Logistics innovation capability and its impacts on the supply chain risks in the Industry 4.0 era

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Abstract

Purpose – The purpose of the paper is to present an empirical study on the logistics innovation capability and its impacts on the supply chain risk in the Australian courier firms. Based on the resource-based review, logistics innovation capability provides valuable insight into mitigating supply chain risks in the Industry 4.0 era.

Design/methodology/approach – The research model focuses on the relationships between logistics innovation capability and supply chain risk. Partial least squares approach for structural equation modelling is used to validate the research model by empirically analysing survey data.

Findings – The empirical result shows negative relationships between logistics innovation capability and supply chain risks. These relationships may imply that firms can mitigate the negative impacts of supply chain risks by developing logistics innovation capabilities. The findings demonstrate the applicability of logistics innovation capability for mitigating supply chain risks in the Australian courier firms.

Originality/value – There are very few empirical studies on the mitigating supply chain risk through logistics innovation capability. The empirical results provide an insight into innovation management and risk management in logistics and supply chain. This insight offers practical guidance for developing and deploying logistics innovation capability to support and enable supply chain risk management strategies in the Industry 4.0 era.

Keywords Innovation, Capability, Supply chain risk, Logistics management, Transport, Industry 4.0

Paper type Research paper

1. Introduction

As market competition for logistics and transport increases, a growing number of logistics and transport firms try to pursue the operational excellence so that the company can provide the excellent logistics operations to gain a firm's market share for sustainable development in

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the long term (Christopher, 1996). This is one of the important objectives of the fourth industrial revolution (Industry 4.0), which accelerates the development of innovation capability in various industries (Frank *et al.*, 2019; Lasi *et al.*, 2014). Supply chain risk is one of the obstacles to achieving operational excellence. Many researchers urge that supply chain risk is a problem in supply chain and logistics (Davis, 1993; Lee, 2002; Miller, 1992; Prater, 2005; Vasco *et al.*, 2010; Wang, 2018). In addition, supply chain risk management plays a vital role in building resilience and achieving sustainability of organisations (Christopher and Peck, 2004). Many previous supply chain risk studies focus on supply chain risk identification and classification (Manuj and Mentzer, 2008; Simangunsong *et al.*, 2012; Sodhi and Lee, 2007; Tang and Nurmaya Musa, 2011; Wang and Jie, 2019). However, lacking resolutions of supply chain risk is a problem, which has also been raised in previous studies (Borut *et al.*, 2012; Guido *et al.*, 2008; Sanchez-Rodrigues *et al.*, 2010; Simangunsong *et al.*, 2012; Wang, 2018). Moreover, the world-leading logistics and transport firm DHL recognises that the supply chain risk may hamper firms towards operational excellence, which is achieved through a focus on systems, cost-effectiveness and speed (Christopher, 1996). Therefore, it is significant to investigate a contingency way to manage supply chain risks.

Innovation capability has a long history of research; it was developed from the resource-based view (RBV) theory. Firms can gain and sustain competitive advantages by developing and deploying valuable resources and capabilities (Olavarrieta and Ellinger, 1997; Wernerfelt, 1984). The RBV theory states that in a firm, the resources comprise skills, technologies, capabilities and infrastructure. The resources and capabilities have to be coordinated and deployed in order to generate competitive advantages (Mohamed *et al.*, 2014). Furthermore, capabilities are complex bundles of skills and accumulated knowledge, exercised through organisational processes, which enable firms to coordinate activities and make use of their assets (Day, 1994). Hafeez *et al.* (2002) regard capability as the ability to make use of resource to perform some task or activity and define a resource as anything tangible or intangible owned or acquired by a firm. RBV of the firm provides valuable insights for understanding how competitive advantage within firms is created and how the advantage is sustained over time. The companies obtain a competitive advantage by accumulating internal resources and capabilities that are rare, valuable and difficult to imitate (Grant, 1991; Olavarrieta and Ellinger, 1997; Russo and Fouts, 1997). Implementing logistics innovation to solve the problems in logistics and transport is not new (Daniel and Fredrik, 2011; Flint *et al.*, 2005; Scott, 2009). Industry 4.0 is rooted in the smart manufacturing concept, which required new technologies and innovation capabilities (Frank *et al.*, 2019). The logistics service providers compete based on their capabilities (Lai, 2004; Wang, 2016b).

Logistics capability improves logistics operations, and an effective logistics operation generates competitive advantage and gains a firm's market share (Mentzer and Flint, 1999; Scott, 2009; Wang *et al.*, 2018). Seeking perfection is one of the key principles of operational excellence in the Industry 4.0. In this study, we argue that logistics innovation capability may help firms to manage supply chain risks through excellent logistics operations. According to a contingency theory, this study attempts to understand the associates between the logistics innovation capabilities and supply chain risks. The findings may imply the supply chain risk management strategies and applicability of logistics innovation for mitigating the supply chain risk in the Australian courier firms. Supply chain risks mainly reflect the negative impacts on logistics operations, such as delays, damage and loss (Sanchez-Rodrigues *et al.*, 2010). Excellent logistics operations need to reduce and mitigate negative impacts. The findings reveal that logistics innovation capability mitigates the impacts of the supply chain risks. This also supports the Industry 4.0 research.

The rest of the paper is structured as follows. Section 2 provides a literature review on logistics innovation capability and supply chain risk. Section 3 shows the research model and

hypotheses development. Section 4 and 5 present the research methodology and empirical data analysis. Section 6 discusses the findings, implications and conclusion.

2. Literature review

Logistics innovation capability

Innovation is an important logistics capability (Fawcett and Stanley, 1997; Hayes *et al.*, 1988; Lu and Yang, 2010; Morash 1996, 2001). Innovation capability is considered as a dynamic capability (Lawson and Samson, 2001). Dynamic capabilities theory was developed from the RBV theory. Teece *et al.* (1997) developed the RBV approach one step further by formulating the dynamic capability perspective. Innovation capability is defined as the firm's ability to continuously transform knowledge and ideas into new products, processes and systems for the benefit of the firm (Lawson and Samson, 2001; Yang, 2012). A dynamic capability is distinct from operational capabilities, which is involved in the current operations of an organisation. Dynamic capabilities, by contrast, refer to "the capacity of an organisation to purposefully create, extend, or modify its resource base"(Helfat, 2007). Winter (2003) describes two different types of capabilities: ordinary or 'zero-level' capabilities as those that allow a firm to 'make a living' in the short term; the other type of capability is dynamic capability. The latter one is higher level capabilities, which can be deployed to extend, modify or create the ordinary or 'zero-level' capabilities (Winter, 2003). Logistics innovation capability is considered as a higher level capability to reconfigure operation capabilities to achieve excellent logistics operations and mitigate supply chain risk. Innovation can reconfigure and transform both external and internal resources in order to adapt the company's strategy (Teece *et al.*, 1997). Logistics innovation refers to the new technology, new services, new processes and new ideas, which are used for improving logistics operations (Scott, 2009). In this paper, the logistics innovation capability is an ability to incorporate the logistics innovation to solve the problem and adapt to a fluctuating environment in a supply chain.

The rapidly changing and uncertain business environment raises challenges to enterprises, and innovation is an important tool for keeping their competitive advantage (Lin, 2006). Notably, some researchers found innovation can be used for reducing supply chain risk (Daniel and Fredrik, 2011; Lin, 2013). Dani (2010) emphasises that building innovative culture, innovative processes and innovation capability are key to managing and mitigating supply chain risks. Also, innovation has positive effects on logistics service and is critical for strengthening the Logistics Service Provider (LSP)–customer relationship, generating customer loyalty, achieving competitive advantage and improving the performance of logistics service firms (Asian, 2019; Flint *et al.*, 2005; Wagner and Sutter, 2012). Lin (2013) suggests that logistics service providers pay more attention to innovation capability, to provide better services for their customers.

For example, FedEx is one of the most successful and innovative 3PL providers in the world. Its overnight delivery service changed how business-to-business and business-to-customer transactions operated, offering businesses the opportunity of using just-in-time techniques which saved warehousing space and reduced overall costs. The introduction of efficient consumer response techniques led to smaller and more efficient shipment sizes, which in turn further reduced costs (Black and Hunter, 2003; Wang, 2016a; Wei *et al.*, 2018).

Supply chain risk

There are multiple ways to define the concept of risk. Everyone has his/her own perspectives to understand and justify the risk. Thus, it is significant to consider the risk factors in a specific context. This study concentrates supply chain risks in logistics and transport operations. For managers, the risk is a threat that something might happen to disrupt normal activities or stop things happening as planned (Flynn *et al.*, 2016; Waters, 2011).

Risks occur because people never know what will happen in the future. People can use the best forecasts and do every possible analysis, but there is always uncertainty about future events (Waters, 2011). Supply chain risk is a complex notion that may come in different forms and may comprise supply chain risk sources, risk consequences and risk drivers (Christopher and Lee, 2004; Jüttner *et al.*, 2003; Manuj and Mentzer, 2008; Rodrigues *et al.*, 2008). In the supply chain risk management literature, the risk is due to unreliable and uncertain resources creating supply chain interruption (Tang and Nurmaya Musa, 2011). In this study, supply chain risk is considered as the impacts, consequences and/or errors (e.g., delays, damages and loss) that may harm the logistics operations.

According to an extensive review of the literature and previous studies, supply chain risk is categorised into three major clusters in this study, (1) company-side risk, (2) customer-side risk and (3) environment-side risk (Murugesan *et al.*, 2013; Sanchez-Rodrigues *et al.*, 2010; Simangunsong *et al.*, 2012; Wang, 2018; Wang *et al.*, 2014). Courier companies deliver a parcel from a point of pickup to a point of destination. Normally, three parties are directly involved in a typical courier delivery: senders, receivers and delivery companies (Wang, 2016a). The three categories balance and simplify the way to assess internal, external and environmental risks in the courier industry (Christopher and Peck, 2004; Miller, 1992).

Company-side risk. In this paper, supply chain risks are concentrated on logistics and transport service providers. The company-side risk can broadly be categorised as the potential disturbances to the flow of goods and information (Ellegaard, 2008). It consists of logistics risk and information risk. Logistics risk is defined as weakness, fault, error, loss and/or unexpected outcome that may influence normal logistics-related activities/processes in transport service providers. Some factors of logistics risk in the literature relating to courier companies include delays in delivery time (Rodrigues *et al.*, 2008; Simangunsong *et al.*, 2012), transport network management (Sanchez-Rodrigues *et al.*, 2008), storage issues (Hauser, 2003), carrier strength (Hauser, 2003) and freight transport operations (Sanchez-Rodrigues *et al.*, 2010). They may disrupt normal operations and cause problems (Hauser, 2003; Rodrigues *et al.*, 2008; Simangunsong *et al.*, 2012). Information risk is defined as information-related unexpected incidents; outcome and/or problems may influence the information in time, accuracy and availability in logistics and transport service providers. Information is the aider in the smooth functioning of the supply chain. The information risk addressed in the literature includes unavailability of information (Guo *et al.*, 2006), information delays (Cucchiella and Gastaldi, 2006), breakdowns of information infrastructure (Blackhurst *et al.*, 2008) and other information and communication issues (Sanchez-Rodrigues *et al.*, 2010).

Customer-side risk. Customer-side risk mainly occurs from customer-related processes, e.g., enquiry and quotation, order receipt, order processing and order amendment. In this paper, customer-related risk, a type of supply chain internal risk which mainly originates from the customer side rather than the company side, may cause disputes and/or influence the normal logistics operations in logistics service providers. Due to the nature of courier delivery, both the consignee (receiver) and the consignor (sender) involved in a transaction play an equally important role in the delivery process (Wang, 2011). It is important to consider both receivers and senders together. In supply chain literature, there are various customer-related risks, e.g., unanticipated customer, reputation, forecast error, delays to customer and receivable risks (Chopra and Sodhi, 2004; Manuj and Mentzer, 2008; Sodhi and Lee, 2007; Sodhi and Tang, 2012).

Environment-side risk. Supply chain risk can arise due to the interactions between the supply chain network and its external environment/events. The environmental risk is an important type of supply chain risk; it has been discussed widely in previous studies (Manuj and Mentzer, 2008; Simangunsong *et al.*, 2012; Sodhi and Lee, 2007; Zsidisin, 2003). In supply chain literature, most environment risks are unavoidable; e.g., driver shortage, road congestions/closures, regulations and natural disaster. Recently, the terrorist attacks, piracy

and unstable politics result in more supply chain risks. As a logistics service provider, courier companies need to consider the external environmental factor beforehand. It is significant to study the environment-side risk in the supply chain. Therefore, in this study, the environment-side risk includes labour, road congestion, natural disasters, fuel price and regulations. (Blackhurst *et al.*, 2008; McKinnon and Ge, 2004; Sanchez-Rodrigues *et al.*, 2010; Simangunsong *et al.*, 2012).

Supply chain risk mitigation

Mitigation is one of the important strategies to manage supply chain risks. Manuj and Mentzer (2008) summarise the existing literature from supply chain and related disciplines to suggest a five-step process for supply chain risk management. The steps consist of risk identification, risk assessment and evaluation, selection of appropriate risk management strategies, strategy implementation and supply chain risk mitigation. Mitigation of supply chain risks is an important part of supply chain risk management. Jüttner *et al.* (2003) suggest the basic constructs of supply chain risk management, including mitigating risks in a supply chain. From a single company view in a supply chain, Miller (1992) suggests risk mitigation strategies including avoidance, control, cooperation and flexibility.

The major categories of techniques of managing the risk include avoidance (i.e., eliminating, withdrawing from or not being involved in the risk), reduction (optimising and mitigating the risk), sharing (transferring, outsourcing or insuring the risk) and retention (accepting and budgeting) (Dorfman, 2008). Furthermore, mitigating supply chain risks does not try to influence or alter the source of risk. Instead, it tries to find ways to adapt and hence minimise the impact of risk (Simangunsong *et al.*, 2012; Wang, 2016a). The supply chain is a complex system consisting of various enterprises processes and relationships (Pettit *et al.*, 2013), and each party connects to the different business partners via separate channels (Lambert and Cooper, 2000). Any change in one party could cause new issues, unexpected consequences and chain reactions in an entire supply chain. Chopra and Sodhi (2004) summarise that capability development is a risk mitigation approach in the supply chain. It minimises the negative supply chain risk impacts.

In this paper, the logistics innovation capability is considered as a supply chain risk mitigation tool to manage the risks and improve supply chain resilience. In the Industry 4.0 era, companies rely on new technologies to achieve better business performance (Frank *et al.*, 2019; Gilchrist, 2016). Logistics innovation capability includes the ability to manage technology and process innovation. Furthermore, the study investigates whether logistics innovation capability affects supply chain risk.

3. Research model and hypothesis development

With the development of Industry 4.0, new technologies and ideas have been widely implemented in the industries. Logistics and supply chain plays a vital role in delivering and connecting the sectors. This may imply the importance of the innovation capability in the logistics and supply chain to support the Industry 4.0 research (Frank *et al.*, 2019; Lasi *et al.*, 2014). Logistics innovation capability is heavily involved in logistics and transport operations; it provides opportunities for improving the business performance, as in packaging innovations that decrease the risk of damaging goods in transit (Daniel and Fredrik, 2011). Containerisation is a typical example of innovating to improve logistics operations and reduce the risks and uncertainty in transit (Scott, 2009). The logistics and transport industry has seen many examples of logistics innovation, for example, smart packaging has become an important research topic in the smart supply chain (Frank *et al.*, 2019; Schaefer and Cheung, 2018). This creative idea can minimise company-side supply chain risks, e.g., reducing waste and improving information sharing (Lasi *et al.*, 2014; Schaefer and Cheung, 2018; Wollschlaeger

et al., 2017). Logistics innovation is capable of managing the logistics risks, which is considered as an important enterprise risk (Scott, 2009; Simangunsong *et al.*, 2012). In this study, the logistics innovation capability comprises new technologies and services, such as real-time online tracking and tracing service; this has been widely used in logistics companies to provide accurate and timely information. The information technologies reduce the supply chain risks, which are caused by delay or unavailability of information (Christopher and Lee, 2004). Material requirement planning (MRP) systems are used to improve the information manipulation, resulting in reducing supply chain risk in firms (Chrwan-jyh and Phillip, 1994). Thus, the following hypothesis is proposed:

H1. Logistics innovation capability is negatively related to company-side risk.

Logistics innovation capability is critical for strengthening the LSP–customer relationship, generating customer loyalty (Asian, 2019; Flint *et al.*, 2005; Wagner and Sutter, 2012). Today's customers have much higher expectations than ever before; many new problems and unexpected issues required creative problem-solving processes. The logistics innovation capability provides an opportunity to resolve the relevant problems and issues, and develop customer relationships. Furthermore, a good relationship between logistics firms and customers may reduce the customer-related uncertainty and risk. For example, FedEx's overnight delivery service changed how business-to-business and business-to-customer transactions operated. This offered businesses the opportunity of using just-in-time techniques, which saved warehousing space and reduced overall costs. The introduction of efficient consumer response (ECR) techniques led to smaller and more efficient shipment sizes, which in turn further reduced the risks (Black and Hunter, 2003). Thus, the following hypothesis is proposed:

H2. Logistics innovation capability is negatively related to customer-related risk.

Environmental risk is an important supply chain risk (Ho *et al.*, 2015). The environmental fluctuations caused unexpected changes, risks and uncertainties, which have impacts on the company performance (Lu *et al.*, 2018; Szu-Yuan *et al.*, 2009), and logistics innovation capability can influence the company performance (Wang, 2018; Wang *et al.*, 2018). One example of logistics innovation capability reducing environment-side risk is logistics companies introduced a flexible fuel factor or fuel surcharge against unstable fuel price (Hoffman, 2006). Today, most transport and logistics companies introduced the fuel surcharge into the delivery cost. Moreover, using new technologies and creative ideas to mitigate environmental uncertainty and risk have been promoted in previous studies (Hayes *et al.*, 1988; Kim, 2006). Thus, the following hypothesis is proposed:

H3. Logistics innovation capability is negatively related to environmental risk.

Overall, the research framework comprises logistics innovation capability and supply chain risk. The measurements of logistics innovation capability in this paper are drawn from previous studies (Braunscheidel and Suresh, 2009; Hayes *et al.*, 1988; Wang *et al.*, 2015). The three categories of supply chain risk, including company-side risk, customer-side risk, and environment-side risk (Sanchez-Rodrigues *et al.*, 2010; Simangunsong *et al.*, 2012), are used to assess the supply chain risks in the Australian courier firms. The conceptual research framework is indicated in Figure 1.

4. Research methods

The study aims to investigate the relationships between logistics innovation capability and the different types of supply chain risks, including company-side risk, customer-side risk, and environment-side risk (Wang, 2018). The partial least squares approach for structural

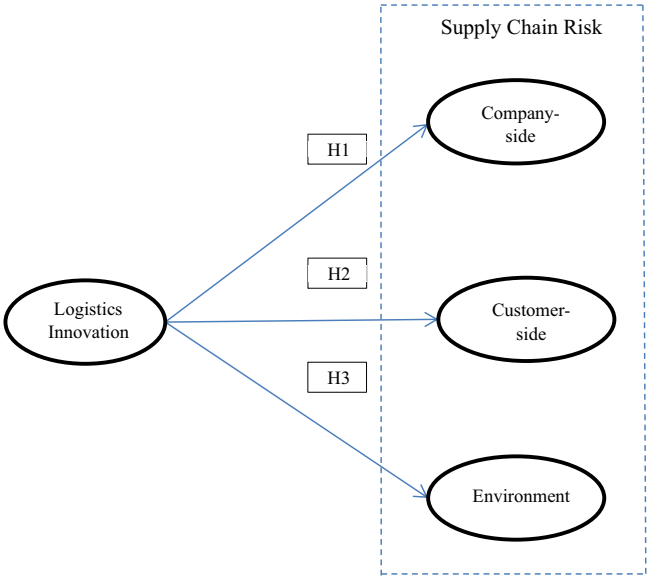

Figure 1.
Research framework

equation modelling (PLS-SEM) is applied to validate the research model by empirically analysing survey data. The SmartPLS version 2.0.M3 statistical software package is used for data analysis. The questionnaire was reviewed and discussed with supply chain and logistics academicians, researchers and managers from world-leading logistics and transport firms in Australia and New Zealand. Pilot testing was conducted before using the instrument for actual data collection. The purpose of a pilot test is to ensure that the preliminary questionnaire is appropriate, valid and well developed. The author designed it with a specific format to collect information from the respondents to develop estimable variables for the individual incentives in a straightforward fashion.

Data collection

The questionnaire survey in this research is a major instrument for collecting primary data. At the beginning of the data collection, the pilot testing of instruments with a small number of participants was conducted. The questionnaire was designed for people currently working in the Australian courier industry, with the knowledge and experience to answer the questions.

The online method was used to circulate questionnaires, and direct electronic data entry was used for recording answers. We used a Web-based survey so that the online questionnaire could be accessed via a PC, Tablet and smartphone. The participants who might not have been able to access computers, e.g., drivers and warehouse staff, could respond to the survey on smartphones. A survey population was selected randomly from the Australian business register online and Australian yellow page.

We deleted the incomplete responses. A total of 160 valid responses have been used for data analysis. The respondents are from five states and three territories in Australia. Over 70 per cent of respondents indicate that they are working at a management level including general/branch/operations manager, sales/customer services manager or other managers. Of all participants, 60 per cent had been working in their current firms for over five years; 66 per cent had more than five years of experience in the transport and logistics industry. This level of

experience would enhance the accuracy of the data, and the quality of responses was satisfactory.

Furthermore, we asked participants to indicate whether or not their companies are implementing supply chain risk management and 90 per cent of respondents indicated that they were aware of the problems/negative impacts of supply chain risks. However, only 50 per cent of respondents recognised risk management/mitigation activities undertaken in their companies. This may imply that the Australian courier companies need to pay more attention to the supply chain risk management strategies.

Measures

Measurement is an important part of business research that facilitates correspondence between the world of concepts and the world of observations (Hammersley, 1992). In the study, a multiple-indicator measure was employed to measure the concepts (Bryman and Bell, 2011), mainly because there are potential problems relying on a single indicator. Also, SEM requires a minimum number of indicators for each latent variable (Loehlin, 2004). Multiple-indicator measures may minimise measurement errors and improve the reliability and validity of measures of concepts (Grinnell and Unrau, 2011). The questionnaire is structured and presented on a seven-point Likert scale. This is a common format for assessing participants' opinions of usability. In the Likert-type scale used in this study, we asked the participants to indicate the degree to which they agree or disagree with each of the logistics innovation capability's statement presented in the firm compared to the major competitors; the value '1' represents 'strongly disagree', and the value '7' represents 'strongly agree'. Due to the nature of risk, we measured the severity of the impact of each risk variable in the firms (Wang *et al.*, 2014). If a risk variable has a very high impact in the firm, the rating should be maximum (i.e. Seven represents 'very severe problem'); if it has no impact, then the rating should be least (i.e. One represents 'no problem') and if it is in between these two ranges, the rating should be between two and six based on their severity.

5. Results

This section presents confirmatory factor analysis results for the measurement model and structure model by using structural equation modelling software SmartPLS. Measurement models were used to assess the reliability and validity of the scale items, and the proposed hypotheses were tested in a structural model. Based on the factor analysis, we confirm that the logistics innovation capability has one underlying factor, and the supply chain risk consists of company-side risk, customer-side risk and environment-side risk.

Measurement model

Reliability is an assessment of the degree of consistency between multiple measurements of a variable (Hair, 2010). This study applied the reliability coefficient with Cronbach's alpha. Validity is another important dimension to indicate the degree of accuracy of measurements. Convergent validity assesses the degree to which two measures of the same concept are correlated (Hair, 2010). Strong correlations are required to ensure convergent validity, and anything greater than 0.7 is considered satisfactory.

In contrast, discriminant validity is the degree to which two conceptually similar concepts are distinct (Hair, 2010) and so indicates that the scale is sufficiently different from other similar concepts. Normally discriminate validity can be determined from the factor correlation matrix; less than 0.7 is considered satisfactory (Hair, 2010). Convergent validity is demonstrated by loadings greater than 0.700, average variance extracted (AVE) greater than 0.500, composite reliability (CR) greater than 0.700 and communalities greater than 0.500.

Discriminant validity is demonstrated by the square root of the AVE being greater than any of the interconstruct correlations (Hair *et al.*, 2012). The factor analysis is used to examine the t-values of the measurement model loading in the study. Table I summarizes the results.

Structural model

The structural model is validated in this section. A path coefficient is used for hypotheses testing. The estimation of the structural relationships in the model was conducted by using a bootstrap routine with 2,000 iterations. The requirement for β to be significant follows the standard suggested by Hair *et al.* (2010) that the relative t-value should be greater than 1.96, which is equivalent to the 95 per cent confidence interval. The significance of β indicates that if a relationship exists in PLS, it can be measured by bootstrapping. A negative β indicates the direction of the relationship as hypothesised, while a positive β indicates the opposite. The standardised path estimates (β) are considered to be large, medium and small for values of greater than 0.37, 0.24 and 0.1, respectively. The absolute value of a path coefficient should be not greater than 1. The Smart PLS is used to estimate the coefficients; results of hypotheses testing in this study are supported as indicated in Table II.

6. Discussion and conclusion

This paper presents an empirical study for investigating the relationships between logistics innovation capability and supply chain risks in the Industry 4.0 era. There are very few empirical studies on mitigating supply chain risk through logistics innovation capability. The results indicate that logistics innovation capability is negatively related

Items	Factor loading	*t*-value
Logistics innovation capability $\alpha = 0.87$, CR = 0.91, AVE = 0.62		
My firm applies creative techniques in freight movement and distribution	0.72	15.99
My firm regularly improves the company's operational systems	0.75	17.56
My firm adopts technologies and innovative solutions for problem-solving	0.81	13.96
My firm applies simplification of operations	0.83	14.84
My firm applies standardisation of operations	0.82	13.61
My firm applies protection for freight safety and risk	0.76	09.92
Company-side risk $\alpha = 0.90$, CR = 0.93, AVE = 0.72		
One inadequate operational strength (e.g., poor fleet/ delivery capacity)	0.86	23.56
Two storage issues (e.g., school/company closed, temperature control)	0.77	09.15
Three delays in pickup/delivery	0.81	17.25
Three poor communication between company and drivers	0.92	36.10
Six poor information sharing within the company	0.88	25.56
Customer-side risk $\alpha = 0.90$, CR = 0.93, AVE = 0.76		
Delays due to customer's mistakes (e.g., not home, incorrect paperwork)	0.85	18.54
Customers changing the preference	0.92	29.71
Inaccurate forecast of customers' freight volume	0.88	25.27
Higher customer expectation (e.g., misunderstanding transit time)	0.85	15.18
Environment-side risk $\alpha = 0.88$, CR = 0.91, AVE = 0.67		
Labour/driver shortage	0.79	22.16
Road congestion/closures	0.83	20.61
Weather/natural disasters/industrial action (e.g., bushfire, strike)	0.82	19.15
Unstable fuel prices	0.83	20.70
Government laws/regulation	0.84	18.40

Note: (1) α = Cronbach's alpha; (2) CR = composite reliability; (3) AVE = average variance extracted

Table I.
Item reliability and validity

to supply chain risks. This implies that the Australian courier companies may mitigate the impacts of supply chain risks by developing logistics innovation capabilities. The new technologies and creative ideas may be adopted for the supply chain risk management strategies. This supports the Industry 4.0 base technologies to integrate the logistics network (Frank *et al.*, 2019). According to the literature review and empirical data analysis, logistics innovation capability has been identified as an important dynamic capability for mitigating supply chain risks. Dynamic capability is a higher level capability, which can be deployed to extend, modify or create the ordinary capabilities (Winter, 2003). Logistics innovation capability is considered as a higher level capability to reconfigure operations capabilities to achieve excellent logistics operations and mitigate the supply chain risks. In addition, logistics innovation refers to the new technology, new services, new processes and new ideas, which are used for improving logistics operations (Scott, 2009). The logistics innovation capability is an ability to incorporate the logistics innovation to solve the problem and adapt to the changing environment. This would help companies to achieve an excellent logistics operation; it is a way to seek perfection and reduce the impacts of supply chain risk in the Industry 4.0 era. Furthermore, the logistics innovation capability is an appropriate way to assist firms to work out how the unexpected problems and risks can be managed. Using innovation capability to mitigate environmental uncertainty and risk has been promoted in previous studies (Hayes *et al.*, 1988; Kim, 2006). This study revisits the logistics innovation capability and further supports the logistics innovation in the Industry 4.0 research studies (Frank *et al.*, 2019; Lasi *et al.*, 2014). For example, smart packaging carried out with the help of new technologies, processes and services may reduce the damage of goods caused during transportation (Schaefer and Cheung, 2018), automation may improve the logistics efficiency (Wollschlaeger *et al.*, 2017), distributed network may reduce the response time (Frank *et al.*, 2019) and online tracking and tracing provide accurate and timely information and reduce risks of delay or unavailability of information (Christopher and Lee, 2004). It is possible that the capability to implement logistics innovations could be used to manage various supply chain risks. In the survey, the items 'the company applies creative techniques in freight movement' and 'the company applies protection for freight safety and risk' gained the highest average mean values. The empirical results may support the implementation of Industry 4.0 base technologies (Frank *et al.*, 2019). The item that scored second-highest average mean value is 'the company applies standardisation of operations'. This may shed light on the digitalisation and automation technology (Wollschlaeger *et al.*, 2017). The overall results demonstrate that being able to bring in innovations in logistics is important for mitigating supply chain risk in the Industry 4.0 era.

The three types of supply chain risk analysed in the Australian courier are company-side risk, customer-side risk and environment-side risk. Based on the survey results, the major

Path	Standardised coefficient (β)	t-value	Result
Logistics innovation capability → Company-side risk	−0.39	5.26*	H1: Supported
Logistics innovation capability → Customer-side risk	−0.28	3.67*	H2: Supported
Logistics innovation capability → Environment-side risk	−0.29	3.31*	H3: Supported

Note: *$p < 0.001$

Table II.
Results of hypotheses using SEM

company-side risks are delays in pickup/delivery, lost/damaged freight, processing errors, poor information sharing and inadequate operational strength. The greatest risk, delays, is also identified in studies by Sanchez-Rodrigues *et al.* (2009) and Manuj and Mentzer (2008). Customer-side risks have been considered a major factor in the logistics and supply chain. Traditionally, in supply chain risk management, customers are distinguished by their position on the supply or demand side (Murugesan *et al.*, 2013). However, senders and receivers play equal and important roles in a delivery. The major customer-side risks were delays due to customers' mistakes, high customer expectation and inaccurate forecasting of customers' freight volume. The greatest environment-side risks including road congestion/closures, unstable fuel prices, labour/driver shortage, uncertainty due to government laws/regulation and weather/natural disasters/industrial action. Road congestion and lack of a driver were also found to be risks by McKinnon and Ge (2004), and unstable fuel prices, regulations and natural disasters were found to be risks by Simangunsong *et al.* (2012). The Australian courier industry has similar problems to those that have been identified in New Zealand, the United Kingdom and Europe.

Every research has limitations (Zikmund, 2013). This study focuses on the Australian courier context; hence, generalisation to other contexts should be done with caution. The supply chain risk measurement tool was based on the subjective judgement and single-survey design in this study (Flynn *et al.*, 2018). The conceptual framework can be further empirically tested in different industries and countries. This would help to improve the validity and reliability of the measurement tools.

This study offers original contributions to the logistics innovation and supply chain risk management in the Industry 4.0 era, including empirically validated measurement models of logistics innovation capability and supply chain risks in the Australian courier companies. The research models and constructs may be used in further research studies and be generalised for different management purposes. The empirical results indicate the significant relationships between logistics innovation capability and supply chain risks. The findings may demonstrate the applicability of logistics innovation capability for mitigating supply chain risks in the Australian courier firms. Furthermore, the findings provide an insight into innovation management and risk management in logistics and supply chain. This offers practical guidance for developing and deploying logistics innovation capability to support and enable supply chain risk management strategies in the Industry 4.0 era. Future study may be conducted to investigate the extent of different types of innovation capability for risk management in different sectors.

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Further reading

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