerequisite for strategic flexibility and responsiveness. ES enables firms to perceive external events and trends that threaten its existence or offer business opportunities to exploit, and to identify the necessary capabilities or skills to be able to effectively adapt to a changing business environment (Beal, 2000; Castanias and Helfat, 2001). In a supply chain context, to develop an integrated and responsive supply chain, firms need to gather information from the business environment, e.g., information about forecasting sales and customer preferences, supply markets, and other trading members.

The ES literature suggests that effectively identifying, gathering, and analysing information about events and trends occurring outside the firm is integrally linked to organizational and strategic planning as well as planning for unexpected changes in environmental conditions (Aguilar, 1967; Albright, 2004; Hambrick, 1982; Hough and White, 2004). Since supply chain integration processes entail information sharing (Chavez et al., 2015) they can act as an information processing mechanism in the OIPT sense (Zsidisin et al., 2015). Information from the external environment is processed and used to develop and coordinate strategic collaboration and helps firms be responsive in dynamic and competitive environments (Hult et al., 2004; Huo et al., 2014). In a supply chain context, we argue that the information gained from scanning the external environment, e.g., new technologies, new markets, and best practices, can be acted upon to improve supplier selection and customer satisfaction. The information can be used to build long-term strategic collaborations with supply chain partners which in turn could lead to the supply chain becoming more responsive to market dynamics and customer needs (Albright, 2004; Koufteros et al., 2012).

From an OIPT perspective, SCI can be viewed as the formulation of a strategic collaboration where supply chain partners share information and resources (Flynn et al., 2010); strategic collaboration being made possible when there is a common schema to interpret information from the environment (Wong et al., 2011). For example, a manufacturer may share its inventory planning and demand forecasts with suppliers and/or its customers may share point of sale information and related market information (Huo et al., 2014). The result is that more insight and coordinated actions can be achieved when the trading partners jointly interpret information related to forecasting sales, customer preferences, supply markets, and new technologies. As such ES acts as an information gathering device to inform and facilitate SCI activities such as supplier involvement in product development (Koufteros et al., 2005), joint decision making (Schoenherr and Swink, 2012), or supplier performance improvement (Sanders et al., 2011). SCI activities increase information processing capacity by involving suppliers and customers in the supply chain planning process with the aim being to more accurately respond to changes in the market.

The SIAP model considers the possibility that scanning “S” directly affects action “A”, especially for highly familiar environmental information (Thomas et al., 1993). Accurate and credible information increases the ability of the supply chain to react effectively to changes through coordinated actions (Chavez et al., 2015). Through ES, firms can also quickly respond to changes in the needs of the market, strategies of competitors, and new technologies. In stable environments ES can be beneficial to firms for responding to new opportunities before competitors. Additionally, ES can help explain demand unpredictability, such that supply chain managers can develop accurate supply chain strategies. Similarly, from an OIPT perspective SCR can be viewed as a strategy that enables firms to react and adapt to the changes in demand and supply (Williams et al., 2013) by interpreting external business environments and using responsiveness to adapt to changes in market dynamics (Albright, 2004; Huo et al., 2014). Therefore, we expect a significant effect of ES on SCI and SCR.

H1: ES has a significant positive effect on SCI.

H2: ES has a significant positive effect on SCR.

Previous research has suggested that effective scanning of the business environment provides a firm with current and valuable information, which influences a firm's ability to align its competitive strategy with its external business environment (Beal, 2000; Yasai-Ardekani and Nystrom, 1996). According to OIPT, information has become an important resource for firms to enhance organizational competitiveness (Bergeron, 2000; Swink and Schoenherr, 2015; Williams et al., 2013). The development of ES capability is important for firms to survive and prosper in a dynamic and competitive market by quickly adapting strategy and structure (Yasai-Ardekani and Nystrom, 1996). Similarly, in more stable industries ES should be established to ensure the most accurate and cost-efficient transmission of information (Lee, 2002). Through effective scanning of the business environment firms can better identify external events and trends that threaten their existence or offer opportunities to exploit, which then become inputs for strategic decisions that deliver operational and financial benefits to the firms (Ahituv et al., 1998; Beal, 2000; Castanias and Helfat, 2001). Our argument is grounded in OIPT's notion that ES provides a firm the capacity to achieve superior performance (Ahituv et al., 1998). Other than the capacity of SCI and SCR to minimize supply chain disruption due to unanticipated changes in the business environment (Fabbe-Costes et al., 2014), there are other capabilities that can respond to new signals or changes in the market. For example, portfolio breadth (Closs et al., 2008; Jacobs, 2007), new product design and development (Koufteros et al., 2005), and production process design (Jacobs et al., 2011) all benefit from external information. While these other means are not included into our model for parsimony and clarity reasons, we argue that ES may directly deliver operational performance.

H3: ES has a significant positive effect on operational performance.

3.2. The role of SCI

According to OIPT, to respond to increasing environmental uncertainty and dynamism firms need to gather and process more and better information to increase responsiveness in supply chains (Daft and Lengel, 1986; Williams et al., 2013). SCI involves long-term strategic collaboration where supply chain partners can share goals, information, and resources (Flynn et al., 2010; Wong et al., 2011; Yu et al., 2013) through a shared schema. Following the argument of Daft and Weick (1984) that organizations act as interpretation systems, the use of shared goals and schema through SCI represents another form of an inter-organizational interpretation system. Thus, SCI is regarded as the "I" in the SIAP model.

Our arguments are grounded in the SIAP model and OIPT's tenet that effective interpretation of information by supply chain partners helps the supply chain to become more responsive (Williams et al., 2013; Wong and Hvolby, 2007). Without the ability to quickly and effectively respond to changes in demand and supply (Williams et al., 2013), opportunities and threats identified by ES cannot be exploited or mitigated. In an integrated supply chain firms can share and jointly utilize high quality information about demand and supply conditions from supply chain partners. Such integration is deemed to be an important prerequisite to a SCR capability (Holsapple and Jones, 2005; Williams et al., 2013). SCI provides insights from the environment as the basis for quickly and effectively responding to the rapidly changing business environment (Flynn et al., 2010; Huo et al., 2014; Wong et al., 2011). Accordingly, we expect that SCI acts as an important enabler of SCR.

H4: SCI has a significant positive effect on SCR.

Researchers have long articulated the important role of SCI in improving firm performance (e.g., Flynn et al., 2010; Huo, 2012; Jacobs et al., 2007; Ralston et al., 2015; Yu, 2015; Yu et al., 2013) and it has been argued that SCI affects firm performance through the creation of operational competitive advantages (Swink et al., 2007). Consistent with the fundamental principle of OIPT, we expect that information processing capability afforded by SCI leads to better operational performance (Wong et al., 2011). In an integrated supply chain, building long-term strategic partnerships with customers and suppliers will facilitate strategic collaboration such as the better understanding of customer requirements, reduction of uncertainty and equivocality, better forecasting of customer demand, and collaboration in planning and joint product development with suppliers, which will, in turn, enable firms to more flexibly produce and deliver better quality products/services at lower cost (Flynn et al., 2010; Wong et al., 2011) with better delivery performance (Danese et al., 2013). The SIAP model argues the link between "I" and "P" (Thomas et al., 1993) because interpretation is used to enact or confirm the validity of a strategy, as well as to create competitive performance in delivery speed, inventory cost reduction, and volume flexibility. We therefore expect a positive link between SCI and operational benefits.

H5: SCI has a significant positive effect on operational performance.

3.3. The role of SCR

A supply chain strategy can be formulated after gathering environmental information via ES and sharing insights with supply chain partners via SCI. The SCR strategy, regarded as action or the "A" in the SIAP model, must be implemented in a timely manner congruent with changes in the business environment. SCR has been viewed as an organizational capability enabling firms to achieve competitive advantage (Gunasekaran et al., 2008; Wang and Wei, 2007; Williams et al., 2013; Yu et al., 2018) and is chosen for this study because time is a key factor for responding to emerging risk from a changing environment, and responsiveness is a key component of time-based competitiveness (Stalk and Hout, 1990). Previous research has suggested that SCR enables firms to quickly respond to changes in an uncertain environment (Kim and Lee, 2010; Williams et al., 2013; Yu et al., 2018), which is likely to result in improving product and volume flexibility, providing fast and reliable delivery, and producing high quality products meeting customer needs. By collaborating with supply chain partners to respond to market changes, a focal firm can gain operational benefits because its supply chain becomes more aligned with its external environment (Kim and Lee, 2010; Qrunfleh and Tarafdar, 2013; Wu et al., 2006). Therefore, based on the extant literature, we argue that developing a responsive supply chain enables firms to improve operational performance.

H6: SCR has a significant positive effect on operational performance.

4. Research methodology

4.1. Sample and data collection

Survey data was collected from China's manufacturing industry between June 2014–January 2015. A total of five regions representing different stages of economic development in China were chosen as the sample pool including Pearl River Delta, Yangtze River Delta, Bohai Sea Economic Area, Central China, and Southwest China. We used the China Enterprises Directory as the starting point for identifying potential participants. To obtain a representative sample, we randomly selected 1500 manufacturing firms from the China Enterprises Directory across the five regions. For each randomly selected manufacturer, we identified a key informant, who typically held a managerial position such as CEO, president, director, or general manager, and was knowledgeable about the firm's supply chain process (Flynn et al., 2010). We contacted key informants (n = 1500) by telephone and email in order to obtain their preliminary agreement to participate in this research. We identified key informants with the help of part-time research assistants (e.g., undergraduate and postgraduate students) and guanxi networks (e.g., personal connections with manufacturing firms, industrial authorities, and local universities). Previous research has suggested that accessing personal guanxi networks is a useful tool to ensure success in collecting survey data in China (Yu et al., 2014; Zhao et al., 2006). Most of the informants had been in their current position for more than five years. Thus, based on position and tenure it is reasonable to expect that the informants had sufficient knowledge to complete the survey (Zhao et al., 2006). The questionnaires and a cover letter explaining the main purpose of the study and assuring confidentiality were sent to 1230 firms that agreed to participate and provide information for this research. After several telephone and email reminders a total of 337 questionnaires were received. Eight returned questionnaires were discarded because of significant missing data leaving 329 completed and useable questionnaires. Even though previous studies in the Chinese context have indicated that it is difficult to obtain a high response rate to surveys, especially when targeting multiple regions of China (Zhao et al., 2006), the effective response rate was 26.75%. Table 1 provides a summary of demographic characteristics of respondents. Part of the survey data were published in Yu et al. (2017) whereby marketing and IT capabilities as antecedents of the SCI construct were examined, and in Yu et al. (2018) whereby SCI and SCR as two dimensions of data-driven supply chain capabilities and their effects on financial performance were examined. The roles of SCI and SCR in linking ES and operational performance examined in the present study extend the previous two papers (Yu et al., 2017, 2018).

------------------------------ Insert Table 1 -------------------------------

4.2. Questionnaire design and measures

Following previous guidance (e.g., Flynn et al., 2010; Yu et al., 2013; Zhao et al., 2011) the English version of the questionnaire was developed and then translated it into Chinese. This was followed by a back-translation to ensure conceptual equivalence. We checked the back-translated English version against the original English version to assure the reliability of the questionnaire. A number of questions were reworded in minor ways to improve the accuracy of the translation and relevance to cultural and business practices in China (Zhao et al., 2006). Even though the measurement scales were used prior and demonstrated to be valid we took extra steps before administering the survey. Content validity was established through a comprehensive analysis of the relevant literature, iterative construct review, and a pilot test with academic and industrial experts (Flynn et al., 2010; Zhao et al., 2011). To assess the content validity of the scales we consulted three academic experts on the basis of their research and consulting activities. Further, we conducted a pilot test with five randomly selected manufacturers using semi-structured interviews. Based on the feedback, redundant and ambiguous items were eliminated or modified in minor ways.

The measurement items used in this study were adopted from the literature and are reported in Table 2. The measures for *ES* were adopted from Barringer and Bluedorn (1999) and Miller and Friesen (1982) and focus on gathering information about business environment from clients and suppliers and other channel members, through explicit tracking of the policies and tactics of competitors, forecasting sales and customer preferences, and special marketing research studies. A seven-point scale was used, ranging from 1 “not ever used” to 7 “used extremely frequently”.

The measures for SCI and SCR were adopted from Wu et al. (2006). We measured *SCI* using five items: developing strategic plans in collaboration with partners, collaborating actively in forecasting and planning with partners, planning future demand collaboratively with partners, collaboration in demand forecasting and planning with partners, and forecasting and planning activities collaboratively with partners. Collaborative forecasting and planning involves a significant amount of joint data interpretation; thus, SCI is treated as “I” in the SIAP model (Thomas et al., 1993). The measurement items for *SCR* include responding more quickly and effectively to changing customer and supplier needs, responding more quickly and effectively to changing competitor strategies, developing new products more quickly and effectively, and increasing SCR to market changes through collaboration. SCR is positioned as a deliberate strategic action, “A” in the SIAP model (Thomas et al., 1993), implemented by the supply chain. All these items were measured using a seven-point scale from 1 (strongly disagree) to 7 (strongly agree).

The perceptual measures for *operational performance* were adapted from the SCM literature (e.g., Flynn et al., 2010; Huo et al., 2014; Wong et al., 2011) and include volume flexibility, delivery performance, inventory cost and product quality, which have been widely used in previous research. Conducting empirical research collecting objective performance data can be very challenging in China, partly because there is little incentive for respondents to provide researchers with accurate accounting data (Zhao et al., 2006). Therefore, consistent with previous empirical studies (e.g., Flynn et al., 2010; Wong et al., 2011) perceptual performance data were used in this study. Respondents were asked to evaluate relative competitive performance over the past three years by comparisons with their main competitors in the industry. The indicators were measured using a seven-point scale, from 1 “much worse than your major competitors” to 7 “much better than your major competitors”.

------------------------------ Insert Table 2 ------------------------------

We used three control variables in the conceptual model, including firm size, firm age and industry type. Firm size, measured by the number of employees (see Table 1), was used as a control because larger firms may have more resources for managing supply chain activities in dynamic business environments and thus may achieve better operational performance than small firms (Huo et al., 2014; Yu et al., 2013). Firm age, measured by the number of years since firm foundation, was controlled because it might be related to performance as older firms might be more likely to overcome performance-threatening liabilities (Yu et al., 2013). Industry type was controlled because firms in differing manufacturing industries may develop different levels of SCI and SCR for performance improvement. We used a dummy variable for industry types. The dummy variable Industry1 refers to automobile, Industry2 refers to chemicals and petrochemicals, Industry3 refers to electronics and electrical, and Industry4 refers to textiles and apparel. As shown in Table 1, they are the four largest manufacturing industries in this study. The base group is other industries (Huo et al., 2014).

4.3. Non-response bias and common-method bias

We assessed non-response bias using the method recommended by Armstrong and Overton (1977) comparing early and late respondents on two important demographic variables (i.e., annual sales and number of employees). The t-test results indicate no significant statistical difference ($p < 0.05$) among the category means for number of employees and sales suggesting that non-response bias is unlikely to be a concern in this study. It would be ideal to compare non-responders to responders to check for bias, but we were not able to track down enough information about non-respondents and therefore are not able to compare them with respondents. This is a limitation that is common for survey based studies.

We assessed common method bias because we gathered data from a single respondent per firm using the self-reported questionnaire survey (Podsakoff et al., 2003). Harman's single-factor test is arguably the most widely known approach for assessing common method bias in a single-method research design (Podsakoff et al., 2003). Previous research has argued that Harman's single-factor test does not eliminate the possibility of common method bias (Podsakoff et al., 2003). We therefore tested common method bias using two approaches. First, confirmatory factor analysis (CFA) was applied to Harman's single-factor model in order to further evaluate common method bias. The CFA generated an unacceptable model fit of χ^2/df (2141.356/189) = 11.330, CFI = 0.661, IFI = 0.663, TLI = 0.624, RMSEA = 0.177 and SRMR = 0.122 (Hair et al., 2010; Hu and Bentler, 1999) significantly worse than those of the measurement model (see Table 2). Second, to further assess common method bias two measurement models were tested and compared; one model including only the traits and the other model including both the traits and a latent factor (Flynn et al., 2010; Podsakoff et al., 2003; Yu et al., 2013; Zhao et al., 2011). This approach provides a further assessment of common method bias. The results indicate that the model with a latent factor changed inconsequentially (CFI by 0.003, IFI by 0.002 and TLI by 0.008). While the above tests suggest common method variance bias is unlikely to be a problem in this study, we acknowledge that these tests are not confirmatory in nature.

5. Data analysis and results

5.1. Measurement model

We performed relevant analyses to assess the unidimensionality, reliability, and validity (discriminant and convergent validity) of the theoretical constructs (Fornell and Larcker, 1981; Gerbing and Anderson, 1988; O'Leary-Kelly and Vokurka, 1998). The results are reported in Tables 2 and 3.

We conducted a CFA to assess the unidimensionality of scale items (Gerbing and Anderson, 1988). The CFA results reported in Table 2 indicate that the measurement model has a good fit (χ^2 / df = 3.285; RMSEA = 0.083; CFI = 0.927; IFI = 0.928; TLI = 0.917; and SRMR = 0.077) (Hair et al., 2010; Hu and Bentler, 1999), which suggests unidimensionality.

We computed Cronbach's alpha and composite reliability (CR) to assess reliability. Table 2 indicates that the Cronbach alpha and CR values of all theoretical constructs were well above the acceptable threshold of 0.70 (Hair et al., 2010). The results therefore provide evidence of reliability.

------------------------------ Insert Table 2 ------------------------------

As shown in Table 2, the measurement model suggests that all indicators in their respective constructs have statistically significant ($p < 0.001$) factor loadings greater than 0.50 (only one item with a loading slightly below 0.50) and that all t-values were greater than 2, thus demonstrating convergent validity (Hair et al., 2010; Hu and Bentler, 1999; O'Leary-Kelly and Vokurka, 1998). Additionally, all of the average variance extracted (AVE) values were greater than the acceptable threshold of 0.50, which provides further evidence of convergent validity (Fornell and Larcker, 1981).

Following the approach recommended by Fornell and Larcker (1981), we assessed discriminant validity by comparing the square root of the AVE for each construct with the correlations with all other constructs in the model. As shown in Table 3, the square root of every AVE for each construct is much larger than any correlation among any pair of latent constructs, which provides evidence of discriminant validity (Fornell and Larcker, 1981).

------------------------------ Insert Table 3 ------------------------------

5.2. Results

We tested the proposed theoretical framework (Figure 1) using structural equation modelling (SEM). The structural model has a good fit (Hair et al., 2006; Hu and Bentler, 1999) and the results are reported in Table 4 and Figure 2. Although firm size, firm age and industry type were each included as a control variable in the structural model; none had a significant effect on operational performance. The structural model reveals that ES is positively and significantly related to SCI ($\beta = 0.459$, $p < 0.001$), SCR ($\beta = 0.103$, $p < 0.05$), and operational performance ($\beta = 0.139$, $p < 0.05$), thus lending support for H1, H2 and H3. The SEM also demonstrates that SCI has a significant positive effect on SCR ($\beta = 0.805$, $p < 0.001$) and that SCR is positively and significantly associated with operational performance ($\beta = 0.404$, $p < 0.001$). Hence, we find support for H4 and H6. However, there is no statistically significant relationship between SCI and operational performance ($\beta = 0.072$, *n.s.*). Thus, H5 is rejected.

------------------------------ Insert Table 4 ------------------------------

------------------------------ Insert Figure 2 ------------------------------

As depicted in Figure 2, we found that ES and SCI affect operational performance through SCR. To identify the extent of the mediating effect of SCR we used a bootstrap approach as it is considered a more powerful approach than the causal steps approach popularized by Baron and Kenny (1986) for estimating mediation and indirect effects (Preacher, 2015; Zhao et al., 2010). Specifically, we used bias-corrected bootstrapping with 10,000 resamples to estimate indirect effects and their significance. Table 5 presents the results of the mediation analysis using estimates of direct and indirect paths.

The bootstrap results indicate that the direct effect of SCI on operational performance is not significant ($\beta = 0.072$, *n.s.*). However, the indirect effect of SCI on operational performance via SCR is positive and significant ($\beta = 0.325$, $p < 0.01$; 95% confidence interval: lower bounds = 0.116, upper bounds = 0.554). The results suggest that SCR acts as a full mediator of the ES–operational performance relationship. Table 5 indicates that ES has a significant direct effect on operational performance ($\beta = 0.139$, $p < 0.10$), and that the indirect effect of ES on operational performance through SCR is also significant and positive ($\beta = 0.224$, $p < 0.001$; 95% confidence interval: lower bounds = 0.145, upper bounds = 0.322). The results indicate that SCR partially mediates the relationship between ES and operational performance.

------------------------------ Insert Table 5 ------------------------------

6. Discussion and implications

6.1. Theoretical implications

This study provides several original theoretical implications for the interpretation of the relationship between ES, SCI, SCR, and firm performance. First, we address a common problem facing strategic management and SCM researchers, i.e., the lack of an integrative and comprehensive framework to understand complex relationships among several constructs, especially constructs from other disciplines. For example, more complex sequential effects of SCI have been recognized (Kim and Lee, 2010; Sanders, 2007) but progress in SCI research is largely limited to the use of contingency and configuration theories (Flynn et al., 2010; Wong et al., 2011). Using the SIAP model (Thomas et al., 1993), this study integrates knowledge from the literatures of strategic management and SCM to reveal the strategic roles of SCI and SCR. While the strategic management literature attempts to explain the performance effects of ES (Beal, 2000; Garg et al., 2003), the roles of SCM practices in facilitating supply-chain- wide interpretation capacity and strategic response are often not captured in theoretical models. On the other hand, the SCM literature addressing the effects of various SCM practices using resource-based view or the like cannot fully explain the mechanisms in which SCI and SCR support strategy processes such as ES to generate operational advantages. The SIAP model can be used to understand the effects of other SCM practices, as long as scanning of environmental information and interpretation of the data is involved to develop an adaptive strategy.

The second implication concerns the application of OIPT. OIPT has been useful in explaining the differing information processing mechanisms for coping with environmental complexity (Flynn and Flynn, 1999) and the distinct roles of internal and external integration (Scheonherr and Swink, 2012; Wong et al., 2011). However, never before has the field systematically divided information gathering and information interpretation while linking them to the supply chain strategy process. Information processing in a supply chain context is not new (Flynn and Flynn, 1999), but its wider application for explaining the SIAP model is new. As mentioned, OIPT could be expanded to encompass a supply chain level analysis. Nair et al. (2016) have explored the roles of environmental sensing in a supply network level. When the SIAP model is applied at the supply chain level it allows us to extend OIPT beyond the boundaries of the firm to consider how multiple supply chain actors gather, interpret and apply information to deal with uncertainty in the external environment. This extended perspective of OIPT helps explain how the scanning for and interpretation of information across supply chain partners, and then integrated and coordinated action, leads to enhanced firm and supply chain performance.

This study expands the role of SCI from an OIPT perspective. Prior to this study SCI was considered to play information sharing and coordination roles to improve SCR through uncertainty reduction (Danese et al., 2013), but the "joint interpretation" roles of SCI to reduce equivocality is a novel perspective added. As such, by positioning SCI as "interpretation" we can explain a related "action" such as SCR and fill the gaps between ES and performance. While studies using OIPT have focused on uncertainty reduction, we extend knowledge of alternate information processing mechanisms (Flynn and Flynn, 1999) for reducing equivocality offered by SCI, to better explain the significance of SCI in creating shared meanings and joint goals despite the potential use of different frames to interpret the environment.

The third implication concerns the opportunity to expand the SIAP model to better explain the ES–SCI–SCR–performance relationships. The strategy literature acknowledges executives base their interpretation of outcomes on the environment to devise new scanning strategies (Thomas et al., 1993). That means the environment is a trigger of scanning activities that could be added to the SIAP model, thus leading to a more comprehensive SIAP model. The strategy literature acknowledges the need for ES at different hierarchical levels but not at a supply chain level. This study reveals the importance of jointly interpreting ES signals with supply chain partners through SCI to devise joint actions to respond to environmental changes (SCR as a supply chain-wide strategy). Thus, theories applying the SIAP model can be extended from the firm to the supply chain level. Nevertheless, our findings suggest that SCI and SCR are crucial but not the only explanatory factors for operational performance. Therefore, there could be other constructs that represent SIAP models. ES is not the only channel of external environmental information and other SCM practices (such as supply chain innovation, supply chain resilience, and supply chain sustainability) require external input to ultimately affect performance. This implies a wealth of new research opportunities. On the other hand, frameworks such as the strategy–structure–performance (SSP) might also be used to explain firm performance from a structural perspective (e.g., Chen et al., 2009; Chow et al., 1995), even though the "strategy" here might have to consider ES and other sources of strategic insights.

The fourth implication can also be viewed as a refinement and extension of SCI research. Although previous studies have investigated the relationship between SCI and firm performance, these studies have generated inconsistent results (Flynn et al., 2010; Yu, 2015). The mixed support in the SCI literature indicates that further investigation is needed to explore the SCI–performance relationship. Our results reveal that there is no significant direct relationship between SCI and operational performance, which is consistent with that reported in several previous studies (Flynn et al., 2010; Yu, 2015). While the existing findings may suggest SCI plays little strategic role, our findings demystify such claims. Our study identifies the strategic roles of SCI on SCR in transforming weak signals into competitive performance. Thus, the present study extends the work of Yu et al. (2018) by investigating the mediating role of SCR from an OIPT perspective. The implication of the SIAP model is that SCI and SCR can be classified as a hierarchical sequence, one after another, in the strategic foresight and actions process. Previous SCM studies (e.g., Yu et al., 2018) have not recognized such crucial strategic roles of SCI. Hence, future research may treat SCI as an interpretation process for achieving shared meaning and goals, from the OIPT perspective, to uncover other supply chain strategies that mediate the SCI–performance relationship (Kim and Lee, 2010; Wu et al., 2006; Yu et al., 2018).

The final important theoretical implication informs the strategic planning literature. We found that the effect of ES on firm performance is partially mediated by the development of responsiveness in supply chains. Although previous research has addressed the importance of ES in the strategic planning process (Albright, 2004; Fabbe-Costes et al., 2014), to the best of our knowledge no previous study has investigated the effect of ES on operational performance in the supply chain context. Our study is an initial attempt at filling the aforementioned gaps in the literature. More specifically, our study suggests that a more refined and nuanced explanation of the ES–performance relationship lies in the supply chain literature. SCR is simply one competitive weapon enabling firms to respond effectively to changes in the market which, in turn, leads to superior operational performance. Other forms of supply chain strategies could be incorporated into the SIAP model to refine understanding of the effects of ES.

6.2. Managerial implications

The study findings suggest that ES activities provide useful information for developing a quick response supply chain (SCR) strategy to supply chain partners. As today's industries are becoming more competitive and dynamic, information from the external environment has become an important resource for firms to capitalize upon to enhance competitiveness. Our study suggests that managers should develop information processing strategies coupled with effective ES, especially for identifying, gathering, and analysing information about events and trends occurring outside the firm that are specifically related to establishing strategic collaboration, SCI, and responsive supply chains. Since more than half of the operational performance benefit from ES is derived from SCI and SCR activities, top executives should learn to scan supply chain related environmental information and provide the information to supply chain managers; the goal being to work with such managers and supply chain partners to adapt to the changing environment.

Second, supply chain managers need to work with senior executives to obtain strategic signals from ES activities, serve as a conduit to facilitate joint interpretation of the strategic signals with business partners, and transform them into strategic insights about changes in suppliers, customers, competitors and markets. Additionally, it is important to then reconfigure the supply chain to respond quickly to the changes. Without integrating these activities through the SIAP model (ES as scanning, SCI as interpretation, and SCR as action), signals from ES and collaboration through SCI would not necessarily lead to better operational outcomes. Managers are advised to find ways to link ES activities with processes for developing and implementing SCM practices, especially responsiveness and integration. Based on the OIPT argument that the levels of responsiveness and integration should be aligned with the levels of dynamic and changing competitive environment, we suggest three processes – ES activities in gathering sufficient and relevant information, SCI activities in processing and sharing the information with supply chain partners, and supply chain responsiveness strategy – ought to be aligned. Bear in mind many firms have adopted process models such as the SCOR model. However, it is important to complement such models with the design of appropriate ES processes and link them to the supply chain strategy processes.

Third, while researchers have long articulated the benefits of building strategic collaboration among supply chain partners, our findings suggest supply chain managers should view SCI as a joint interpretation process and a potential preparation for big data initiatives. Managers should recognize the improved SCR associated with SCI instead of viewing SCI exclusively as an initiative to achieve cost efficiency. The mediation analysis strongly suggests that if firms focus only on developing a close and integrated relationship without developing a shared schema for interpreting the environmental information and translating insights from the shared information into quick actions, they may not be able to fully leverage the potential operational benefits. Our study reveals SCR is one of the key strategies that enable firms to achieve superior operational performance. While SCI did not directly affect operational performance it is, nevertheless, a key antecedent to the development of SCR. In fact, since all of the operational performance benefit of SCI is delivered through SCR, managers seeking to obtain operational benefits should invest in improving responsiveness in conjunction with SCI.

Fourth, as a mental model guiding managers to become more holistic and systems-oriented thinkers, this study provides an example of how the SIAP model can be a useful framework that helps mangers better understand the ES–SCM practices (SCI/SCR)–performance relationships. With the emphasis on scanning “S” as the first step, this framework will be useful for managers considering implementing supply chain big data analytics to further consider other types of data to scan “S”, and different means to interpret “I”, including the use of artificial intelligence and machine learning, and to support a supply chain strategy be it responsiveness (SCR), lean, smart, or intelligence. More importantly, using SIAP as a mental model drives a constant search for fits between strategy and the environment to better cope with today’s turbulent and uncertain environment.

7. Directions for future research

The study has a number of limitations that present opportunities for future research. First, our conceptualization of ES from a SIAP perspective focuses on gathering information about business environments from supply chain partners. The ES literature suggests that effective scanning of both the external environment and the internal circumstances of a firm is important to performance improvement (Garg et al., 2003). Thus, future research should examine the aspects of both the firm’s external environment and its internal circumstances and their differential impacts on SCM and firm performance.

Second, another limitation is that this study conceptualized SCI as an aggregate construct. The SCI literature has examined SCI as a multidimensional construct inclusive of internal integration, customer integration, and supplier integration (Flynn et al., 2010). Thus, future research should investigate the different dimensions of SCI and their relative impact on responsiveness and firm performance.

Third, future research should examine the relationship between ES, SCM practices, and firm performance in different economies to confirm the results obtained in this study. Studies that compare ES in a supply chain context in developed versus developing nations may also be of interest (Sawyerr, 1993).

Fourth, this study considered supply chain responsiveness as the "action'. However, supply chain responsiveness might be investigated more granularly to determine which dimensions of responsiveness are most critical, e.g., volume or mix flexibility, price changes, supply base changes or investments.

Fifth, this study considered operational performance as an important performance outcome of SCI and SCR. However, previous research (e.g., Wu et al., 2006; Yu et al., 2018) suggests that integrated and responsive supply chains improve financial and marketing performance. Therefore, a possible direction for future research could be to examine how SCI and SCR bear on a wider range of performance measures.

Lastly, related to the sample, another limitation relates to the single respondent design. The perspectives of individuals within the firm may not be uniform or the respondent may not represent the dominant view within the firm. Multiple respondents at each firm could improve the study's reliability and incorporating a broader range of industries could enhance generalizability.

8. Conclusions

Our study extends the SCM literature in several important ways. The first is through importing the SIAP model, which forms a bridge to the strategy literature and brings a new perspective to the supply chain literature. The use of the SIAP model enables a more precise application of the OIPT in the supply chain context. To the best of our knowledge, the use of the SIAP model herein is the first in an empirical study focused on comprehensively explaining the performance effects of ES through the development of two SCM practices – supply chain responsiveness and integration. The demonstration that the SIAP model serves as an integrative framework for refining understanding of the ES–SCI–SCR–performance leads to the implication that other scanning and SCM practices could be studied in a more comprehensive manner. The second implication is that this study positions OIPT in conjunction with the SIAP model as a new way to refine disparate knowledge on ES, SCI, SCR and performance. The SIAP model can also be extended to account for the environment and other explanatory variables. From a practical perspective our empirical findings, especially the indirect effect of ES through SCI and SCR, provide useful insights for supply chain managers and their top executives.

Appendix: questionnaire

1. Environmental scanning. Please indicate the extent to which the following scanning devices are used by your firm to gather information about its environment (1 = Not ever used; 7 = Used extremely frequently).

- Routine gathering of opinions from clients
- Explicit tracking of the policies and tactics of competitors
- Forecasting sales and customer preferences
- Special marketing research studies
- Gathering of information from suppliers and other channel members

2. Supply chain integration. Please indicate the degree to which you agree to the following statements relating to your company's supply chain capability (1 = Strongly disagree; 7 = Strongly agree).

- Our company develops strategic plans in collaboration with our partners
- Our company collaborates actively in forecasting and planning with our partners
- Our company projects and plans future demand collaboratively with our partners
- Collaboration in demand forecasting and planning with our partners is something we always do in our company
- Our company always forecasts and plans activities collaboratively with our partners

3. Supply chain responsiveness. Please indicate the degree to which you agree to the following statements relating to your company's supply chain capability (1 = Strongly disagree; 7 = Strongly agree).

- Compared to our competitors, our supply chain responds more quickly and effectively to changing customer and supplier needs
- Compared to our competitors, our supply chain responds more quickly and effectively to changing competitor strategies
- Compared to our competitors, our supply chain develops and markets new products more quickly and effectively
- In most markets, our supply chain is competing effectively
- The relationship with our partner has increased our supply chain responsiveness to market changes through collaboration

4. Operational performance. Please evaluate the scale below how your firm compares to your major industrial competitors over the last three years (1 = Much worse than your major competitors; 7 = Much better than your major competitors).

- Rapidly change production volume
- Deliver products quickly or short lead-time
- Provide on-time delivery to our customers
- Provide reliable delivery to our customers
- Produce consistent quality products with low defects
- Produce products with low inventory costs

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Table 1: Demographic characteristics of respondents (n=329)

	Percent (%)		Percent (%)
Industries		**Respondent location**	
Automobile	34.3	Pearl River Delta*	5.2
Chemicals and petrochemicals	15.2	Yangtze River Delta	10.0
Electronics and electrical	7.9	Bohai Sea Economic Area	6.6
Fabricated metal product	2.4	Central China	8.2
Food, beverage and alcohol	2.7	Southwest China	69.9
Rubber and plastics	4.0	**Annual sales (in million Yuan)**	
Textiles and apparel	33.4	Below 10	10.9
Number of employees		10 – 50	16.1
1 – 100	17.0	50 – 100	13.4
101 – 200	10.9	100 – 500	17.0
201 – 500	19.8	500 – 1000	7.9
501 – 1000	8.2	Above 1000	34.7
1001 – 3000	16.4	**Firm age (years)**	
> 3000	27.7	≤10	31.3
Years in current position		11 – 20	31.6
≤ 5	41.3	21 – 30	10.6
6-10	30.7	> 30	26.4
> 10	28.0		

Note: * The sample includes one firm in Taiwan and one firm in Hong Kong.

Table 2: CFA results: reliability and validity

Measurement Items	Factor loadings	t-values	α	CR	AVE
1. Environmental scanning			0.862	0.864	0.562
Routine gathering of opinions from clients	0.772	–			
Explicit tracking of the policies and tactics of competitors	0.812	14.744			
Forecasting sales and customer preferences	0.773	14.013			
Special marketing research studies	0.754	13.640			
Gathering of information from suppliers and other channel members	0.622	11.039			
2. Supply chain integration			0.944	0.944	0.772
Our company develops strategic plans in collaboration with our partners	0.900	–			
Our company collaborates actively in forecasting and planning with our partners	0.921	26.951			
Our company projects and plans future demand collaboratively with our partners	0.899	25.377			
Collaboration in demand forecasting and planning with our partners is something we always do in our company	0.837	21.516			
Our company always forecasts and plans activities collaboratively with our partners	0.832	21.284			
3. Supply chain responsiveness			0.940	0.943	0.767
Compared to our competitors, our supply chain responds more quickly and effectively to changing customer and supplier needs	0.878	–			
Compared to our competitors, our supply chain responds more quickly and effectively to changing competitor strategies	0.934	26.058			
Compared to our competitors, our supply chain develops and markets new products more quickly and effectively	0.835	20.546			
In most markets, our supply chain is competing effectively	0.887	23.202			
The relationship with our partner has increased our supply chain responsiveness to market changes through collaboration	0.840	20.761			
4. Operational performance			0.865	0.880	0.565
Rapidly change production volume	0.576	–			
Deliver products quickly or short lead-time	0.886	11.548			
Provide on-time delivery to our customers	0.900	11.640			
Provide reliable delivery to our customers	0.925	11.795			
Produce consistent quality products with low defects	0.607	9.066			
Produce products with low inventory costs	0.488	7.682			
Model fit statistics: χ^2 = 601.136; df = 183; χ^2 / df = 3.285; RMSEA = 0.083; CFI = 0.927; IFI = 0.928; TLI = 0.917; SRMR = 0.077					

Table 3: Descriptive statistics

	Mean	S.D.	ES	SCI	SCR	OP
Environmental scanning (ES)	5.373	1.016	0.749[a]			
Supply chain integration (SCI)	4.661	1.266	0.428**	0.879		
Supply chain responsiveness (SCR)	4.660	1.269	0.441**	0.811**	0.876	
Operational performance (OP)	5.129	0.989	0.405**	0.548**	0.606**	0.752

Note: [a] **Square root of AVE is on the diagonal.**
** **Correlation is significant at the 0.01 level (2-tailed).**

Table 4: Results of hypothesis test using SEM

Structural paths	Standardised coefficient	t-values	Hypothesis test
Environmental scanning → Supply chain integration	0.459***	7.637	H1: Supported
Environmental scanning → Supply chain responsiveness	0.103*	2.525	H2: Supported
Environmental scanning → Operational performance	0.139*	2.234	H3: Supported
Supply chain integration → Supply chain responsiveness	0.805***	16.304	H4: Supported
Supply chain integration → Operational performance	0.072	0.677	H5: Not supported
Supply chain responsiveness → Operational performance	0.404***	3.589	H6: Supported
Control variable			
Firm size → Operational performance	-0.061	-1.066	
Firm age → Operational performance	0.076	1.327	
Industry type1 → Operational performance	0.020	0.235	
Industry type2 → Operational performance	-0.086	-1.184	
Industry type3 → Operational performance	-0.058	-0.925	
Industry type4 → Operational performance	-0.094	-1.108	
Variance explained (R^2)	R^2		
R^2 Supply chain integration	0.211		
R^2 Supply chain responsiveness	0.734		
R^2 Operational performance	0.333		
Model fit statistics: χ^2 = 810.611; df = 297; χ^2/df = 2.729; RMSEA = 0.073; CFI = 0.920; IFI = 0.921; TLI = 0.905; SRMR = 0.075			

*** $p < 0.001$; * $p < 0.05$.

Table 5: Results of bootstrapping test for mediation

Structural paths	Direct effect	Indirect effect	SE of indirect effect	95% CI for indirect effect	Result
ES→SCR→OP	0.139†	0.224***	0.044	0.145–0.322	Partial mediation
SCI→SCR→OP	0.072	0.325**	0.111	0.116–0.554	Full mediation

Note: ES = environmental scanning; SCR = supply chain responsiveness; SCI = supply chain integration; OP = operational performance; SE = bootstrap standard error; CI = bootstrap confidence interval; Standardized effects; 10,000 bootstrap samples.
*** $p < 0.001$; ** $p < 0.01$; † $p < 0.10$.

Figure 1: Proposed conceptual model

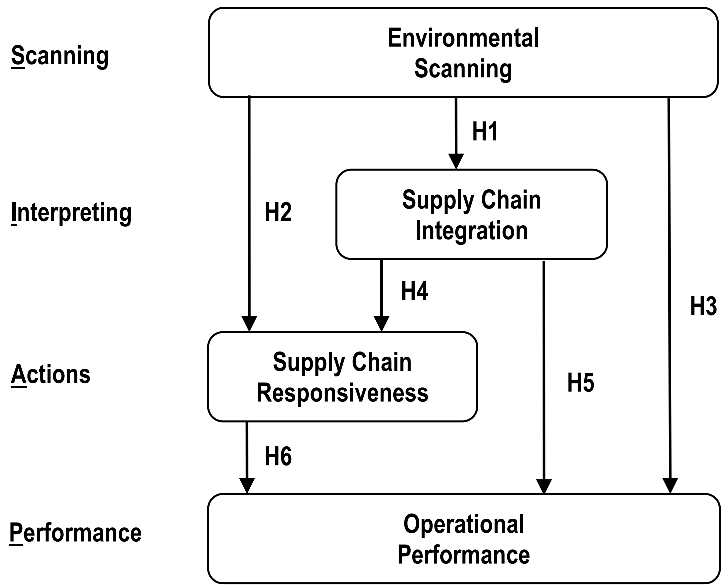
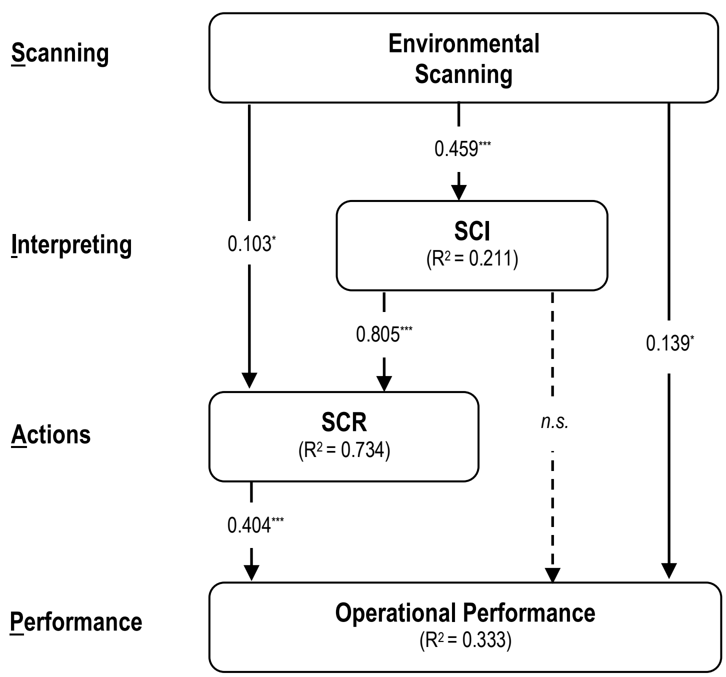


Figure 2: Model estimation results



Fit index: χ^2/df = 2.729; RMSEA = 0.073; CFI = 0.920; IFI = 0.921; TLI = 0.905; SRMR = 0.075; Note: *** $p < 0.001$; * $p < 0.05$.