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Supply chain resilience, firm performance, and management policies in the liner shipping industry

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ABSTRACT

This study empirically examines a model that describes the relationship between supply chain resilience (SCR) and firm performance by using survey data collected from the Taiwanese liner shipping industry. In the model, the theoretical constructs of SCR consist of a risk management culture, agility, integration, and supply chain (re-)engineering. The results from testing the model show that the positive direct effects of a risk management culture on agility, integration, and supply chain (re-)engineering are significant and that risk management performance contributes to firm performance. The findings also suggest that risk management performance plays a crucial role in the positive effects of the three types of SCR (i.e., agility, integration, and supply chain (re-)engineering) on firm performance. Managers are advised to focus on the role of risk management performance to realize the performance value of SCR.

1. Introduction

Businesses compete no longer on an individual basis but as a member of a supply chain (SC) (Christopher, 2000). A well-managed SC is thus one of the enduring resources to enhance a firm's competitive strength. Determining how to lower inventory levels, reduce lead times, increase SC efficiency, and enhance profit is a formidable challenge confronting many managers. Further, specialization in industry and the globalization of materials and markets encourage manufacturers to outsource their productive activities to nations with lower wages to reduce costs. On the other hand, manufacturers market their products to emerging countries with strong purchasing power such as the BRICS (Brazil, Russia, India, China, and South Africa) to increase their potential revenue. It is natural for SC members to transform themselves from local to regional or global operations. As an SC expands to include members from different cultures, locations, and time zones, SC management (SCM) becomes a complicated and challenging task.

The liner shipping industry is the cornerstone of the semi-manufactured and manufactured goods market with the objective of increasing the goods' availability and generating higher profits. To achieve this objective, shipping lines need to constantly increase their number of container ships in order to provide broader geographical coverage for their shipping service. Many liner shipping companies began their operations by providing shipping service for a single nation and subsequently

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expanded to cover a cluster of nations in a region and many nations globally. The expansion of shipping service coverage and service routes renders liner shipping companies' operations complicated and fragile. Indeed, widespread political instability, climate change, communicable diseases, and terrorist attacks frequently increase the likelihood of SC disruptions. For instance, the 9/11 terrorist attack, damage from Hurricane Katrina, the Tohoku earthquake in Japan in 2011, the Debt Crisis in the EU, and the 2011 flooding in Thailand have all significantly hindered SCM (Pettit et al., 2013).

Further, the liner shipping industry needs to tackle operational challenges related to unstable economic cycles, empty container repositioning, seafarer shortages, escalating bunker prices, cargo space oversupply, fluctuating ship prices, and port closures (e.g., port closures due to an explosion at the Tianjin Port, the industrial strike at the port of Long Beach and Los Angeles, the earthquake and tsunami in Japan, and the Hanjin Shipping bankruptcy in Korea). Damages to ships due to collisions, fire, explosions, warfare, terrorist attacks, piracy, and so forth have also weakened organizations' ability regarding SC resilience (SCR). To be proactive, port authorities and liner operators have to change their business mindset. They must now consider not only whether a disruption will occur but also when the disruption will occur and how long the effects will last before they can operate as usual. In addition to SC costs and efficiency, they have to improve the resilience of their SC (i.e., SCR) to ensure the continued operations of the whole SC and eventually ensure the long-lasting competitiveness of their SC (Christopher and Peck, 2004; Zsidisin and Wagner, 2010).

SCR is key to the success of enterprises and SCs (Ambulkar et al., 2015; Hohenstein et al., 2015; Pereira et al., 2014; Soni et al., 2014; Wieland and Wallenburg, 2013): it is useful for enterprises to quickly assess the impacts of risks on the SC and the possible levels of recovery during disruptions, which improves collaboration between SC partners (Soni et al., 2014). SCR can be defined as an enterprise's ability to identify bottlenecks and potential risks in managing an SC, which allows it to adopt effective measures before an SC is disconnected (Brandon-Jones et al., 2014).

SCR is one of the most important aspects of SCM, and its enablers have been extensively studied, such as SC risk management (e.g., Ivanov et al., 2014; Pettit et al., 2013; Ratick et al., 2008; Soni et al., 2014; Spiegler et al., 2012; Vugrin et al., 2011), social capital (Johnson et al., 2013), relational competencies (Wieland and Wallenburg, 2013), procurement (Pereira et al., 2014), resource reconfiguration (Ambulkar et al., 2015) and firm innovativeness (Gölgeci and Ponomarov, 2015). According to a study conducted by Alcantara (2014), 81% of the respondents report that they encountered at least one SC disruption in 2013, and almost one-quarter of the respondents (23.6%) report annual cumulative losses of at least €1 million due to SC disruptions. The profitability and economic sustainability of many firms are greatly threatened because of their inability to manage uncertainty and the risks they encounter. For instance, based on a survey of 800 American companies that have experienced an SC disruption at least once, Hendricks and Singhal (2005) find that SC disruptions decrease a company's operating income and sales by 107% and 7%, respectively, and unfortunately, increase its costs by 11%. Further, when risk events occurred, these two negative impacts continued for at least another two years, and the companies' stock prices experienced a rapid drop. Thus, the performance value of SCR cannot be neglected.

There are three motivations for this study. First, although SCR has been identified as one of the most important issues in contemporary SCM (Brandon-Jones et al., 2014; Ivanov et al., 2014; Spiegler et al., 2012; Urciuoli et al., 2014), the theoretical basis for understanding SCR is fragmented and lacks systematic integration. Extant studies on SCR are mostly qualitative (e.g., Azevedo et al., 2013; Jüttner and Maklan, 2011; Johnson et al., 2013; Leat and Revoredo-Giha, 2013; Scholten et al., 2014; Urciuoli et al., 2014; Wedawatta et al., 2010), and quantitative studies based on large-scale surveys on SCR are scant (e.g., Ambulkar et al., 2015; Brandon-Jones et al., 2014). To narrow the gap between practice and theory, this study uses a rigorous quantitative research technique to examine the relationship between firms' SCR capability and their performance. Second, most SCR studies have focused on surveying the manufacturing industry (e.g., Azevedo et al., 2013; Carvalho et al., 2012; Colicchia et al., 2010; Jüttner and Maklan, 2011; Pettit et al., 2010; Wieland and Wallenburg, 2013), but to the authors' knowledge, there is a very limited number of SCR conceptualization studies dedicated to the liner shipping industry (e.g., Bhaskar et al., 2014), which is characterized by a competitive and unstable operating environment. Third, there are no commonly accepted sub-constructs for SCR (Hohenstein et al., 2015), and there is little empirical evidence on how different theoretical constructs/measurements of SCR simultaneously influence firm performance. While some previous studies have simply treated SCR as a dependent variable in examining how factors influence it and how the relationship between SCR and certain independent variables is moderated by other variables (e.g., Brandon-Jones et al., 2014; Jüttner and Maklan, 2011), other studies have merely focused on the influence of various SCR constructs on an SC's customer values (Wieland and Wallenburg, 2013). In short, very few of the above-mentioned studies have discussed the relationships between the different SCR sub-constructs/measurements and firm performance or the mediating effect of risk management performance on the relationship between SCR and firm performance. Considering these research voids, this study aims to examine these relationships by using data collected from one of the most important service industries, the liner shipping industry, to empirically examine the impact of SCR on firm performance from the resource-based view (RBV). The questions answered by this study are as follows:

- What are the theoretical constructs/measurements of SCR and their interrelationships with firm performance in the liner shipping industry?
- How do the different types of SCR affect firm performance in the liner shipping industry?

2. Literature review and major concepts

To establish the research model, this section reviews the research on SCR and firm performance and elaborates on the relationship between them from a RBV perspective. According to PricewaterhouseCoopers (2016), a resilient SC can increase a firm's competitive advantage and performance and can react to disruptive events faster than its competitors to achieve an increased market share.

2.1. SCR

2.1.1. Definition and dimensions of SCR

SCR represents "the system's adaptive capability to deal with temporary disruptive events" (Soni et al., 2014, p. 13). An organization may adopt a series of precautions to mitigate damage caused by known and detectable disruptions (Ivanov et al., 2014; Pettit et al., 2013). For example, an organization may investigate in advance the risk factors that threaten its SC and evaluate its SC's level of sensitivity to the identified risk factors. Doing so can help strengthen the SC's ability to cope with temporary disruptive events and maintain SC robustness (Pettit et al., 2010). For inevitable risks, an organization should prepare buffer resources to increase its SC's adaptive capability to handle unavoidable events (Ratick et al., 2008; Vugrin et al., 2011).

The literature has proposed various measurements of SCR, such as agility, collaboration, information sharing, sustainability, risk and revenue sharing, trust, visibility, risk management culture, adaptive capability, and structure (Soni et al., 2014). To understand the interaction between each measure and their relationship to performance, studies must first consider the variables that compose each measure. However, there is significant disparity in the literature regarding the variables in SCR (Hohenstein et al., 2015; Jüttner and Maklan, 2011). For instance, while some studies propose that SCR is a unidimensional construct (e.g., Ambulkar et al., 2015; Brandon-Jones et al., 2014; Gölgeci and Ponomarov, 2015), others argue that SCR encompasses agility and robustness (e.g., Wieland and Wallenburg, 2012, 2013), and some scholars adopt even more constructs (e.g., Azadeh et al., 2014; Hohenstein et al., 2015; Johnson et al., 2013; Pereira et al., 2014; Pettit et al., 2013; Scholten et al., 2014). For example, Azadeh et al. (2014) use the following four constructs of SCR: flexibility, redundancy, velocity, and visibility. Other constructs that have been used include capacity (Hohenstein et al., 2015), culture (Hohenstein et al., 2015), information sharing (Hohenstein et al., 2015; Pereira et al., 2014), collaboration (Johnson et al., 2013; Pereira et al., 2014; Scholten et al., 2014), SC (re-)engineering (Scholten et al., 2014), risk awareness (Scholten et al., 2014), and knowledge management (Scholten et al., 2014). While each of these factors represents an important component of SCR, there are also quite a few overlapping areas between them. The framework of this study follows the report by Christopher and Peck (2004), who indicate that the SCR of a company can be measured by its risk management culture, agility, collaboration, and SC (re-)engineering ability.

2.1.2. Elements of SCR: risk management culture, agility, integration and SC (re-)engineering

The formation of an organizational culture helps organizations create common core values and behavioral standards for their members, which aids organizations in reaching their goals (Kuhn and Youngberg, 2002; Mello and Stank, 2005; Summerill et al., 2010). Risk management culture, which is an important element of SCR, is the overall organizational philosophy that places risk management as a priority (Sheffi and Rice, 2005). Creating a risk management culture within an organization can help managers decrease the risks for both the organization and its partners (Christopher and Peck, 2004). As researchers have noted, "to be resilient, organizations need to develop appropriate management policies and actions that assess risk continuously and coordinate the efforts of their supply network" (Scholten et al., 2014, p. 215).

Agility focuses on "rapid system reconfiguration in the face of unforeseeable changes" (Bernardes and Hanna, 2009, p. 30). When there are changes in customers' demands or disruptions in the SC, organizations with less agility will expose partners in their SC to operational risk (Azevedo et al., 2013). The main elements of agility are visibility and velocity (Christopher and Peck, 2004). The former represents a clear understanding of upstream and downstream partners' available stocks, supply and demand conditions, as well as production and purchase timelines, whereas the latter refers to the SC's speed of recovery after a disruption occurs (Azevedo et al., 2013). An organization's agility is also affected by its SC partners' ability to react (Braunscheidel and Suresh, 2009). For example, through cooperation with a highly responsive supplier, a manufacturer can effectively lower its inventory risks (Chopra and Sodhi, 2004). For a container ship operator, agility refers to its ability to respond to changes in the external environmental in order to cope with a volatile market. Organizational abilities related to agility may include an organization's sensitivity to the external environment, service routes, and flexibility in exchanging cargo hold slots, as well as its partners' ability to react.

Integration represents the cooperation (Huo, 2012) and coordination (Glenn Richey, 2009; Swaminathan et al., 1998) between organizational departments or functions. Within an SC system, integration may refer to internal integration, which is the coordination between various organizational functions, or external integration, which is the long-term commitment and collaboration with SC partners to meet customers' demands (Cao et al., 2015). Since both types of integration are often accompanied by high risks, organizations need to establish effective information exchanges between them to decrease uncertainty (Christopher and Peck, 2004). For instance, an enterprise may use a potential partner's level of SC integration to determine whether to start a strategic alliance or cooperatively manage intra- and inter-organizational processes (Huo,

2012) in order to decrease SC uncertainty and more effectively manage risks (Sinha et al., 2004). Integration is reflected in information sharing and operational integration between organizations, which enable SC members to send information and react quickly in the face of disruptions. Moreover, it involves sharing experiences among SC partners after the disruptions are overcome (Sheffi, 2001).

(Re-)engineering refers specifically to the design of new business processes (Davenport, 1993), and SC (re-)engineering involves integrating processes and activities for product and service flow optimization. SC (re-)engineering efforts include business improvement programs that enable enterprises to undertake radical business process redesigns (Hammer, 1996). To establish a resilient SC, organizations must also have knowledge and an understanding of SC structures (Soni et al., 2014). "Resilience must be built into a supply chain in advance of a disturbance and incorporate readiness to enable an efficient and effective response" (Scholten et al., 2014, p.212). In existing SC designs, Jüttner (2005) believes that risk assessment tools can be utilized to find the weakest link in SC network, thereby allowing effective precautions before a disruption occurs. Moreover, because of the potential for sudden disruptions in an SC, SC design must also consider process redundancies, excessive capacities (Mason-Jones and Towill, 1998), and SC partners' risk awareness (Christopher and Peck, 2004).

2.2. Performance

2.2.1. Risk management performance

Risk management performance refers to a company's ability to confront opportunities and threats in its environment (Andersen, 2009). Different kinds of constructs have been used to measure firms' risk management performance. For example, Carreno et al. (2007) measure risk management performance by using four constructs: identification of risk, risk reduction, disaster management, and governance and financial protection. Kloss-Grote and Moss (2008), on the other hand, construct a risk management performance assessment based on two basic concepts—risk management ability and resource input level for risk management.

2.2.2. Firm performance

A review of the extant literature shows that there is a wide range of opinions regarding firm performance. Most studies focus on firms' financial performance and use measures such as ROA, profitability ratios, and market value ratios as evaluation criteria (Andersen, 2009; Fairbank, 2006; Yang, 2012). However, other researchers (e.g., Jun and Rowley, 2014) have already noted that SC evaluations based on financial performance may have some limitations that render it difficult to describe the performance of certain enterprise structures. This study adopts a general performance concept as the criteria for evaluating firm performance. Thus, the evaluation criteria used in this study integrates measures of operational performance and financial performance (Ou et al., 2010), such as customer loyalty, customer satisfaction, service level, market share, and net profit before tax.

2.3. The impact of SCR on performance: a RBV perspective

The RBV evaluates competitive advantages based on the internal distinctive competence (i.e., resources) of an organization (Barney, 1991; Wernerfelt, 1984). Daft (2004) defines resources as tangible properties and intangible abilities that an enterprise can control and use to increase its effectiveness and performance through strategic thinking. Barney (1991) also divides resources into tangible and intangible resources and lists the following four characteristics: value, rareness, imperfect imitability, and non-substitution. The RBV has been used in SC-related studies to explain various resources that are considered antecedents of performance, such as strategic capabilities (Ordanini and Rubera, 2008), service capabilities (Lu and Yang, 2010), marketing capabilities (Ahmed et al., 2014), IT innovation capabilities (Wu and Chiu, 2015), strategic environmental sourcing (Schoenherr et al., 2014) and strategic logistics resources (Wong and Karia, 2010).

Adopting the RBV, previous studies have examined the factors that affect organizations' ability to improve their SCR, such as visibility (Brandon-Jones et al., 2014) and human capital resources (Blackhurst et al., 2011). However, SCR can also be viewed as a type of organizational resource that helps organizations adapt to the environment for sustainable development (Ponomarov and Holcomb, 2009), which may lead to better operational performance, service satisfaction, customer loyalty and ultimately improve firms' financial performance. Furthermore, the RBV can be used as a basis to explain the contribution of various types of SCR to firm performance. Various types of SCR fall into the RBV's definition of resources, such as agility (Chiang et al., 2012; Christopher and Peck, 2004; Sharifi and Zhang, 2001), integration (Rodríguez-Díaz and Espino-Rodríguez, 2006) and SC (re-)engineering (Craighead et al., 2007), which may help increase the stability and profitability of the SC. This study uses the RBV perspective to evaluate the impact of various types of SCR (i.e., agility, integration and SC (re-)engineering) on both risk management performance and firm performance in the liner shipping industry context.

3. Hypothesis development

In this section, we develop a series of hypotheses on the relationship between different types of SCR and performance. Fig. 1 presents the conceptual model.

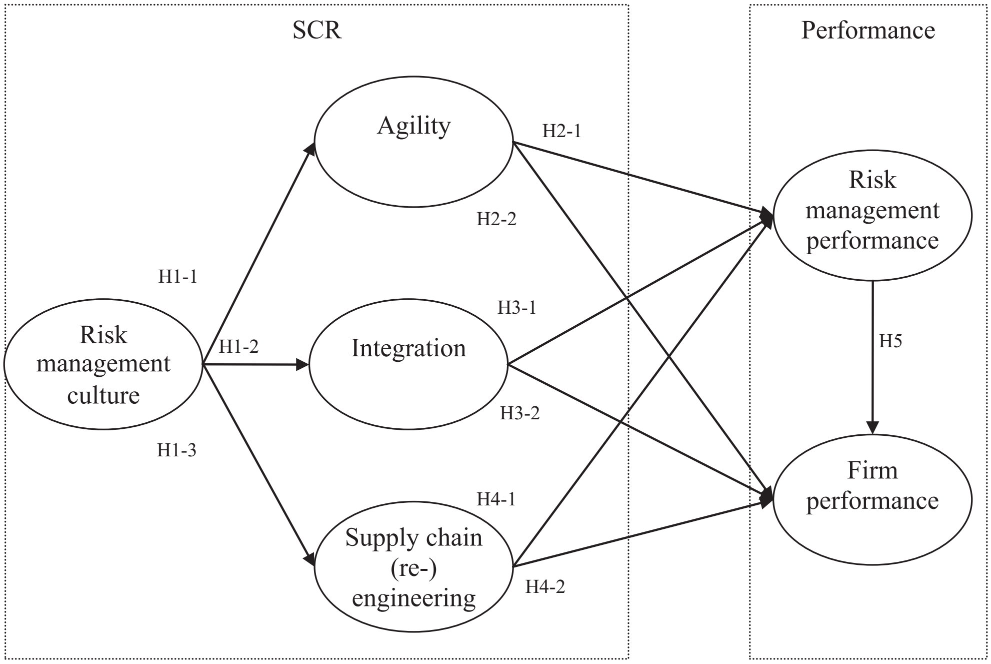

Fig. 1. Proposed model.

3.1. The impact of a risk management culture on agility, integration, and SC (re-)engineering

The establishment of a risk management culture can effectively incorporate risk management procedures into a firm's entire operating structure, thereby ensuring the normal operation of the SC (Sheffi and Rice, 2005). For example, one of the obstacles in SC visibility is the lack of information exchange between organizations (Christopher and Peck, 2004), which results in higher operational risks for enterprises because of their belated awareness of disruptions. When risk management knowledge is shared and risk awareness is established, SCs may overcome the wall between organizations and gain more awareness of external environmental changes (Faisal et al., 2006). Similarly, enterprises can establish appropriate management policies and actions for responding to uncertainty (Kuhn and Youngberg, 2002). Hence, a risk management culture can help liner shipping companies understand the opportunities and threats in the business environment and respond rapidly to the changing market. Without the philosophy of risk management, it would be difficult for liner shipping companies to maintain flexibility in their operations. Based on the above, it is logical to propose the following hypothesis:

H1-1 For liner shipping companies, a risk management culture has a positive impact on agility.

Organizations' different perspectives and attitudes toward risk often influence the extent to which they share risk event-related information (Soni et al., 2014). The establishment of a risk management culture facilitates the sharing of risk information between organizations (Christopher and Peck, 2004) and helps consolidate enterprises' external and internal information. Moreover, in a risk management culture, organizations are encouraged to focus on the normal operation of the SC and not on the operational performance of their individual departments. Such a culture increases the awareness of disruptions and improves organizations' reaction ability during a disruption, helping enterprises cooperate with other members upstream and downstream of the SC. For liner shipping companies, a risk management culture can enhance the effectiveness of inter-departmental information sharing and improve cooperation and collaboration with SC partners, such as shippers, customs brokers, and ports. Thus, this study proposes the following hypothesis:

H1-2 For liner shipping companies, a risk management culture has a positive impact on integration.

A risk management culture enhances the awareness of SC risks, improves the risk management ability of SC partners, and increases an organization's capability to recognize important changes in the SC. Without the awareness of risk management, it would be difficult for liner shipping companies to allocate more resources to deal with incidents related to SC risks. Thus, this study proposes the following hypothesis:

H1-3 For liner shipping companies, a risk management culture has a positive impact on SC (re-)engineering.

3.2. The impact of agility, integration, and SC (re-)engineering on performance

A company's agility falls into the RBV's definition of resources (Chiang et al., 2012; Christopher and Peck, 2004; Sharifi and Zhang, 2001). For example, organizations will develop a specific level of agility based on the level of agility they require (Sharifi and Zhang, 2001). This relates to the imperfect imitability characteristic of agility. Beyond helping organizations mitigate risk in the SC (Christopher and Peck, 2004), agility also provides resources during SC disruptions that help maintain SC stability; thus, agility also has a "value" characteristic. Agility can help liner shipping companies to quickly adapt to environmental influences, respond appropriately to changes, react even faster to SC partners, and increase SC stability (Mason and Nair, 2013). Based on the RBV, this study proposes the following hypothesis:

H2-1 For liner shipping companies, agility has a positive impact on risk management performance.

The previous literature has elaborated the relationship between agility and firm performance (e.g., Swafford et al., 2008; Tse et al., 2016; Wieland and Wallenburg, 2013; Yang, 2014). For example, Yang (2014) concludes that SC agility influences firm performance via cost efficiency, while Tse et al. (2016) indicate that SC agility affects firm performance directly. Swafford et al. (2008) also report that SC agility can improve business performance. Therefore, agility may have a positive impact on firm performance for liner shipping companies. Based on the RBV, this study proposes the following hypothesis:

H2-2 For liner shipping companies, agility has a positive impact on firm performance.

The exchange of information among SCM partners is the foundation for integration (Scholten et al., 2014). However, organizations must invest in resources, accumulate experience, and establish trust over the long term in order to share information (Rodríguez-Díaz and Espino-Rodríguez, 2006). This also relates to the imperfect imitability characteristic of integration. Moreover, collaborative partnerships not only play a key role before and during a disruption but also decrease the likelihood of the bullwhip effect (Lee et al., 1997); thus, integration also has a "value" characteristic. Moreover, effective integration among SCM parties increase visibility (Christopher and Peck, 2004) and decrease uncertainty (Soni et al., 2014). Thus, inter-departmental and inter-enterprise integration may have a positive impact on risk management performance for liner shipping companies. Based on the RBV, this study proposes the following hypothesis:

H3-1 For liner shipping companies, integration has a positive impact on risk management performance.

Many studies show that integration increases firm performance (e.g., Flynn et al., 2010; Liu et al., 2015; Wieland and Wallenburg, 2013; Xu et al., 2014). For example, Wieland and Wallenburg (2013) find that communication with suppliers and customers can improve the customer value of firms in an SC through robustness, and Flynn et al. (2010) conclude that greater internal integration leads to higher business performance. Xu et al. (2014) also find that supplier integration and customer integration affect business performance directly. Thus, integration may have a positive impact on firm performance for liner shipping companies. Based on the RBV, this study proposes the following hypothesis:

H3-2 For liner shipping companies, integration has a positive impact on firm performance.

Craighead et al. (2007) believe that by nature, all SCs have risks. The severity of the impact of an SC disruption depends on the SC's risks detection/warning and recovery abilities, as well as the resources it owns. SC (re-)engineering not only can help identify the weakest link in the SC but can also effectively reduce the threat caused by the disruption and increase the SC's subsequent recovery ability (Craighead et al., 2007). Based on the RBV, this study proposes the following hypothesis:

H4-1 For liner shipping companies, SC (re-)engineering has a positive impact on risk management performance.

We argue that SC (re-)engineering improves firm performance. For example, allocating more resources to deal with incidents related to SC risks improves the overall service level under market uncertainly. Moreover, with knowledge of SC structures, shipping companies can be more efficient and responsive to the disruption, which can benefit their customers. Such knowledge can also increase enterprises' competitiveness and earning power (Rodríguez-Díaz and Espino-Rodríguez, 2006). Based on the RBV, this study proposes the following hypothesis:

H4-2 For liner shipping companies, SC (re-)engineering has a positive impact on firm performance.

3.3. The impact of risk management performance on firm performance

Both theories and business cases generally indicate that risk management performance is positively related to firm performance (Andersen, 2009; Jun and Rowley, 2014; Ping and Muthuveloo, 2015). For instance, the ability to confront opportunities and threats in the environment helps firms satisfy customers' requirements under market uncertainty and, in turn, increases firms' market share and growth. A greater risk management ability can help liner shipping companies mitigate the adverse impacts of SC vulnerability, which will reduce costs and lead to better financial performance. For example, both shipowners and cargo insurers can use insurance as a risk control measure to improve firm performance under risk and uncertainty (Georgescu, 2011). This leads to the following hypothesis:

H5 For liner shipping companies, risk management performance has a positive impact on firm performance.

In summary, a model for SCR and performance is proposed for empirical examination in this study and is depicted in Fig. 1.

4. Method

4.1. Sampling

The majority of cross-continent trade is transported by ships. Unfortunately, however, the global liner shipping industry has experienced a historical market downturn over the last several years. The repercussions from the collapse of large shipping companies such as Hanjin Shipping represent a typical example of the close interdependencies among ship alliance members, ship lessors, port operators, freight forwarders, insurers and cargo owners (Lloyd's List, 2016). The long-lasting market recession for most shipping companies has caused the maritime sector to struggle, and the sector has become more sensitive to risk than other transport industries (Osler, 2016). The SC vulnerability became clear after the disruption of just-in-time operations when Hanjin ships were not allowed to enter discharging ports to unload their cargo (Tate, 2016). Thus, a shipping company that does not have a risk management policy might not be sufficiently resilient and could easily become a victim of the market recession. This study therefore aims to investigate the influence of SCR on firm performance in the liner shipping industry context.

The sample population of this study was Taiwanese liner shipping companies. Taiwan, a small, resource-absent island, is highly dependent on sea transportation and foreign trade. In 2014, the country was the world's 20th largest merchandise exporter and the world's 18th largest importer (WTO, 2015). In addition, Taiwan lies on major trade routes, such as the East Asia to Europe route and transpacific service route. The liner shipping industry frequently faces a high likelihood of SC disruption, which may make risk management unique for liner shipping companies. The 253 companies used within the survey were obtained from the membership directory of Taiwan Shipping Agents Association and National Association of Chinese Shipowners (Taiwan). Companies not involved in liner shipping operations were excluded from our mailing list.

4.2. Questionnaire design

The questionnaire scales used in this research were based on previous studies (Christopher and Peck, 2004; Fawcett et al., 1997; Jüttner and Maklan, 2011; Johnson et al., 2013; Shang and Marlow, 2005; Wagner and Bode, 2008; Wieland and Wallenburg, 2013). In this study, five-point Likert scales were used for rating. Likert scales were first developed in 1932 as the popular two-directional, five-point response, and it is impossible to incorrectly build a Likert scale (Allen and Seaman, 2007). In a study by Maurer and Pierce (1998), the five-point Likert scale is employed to compare the Likert scale with traditional measures of self-efficacy, and indicates that both provide similar results. Moreover, Dawes (2008) conducts an experiment by using five-, seven-, and 10-point scales, and finds that the five- and seven-point Likert scales produced the same mean score once they were rescaled. Thus, five-point Likert scales were employed in our research questionnaire.

A preliminary survey was pre-tested in Taiwan by interviewing three practitioners with relevant work experience in order to identify and correct problems such as the sequence or wording of the questions. After the pilot test, the revised questionnaires using multiple-item scales were formulated, as shown in Appendix A. The questionnaire consists of four parts: SC risks, SCR, risk management performance, and firm performance. Twenty-nine items selected as measures of SC risks (e.g., demand-side risk, supply-side risk, infrastructure risk and disaster risk) were based on the previous literature (Wagner and Bode, 2008). Respondents were asked to indicate the degree to which the listed SC risks negatively influenced their company or their container ship operator by using a five-point Likert scale, where 1 represented "no influence" and 5 represented "huge influence".

The twenty-nine indicators employed to assess the four types of SCR (i.e., risk management culture, agility, integration, and SC (re-)engineering) were reported in the previous literature (Christopher and Peck, 2004; Jüttner and Maklan, 2011; Johnson et al., 2013). Respondents were asked to provide a rating regarding the extent to which they agreed that the statement described their company's SCR by using a five-point Likert scale anchored by "1 = strongly disagree" and "5 = strongly agree". Moreover, the study adopted existing validated items to assess risk management performance (Wagner and Bode, 2008) and firm performance (Fawcett et al., 1997; Shang and Marlow, 2005; Wagner and Bode, 2008; Wieland and Wallenburg, 2013). Specifically, respondents were asked to provide a rating of their company's satisfaction level with its risk management performance and firm performance by using a five-point Likert scale anchored by "1 = strongly dissatisfied" and "5 = strongly satisfied".

4.3. Analytical steps of the methodology

The analytical steps of the methodology are shown in Fig. 2. The partial least squares structural equation modeling (PLS-SEM/PLS) approach was used to test the research hypotheses, and all analyses were carried out using the SPSS version 12.0, AMOS version 19 and the SmartPLS version 2.0.M3 statistical packages (Ringle et al., 2005).

5. Analysis results

5.1. Response rate

The data collection phase of the study began in the beginning of May 2014 and concluded in the middle of October 2014. The questionnaires were officially presented to all the included shipping companies during this period. The total number of usable responses was 112, for an overall response rate of 44.3% (112/253).

5.2. Representativeness

Non-response bias was tested by using an independent-sample *t* test that compared the responses that were received during the first 3/4 and final 1/4 of the questionnaire response period (Armstrong and Overton, 1977). The returned surveys were compared based on their total sales volume, number of full-time employees, and the levels of all the Likert ratings. Most items, except one item on risk management culture (c4) and one item on integration (i2), were not statistically significant at the 0.05 level, which suggests that non-response bias may not be a problem in this study.

5.3. Profile of the respondents

In all, 75% of the respondents had managerial responsibilities, which is very important for this study because they can provide an integrated and responsible view of their firms' affairs. In addition, 78% of the firms had been in operation for more than 21 years; 17% for between 11 and 20 years; and nearly 5% for less than 10 years. Nearly 34% of the respondents reported that their firms' 2013 total sales volume was less than 16.7 million USD; 30%, 66.7 million USD or more; and 36.4%, between 16.7 and 66.7 million USD. In terms of number of employees, 26% had more than 250 employees, 34% had fewer than 51 employees, and 40% had between 51 and 250 employees. Most of the sampled firms were local companies (57.3%) in Taiwan, whereas only 27.3% were foreign companies.

5.4. Perceptions of SC risk

To understand the effects of different types of SC risk on firm operations from the liner shipping companies' perspective, the respondents of liner shipping companies were asked to rate each item for SC risk by using a five-point Likert scale

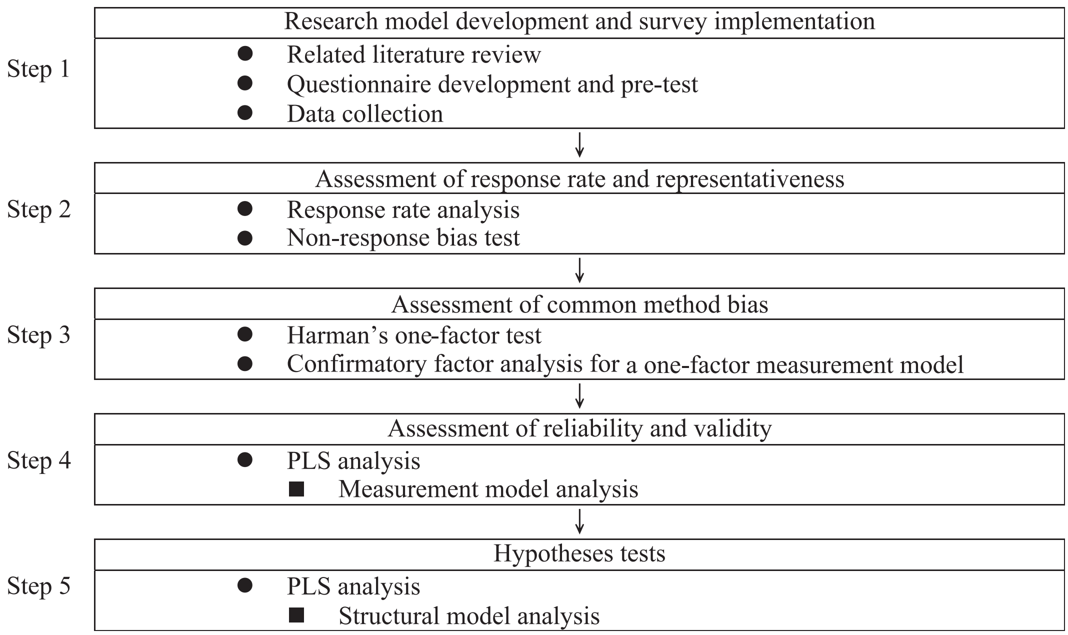

Fig. 2. Analytical steps of the methodology.

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ranging from "1 = absolutely no influence" to "5 = strong influence". As shown in Table 1, an examination of the 29 types of SC risk revealed that the top-five SC risks that strongly influence firm operations (their mean scores were over 3.40) are as follows:

r8. Rapid increases or drastic changes in fuel prices.
r9. Excessive or drastic changes in the market's shipping space.
r1. Problems arising from sluggish demand owing to the global recession.
r26. Natural disasters (such as an earthquake, flood, extreme weather, and tsunami).
r24. Unstable political environments, wars, riots, or other social-political crises.

5.5. Assessment of common method bias

As this study involves cross-sectional correlational variables, it is vulnerable to common method bias (CMB) (Siemsen et al., 2010). A Harman's one-factor test (Podsakoff and Organ, 1986) for CMB was performed on the six scales (i.e., risk management culture, agility, integration, SC (re-)engineering, risk management performance, and firm performance) with 42 items by using principal components analysis, where the unrotated factor solution was examined. The results revealed the existence of nine factors with eigenvalues greater than one, with the first factor explaining only 39.94% of the variance and not explaining the majority of the variance. To further assess CMB, a confirmatory factor analysis was applied on the one factor and measurement model (Korsgaard and Roberson, 1995). The model fit indices for the one-factor model (χ^2 (819) = 2829.29, GFI = 0.39, AGFI = 0.33, RMSEA = 0.15) were significantly worse than those for the measurement model. These findings suggest that the CMB is not an issue in this study.

Table 1
Respondents' perceptions on supply chain risk.

Types of supply chain risk (5 Constructs/29 Measures)	Mean	Standard deviation
Demand-side Risk		
r1. Problems arising from sluggish demand owing to the global recession.	3.90	0.900
r2. Unexpected or drastic changes in client demands.	3.21	0.963
r3. Clients providing insufficient or exaggerated purchase orders or quantity demanded.	2.77	0.969
r4. Key accounts or freight forwarders transfer orders without notice.	3.04	1.040
Supply-side Risk		
r5. Schedule conflicts in dispatching empty cargo containers.	3.23	1.048
r6. Unstable quality of delivery.	2.96	0.986
r7. Overseas agents go out of business without notice.	2.73	1.272
r8. Rapid increases or drastic changes in fuel prices.	4.01	0.939
r9. Excessive or drastic changes in the market's shipping space.	3.95	1.012
r10. Insufficient or overcrowded docks.	3.27	1.107
r11. Shortage of sailors.	2.47	1.102
r12. Increases or drastic changes in the cost of shipbuilding.	3.13	1.078
Regulatory, Legal, and Bureaucratic Risk		
r13. Changes in the political environment caused by new laws or regulations.	3.15	1.033
r14. Obstacles from government regulations for supply chain setup and operation.	3.16	1.049
r15. Delays in custom clearance for cargo containers.	2.92	1.058
r16. Delays in the ship's schedule to enter or leave the harbor.	3.04	1.150
Infrastructure Risk		
r17. Ship shutdown or a loss in the shipping space owing to regional destructions (such as a strike, fire, explosion, and industrial accident).	3.30	1.199
r18. Ship shutdown or a loss in the shipping space owing to physical damage to the ship (such as a collision, fire, and explosion).	3.13	1.253
r19. Interruptions caused by failed or damaged internal information or communication systems in the company (such as computer viruses or software problems).	2.66	1.070
r20. Ship shutdown owing to its own technical problems (such as the ship is too old or the equipment is impaired).	2.71	1.077
r21. Ship shutdown owing to its supply chain partner's technical problems (such as old or damaged cargo-handling gear at the harbor).	2.96	1.116
r22. Failed or damaged external information or communication systems.	2.77	1.022
r23. Regional destruction or interruption of road infrastructure.	2.73	1.170
Disaster Risk		
r24. Unstable political environments, wars, riots, or other social-political crises.	3.44	1.176
r25. Illness or infectious diseases (such as SARS and H1N1).	2.95	1.139
r26. Natural disasters (such as an earthquake, flood, extreme weather, and tsunami).	3.49	1.215
r27. International terrorist attacks.	3.06	1.240
r28. Pirates.	2.93	1.235
r29. Illegal trades and organized crimes.	2.79	1.158

Note: Mean scores are on a five-point Likert-type scale.

5.6. Measurement model

The results of the PLS analysis are presented in Tables 2 and 3. The convergent validity and discriminant validity of the measurement model were evaluated by examining the loadings and cross-loadings of the indicators, which are presented in Table 2. All of the indicators load higher on the construct of interest than on any other variables, thereby providing evidence for the constructs' discriminant validity (Hair et al., 2014). Moreover, most of the individual factor loadings were greater than 0.707 (Hair et al., 2014), with a range from 0.682 to 0.921, thereby assuring convergent validity.

The results regarding reliability are shown in Table 3. The composite reliabilities of the different measures range from 0.900 to 0.941; thus, they all exceed the 0.700 cut-off value proposed by Fornell and Larcker (1981). Table 3 presents the validity test results. The average variance extracted (AVE) of each measure fulfilled Fornell and Larcker's (1981) accepted value of 0.5, supporting the convergent validity of our measures. Moreover, the square root of AVE values were all greater than the inter-correlation values, thereby assuring discriminant validity (Hair et al., 2014). In sum, the results of Table 3 provide evidence that the measures have sufficient reliability and validity.

5.7. Structural model

The results of the PLS analysis for the research model are presented in Fig. 3 and Table 4. Bootstrapping with 5000 samples was used to evaluate the standard errors and t-values of the path coefficients (Hair et al., 2014). The results in Fig. 3 and Table 4 indicate that a risk management culture has a direct and statistically significant relationship with liner shipping companies' agility (path coefficient = 0.535, $P < 0.001$), integration (path coefficient = 0.671, $P < 0.001$), and SC (re-)engineering (path coefficient = 0.745, $P < 0.001$). The results thus support H1-1, H1-2, and H1-3 and indicate that a risk management culture is a key factor for enhancing a liner shipping company's agility, integration and SC (re-)engineering. Moreover, the hypothesized positive relationships between agility and risk management performance (H2-1, path coefficient = 0.277, $P < 0.05$), between integration and risk management performance (H3-1, path coefficient = 0.215,

Table 2
Factor loadings (bolded) and cross loadings.

Indicator	Construct					
	Risk management culture	Agility	Integration	Supply chain (re-)engineering	Risk management performance	Firm performance
c1	**0.858**	0.462	0.591	0.702	0.548	0.402
c2	**0.906**	0.519	0.592	0.657	0.485	0.366
c3	**0.907**	0.431	0.612	0.686	0.502	0.331
c4	**0.741**	0.438	0.521	0.482	0.391	0.362
c5	**0.821**	0.411	0.477	0.586	0.389	0.239
c6	**0.844**	0.456	0.607	0.650	0.491	0.472
a1	0.520	**0.869**	0.554	0.334	0.503	0.360
a2	0.477	**0.899**	0.578	0.357	0.534	0.531
a3	0.369	**0.788**	0.507	0.331	0.386	0.402
a6	0.398	**0.765**	0.374	0.186	0.329	0.315
i1	0.462	0.590	**0.806**	0.359	0.462	0.405
i2	0.533	0.480	**0.765**	0.477	0.517	0.364
i3	0.485	0.430	**0.770**	0.417	0.326	0.381
i4	0.544	0.548	**0.857**	0.484	0.498	0.464
i5	0.605	0.516	**0.823**	0.539	0.483	0.419
i7	0.622	0.431	**0.820**	0.559	0.509	0.516
i8	0.510	0.473	**0.799**	0.424	0.489	0.562
s1	0.595	0.448	0.503	**0.741**	0.515	0.476
s4	0.695	0.257	0.562	**0.871**	0.498	0.362
s5	0.634	0.280	0.475	**0.921**	0.528	0.391
s6	0.602	0.300	0.404	**0.840**	0.421	0.393
s7	0.637	0.286	0.524	**0.879**	0.478	0.416
rp1	0.423	0.447	0.438	0.460	**0.866**	0.591
rp2	0.402	0.430	0.475	0.395	**0.874**	0.574
rp3	0.594	0.435	0.507	0.656	**0.807**	0.463
rp4	0.447	0.435	0.484	0.423	**0.840**	0.492
rp5	0.483	0.518	0.572	0.495	**0.851**	0.650
p1	0.268	0.373	0.414	0.354	0.565	**0.811**
p2	0.406	0.427	0.448	0.391	0.594	**0.863**
p3	0.326	0.452	0.437	0.406	0.592	**0.798**
p4	0.400	0.383	0.514	0.418	0.581	**0.908**
p5	0.434	0.456	0.537	0.422	0.601	**0.842**
p6	0.344	0.419	0.486	0.413	0.480	**0.824**
p7	0.382	0.391	0.477	0.399	0.430	**0.781**
p8	0.201	0.269	0.283	0.318	0.404	**0.682**

c = Risk management culture, a = Agility, i = Integration, s = Supply chain (re-)engineering, rp = Risk management performance, p = Firm performance.

Table 3
Inter-construct correlations: Consistency and reliability tests.

	AVE	Composite reliability	Risk management culture	Agility	Integration	Supply chain (re-)engineering	Risk management performance	Firm performance
Risk management culture	0.720	0.939	**0.848**					
Agility	0.693	0.900	0.535	**0.832**				
Integration	0.650	0.929	0.671	0.613	**0.806**			
Supply chain (re-)engineering	0.727	0.930	0.745	0.370	0.582	**0.853**		
Risk management performance	0.666	0.941	0.429	0.490	0.556	0.479	**0.816**	
Firm performance	0.719	0.927	0.556	0.537	0.587	0.575	0.658	**0.848**

* Square root of the AVE on the diagonal.

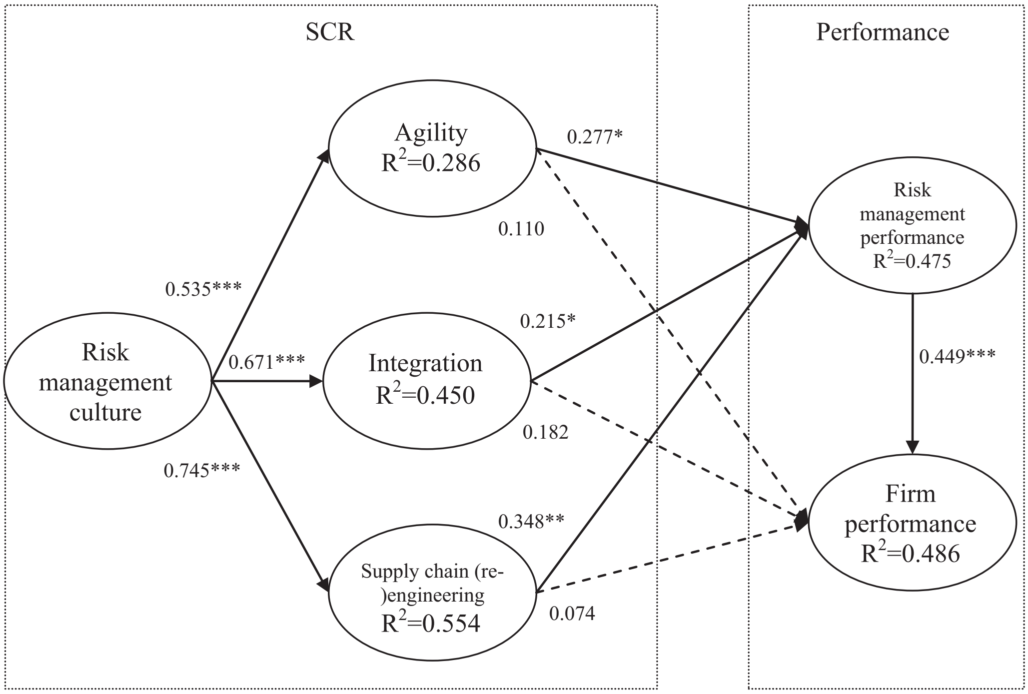

Fig. 3. Structural model results. * Represents significance at $P < 0.05$; ** $P < 0.01$; and *** $P < 0.001$. R^2 indicates the amount of variance explained by the model.

Table 4
Structural model results.

	Paths	Path coefficient	Standard Error	t-value	Supported/Not supported
H1-1	Risk management culture → Agility	0.535	0.087	6.123	Supported
H1-2	Risk management culture → Integration	0.671	0.060	11.214	Supported
H1-3	Risk management culture → Supply chain (re-)engineering	0.745	0.043	17.251	Supported
H2-1	Agility → Risk management performance	0.277	0.117	2.372	Supported
H2-2	Agility → Firm performance	0.110	0.137	0.805	Not supported
H3-1	Integration → Risk management performance	0.215	0.103	2.086	Supported
H3-2	Integration → Firm performance	0.182	0.111	1.642	Not supported
H4-1	Supply chain (re-)engineering → Risk management performance	0.348	0.123	2.823	Supported
H4-2	Supply chain (re-)engineering → Firm performance	0.074	0.117	0.632	Not supported
H5	Risk management performance → Firm performance	0.449	0.107	4.179	Supported

$P < 0.05$), and between SC (re-)engineering and risk management performance (H4-1, path coefficient = 0.348, $P < 0.01$) are supported, indicating that liner shipping companies need to improve their agility, integration and SC (re-)engineering to achieve better firm performance. However, no paths are statistically significant between the three types of SCR and firm performance, including H2-2 (agility → firm performance, path coefficient = 0.110, $P > 0.05$), H3-2 (integration → firm performance, path coefficient = 0.182, $P > 0.05$), and H4-2 (SC (re-)engineering → firm performance, path coefficient = 0.074,

Table 5
Total effects indicated by the structural model results.

	Agility	Integration	Supply chain (re-)engineering	Risk management performance	Firm performance
Risk management culture	0.535	0.671	0.745	0.551	0.484
Agility	–	–	–	0.277	0.235
Integration	–	–	–	0.215	0.279
Supply chain (re-)engineering	–	–	–	0.348	0.231
Risk management performance	–	–	–	–	0.449

Note: –, No relationship.

$P > 0.05$). The hypothesized positive relationship between risk management performance and firm performance is also supported (H5, path coefficient = 0.449, $P < 0.001$), suggesting that risk management performance is an important factor for liner shipping companies to improve their firm performance. A Sobel (1982) test was then conducted to provide additional evidence for the mediation effect, and the results reveal significant indirect effects between risk management culture and risk management performance through the three types of SCR (i.e., agility, integration and SC (re-)engineering) ($z = 2.209$, $P < 0.05$ for agility; $z = 2.052$, $P < 0.05$ for integration; $z = 2.792$, $P < 0.05$ for SC (re-)engineering). Moreover, the three types of SCR indirectly and positively affect firm performance via risk management performance ($z = 2.062$, $P < 0.05$ for agility; $z = 1.869$, $P < 0.1$ for integration; $z = 2.346$, $P < 0.05$ for SC (re-)engineering). In sum, the results show that the three types of SCR (i.e., agility, integration and SC (re-)engineering) completely mediate the relationship between risk management culture and risk management performance and that risk management performance completely mediates the relationship between the three types of SCR and firm performance. Table 5 presents the standardized structural parameter estimates (total effects), whose implications will be discussed in the next section.

6. Discussion

Among the four SCR constructs, risk management culture has the greatest total influence on both risk management performance and a liner shipping company's overall performance. Risk management culture also has a positive influence on agility (H1-1), integration (H1-2) and SC (re-)engineering abilities in liner shipping companies (H1-3). These results imply that liner shipping companies that have a better risk management culture are more likely to have higher degrees of agility, integration, and SC (re-)engineering. This finding not only provides support to previous related studies (i.e., Cao et al. (2015), illustrating the impact of organizational culture on SC integration; and Williams et al. (2009), reporting that an SC security culture can enhance organizational resilience) but also reveals the importance of a risk management culture for improving liner shipping companies' performance. Considering that risk management culture has the greatest total influence on liner shipping companies' performance, a risk management culture can be confidently claimed to be one of the most critical variables in maximizing the performance for liner shipping companies. Liner shipping companies (such as Maersk Line and Evergreen Marine Corp.) that have made larger investments in their risk management departments have thus far financially outperformed their competitors.

The RBV was used to establish a theoretical basis for this study on the relationships between SCR and both risk management performance and firm performance. SCR was viewed as a type of resource that helps liner shipping companies mitigate SC risks, maintain business continuity in the face of disruption, and increase productivity and efficiency under changing environments. All three types of SCR, agility, integration and SC (re-)engineering, have a positive significant impact on risk management performance (H2-1, H3-1, and H4-1). This finding implies that visibility and velocity, internal and external coordination, and knowledge of SC structures contribute to risk management performance. By contrast, these three types of SCR have no significant direct influence on firm performance (H2-2, H3-2 and H4-2); rather, they indirectly influence firm performance through risk management performance. Thus, agility, integration, and SC (re-)engineering have to be transformed into risk management performance before they can create superior firm performance. This finding is similar to that of Yang (2014), who shows that SC agility can enhance firm performance through cost efficiency, and to that of Huo (2012), who indicates that customer integration can enhance firm performance via customer-oriented performance. As SCR requires extra resources and investments (e.g., extra labor and equipment) to overcome unexpected incidents, it may not have a direct, positive impact on firm performance. Thus, the direct effects of SCR on firm performance may be reduced by the required preparations and investments and may result in a negligible direct impact on firm performance.

Although the three types of SCR (i.e., agility, integration and SC (re-)engineering) are not directly associated with firm performance, they influence firm performance through risk management performance. Risk management performance has a positive significant effect on firm performance (H5). This finding is consistent with those of Andersen (2009), Jun and Rowley (2014), and Ping and Muthuveloo (2015), and it implies that an organization's risk management ability and resource input level for risk management contribute to its performance. The ability to rapidly respond to the changing market also helps companies meet customer needs and mitigate the negative impacts of SC vulnerability, which increases firms' revenue and profit.

To provide practical insights, the authors compare the findings with actual shipping policies to address the three key questions. First, how do agile practices positively influence carriers' risk performance in the real world? Many agile practices are frequently used by shipping liners. For example, the top-20 leading liner companies have time-chartered a large percentage of their fleets in the last decade to avoid owning a large amount of tonnage during a market downturn and to maintain their service capacity in the meantime. Ship-owners also constantly change their routings from around-the-world routing to pendulum routing, and seafarers are trained to work first as an ordinary seaman, then as an able-body seaman, and finally as a general purpose seaman. Further, deck officers are now trained to handle both ship navigation and radio operations. Thus, these practices show that carriers' employees are capable of executing multiple kinds of tasks and jobs.

Second, do we have any examples to show carriers' integration practices positively affect their risk performance? Liner companies' services are also increasingly integrated, and alliance members have shared and integrated most of their data on logistics solution systems such as Cargo Smart. Ocean container carriers are also integrating their sea transportation services with their own quayside container terminal operations to reduce the potential risks of service interruptions resulting from berth unavailability. For instance, APM Terminals (APMT), a member of the AP-Moller Group, signed an agreement worth $1bn to purchase the remaining 39% of rival terminal operator Grup Maritim TCB in 2015. This example demonstrates that a company's integration between the upstream and downstream SC members can increase the flexibility of its operation.

Third, why is there a positive relationship between SC (re-)engineering and carriers' risk performance? SC (re-) engineering is essential for large liner companies to survive in an unpredictable environment. For instance, Maersk Lines, COSCO, Evergreen and so forth have set up risk management departments and risk management committees. Further, the enforcement of the ISM (International Safety Management) Code in 1998 induced many ocean carriers to reorganize their operations departments to include ISM internal audit teams. Most carriers already have built up ISM departments or teams to address issues related to SC risk management. Indeed, the Australia Transport Safety Bureau (2012) has surveyed carriers, and the results show that including safety management systems in regular business operations does improve safety performance for carriers.

Large container liner companies such as Evergreen Marine Corp. have long established risk management offices, and they regularly inspect their daily operational practices to prevent dangers from occurring and to reduce losses arising from risk. Container liners thus have to buy hull and machinery insurance, protection and indemnity insurance (P&I), piracy attack insurance and so forth to counter the various potential risks, and container liners with good risk management practices can reduce the chance that risks occur. Although all the insurance premiums and the initial calls by P&I firms are initially a burden for carriers, with a good risk performance record, these fees can be greatly reduced, and the overall financial performance of container carriers can be greatly improved. Liner companies with large risk management offices are mostly well-known ocean carriers, and their market shares and annual revenues are greater than those of ocean carriers without risk management offices.

7. Conclusion and implications

This study evaluates the relationships between risk management culture, agility, integration, SC (re-)engineering, risk management performance, and the firm performance of liner shipping firms in Taiwan and provides several contributions to the relevant literature and SCR practice. First, it examines different types of SCR and their interrelationships with firm performance. Second, it reveals the impacts of different types of SCR on firm performance from the RBV perspective. Finally, it provides several guidelines for management personnel to understand how to commit effort and resources in response to different types of SCR. These guidelines also provide a detailed illustration of how to manage different measures of SCR in order to increase firm performance. The efforts devoted to this study are a great addition to the existing literature. In the past, there have been relatively few empirical studies on the different types of SCR and their effect of firm performance based on a single model. Prior studies have also devoted little attention to the mediating effects among different types of SCR and firm performance. Thus, this study supplements previous research by linking risk management culture, agility, integration, and SC (re-)engineering to risk management performance and firm performance. The analysis shows the perfect mediating effects in the relationships among the different types of SCR and performance and thus provides a greater level of richness to the SCR-performance model. Specifically, this study identifies four types of SCR and finds that a risk management culture directly influences the other factors. In fact, a risk management culture is the major driver of firm performance. Most importantly, this study contributes to SCR implementation by helping liner shipping managers understand how to direct their efforts to achieve superior performance.

The first managerial implication of this research is that liner shipping firms must develop different types of SCR to improve their overall performance. For liner shipping firms to improve their SCR, they must first focus on establishing a risk management culture. If firms have a weak risk management culture—such as insufficient training against disruptions, low risk awareness, and poor sharing of risk management knowledge—it will be difficult for them to respond to appropriately changes, to increase their ability to share information between organizations during times of disruption, and to allocate in advance more resources to deal with incidents related to SC risks. Second, companies must pay attention to agility (including their sensitivity to the business environment, their response to market changes, and even their partners' ability to react), integration (including intra- and inter-organizational sharing of information and operation integration), and SC (re-) engineering (including knowledge and understanding of SC structures) because these factors directly influence risk management performance, which leads to greater firm performance. If there is no resource constraint, firms should develop these four types of SCR simultaneously because the ultimate firm performance can only be reached when all four are fully developed. For example, if a firm lacks agility, its risk management culture cannot utilize the advantages of the agility mediator to improve risk management performance, which ultimately improves firm performance. In sum, the best way to achieve firm performance is to develop a risk management culture and to then focus on developing agility, integration and SC (re-) engineering. In the era of labor specialization and globalization, SCs often appear as weak and complicated. Similarly, service routings of liner shipping firms are also globalized. In terms of demands, liner shipping firms face problems that arise from global economic cycles, and with regard to supply, there are also severely unstable factors, such as personnel shortages on international ships, changes in fuel pricing, and fluctuations in the cost of ship construction. The difficulty in controlling operational costs and efficiency makes it difficult for liner shipping firms to use cost and efficiency as their competitive advantages. Instead, the ability to predict changes in the SC, timely reaction in the face of disruptions, and the ability to mitigate negative effects of SC vulnerability are important. Liner shipping firms must prudently develop SCR to ensure the smooth operation of their SC.

This study has some limitations, as well as some opportunities for future study. First, the research sample was drawn from liner shipping firms in Taiwan. Future research could conduct an international comparison to enhance the generalization of the research findings. Second, the results of this research provided only a starting point for more rigorous studies on SCR. Some new emerging factors (such as resource sharing and alliances may have potential moderating and mediating effects on SCR) related to the relationship between SCR and liner companies' performance should be updated and used in our model for the future study. Moreover, further studies are needed to generate more in-depth knowledge regarding how to enhance SCR in the liner shipping industry. Finally, cross-sectional data were collected in this research to minimize causal inference. Future empirical efforts in the area might consider the use of panel data to reveal how perceptions of SCR and performance change over time.

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Appendix A. Items used in developing the scales

A.1. Supply chain risk

Please evaluate the degree to which the supply chain risk factors listed below negatively influenced your company or your container ship operator in the past three years (from 1 "no influence" to 5 "huge influence").

A.1.1. Demand side risk

r1. Problems arising from sluggish demand owing to the global recession.
r2. Unexpected or drastic changes in client demands.
r3. Clients providing insufficient or exaggerated purchase orders or quantity demanded.
r4. Key accounts or freight forwarders transfer orders without notice.

A.1.2. Supply side risk

r5. Schedule conflicts in dispatching empty cargo containers.
r6. Unstable quality of delivery.
r7. Overseas agents go out of business without notice.
r8. Rapid increases or drastic changes in fuel prices.
r9. Excessive or drastic changes in the market's shipping space.
r10. Insufficient or overcrowded docks.
r11. Shortage of sailors.
r12. Increases or drastic changes in the cost of shipbuilding.

A.1.3. Regulatory, legal, and bureaucratic risk

r13. Changes in the political environment caused by new laws or regulations.
r14. Obstacles from government regulations for supply chain setup and operation.
r15. Delays in custom clearance for cargo containers.
r16. Delays in the ship's schedule to enter or leave the harbor.

A.1.4. Infrastructure risk

r17. Ship shutdown or a loss in the shipping space owing to regional destructions (such as a strike, fire, explosion, and industrial accident).
r18. Ship shutdown or a loss in the shipping space owing to physical damage to the ship (such as a collision, fire, and explosion).
r19. Interruptions caused by failed or damaged internal information or communication systems in the company (such as computer viruses or software problems).
r20. Ship shutdown owing to its own technical problems (such as the ship is too old or the equipment is impaired).
r21. Ship shutdown owing to its supply chain partner's technical problems (such as old or damaged cargo-handling gear at the harbor).
r22. Failed or damaged external information or communication systems.
r23. Regional destruction or interruption of road infrastructure.

A.1.5. Disaster risk

r24. Unstable political environments, wars, riots, or other social-political crises.
r25. Illness or infectious diseases (such as SARS and H1N1).
r26. Natural disasters (such as an earthquake, flood, extreme weather, and tsunami).
r27. International terrorist attacks.
r28. Pirates.
r29. Illegal trades and organized crimes.

A.2. Supply chain resilience

Please indicate your level of agreement regarding the following statements with respect to your company or your container ship operator (from 1 "strongly disagree" to 5 "strongly agree").

A.2.1. Risk management culture

c1. The company uses different means to encourage its employees to share their knowledge about risk management.
c2. The company has included the subject of risk management as an important topic in new personnel training.
c3. The company provides training to its employees regarding the necessary measures to take in the event of a risk incident.
c4. Ensuring the proper functioning of the supply chain is every employee's top priority.
c5. Risk awareness is common in our company.
c6. The company believes that "risk management" and "job performance" are equally important.

A.2.2. Agility

a1. The company is fairly sensitive to the opportunities and threats in the business environment.
a2. The company can rapidly respond to the changing market.
a3. The company reserves extra service capacity in response to the rapidly changing market.
a4. The company can provide customized services to clients (such as shippers and freight forwarders).
a5. The company fully authorizes its managers to make special accommodations for important clients.
a6. One of the company's important criteria for finding collaborative partners is their agility and ability to react.
a7. The company frequently adjusts the course of the ships in response to the rapidly changing market.
a8. The company's employees are capable of executing multiple kinds of tasks and jobs.

A.2.3. Integration

i1. The company has adopted information systems (such as ERP) to assist in information sharing.
i2. Information about the operations of different departments is shared effectively in the company.
i3. The company's compensation and motivation mechanisms consist of factors that promote integration.
i4. The company effectively shares information about its operation with our important suppliers and/or clients.
i5. The company's integration with the upstream and downstream supply chain members has increased the flexibility of its operation.
i6. The company has made supply chain agreements with some suppliers and clients to share the remuneration and risks together.

i7. The company has successfully integrated the clients' and/or suppliers' operations via cross-company information platforms or related activities.
i8. The company can integrate clients' innovative ideas to design new services.

A.2.4. Supply chain (re-)engineering

s1. The company considers its risk management ability to be one of the important criteria in the process of choosing suppliers or strategic partners.
s2. The company frequently redistributes the fleet of ships in response to drastic changes in the market.
s3. The company's high-level executives believe that some "extra" resources (such as manpower and equipment) are not wasted; rather, they are preparations for sudden incidents.
s4. The company already has the risk management mission statements or strategies in writing.
s5. The company already has specific departments or teams to deal with issues related to supply chain risk management.
s6. The company has already included the item of risk management performance in personal KPIs.
s7. The company has allocated more resources to deal with incidents related to supply chain risks.

A.3. Risk management performance and firm performance

The items below are related to the aspects of performance indicators at your company or your container ship operator. Please rate your level of satisfaction with the following statements (from 1 "strongly dissatisfied" to 5 "strongly satisfied").

A.3.1. Risk management performance

rp1. The company's ability to confront opportunities and threats in the environment compared to three years ago.
rp2. The company's risk management ability compared to three years ago.
rp3. The company's resource input into risk management compared to three years ago.
rp4. The company's level of agility compared to three years ago.
rp5. The company's level of integration between upstream and downstream supply chains compared to three years ago.

A.3.2. Firm performance

p1. The company's level of customer loyalty compared to its major competitors.
p2. The company's level of customer satisfaction compared to its major competitors.
p3. The company's corporate identity compared to its major competitors.
p4. The company's overall service level compared to its major competitors.
p5. The company's operational performance compared to its major competitors.
p6. The company's sales volume compared to its major competitors.
p7. The company's market share compared to its major competitors.
p8. The company's net profit before tax compared to its major competitors.

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