International Journal of Operations & Production Management

Supply chain risk's impact on corporate financial performance

Hong Long Chen,

Supply chain risk's impact on corporate financial performance

Hong Long Chen
Department of Business and Management, National University of Tainan, Tainan, Taiwan

Received 3 February 2016
Revised 18 May 2016
11 August 2016
23 January 2017
Accepted 22 October 2017

Abstract

Purpose – Researchers have long sought to understand how risks in supply chains (SCs) affect firm performance. Yet, they have not fully subjected claims of how SC risks affect firm financial performance to theoretical and empirical scrutiny. The purpose of this paper is to investigate the links between SC risks and firm financial performance.

Design/methodology/approach – The author analyzes how SC risks affect firm financial performance from the perspective of marginal financial performance (MFP) using survey and financial statement data. The author employs structural equation modeling to examine the hypotheses using 106 Taiwanese listed companies across 20 industries.

Findings – The findings regarding the importance of industry-specific risk, organizational risk, internal business process risk, and demand risk are consistent with prior studies. The author finds that demand risk has an MFP of −0.20, the highest negative effect among the risk variables. The findings also show that industry-specific risk possesses an MFP of −0.16, the second-highest negative effect, despite having no direct effect on financial performance.

Research limitations/implications – This paper examines how SC risks affect MFP via combining survey and financial statement data. It does not assume the reported MFP estimates apply to all businesses in other countries. However, future research could triangulate our findings.

Originality/value – This study combines survey and financial data to analyze how SC risks affect firm financial performance. Specifically, it provides a methodology for estimating quantitative cause-effect relationships between SC risk and firm financial performance, an important topic that receives less research interest in the field of supply chain management.

Keywords Risk and performance, Financial performance, Risk measurement, Supply chain risk

Paper type Research paper

1. Introduction

In modern business environments characterized by ever-increasing competition and globalization, managers use innovative technologies and strategies to achieve and sustain competitive advantages (Chan and Qi, 2003). Because supply chains (SCs) consist of all activities associated with the flow and transformation of goods from the raw material stage to the end user (Handfield and Nichols, 1999), effective supply chain risk management (SCRM) via coordination and collaboration among SC partners is key to ensuring profitability and continuity (Brindley, 2004; Tang, 2006). Not surprisingly, a considerable amount of literature has accumulated on the subject (e.g. Kleindorfer and Saad, 2005; Ritchie and Brindley, 2007; Rotaru *et al.*, 2014; Zsidisin, 2003; Zsidisin and Ellram, 2003).

One recent finding, for example, is that two organization-level factors, perceived operational similarity and market leadership, significantly influence the risk manager's likelihood of learning what might trigger other firms' operational losses (Hora and Klassen, 2013). Another finding is that improved internal integration of core business processes within a company enhances demand visibility and thus decreases demand risk (Kache and Seuring, 2014).

However, despite the panoply of studies that acknowledge the importance of SCRs to firm performance (e.g. Bavarsad *et al.*, 2014; Cao and Zhang, 2011; Ghadge *et al.*, 2013; Ritchie and Brindley, 2007; Tracey *et al.*, 2005; Zhao *et al.*, 2013), relatively few analyze the impact of supply chain risk (SCR) on firm financial performance. Although few studies do examine the effects of SCR on financial performance, they largely rely on perceptual

International Journal of Operations & Production Management
© Emerald Publishing Limited
0144-3577
DOI 10.1108/IJOPM-02-2016-0060

measures (e.g. Bavarsad *et al.*, 2014; Cao and Zhang, 2011; Zhao *et al.*, 2013), which fail to provide real financial performance quantitatively.

Therefore, the main objective of this research is to assess how SCR affects firm financial performance from the perspective of marginal financial performance (MFP) by using a combined method of surveys and financial reports. Such assessment is significant, as the primary aspect of SCR, according to its definition, involves assessing the impact of an incident or failure in SC operations on financial performance (Zsidisin, 2003).

The rest of this paper is organized as follows. Section 2 reviews related studies, Section 3 delineates the test hypotheses, Section 4 describes the sample collection and presents the research methodology, and Section 5 depicts the statistical tests and model building. Section 6 discusses the implications of the research results. Section 7 presents the research summary and conclusions.

2. Research background

A SC is an integrated process wherein raw materials become final products and then are delivered to customers through distribution, retail, or both (Cohen and Moon, 1990). SCR is the potential occurrence of an incident or failure in the process of planning, executing, monitoring, and controlling SC operations that results in a financial loss for the purchasing firms (Zsidisin, 2003). Whilst managing SCR is critical to maintaining competitive advantage in the ever-changing business environment, SCRM via coordination or collaboration among supply chain partners (Brindley, 2004; Tang, 2006), has drawn great attention from practitioners and researchers alike.

Numerous academics and practitioners perform extensive research to develop SCRM models by examining and identifying the determinants of risk performance in SCs (e.g. Cucchiella and Gastaldi, 2006; Kleindorfer and Saad, 2005; Kraljic, 1983; Neiger *et al.*, 2009; Rao and Goldsby, 2009; Ritchie and Brindley, 2007; Rotaru *et al.*, 2014; Wu *et al.*, 2006; Zsidisin, 2003; Zsidisin and Ellram, 2003). For example, based on an analysis of in-depth interviews with purchasing professionals from nine manufacturing companies, Zsidisin *et al.* (2000) note that purchasing organizations should create contingency plans and implement process-improvement and buffer strategies in response to supply risks.

Lewis (2003) uses a case-based approach to develop a preliminary model of operational risk based upon the input and outcome dimensions of causal events and negative consequences. He then revises his model based on the empirical findings from four operational failure case studies from a financial services provider, a retail firm, an industrial components manufacturer, and an aerospace components manufacturer. Zsidisin and Ellram (2003) use regression analysis to examine the relationship between supply risk sources and techniques to manage that risk. Based on a sample of 261 purchasing organizations, they conclude that a significant correlation exists, and purchasing organizations indeed address various sources of supply risk by implementing management techniques that reduce the likelihood of detrimental events.

Using a secondary analysis of the published and grey literature supplemented by case studies, Finch (2004) notes that large corporations increase their exposure to the risk of information management and maintenance by having small- and medium-size enterprises as partners in critical positions in the SC. Gaudenzi and Borghesi (2006) propose an analytical hierarchy process (AHP) model to identify SCR factors. Based on a case study of a focal company, they conclude that the involvement of managers from different disciplines is essential in establishing a complete risk analysis.

Ritchie and Brindley (2007) employ conceptual and empirical work in SC management and other related fields to develop a conceptual SCRM framework that integrates the dimensions of risk and performance to categorize SCR drivers. Tsai *et al.* (2008) combine transaction cost theory and the resourced-based view to develop a framework of risk events and then use the AHP to calibrate the relative importance of the risk events. Using a sample of 116 retail chains, they conclude that outsourcing risk perception is positively related to the range of logistical functions outsourced.

Subsequent work by Jiang *et al.* (2009) uses a combined method of factor analysis and logistic regression analysis to determine the reasons for labor turnover in order to help managers deal with labor-related SCRs. Using a sample of 634 manufacturing workers from various industries (e.g. electrical and electronic, plastic and rubber, machinery, industrial chemicals, and furniture and fixture industries), they show that meager human resource management practices, poor production and operations management activities, and unfair buyer behaviors are significant predictors of labor turnover for migrant workers. Blos *et al.* (2009) use an exploratory case study methodology to identify the SCRs in the automotive and electronic industries and conclude that better SC communication, business training programs, and the creation of a chief risk officer are significant practices to manage SCRs.

Based on a study of 223 purchasing managers and buyers of direct materials using the structural equation modeling (SEM) technique, Ellis *et al.* (2010) note that both the probability and the magnitude of supply disruption are important to buyers' overall perceptions of supply disruption risk. Building on the risk management process in Tummala *et al.* (1994), Tummala and Schoenherr (2011) propose a structured and ready-to-use approach for managers to assess and manage risks in SCs. Colicchia and Strozzi (2012) use a systematic literature-network analysis to outline a research agenda that facilitates the development of models for managing SCRs.

Recently, Ghadge *et al.* (2013) use a systems-thinking approach to develop a framework for SCRM and test the framework using an industrial case study. They claim that their framework is able to assess risk and predict failure points along with their overall risk impact in the SC network. Using content analysis to execute a systematic literature review of 103 articles published in ten leading logistics, SCM, and operations management journals, Kache and Seuring (2014) examine the links among collaboration, integration, risk, and performance in SCs and conclude that collaboration and integration are as central to SCM as risk and performance management. More recently, Pradhan and Routroy (2016) use SEM to examine the relationship between supply risk and supply management. Based on a sample of 239 SC managers, they conclude that supply risk management has a direct positive effect and an indirect positive effect (mediated by contract management) on supply management performance.

Although many studies use a wide variety of measures to describe SCRM performance and the input characteristics that affect the performance, relatively few investigate the effects of SCRs on firm performance. Some studies (e.g. Bavarsad *et al.*, 2014; Cao and Zhang, 2011; Zhao *et al.*, 2013) do examine SCRs' impacts on firm performance; these studies, however, focus on delineating the relationships between SCRs and firm performance[1]. Therefore, there appears to be a lack of research focusing on the impact of SCRs on financial performance.

In addition, SCR models in the SCM literature largely rely on perceptual measures (e.g. Chen, 2011, 2012; Ellis *et al.*, 2010; Hora and Klassen, 2013; Zhao *et al.*, 2013). The values of these perceptual measures, such as a seven-point Likert scale measuring the extent to which a respondent perceives performance as "strongly disagree" (= 1) to "strongly agree" (= 7), test hypotheses or develop models.

Although the reliability and validity of such perceptual measures have been rigorously proven (Ketokivi and Schroeder, 2004), perceptual measures, however, fail to provide real financial performance quantitatively. This is significant, as the primary aspect of SCRs, according to its definition, involves assessing the impact of an incident or failure in SC operations on financial performance (Zsidisin, 2003). Consequently, there is a need for research that explores and assesses how SCRs affect MFP[2].

Some extant studies in the field of supply chain finance (SCF) research (e.g. Lanier *et al.*, 2010; Pfohl and Gomm, 2009; Shi and Yu, 2013; Timme and and Wanberg, 2011; Wuttk *et al.*, 2013) investigate the relationships between SC execution and financial performance; they, however, concentrate on SC performance's impacts on financial performance, or linkages between SC and financial performance. Few focus on the effects of SCRs on financial performance. For example, Presutti and Mawhinney (2007) use the balanced scorecard approach (Kaplan and Norton, 1996) to demonstrate critical link between a firm's overall SC performance and economic value added.

Pfohl and Gomm (2009) analyze the roles of financial flows in SCs and SC performance's impacts on these flows and thus develop a conceptual SCF framework that integrates the objects, actors, and levers of SCF to optimize financial flows. Drawing on the resource-based view of the corporation, Ellinger *et al.* (2011) assess the relationships between SCM competency and financial performance using Delphi-style opinion data from AMR Research's Supply Chain Top 25 rankings. They conclude that firms recognized by industry experts for SCM competency have significantly higher financial performance than their close competitors and industry averages.

Subsequent work by Wuttk *et al.* (2013) notes that harmonization of physical and financial flows across SC networks is important to overall SC performance. Using a case study of six manufacturing firms, they propose a SCF adoption framework for managers to better synchronize these flows, thus improving working capital and reducing costs. Using content analysis to perform a systematic literature review of 49 research articles published between 1990 and 2011, Shi and Yu (2013) conclude that effective SCM increases both accounting- and market-based financial performance measures through the improvements in revenue growth, operating costs reduction, and working capital efficiency.

Recently, based on an in-depth case study of two international banks, Silvestro and Lustrato (2014) note that improved SC integration that requires an understanding of the flow of physical and financial resources across supply networks enhances optimization of manufacturer's liquidity and working capital. Vázquez *et al.* (2016) use a two-factor ANOVA model to examine link between SC performance and working capital management and conclude that improved financial cooperation in SCs enhances production efficiency in plants throughout the value chain.

3. Research hypotheses

Now the question is how to estimate the impact of changes in a risk construct in SCs on MFP.

To answer this question, we propose a conceptual corporate SCR financial model (see Figure 1) consisting of six dimensions. The proposed model is based on an extensive review of the interdisciplinary literature and consultation with several experienced researchers and practitioners.

Central to our model is that industry-specific uncertainties and firm-level risks affect SCR, which has a direct impact on corporate financial performance. Industry-specific uncertainties are those that may not affect all sectors of the economy as a whole, but rather specific industry segments (Rao and Goldsby, 2009; Ritchie and Marshall, 1993). Prominent examples of industry-specific uncertainties are input market uncertainties, product market uncertainties, and competitive uncertainties, which have certain impacts on SCR (Miller, 1991).

For example, Miller (1991) states that unexpected changes in the demand for an industry's output may affect a firm's output, increasing SCR for downstream members. Simons (1999) notes that competitive risk that influences a firm's ability to differentiate its products from its competitors plays an important role in SCR and market competitiveness. Fynes *et al.* (2005) conclude that competitive uncertainties in the market environment are a critical contingency variable in conceptual and empirical studies in SCRM.

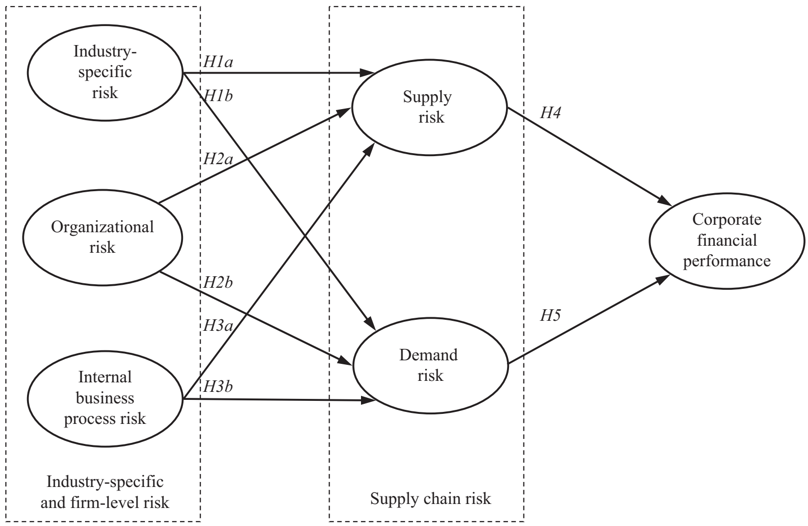


Figure 1.
Conceptual SCR financial model

A subsequent study, Tang (2006), demonstrates that input market uncertainty leads to uncertain quality and reliability, thereby increasing SCR for downstream members. Schoenherr *et al.* (2008) note that labor strikes, process breakdowns, supplier disruptions, logistical failures, and political and competitive uncertainties adversely affect SC stability. Jiang *et al.* (2009) conclude that uncertainty in labor markets causes a reduction in final-product quality that increases the level of inherent risk for downstream members of the SCs.

Based on Miller (1991), Simangunsong *et al.* (2012) recommend coordination with industry leaders to stabilize the market and reduce competitive uncertainties. Recently, Selviaridis and Norrman (2014) suggest that firms in service SCs commonly transfer competitive uncertainty in price and cost to downstream members of the SCs. Thus, we propose that:

H1a. Supply risk is positively related to industry-specific uncertainties.

H1b. Demand risk is positively related to industry-specific uncertainties.

Though researchers commonly suggest that external risk (i.e. industry risk) adversely affects SC performance (Rao and Goldsby, 2009; Simons, 1999; Simangunsong *et al.*, 2012), internal business risk has the potential to degrade SC operating conditions and, thereby, their performance outcomes (Mann, *et al.*, 2010). Many scholars contend that supply risk is contingent upon internal business management (Bavarsad *et al.*, 2014; Kaplan and Norton, 2001). Through a better internal business management, a focal firm can improve collaboration with supplier firms and thus achieve a high level of lean supply operations (Stratton and Warburton, 2003).

Simatupang *et al.* (2004) report that firms seek ways to improve their internal business processes to improve competitiveness in SCs by adopting the theory of constraints approach. Rao and Goldsby (2009) suggest that uncertainties in internal business processes and organization increase risk in product quality, which in return affect the production or consumption of a company's product. Kache and Seuring (2014) report that improved internal integration of core business processes within a company enhances demand visibility. In general, researchers suggest that the better organizational and internal business management is, the better SC performance is (Rao and Goldsby, 2009; Stratton and Warburton, 2003; Simangunsong *et al.*, 2012). Hence, we hypothesize:

H2a. Supply risk is positively related to organizational risk.

H2b. Demand risk is positively related to organizational risk.

H3a. Supply risk is positively related to internal business process risk.

H3b. Demand risk is positively related to internal business process risk.

In particular, studies have long recognized SCRM as a key factor in business performance (e.g. Chen and Paulraj, 2004; Cucchiella and Gastaldi, 2006; Ellis *et al.*, 2010; Kache and Seuring, 2014; Tan *et al.*, 1998; Trkmana and McCormack, 2009). For example, using a sample of 474 manufacturing managers and LISREL analysis, Tracey *et al.* (2005) show that performance risk in SCM capabilities (outside-in, inside-out, and spanning) is an important determinant of a firm's business performance. Based on a systematic literature review, Cucchiella and Gastaldi (2006) conclude that improved SCRM leans the production process, increases consumer satisfaction, and enhances inside productivity, thereby producing better business performance.

Though SC disruption risk has immediate or delayed negative effects on business performance over the short run and/or long run, depending on the severity of the disruption and the business's recovery capabilities (Sheffi and Rice, 2005). Craighead *et al.* (2007) and Hendricks and Singhal (2005, 2008, 2009) further note that return on sales, return on assets (ROA) and stock returns are negatively associated with SC disruption risk. Trkmana and McCormack (2009) state that the likelihood of supply disruption is a key challenge to SCRM. Ellis *et al.* (2010) explore and operationalize the relationships in the magnitude of supply disruption, the probability of supply disruption, and overall supply disruption risk.

Cao and Zhang (2011) report that SC collaboration helps firms leverage resources and knowledge of their suppliers and customers to reduce SCR. It thus has a positive impact on business performance. Wagner *et al.* (2012) uses regression analysis to examine the relationships between SC fit (i.e. strategic consistencies between a product's supply and demand uncertainty and the underlying SC design) and the financial performance of the firm. Using a sample of 259 manufacturing firms, they conclude that the higher the products' supply and demand uncertainty is, the lower the ROA of the firm has.

In addition, Kache and Seuring (2014) assess the links among collaboration, integration, risk, and performance in SCs and suggest that SC collaboration and integration are central to SCRM. Therefore, we hypothesize:

H4. Supply risk has a significant negative effect on firm financial performance.

H5. Demand risk has a significant negative effect on firm financial performance.

4. Research methodology

4.1 Participants and procedures

The survey instrument is based on a detailed examination of literature in the SCM and organization-theory fields, as well as consultation with several experienced researchers. Prior to the data collection, a panel of SC practitioners from different industries reviewed the questionnaire for structure, readability, clarity, and completeness. The final version of the survey questionnaire comprises two sections. The first section, composed of open-ended questions, gathers detailed background information of the companies such as annual revenue, capital, and industrial sector.

The second section of the survey consists of multiple-choice questions in which respondents indicate on a seven-point Likert scale the extent to which levels of certain risk variables are in SC in the year. (If not otherwise indicated, all measures use a scale in which −3 means "strongly disagree," 0 means "neutral," and 3 means "strongly agree." High and low scores suggest high and low risk, respectively.)

Data collection occurred in two stages. In the first stage, we contact the companies listed on the Taiwan Stock Exchange. The reasons we choose the listed companies are that they are commonly much larger and more representative of their industries, and they publish annual and interim (semi-annual and quarterly) financial reports, making computation of financial performance ratios possible.

The sample respondents were expected to have experience or knowledge in SCM. The target respondents are CEOs, presidents, general managers, directors, or managers in the industries, excluding those in financial services sectors. The sample companies cover 20 TSIC[3] codes: cement (TSIC 01), food (TSIC 02), rubber (TSIC 03), textiles (TSIC 04), electric machinery (TSIC 05), electronics and cables (TSIC 06), paper and pulp (TSIC 09), iron and steel (TSIC 10), construction and building materials (TSIC 14), tourism (TSIC 16), retail (TSIC 18), miscellaneous (TSIC 20), chemicals (TSIC 21), computer and peripheral equipment manufacturing (TSIC 25), optoelectronics (TSIC 26), internet-based workplace communications (TSIC 27), electronic components (TSIC 28), electrical distribution (TSIC 29), information services (TSIC 30), and electronics miscellaneous (TSIC 31). The 22 sectors include 1,402 companies in 2013.

Of the 1,402 listed companies on the Taiwan Stock Exchange that we invited to participate in this research, 123 participated during the period of November to December 2013. On a seven-point Likert scale, they indicate the extent to which level of a particular risk variable exists in their SCs that year. Out of the 123 responses received (17 incomplete), 106 are usable, resulting in a 7.56 percent response rate. Table I shows the characteristics of the respondents.

In the second stage, we collect the 106 firms' 2013 annual balance sheets and income statements from the *Taiwan Economic Journal* (*TEJ*) database to compute financial ratios, which we use to evaluate firm financial performance in 2013.

4.2 Measures and analysis

We choose profit margin (PM), ROA, and return on equity (ROE) to measure corporate financial performance. The rationales are straightforward: PM indicates a firm's overall operating performance (Salancik and Pfeffer, 1980), ROA indicates how efficiently a firm's management generates income from firm resources (Mahajan and Singh, 2013), and ROE measures how efficiently companies produce earnings from shareholder capital (Lau and Sholihin, 2005). We calculate PM, ROA, and ROE using the following formulas:

$$\text{Profit margin} = \text{Net income/sales} \tag{1}$$

$$\text{Return on assets} = \text{Net income/total assets} \tag{2}$$

$$\text{Return on equity} = \text{Net income/stockholders' equity} \tag{3}$$

We compute PM, ROA, and ROE using data from *TEJ*. The 106 listed firms' PMs, ROAs, and ROEs range from −89.69 to 37.21 percent, −25.93 to 29.41 percent, and −55.57 to 40.75 percent, respectively. The respective lower quartile, median, and upper quartile values of the firms' PMs are −0.80, 3.35, and 9.41 percent, those of the firms' ROAs are −0.78, 2.20, and 6.40 percent, and those of the firms' ROEs are −1.28, 3.45, and 9.66 percent. The respective mean values of the firms' PMs, ROAs, and ROEs are 2.25, 2.80, and 4.18 percent, with corresponding standard deviations of 16.23, 7.47, and 12.66 percent.

Variables	Total responses	Total companies in the industry in 2013	Percentage
TSIC			
01	1	7	14.3
02	3	25	12.0
03	3	30	10.0
04	6	55	10.9
05	6	76	7.9
06	2	17	11.8
09	1	7	14.3
10	4	41	9.8
14	1	70	1.4
16	1	22	4.5
18	2	26	7.7
20	10	97	10.3
21	11	124	8.9
25	3	111	2.7
26	9	126	7.1
27	6	80	7.5
28	15	197	7.6
29	1	40	2.5
30	3	37	8.1
31	18	214	8.4
Firm Size			
1-100	11		
101-300	33		
301-500	21		
501-1000	21		
1001-2000	10		
2001-5000	7		
5001-10000	2		
10001+	1		
Job Title			
CEOs/presidents	7		
General managers	13		
Directors	11		
Senior managers	64		
Others	11		

Table I.
Sample demographic characteristics (106 responses)

The industry-specific risk, organizational risk, internal business process risk, supply risk, and demand risk variables are based on a systematic review of literature concentrating on a research question that tries to identify, appraise, choose, and synthesize all evidence relevant to that question (Adams *et al.*, 2006). Important to the review process is the use of explicit, reproducible criteria, an appraisal of the quality of the research, and the strength of the findings (Tranfield *et al.*, 2003). We broadly adopt review methodology detailed by Tranfield *et al.* (2003) and Colicchia and Strozzi (2012)[4].

Industry-specific risk is measured on a seven-item scale based on the representative studies, including Chen and Paulraj (2004) and Miller (1991). Sample items are "ISR1: The industry faces high uncertainty of input markets," "ISR2: The industry faces high uncertainty of product markets," "ISR3: The industry faces high policy uncertainty due to frequent changes in government policy," and "ISR 4: The industry is characterized by rapidly changing technology."

Organizational risk is measured on a seven-item scale based on representative studies, including Finch (2004), Miller (1991), and Rao and Goldsby (2009). Sample items are

"OR1: We face a high firm-specific input supply uncertainty due to competition of scarce resources," "OR2: We consistently face a lack of skilled labor, and it is difficult for us to retain our skilled labor," "OR3: Our accounts receivable is well managed, and we pay our suppliers without delay," and "OR4: We provide right incentives for supporting activity and functional performance that contribute optimally to firm, not just for agency's personal welfare or sub-optimization across business functions."

Internal business process risk is measured on a ten-item scale based on representative studies, including Finch (2004), Kaplan and Norton (1996), Kleindorfer and Saad (2005), and Rao and Goldsby (2009). Sample items are "IBPR1: We have a relatively high average cost per transaction compared to our competitors," "IBPR2: We continuously improve the production-cycle time of our products," "IBPR3: Our firm's manufacturing process quality is relatively low compared to our competitors," and "IBPR 4: Time to market of new product/ service is relatively long compared to our competitors."

Supply risk is measured on a nine-item scale based on representative studies, including Kraljic (1983), and Lee and Billington (1993). Sample items include "SR1: The suppliers are unable to handle our volume demand changes," "SR2: The suppliers are unable to fully work together with us to achieve our goals," and "SR3: The suppliers are unable to consistently meet our quality requirements," and "SR4: The suppliers are unable to consistently provide competitive pricing for the same goods and services."

Demand risk is measured on a seven-item scale based on representative studies, including Chen and Paulraj (2004), Tummala and Schoenherr (2011), and Zsidisin (2003). Sample items include "DR1: Our master production schedule has a high percentage of variation in demand," "DR2: Our market has excess supplier capacity," "DR3: Our market constantly experiences new ideas and emerging technology for creating new products," and "DR4: The volume and/or composition of demand is difficult to predict."

The methodology to test the hypotheses and, hence, to quantify the impact of SC risk on firm financial performance is threefold. First, this study performs an isolated model analysis of each risk dimension to evaluate the ability of the set of items to its associated dimension. Items with factor loadings smaller than 0.50 are primary candidates for deletion. We assess further deletion of a dimension's item scales for refining the initial measurement instrument through repeated model fittings based on examining standardized loadings, interpretability, and content validity along with a minimum standardized root mean square residual (RMSR) procedure (Wallace *et al.*, 2004) [5]. This process of removing variables (i.e. item scales) with excessive errors that contribute little valid variance to the measurement model reduces measurement noise (Kaplan, 1990; Saklofske and Zeidner, 1995).

Second, this study develops the overall measurement model from the refined measurement instrument based on the confirmatory factor analysis (CFA) (Hair *et al.*, 2009; Harrington, 2008). Third, this study uses SEM (Kline, 2010; Lee, 2007) to test our hypotheses and thus quantifies the impact of each risk construct on firm financial performance.

5. Research results

This section depicts the statistical tests and model building. Section 5.1 analyzes the isolated models. Section 5.2 delineates the analysis of the corporate SCR financial-measurement model, and section 5.3 reports the test results of the corporate SCR financial model.

5.1 Analysis of isolated models

The first objective of analysis of isolated models is to create a parsimonious measurement model for SCRs. The second objective is to generate sufficient conditions regarding the sample size for a valid, stable factor solution. Table II lists the item scales ultimately retained for each performance dimension. The fit measures for the isolated models based on the refined scales concluded from repeated model fittings using an RMSR procedure show a

Variable	Factor loadings	Measure
Corporate financial performance	CR = 0.75, AVE = 0.83, RMSR < 0.01	
CFP1	0.78	Profit margin
CFP2	1.03	Return on assets
CFP3	0.90	Return on equity
Industry-specific risk	CR = 0.80, AVE = 0.54, RMSR = 0.03	
ISR2	0.57	The industry faces high uncertainty of product markets
ISR4	0.74	The industry is characterized by rapidly changing technology
ISR6	0.60	The rate of process obsolescence is high in the industry
ISR7	0.96	The production technology changes frequently
Organizational risk	CR = 0.80, AVE = 0.61, RMSR < 0.01	
OR1	0.66	We face a high firm-specific input supply uncertainty due to competition of scarce resources
OR2	0.86	We consistently face a lack of skilled labor, and it is difficult for us to retain our skilled labor
OR3	0.82	Our accounts receivable is well managed, and we pay our suppliers without delay[a]
OR4	0.76	We provide right incentives for supporting activity and functional performance that contribute optimally to firm, not just for agency's personal welfare or sub-optimization across business functions[a]
Internal business process risk	CR = 0.80, AVE = 0.52, RMSR = 0.03	
IBPR2	0.84	We continuously improve the production-cycle time of our products [a]
IBPR3	0.66	Our firm's manufacturing process quality is relatively low compared to our competitors
IBPR4	0.71	Time to market of new product/service is relatively long compared to our competitors
IBPR5	0.64	Our production planning has a low level of accuracy
Supply risk	CR = 0.75, AVE = 0.58, RMSR < 0.01	
SR2	0.65	The suppliers are unable to fully work together with us to achieve our goals
SR3	0.89	The suppliers are unable to consistently meet our quality requirements
SR4	0.72	The suppliers are unable to consistently provide competitive pricing for the same goods and services
Demand Risk	CR = 0.75, AVE = 0.83, RMSR < 0.01	
DR1	0.85	Our master production schedule has a high percentage of variation in demand
DR4	0.89	The volume and/or composition of demand is difficult to predict
DR7	0.99	Our products are with short life cycles

Note: [a]Reverse-coded item; item measure's sign is reversed

Table II. Financial performance and final survey items in the SCR financial-measurement model

good fit with the observed data. The RMSRs of the isolated models are either equal to or smaller than 0.03, which indicates a good model fit (Harrington, 2008).

The respective composite reliabilities (CRs), average variance extracted (AVE), and standardized factor loadings range from 0.75 to 0.80, from 0.52 to 0.83, and from 0.57 to 1.03, respectively, which are higher than the recommended respective threshold values of 0.60, 0.50, and 0.50 (Fornell and Larcker, 1981; Kline, 2010). We therefore conclude that the item scales provide an adequate and reliable measure of fit for the six dimensions of the measurement model.

5.2 Analysis of overall measurement model

The objective of analysis of overall measurement model is to create a valid corporate SCR financial-measurement model for testing the hypothesized model (Figure 1). The corporate SCR financial-measurement model, which is congeneric, includes the *corporate financial* *performance*, *industry-specific risk*, *organizational risk*, *internal business process risk*, *supply risk*, and *demand risk* constructs that correlate with all other constructs. To test for convergent validity, we use the standardized factoring loadings, CR, and AVE to evaluate the relative convergence among item measures. High loadings on a factor indicate that they converge on a common point, suggesting high convergent validity (Harrington, 2008). All standardized factor loadings range from 0.58 to 1.03 and are significant at the $p < 0.001$ level, suggesting the existence of convergent validity.

The square of a standardized factor loading addresses how much the latent construct explains the variation in an item measure, which is termed the variance extracted of the measure. Hence, an AVE of 0.5 or higher demonstrates adequate convergence. This indicates that, on average, less error remains in the measures than variance explained by the latent construct (Kline, 2010). As the bottom of Table III shows, the respective AVE values of corporate financial performance, organizational risk, internal business process risk, supply risk, demand risk, and industry-specific risk are 0.82, 0.61, 0.50, 0.50, 0.80, and 0.55, respectively, suggesting an adequate convergence for all the constructs.

In addition, CR, computed from the squared sum of factor loadings for a construct, divided by the squared sum of factor loadings and the sum of error-variance terms for the construct, shows whether the measures consistently represent the same latent construct. A CR of 0.6 or higher indicates convergent validity (Kline, 2010; Lee, 2007). The bottom of Table III shows that the respective CR values of corporate financial performance, organizational risk, internal business process risk, supply risk, demand risk, and industry-specific risk are 0.75, 0.80, 0.79, 0.75, 0.75, and 0.80, confirming an adequate convergence for all the constructs.

To test for discriminant validity, the extent to which a construct is actually distinct from other constructs, we compare the AVE values for any two constructs with the square of the correlation estimate between the constructs, which is a more rigorous test (Fornell and Larcker, 1981). As seen in Table III, the AVE value of corporate financial performance is 0.82, which is greater than the square of the correlation estimate between corporate financial performance and any of the other constructs. The AVE value of organizational risk is 0.61, which is greater than the square of the correlation estimate between organizational risk and any of the other constructs; likewise, the AVE values of internal business process risk, supply risk, demand risk, and industry-specific risk are all greater than the square of their respective correlation estimates. This comparison suggests that any latent constructs in the measurement model explain more of the variance in item measures than they share with other latent constructs, providing strong evidence of discriminant validity for the measurement model.

The analysis results of the measurement model suggest an adequate fit with the data. The model (χ^2/df = 1.585, which is smaller than the threshold value of 2.000 suggested by

Variable	Corporate financial performance	Organizational risk	Internal business process risk	Supply risk	Demand risk	Industry-specific risk
Corporate financial performance	1					
Organizational risk	0.02	1				
Internal business process risk	0.01	0.34	1			
Supply risk	0.00	0.36	0.37	1		
Demand risk	0.04	0.35	0.00	0.03	1	
Industry-specific risk	0.01	0.00	0.04	0.02	0.59	1
Average variance extracted	0.82	0.61	0.50	0.50	0.80	0.55
Composite creditability	0.75	0.80	0.79	0.75	0.75	0.80

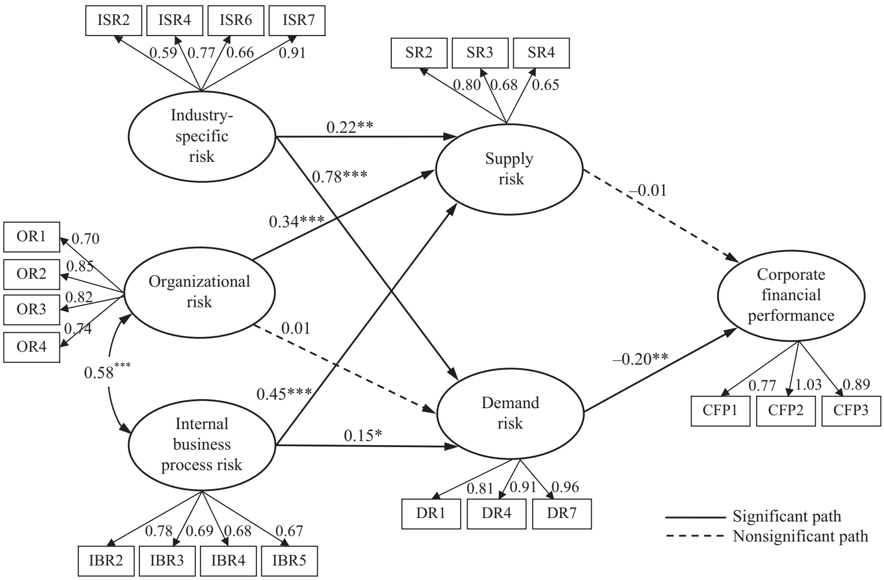
Table III.
Squared correlations, average variance extracted, and composite creditability of the SCR financial-measurement model

Kline (2010); CFI = 0.928 and TLI = 0.910 are both higher than the threshold value of 0.900 suggested by Fornell and Larcker (1981), and the RMSEA = 0.076 is smaller than the threshold value of 0.080 (Kline, 2010; Lee, 2007).

5.3 Testing the corporate SCR financial model

This section describes how this study tests the hypothesized model and what the test results are. We test the hypothesized model (Figure 1) using SEM (Kline, 2010; Lee, 2007). The model-fit indices suggest that the model fits the data adequately, where the model χ^2/df = 1.607, CFI = 0.926 TLI = 0.911, and RMSEA = 0.076. This insignificant difference in the relative χ^2(1.585 vs 1.607) strongly suggests model validity (Kline, 2010).

Figure 2 presents the results of the eight hypothesized relationships (*H1a-H5*) among the study constructs, and Table IV summarizes the results of the hypotheses tests. Of the eight, three are highly significant at the 0.001 level, two are significant at the 0.05 level, one is mildly significant at the 0.10 level, and two are nonsignificant. *H1a* and *H1b*, which infer that industry-specific risk has a direct positive impact on supply and demand risk,



Notes: *$p<0.10$; **$p<0.05$; ***$p<0.001$

Figure 2.
Corporate SCR financial model

Hypothesized path	Standardized path coefficient	Result
H1a: industry-specific risk → (+) supply risk	0.22**	Supported
H1b: industry-specific risk → (+) demand risk	0.78***	Supported
H2a: organizational risk → (+) supply risk	0.34***	Supported
H2b: organizational risk → (+) demand risk	0.01	Not supported
H3a: internal business process risk → (+) supply risk	0.45***	Supported
H3b: internal business process risk → (+) demand risk	0.15*	Supported
H3: supply risk → (−) corporate financial performance	−0.01	Not supported
H4: demand risk → (−) corporate financial performance	−0.20**	Supported

Notes: *$p < 0.10$; **$p < 0.05$; ***$p < 0.001$

Table IV.
Summary of hypothesis test results

are significant at the 0.001 and 0.05 levels, respectively. The corresponding coefficients of paths linking industry-specific risk to supply risk and demand risk are 0.22 and 0.78. Parameter estimates using the maximum likelihood (ML) method find the total combined effect of industry-specific risk through supply risk and demand risk on corporate financial performance is −0.16, as shown in Table V.

H2a to *H2b* infer that organizational risk has a direct impact on supply risk and demand risk. We find the connection highly significant at the 0.001 level (*H2a*) and nonsignificant at the 0.100 level (*H2b*). The respective coefficients of the paths linking organizational risk to supply risk and demand risk are 0.34 and 0.01. Parameter estimates using the ML method (Table V) find the total combined effect of organizational risk through supply risk and demand risk on corporate financial performance is −0.01.

H3a-H3b infer that internal business process risk has a direct impact on supply risk and demand risk. We find the connection highly significant at the 0.001 level (*H2a*) and mildly significant at the 0.100 level (*H2b*). The respective coefficients of the paths linking internal business process risk to supply risk and demand risk are 0.45 and 0.15. Parameter estimates using the ML method (Table V) find the total combined effect of internal business process risk through supply risk and demand risk on corporate financial performance is −0.04.

Tests of *H4-H5* find that although demand risk directly affects (significant at the 0.05 level) corporate financial performance, however, supply risk has a nonsignificant impact on corporate financial performance. The path coefficient that links demand risk to corporate financial performance is −0.20, suggesting a direct negative effect of −0.20.

6. Discussion

Our findings regarding the importance of industry-specific risk, internal business process risk, and demand risk on corporate financial performance are consistent with prior studies (e.g. Cao and Zhang, 2011; Kache and Seuring, 2014; Miller, 1991; Rao and Goldsby, 2009; Selviaridis and Norrman, 2014; Simangunsong *et al.*, 2012; Stratton and Warburton, 2003). The present study extends the state of knowledge of how SC risk affects firm financial performance quantitatively.

Specifically, previous studies (e.g. Bavarsad *et al.*, 2014; Cao and Zhang, 2011; Tracey *et al.*, 2005; Zhao *et al.*, 2013) focus on describing SCRM performance and the input characteristics that affect firm performance. Few examine how SC risk affects firm financial performance from the MFP perspective using a combined method of a survey and financial reports.

As shown in Table V, for example, a 1 percent increase in industry-specific risk results in 0.22 and 0.78 percent increases in supply risk and demand risk, respectively, causing a 0.16 percent decrease in corporate financial performance. The results regarding the important effects of industry-specific risk on supply and demand risk are consistent with previous research (e.g. Fynes *et al.*, 2005; Jiang *et al.*, 2009; Schoenherr *et al.*, 2008; Selviaridis and Norrman, 2014; Simangunsong *et al.*, 2012).

	Industry-specific risk			Organizational risk			Internal business process risk			Supply risk			Demand risk		
Variable	DE	IE	TE	DE	IE	TE	DE	IE	TE	DE	IE	TE	DE	IE	TE
Supply risk	0.22		0.22	0.34		0.34	0.45		0.45						
Demand risk	0.78		0.78	0.01		0.01	0.15		0.15						
Corporate financial performance		−0.16	−0.16		−0.01	−0.01		−0.04	−0.04	−0.01		−0.01	−0.20		−0.20

Table V. Direct, indirect and total cause effects

Likewise, a 1 percent 0.45 and 0.15 percent increases in supply risk and demand risk, respectively, incurring a 0.04 percent decrease in corporate financial performance. The results concerning the importance of internal business process risk on supply and demand risk are consistent with previous research (e.g. Kache and Seuring, 2014; Rao and Goldsby, 2009; Stratton and Warburton, 2003).

Further, a 1 percent increase in demand risk causes a 0.20 percent decrease in corporate financial performance, suggesting that demand risk has an MFP of −0.20, the highest negative effect among the variables. Industry-specific risk has an MFP of −0.16, the second-highest negative effect despite having no direct effect on corporate financial performance. This finding suggests that indirect SC risk may generate synergistic interaction effects that are more significant than direct risk.

Tests of *H2b* and *H4* reveal that organizational risk and supply risk have nonsignificant impacts on demand risk and firm financial performance, respectively. These results are somewhat unexpected, because the general perception in the reviewed literature suggests that organizational risk affects demand risk and financial performance is significantly subject to supply risk.

One possible explanation of organizational risk's nonsignificant effect on demand risk is that item scales ultimately retained for the construct of *organizational risk* are more relative to supply side perspective, such as competition of scarce resources and paying suppliers without delay (see Table II). Another explanation is that while organizational risk is potentially important to demand for company products, firms in Taiwanese industries are able to decouple demand in products from this risk through effective management of buyer-supplier relationship. As a senior manager highlighted in a post-survey interview:

> We always try to maintain a good relationship with our buyers. In the cases when our buyers are not satisfied with service quality, or there are unanticipated, harmful effects incurred due to the production or consumption of our company's products, we respond promptly, with a full explanation, to address and correct it. This minimizes the impact of dissatisfaction on customer loyalty.

Furthermore, prior SCRM studies ask survey respondents to directly indicate on Likert scales the extent to which certain SCR variables likely affect financial performance, or to which levels of certain SCR and financial variables are in a specific time period. Therefore, one possible explanation of supply risk's nonsignificant effect on financial performance is that a perception gap exists between how respondents feel SCR variables affect financial performance vs how SCR variables actually affect financial performance.

Another explanation may be that although supply risk is an important factor of demand for company products, firms in Taiwanese industries may be able to decouple financial performance from this type of risk through proactive management of supply side relationship. As a senior manager highlighted in a post-survey interview:

> We always try to maintain a good relationship with our suppliers. However, in the cases when our suppliers are not able to provide competitive pricing for the same goods and services, we will first try to negotiate it down and are ready to change our suppliers.

Nevertheless, more research is needed to clarify the unexpected results with regard to organizational risk's effect on demand risk as well as supply risk's effect on financial performance.

7. Conclusions

Extensive studies in the SCM field develop SCRM models through examining and identifying the determinants of risk performance in SCs. However, few studies investigate how changes in SC risks affect firm financial performance. This study therefore develops a corporate SCR financial model based on the MFP perspective using the combined method of a survey and financial reports. Analysis of the SCR financial model reveals that demand risk produces the largest negative impact (MFP = −0.20) on corporate financial performance, and industry-specific risk generates the second largest negative impact (MFP = −0.16) on corporate financial performance, although itself without direct effect.

By adding to the benefits of existing SCRM models (e.g. Bavarsad *et al.*, 2014; Cao and Zhang, 2011; Ghadge *et al.*, 2013; Ritchie and Brindley, 2007; Tracey *et al.*, 2005; Zhao *et al.*, 2013), this study contributes a methodology for estimating the effects of SCRs on financial performance. Thus, this study addresses part of the fundamental improvement of SCRM performance models. Nonetheless, more research is needed to further clarify the nonsignificant impacts of organizational risk and supply risk on demand risk and corporate financial performance, respectively, although several possible explanations are provided.

Notes

1. For example, Zhao *et al.* (2013) use the maximum likelihood estimation (MLE) method to examine the relationships among supply chain risks (SCRs), supply chain integration (SCI), and company performance. Based on a sample of 317 manufacturing plant managers, they show that SCRs are negatively related to SC integrations, and SC integrations are positively related to company performance measured by schedule attainment, competitive performance, and customer satisfaction.
2. We define MFP as change in percentage of a construct (determinant) in SCRs resulting in change in financial performance quantitatively.
3. The Taiwan Standard Industrial Classification (TSIC) was developed under the auspices of the Office of the Directorate General of Budget, Accounting & Statistics of Executive Yuan.
4. Our review strategy consists of four steps. The first step forms a review panel composed of domain-relevant academics and experts with an interest in performance measurement and SCM. In the second step, we search databases for relevant studies of performance measurement and SCM. In the third step, we use the Delphi method, a process composed of a structured design for group communication for resolving complex problems (Linstone and Turoff, 2002), to develop an analytic framework. In the fourth step, we sort measures into each construct of the analytic framework.
5. A Type I error (α) occurs when incorrectly rejecting a true null hypothesis; a Type II error (β) occurs when incorrectly accepting a false null hypothesis. A Type II error is affected by the Type I error and sample size (Keller, 2008). Specifically, when decreasing the sample size and/or the significance level of a Type I error (e.g., from $\alpha = 0.05\text{-}0.01$), it increases the value of the Type II error (β). In this study, our significance levels of Type I errors and the sample size remain constant throughout model building process. Therefore, although we deleted some item scales of each dimension, it would not affect Type II errors.

References

Adams, R., Bessant, J. and Phelps, R. (2006), "Innovation management measurement: a review", *International Journal of Management Reviews*, Vol. 8 No. 1, pp. 21-47.

Bavarsad, B., Boshagh, M. and Kayedian, A. (2014), "A study on supply chain risk factors and their impact on organizational performance", *International Journal of Operations and Logistics Management*, Vol. 3 No. 3, pp. 192-211.

Blos, M.F., Quaddus, M., Wee, H.M. and Watanabe, K. (2009), "Supply chain risk management (SCRM): a case study on the automotive and electronic industries in Brazil", *Supply Chain Management: An International Journal*, Vol. 14 No. 4, pp. 247-52.

Brindley, C. (2004), *Supply Chain Risk*, Ashgate Publishing, Farnham.

Cao, M. and Zhang, Q. (2011), "Supply chain collaboration: impact on collaborative advantage and firm performance", *Journal of Operations Management*, Vol. 29 No. 3, pp. 163-180.

Chan, F.T.S. and Qi, H.J. (2003), "An innovative performance measurement method for supply chain management", *Supply Chain Management: An International Journal*, Vol. 8 No. 3, pp. 209-223.

Chen, H.L. (2011), "An empirical examination of project contractors' supply-chain cash flow performance and owners' payment patterns", *International Journal of Project Management*, Vol. 29 No. 5, pp. 604-614.

Chen, H.L. (2012), "Empirical behavioral analysis of project contractors' supply-chain payment terms", *Supply Chain Management: An International Journal*, Vol. 17 No. 3, pp. 277-289.

Chen, I.J. and Paulraj, A. (2004), "Towards a theory of supply chain management: the constructs and measurements", *Journal of Operations Management*, Vol. 22 No. 2, p. 119.

Cohen, M.A. and Moon, S. (1990), "Measuring supply chain performance", *International Journal of Operations and Production Management*, Vol. 19 No. 3, pp. 275-292.

Colicchia, C. and Strozzi, F. (2012), "Supply chain risk management: a new methodology for a systematic literature review", *Supply Chain Management: An International Journal*, Vol. 17 No. 4, pp. 403-418.

Craighead, C.W., Blackhurst, J., Rungtusanathan, M.J. and Handfield, R.B. (2007), "The severity of supply chain disruptions: design characteristic and mitigation capabilities", *Decision Science*, Vol. 38 No. 1, pp. 131-156.

Cucchiella, F. and Gastaldi, M. (2006), "Risk management in supply chain: a real option approach", *Journal of Manufacturing Technology Management*, Vol. 17 No. 6, pp. 700-720.

Ellinger, A.E., Natarajarathinam, M., Adams, F.G., Gray, J.B., Hofman, D. and O'Marah, K. (2011), "Supply chain management competency and firm financial success", *Journal of Business Logistics*, Vol. 32 No. 3, pp. 214-226.

Ellis, S.C., Henry, R.M. and Shockley, J. (2010), "Buyer perceptions of supply disruption risk: a behavioral view and empirical assessment", *Journal of Operations Management*, Vol. 28 No. 1, pp. 34-46.

Finch, P. (2004), "Supply chain risk management", *Supply Chain Management: An International Journal*, Vol. 9 No. 2, pp. 183-196.

Fornell, C. and Larcker, D.F. (1981), "Evaluating structural equation model with unobservable variables and measurement error", *Journal of Marketing Research*, Vol. 18 No. 1, pp. 39-50.

Fynes, B., De Burca, S. and Voss, C. (2005), "Supply chain relationship quality, the competitive environment and performance", *International Journal of Production Research*, Vol. 43 No. 16, pp. 3303-3320.

Gaudenzi, B. and Borghesi, A. (2006), "Managing risks in the supply chain using the AHP method", *International Journal of Logistics Management*, Vol. 17 No. 1, pp. 114-136.

Ghadge, A., Dani, S., Chester, M. and Kalawsky, R. (2013), "A systems approach for modelling supply chain risks", *Supply Chain Management: An International Journal*, Vol. 18 No. 5, pp. 523-538.

Hair, J.F., Black, W.C., Babin, B.J. and Anderson, R.E. (2009), *Multivariate Data Analysis*, Prentice Hall, Hoboken, NJ.

Handfield, R.B. and Nichols, E.L. (1999), *Supply Chain Management*, Prentice-Hall, Upper Saddle River, NJ.

Harrington, D. (2008), *Confirmatory Factor Analysis*, Oxford University Press, New York, NY.

Hendricks, K.B. and Singhal, V.R. (2005), "The association between supply chain glitches and operating performance", *Management Science*, Vol. 51 No. 5, pp. 695-711.

Hendricks, K.B. and Singhal, V.R. (2008), "The effect of product introduction delays on operating performance", *Management Science*, Vol. 54 No. 5, pp. 878-892.

Hendricks, K.B. and Singhal, V.R. (2009), "Demand-supply mismatch and stock market reaction: evidence from excess inventory announcements", *Manufacturing and Service Operations Management*, Vol. 11 No. 3, pp. 509-524.

Hora, M. and Klassen, R.D. (2013), "Learning from others' misfortune: Factors influencing knowledge acquisition to reduce operational risk", *Journal of Operations Management*, Vol. 31 Nos 1-2, pp. 52-61.

Jiang, B., Baker, R. and Frazier, G. (2009), "An analysis of job dissatisfaction and turnover to reduce global supply chain risk: evidence from China", *Journal of Operations Management*, Vol. 27 No. 2, pp. 169-184.

Kache, F. and Seuring, S. (2014), "Linking collaboration and integration to risk and performance in supply chains via a review of literature reviews", *Supply Chain Management: An International Journal*, Vol. 19 Nos 5/6, pp. 664-682.

Kaplan, A. (1990), "Evaluating and modifying covariance structure models: a review and recommendation", *Multivariate Behavioral Research*, Vol. 25 No. 2, pp. 137-155.

Kaplan, R.S. and Norton, D.P. (1996), "Using the balance scorecard as a strategic management system", *Harvard Business Review*, Vol. 74 No. 1, pp. 75-85.

Kaplan, R.S. and Norton, D.P. (2001), *The Strategy-Focused Organization: How Balanced Scorecard Companies Thrive in the New Business Environment*, Harvard Business School Press, Boston, MA.

Keller, G. (2008), *Managerial Statistics*, South-Western, Mason, OH.

Ketokivi, M.A. and Schroeder, R.G. (2004), "Perceptual measures of performance: fact or fiction?", *Journal of Operations Management*, Vol. 22 No. 3, pp. 247-264.

Kleindorfer, P.R. and Saad, G.H. (2005), "Managing disruption risks in supply chains", *Production and Operations Management*, Vol. 14 No. 1, pp. 53-68.

Kline, R.B. (2010), *Principles and Practice of Structural Equation Modeling*, The Guilford Press, New York, NY.

Kraljic, P. (1983), "Purchasing must become supply management", *Harvard Business Review*, Vol. 61 No. 5, pp. 109-117.

Lanier, D. Jr, Wempe, W.F. and Zacharia, Z.G. (2010), "Concentrated supply chain membership and financial performance: chain- and firm-level perspectives", *Journal of Operations Management*, Vol. 28 No. 1, pp. 1-16.

Lau, C.M. and Sholihin, M. (2005), "Financial and nonfinancial performance measures: how do they affect job satisfaction?", *The British Accounting Review*, Vol. 37 No. 4, pp. 389-413.

Lee, H. and Billington, C. (1993), "Material management in decentralized supply chains", *Operations Research*, Vol. 41 No. 5, pp. 835-847.

Lee, S.Y. (2007), *Structural Equation Modeling: A Bayesian Approach*, John Wiley & Sons, West Sussex.

Lewis, M. (2003), "Cause, consequence and control: towards a theoretical and practical model of operational risk", *Journal of Operations Management*, Vol. 21 No. 2, pp. 205-224.

Mahajan, P. and Singh, F. (2013), "How do pre-slowdown financial characteristics impact the firms' relative financial performance during economic recession? An empirical investigation", *Asia-Pacific Journal of Management Research and Innovation*, Vol. 9 No. 4, pp. 369-378.

Mann, H., Kumar, U., Kumar, V., Jit, I. and Mann, S. (2010), "Drivers of sustainable supply chain management", *IUP Journal of Operations Management*, Vol. 9 No. 4, pp. 52-63.

Miller, K. (1991), "A framework for integrated risk management in international business", *Journal of International Business Studies*, Vol. 23 No. 2, pp. 311-331.

Neiger, D., Rotaru, K. and Churilov, L. (2009), "Supply chain risk identification with value-focused process engineering", *Journal of Operations Management*, Vol. 27 No. 2, pp. 154-168.

Pfohl, H.C. and Gomm, M. (2009), "Supply chain finance: optimizing financial flows in supply chains", *Logistics Research*, Vol. 1 No. 3, pp. 149-161.

Pradhan, S.K. and Routroy, S. (2016), "Supply management integration model for Indian manufacturing industries", *International Journal of Operations & Production Management*, Vol. 36 No. 7, pp. 781-802.

Presutti, W.D. and Mawhinney, J.R. (2007), "The supply chain-finance link", *Supply Chain Management Review*, Vol. 11 No. 6, pp. 32-38.

Rao, S. and Goldsby, T.J. (2009), "Supply chain risks: a review and typology", *The International Journal of Logistics Management*, Vol. 20 No. 1, pp. 97-123.

Ritchie, B. and Brindley, C. (2007), "Supply chain risk management and performance: a guiding framework for future development", *International Journal of Operations & Production Management*, Vol. 27 No. 3, pp. 303-322.

Ritchie, B. and Marshall, D. (1993), *Business Risk Management*, Chapman & Hall, London.

Rotaru, K., Wilkin, C. and Ceglowski, A. (2014), "Analysis of SCOR's approach to supply chain risk management", *International Journal of Operations & Production Management*, Vol. 34 No. 10, pp. 1246-1268.

Saklofske, D.H. and Zeidner, M. (1995), *International Handbook of Personality and Intelligence*, Plenum Press, New York, NY.

Salancik, G.R. and Pfeffer, J. (1980), "The effects of ownership and performance on executive tenure in U.S. corporations", *Academy of Management Journal*, Vol. 23 No. 4, pp. 653-664.

Schoenherr, T., Tummala, V.M.R. and Harrison, T.P. (2008), "Assessing supply chain risks with the analytic hierarchy process: providing decision support for the off-shoring decision by a U.S. manufacturing company", *Journal of Purchasing and Supply Management*, Vol. 14 No. 2, pp. 100-111.

Selviaridis, K. and Norrman, A. (2014), "Performance-based contracting in service supply chains: a service provider risk perspective", *Supply Chain Management: An International Journal*, Vol. 19 No. 2, pp. 153-172.

Sheffi, Y. and Rice, J. Jr (2005), "A supply chain view of the resilient enterprise", *MIT Sloan Management Review*, Vol. 47 No. 1, pp. 41-48.

Shi, M. and Yu, W. (2013), "Supply chain management and financial performance: literature review and future directions", *International Journal of Operations & Production Management*, Vol. 33 No. 10, pp. 1283-1317.

Silvestro, R. and Lustrato, P. (2014), "Integrating financial and physical supply chains: the role of banks in enabling supply chain integration", *International Journal of Operations & Production Management*, Vol. 34 No. 3, pp. 298-324.

Simangunsong, E., Hendry, L.C. and Stevenson, M. (2012), "Supply-chain uncertainty: a review and theoretical foundation for future research", *International Journal of Production Research*, Vol. 50 No. 16, pp. 4493-4523.

Simatupang, T.M., Wright, A.C. and Sridharan, R. (2004), "Applying the theory of constraints to supply chain collaboration", *Supply Chain Management: An International Journal*, Vol. 9 No. 1, pp. 57-70.

Simons, R.L. (1999), "How risky is your company?", *Harvard Business Review*, Vol. 77 No. 3, pp. 85-95.

Stratton, R. and Warburton, R.D.H. (2003), "The strategic integration of agile and lean supply", *International Journal of Production Economics*, Vol. 85 No. 2, pp. 183-198.

Tan, K.C., Kannan, V.R. and Handfield, R.B. (1998), "Supply chain management: Supplier performance and firm performance", *International Journal of Purchasing and Material Management*, Vol. 34 No. 3, pp. 2-9.

Tang, C.S. (2006), "Perspectives in supply chain risk management", *International Journal of Production Economics*, Vol. 103 No. 2, pp. 451-488.

Timme, S.G. and Wanberg, E. (2011), "How supply chain finance can drive cash flow", *Supply Chain Management Review*, Vol. 15 No. 1, pp. 18-24.

Tracey, M., Lim, J.S. and Vonderembse, M.A. (2005), "The impact of supply-chain management capabilities on business performance", *Supply Chain Management: An International Journal*, Vol. 10 No. 3, pp. 179-191.

Tranfield, D., Young, M., Partington, D., Bessant, J. and Sapsed, J. (2003), "Knowledge management routines for innovation projects: developing a hierarchical process model", *International Journal of Innovation Management*, Vol. 7 No. 1, pp. 27-49.

Trkmana, P. and McCormack, K. (2009), "Supply chain risk in turbulent environments: a conceptual model for managing supply chain network risk", *International Journal of Production Economics*, Vol. 119 No. 2, pp. 247-258.

Tsai, M., Liao, C. and Han, C. (2008), "Risk perception on logistics outsourcing of retail chains: Model development and empirical verification in Taiwan", *Supply Chain Management: An International Journal*, Vol. 13 No. 6, pp. 415-424.

Tummala, R. and Schoenherr, T. (2011), "Assessing and managing risks using the supply chain risk management process (SCRMP)", *Supply Chain Management: An International Journal*, Vol. 16 No. 6, pp. 474-483.

Tummala, V.M.R., Nkasu, M.M. and Chuah, K.B. (1994), "A framework for project risk management", *ME Research Bulletin*, Vol. 2, pp. 145-71.

Vázquez, X.H., Sartal, A. and Lozano-Lozano, L.M. (2016), "Watch the working capital of tier-two suppliers: a financial perspective of supply chain collaboration in the automotive industry", *Supply Chain Management: An International Journal*, Vol. 21 No. 3, pp. 321-333.

Wagner, S.M., Grosse-Ruyken, P.T. and Erhun, F. (2012), "The link between supply chain fit and financial performance of the firm", *Journal of Operations Management*, Vol. 30 No. 4, pp. 340-353.

Wallace, L., Keil, M. and Rai, A. (2004), "How software project risk affects project performance: an investigation of the dimensions of risk and an exploratory model", *Decision Sciences*, Vol. 35 No. 2, pp. 289-321.

Wu, T., Blackhurst, J. and Chidambaram, V. (2006), "A model for inbound supply risk", *Computers in Industry*, Vol. 57 No. 4, pp. 350-365.

Wuttk, D.A., Blome, C., Foerst, K. and Henke, M. (2013), "Managing the innovation adoption of supply chain finance: empirical evidence from six European case studies", *Journal of Business Logistics*, Vol. 34 No. 2, pp. 148-166.

Zhao, L., Huo, B., Sun, L. and Zhao, X. (2013), "The impact of supply chain risk on supply chain integration and company performance: a global investigation", *Supply Chain Management: An International Journal*, Vol. 18 No. 2, pp. 115-131.

Zsidisin, G.A. (2003), "Managerial perceptions of supply risk", *Journal of Supply Chain Management*, Vol. 39 No. 4, pp. 14-26.

Zsidisin, G.A. and Ellram, L.M. (2003), "An agency theory investigation of supply risk management", *Journal of Supply Chain Management*, Vol. 39 No. 2, pp. 15-27.

Zsidisin, G.A., Panelli, A. and Upton, R. (2000), "Purchasing organization involvement in risk assessments, contingency plans, and risk management: an exploratory study", *Supply Chain Management: An International Journal*, Vol. 5 No. 4, pp. 187-198.

About the author

Hong Long Chen (PhD, University of Florida) is a Professor in the Department of Business and Management at the National University of Tainan, Taiwan. His research interests are project finance, corporate finance, performance management and supply chain management. He is an Editorial Board of the *International Journal of Project Management* and the *International Journal of Information Technology Project Management*. He is also a Reviewer of several prestigious journals, such as the *IEEE Transactions on Engineering Management*, *Supply Chain Management: an International Journal*, *International Journal of Production Economics*, *International Journal of Project Management*, *International Journal of Production Research*, *Journal of Business Economics and Management*, *Journal of Management in Engineering*, and *Construction Management and Economics*. Hong Long Chen can be contacted at: along314@mail.nutn.edu.tw