Industrial Management & Data Systems

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Received 30 April 2015
Revised 19 August 2015
8 September 2015
Accepted 11 September 2015

Abstract

Purpose – The purpose of this paper is to help the financial institutions improve the predictability of business failure of supply chain finance (SCF) clients with the use of external big data set.

Design/methodology/approach – A prediction model for the business failure of SCF clients was built upon different theoretical perspectives. Logistic regression method was deployed to test the model.

Findings – The authors develop a model that illustrates several key determinants to predict the probability of business failure of SCF clients based on several theoretical perspectives. The results show that taxable sales revenue, frequency of making value added tax (VAT) payment, number of counterparty for VAT invoice issuance, frequency of VAT invoice issuance and firm age are negatively correlated with business failure of SCF clients while the VAT paid and industry clockspeed are positively correlated with their business failure.

Practical implications – This paper shows how financial institutions can effectively leverage the external information sources through "unconventional" predictor variables in order to reduce the credit risks associated with business failure of SCF clients.

Originality/value – This paper is one of the first to focus on the potential use of financial big data set from external sources to improve of predictability of financial institutions on the business failure of SCF clients. In addition, this paper is a pivotal study on the financial client risk assessment based on taxpaying behaviors, tax amount, firm and industry characteristics.

Keywords Business failure, Financial big data, Industry organization perspective, Organization ecology perspective, Organization studies perspective, Supply chain finance

Paper type Research paper

Introduction

Managing financial client risk is more challenging than ever in the financial industry in China as many financial institutions have proactively offered innovative financial service solutions to both SMEs (which are potentially risky) and core firms (i.e. powerful supply chain players) to increase profits and market reputation. One remarkable financial service solution is known as supply chain finance (SCF), which is a short-term credit to optimize the cash flows and working capitals of collaborating firms within a specified supply chain. While the SCF is highly perceived by the industry as a promising business, it comes with significant risks as the SCF involves the commitment of multiple parties in a SCF contract on timely fulfillment of obligations, as well as the complex assessment of creditworthiness and authenticity of supply chain transaction data (Shenzhen Development Bank Limited Company (SDB) and China Europe International Business School, 2009). Given that the SCF is not secured by fixed collateral, the financial institutions are vulnerable to significant risks when the opportunistic behaviors and supply chain disruption (i.e. negative deviation from the normal course of supply chain activities because of unexpected fatal incidents) arise from the business failure of SCF

Industrial Management & Data Systems
Vol. 115 No. 9, 2015
pp. 1683-1703

0263-5577
DOI 10.1108/IMDS-04-2015-0161

clients. As a result, more and more financial institutions look for new advanced analytics to detect the SCF clients' business failure, which refers to a situation where the SCF clients cease to exist due to the inability to absorb negative shocks and respond to all kinds of supply chain environmental changes (Amankwah-Amoah and Debrah, 2010; Watson and Everett, 1993), in the early stage.

Improving the predictability of business failure of SCF clients is critical to the success of SCF business as it makes financial institutions possible to introduce preventive strategies, thus improving the overall non-performing SCF loan ratio effectively. Given that the new financial regulatory requirements in China highlight governance, risk exposure and transparent data analysis (Li *et al.*, 2014), it becomes imperative for financial institutions in China to develop relevant prediction models. In this paper, we develop a logistic regression model to demonstrate how the financial institutions can utilize the external big data set to improve the predictability of SCF clients' business failure. Our paper provides a pivotal solution to the financial institutions which require a careful selection of SCF clients through innovative and cost effective financial client risk assessment.

The rest of the paper is organized as follows. The second section, highlights the SCF risk management in big data era in China. The third section, demonstrates the criticality of big data for the financial industry in the knowledge economy era. The fourth section, provides an overview of business failure from different perspectives. The fifth section, highlights the development of the proposed hypotheses. The sixth section, illustrates the research methodology and the hypotheses results. It is followed by a discussion of management implications and a conclusion in last two sections, respectively.

SCF risk management in big data era in China

SCF is to provide downstream buyers or upstream suppliers with a short-term credit to improve their working capital and unlock financial liquidity of their collaborating supply chain partners in order to avoid the resilience of supply chain (Wuttke *et al.*, 2013; Zhang, 2010). In current China, most SCF clients are SMEs and supported by core firms (i.e. powerful supply chain partners). From the risk management perspective, SCF is a multiple-party financing arrangement and is repaid through the cash conversions of current assets (e.g. accounts receivable, inventory and prepayment) being financed by SCF (Wuttke *et al.*, 2013; Zhang, 2010). As the SCF involves the commitment of multiple parties on timely fulfillment of obligations, it requires the financial institutions to conduct a comprehensive assessment of SCF clients with the careful consideration of various risk dimensions, including the repayment abilities derived from the conversion of current assets being financed by the SCF financial institution into sales revenue, the authenticity of supply chain transaction data, the supply chain effectiveness (as reflected in supply chain partnership), the business environmental dimension and the operational dimension (SDB and China Europe International Business School, 2009). As such, the SCF financial institutions needs to rely much on a sophisticated model to determine the creditworthiness of SCF clients. Otherwise, the SCF financial institutions will suffer from significant losses when the opportunistic behaviors and supply chain disruption arise from the unexpected business failure of SCF clients.

While the early detection of business failure of SCF clients is important to the success of SCF, the financial institutions in China face hindrances in developing sophisticated models due to the complex credit environment and the issues of less accountable and transparent corporate governance in China. In addition, as most financial institutions are accustomed to controlling risks through traditional security (e.g. fixed collaterals) and

measures (e.g. analyzing the capital asset of the financial clients and the value of collaterals), they are relatively new to develop environmental and behavior indicators that provide early warning of shifts in financial status and risk-taking behaviors in the knowledge economy, which is defined as "the production and services based on knowledge-intensive activities that contribute to an accelerated pace of technical and scientific advance, as well as rapid obsolescence" (Powell and Snellman, 2004).

Given that the sophisticated prediction model is difficult to develop, most SCF financial institutions in China currently rely on the "revised" traditional approach to deal with SCF credit analysis. The traditional approach, sometimes known as 5C approach (Edwards, 1997; Wood, 1981), emphasizes the importance of Capital (the value of capital assets), Collateral (cash and assets to secure a loan), Character (the financial history of financial clients), Capacity (the ability to generate sales revenue) and Condition (the external circumstances that influence the repayment ability) of a financial client. Since the SME financial clients have no fixed collateral and few capital assets, most SCF financial institutions in China shift their focus to analyze the invoices, contractual guarantees, supply chain transaction structure, as well as the capital and reputation of core firms. It comes with big problems when opportunistic behaviors and supply chain disruption arise from the business failure of SCF financial clients.

The criticality of big data for the financial industry in the knowledge economy era

Big data can be characterized as the high volume of data, the high velocity of nearly real-time or real-time data creation, and the high variety of data from different sources (McAfee and Brynjolfsson, 2012). Research indicates that there are growing prevalence of big data across various mainland industries, of which the most notable are government sector, internet business and finance (Liu *et al.*, 2014). With considerable growth in demands for big data use and the number of big data applications in China (Li *et al.*, 2014), many organizations, including financial institutions, are exploring how to professionally use the ever-increasing volume of data for better prediction of individual action, consumer choice, search behaviors and risk occurrences (George *et al.*, 2014). From the knowledge management perspective, big data is a potential tool for creating values across sectors of knowledge economy since the organizational decision makers are enabled with information, skills and capabilities for performance analysis, customer segmentation, risk evaluation and detection, and new innovations (Barton and Court, 2012; Bose, 2009; Mckinsey Global Institute, 2011). Against this background, the financial institutions, which are typically knowledge-intensive, highly regulated and more inclined to manage risks and uncertainties (Shih *et al.*, 2010), will place significant emphasis on fraud analysis and financial reporting (Capgemini, 2014).

While the opportunities arisen from big data are significant, so too are the managerial challenges. Managers have to find the patterns in big data sets they own or could have access to, convert them "smart" business insights (Brynjolfsson and McAfee, 2012), and systemically manage knowledge and experience (Shih *et al.*, 2010). It relies on whether the organizations can embed the social and working conditions that foster big data management skills (Shih *et al.*, 2010), cross-functional synergies and commitments at all levels (Gupta *et al.*, 2000; Rezgui, 2007). In addition, it requires organizations to take a systematic approach to reviewing the technology advances and the critical issues related to the big data implementation and management within the context of big data analytics (Bose, 2009; Parmar *et al.*, 2014).

An overview of business failure from various perspectives

Business failure is portrayed in this paper as a situation where the SCF clients cease to exist due to the inability to absorb negative shocks and respond to all kinds of supply chain environmental changes (Amankwah-Amoah and Debrah, 2010; Watson and Everett, 1993) for several reasons. First, following Boardman *et al.* (1981) and Thornhill and Amit (2003), we concern much about whether the SCF clients have sufficient capital to cover the obligations of the business. If bankruptcy occurs, the SCF financial institutions definitely suffer most. Second, bankruptcy has long tradition in a large body of accounting and financial management literature (Altman, 1984). Third, while bankruptcy is the major part of our definition, we find that our definition would only be complete when some principal ideas of strategic management are considered. Amankwah-Amoah and Debrah (2010) and Watson and Everett (1993) have viewed business failure as a situation where the firms cease to exist due to the inability to identify and respond to changes in their environment. As the SCF institutions need to understand both SCF clients and the supply chain environment in order to effectively monitor the risks associated with supply chain transactions, we extend the scope of business failure by highlighting the importance of internal capabilities and supply chain environmental changes. Various definitions of business failure is presented in Table I.

Based on the review of literature, which is shown in Table II, we recognize that most strategic management literature highlight internal factors and external factors of business failure and adopt three perspectives – organization studies (OS) perspective, industry organization (IO) perspective and organization ecology (OE) perspective. The OS perspective emphasizes the management capabilities and strategic choices in responding, controlling and even shaping the environment for firm survival (Argenti, 1976). By contrast, both the IO and OE perspective promote "environmental determinism." The IO perspective emphasizes that external environment would impose pressures and constraints on firms' strategies that would lead to business failure (Anderson and Tushman, 2001; Slater and Narver, 1994). Working in the similar rein, the OE perspective emphasizes the role of other firms in determining the success or failure of business (Bauum and Singh, 1994; Hannan and Freeman, 1978).

By integrating the OS and IO/OE perspectives, business failure of SCF clients can be viewed as a part of organizational life cycle in which the fatal decisions happen when

Table I.
Definitions of business failure

Articles	Definitions	Used or modified by
Boardman *et al.* (1981)	Viewed as the lacking of sufficient capital to cover the obligations of the business	Thornhill and Amit (2003)
Gillespie and Dietz (2009)	Portrayed as "a single major incident, or cumulative series of incidents, resulting from the action (or inaction) of organizational agents that threatens the legitimacy of the organization and has the potential to harm the well-being of one or more of the organization's stakeholders"	Mellahi and Wilkinson (2010)
Hamilton (2006)	Viewed as "the substantial loss of customers, clients, and market value that causes an organization to cease operations in its current form, relinquish its existing organizational identity, and lose the ability to self-govern"	Amankwah-Amoah and Debrah (2010)
Watson and Everett (1993)	Refers to a situation where the firms cease to exist due to the inability to identify and respond to changes in their environment	Amankwah-Amoah (2014)

Table II.
Business failures: causes, theoretical perspectives, symptoms and consequences

Articles	Causes of organizational failure	Theoretical perspective for the causes	Symptoms of organizational failure	Consequences of organizational failure
Amankwah-Amoah (2014)	*General* Poor business decisions Lack of skilled personnel to foresee strategic implementation Mismanagement Faulty routines and processes Poor attitude to work *External factors* Globalization and liberalization *Internal factors* Decision makers' characteristics Frequent changes in top management Influences of external actors and managerial constraints Firm's strategy or lack of clear strategy Organizational culture	Organizational studies (OS) perspective Industrial organization (IO) perspective Organizational studies (OS) perspective		Negative externalities such as stigma, financial and psychological costs Positive externalities such as learning, knowledge diffusion, access to key resources, capabilities and market Demise of the airline (the case company)
Mellahi and Wilkinson (2004)	*External causes* Turbulent customer demand & strategic competition Technological uncertainty Dynamism Munificence Complexity Crowding population density Industry life cycle (ILC)	Industrial organization (IO) perspective Organizational Ecology (OE) perspective	*General symptoms* Shrinking financial resources Negative profitability Shrinking market Loss of legitimacy Exit from international markets	

(*continued*)

Table II.

Articles	Causes of organizational failure	Theoretical perspective for the causes	Symptoms of organizational failure	Consequences of organizational failure
	Internal causes Liability of newness Liability of smallness Poor group thinking Homogeneity of the top management team Tenure Managerial successions Cure of success Threat rigidity effect theory Poor group thinking Homogeneity of the top management team Tenure Managerial successions Cure of success Threat rigidity effect theory	Organization studies (OS) & Organizational psychology (OP) perspectives		
Mellahi and Wilkinson (2010)	*External causes* Gradual changes in business environment	Chaos theory	*General symptoms* Cesspool syndrome: competent people leave the organization Omission bias in decision making	
	Abrupt transformations process	Industrial organization (IO) perspective		
	Internal causes Managers' inadequacies in handling external threats and	Organizational studies (OS)		

the top managers face the crisis triggered by some internal or external events (Cameron *et al.*, 1987; Whetten, 1987). Business failure happens when a critical incident or a series of incidents, resulting from the action of stakeholders threaten the legitimacy and survival of SCF client firms (Bauum and Singh, 1994; Gillespie and Dietz, 2009; Hannan and Freeman, 1978; Mellahi and Wilkinson, 2010).

Based on the integration of the three perspectives, we propose a unified framework, which is shown in Figure 1, to analyze the business failure of SCF clients. We argue that their business failure are more likely to occur when they have low capacity to absorb negative shocks, low responsiveness to customer budget sensitivity and retention, low adaptability to supply chain relationship and drastic changes of external business environment. Our argument is predicated on the assumption that the locus of control for the business failure is internal to SCF clients while the context for the failure may involve external influences (Gillespie and Dietz, 2009). In this paper, we highlight more on internal factors that typically indicate the vulnerability to liquidity risks and operation risks of SCF clients. In addition, we recognize the potential impact of changes in external business environment on business failure.

Development of the proposed hypotheses

As presented in Figure 1, the likelihood of business failure of SCF clients can be attributed to low capacity to absorb negative shocks. The distressed SCF clients, mostly SMEs, have neither adequate working capital nor assets to serve as buffers that cushion against negative incidents. It is especially the case when the survival conditions for SMEs in China are deteriorating after the global financial crisis in 2008 (Cao and Huang, 2012). From the IO perspective, business failure is likely to occur when the firms have scarce resources (Anderson and Tushman, 2001). From the financial management perspective (Altman, 1967), the unavailability of resources of SCF clients can be highly reflected in low profitability since the SMEs in China are disadvantaged with respect to access to capital markets. In this paper, two measures, which include taxable sales revenue and enterprise income tax (EIT) are used to indicate the level of profitability. It is anticipated that the SCF clients with low taxable sales revenue have poor financial health. Thus, it gives rise to the following hypothesis:

H1. The lower the taxable sales revenue of SCF clients, the higher the chance of their business failure.

EIT, which is a direct tax on the remaining gross income, can also be used to reflect the profitability of firms operating in China. Based on the Chinese EIT law (EU SME Center, 2012), all companies generating income within China are subject to EIT. Specifically, the general enterprises and high-tech enterprises have to pay the EIT at a rate of 25 and 15 percent, respectively. As lower EIT implies low profitability, it is anticipated that lower EIT is linked to higher chance of business failure. Thus, it give rise to the following hypothesis:

H2. The lower the EIT paid by SCF clients, the higher the chance of their business failure.

In China, firms have to pay the Chinese value-added tax (VAT), which is an indirect tax excluded in price. Put differently, the VAT can be used to reflect the reduction in values generated in the supply chain processes in China. Under the China VAT system (KPMG, 2013), all import firms operating in China have to pay a specific rate,

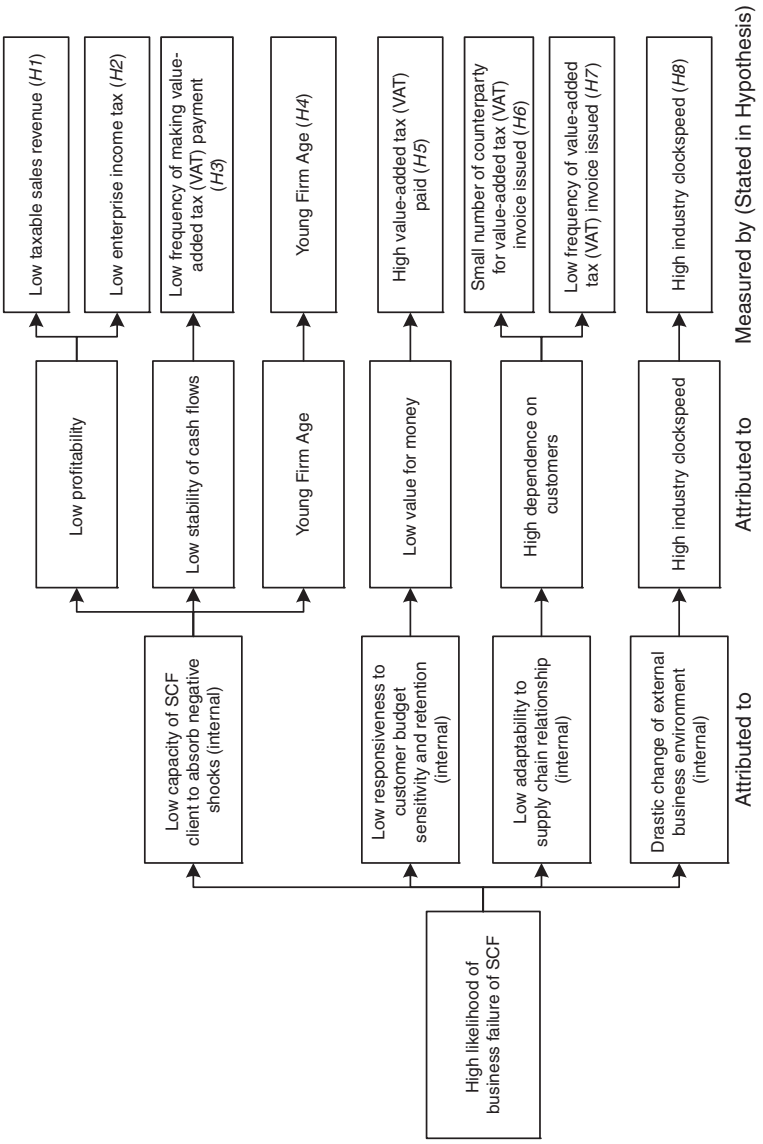

Figure 1.
A unified framework to analyze business failure

approximately from 13 to 17 percent while all export firms operating in China, except those qualified in the export credit scheme, have to pay at a rate of 17 percent.

For firms making a total payment of more than a specific amount, they are eligible to file and make their VAT payment more frequently, and vice versa. Given that the frequency of making VAT payment reflects the stability of cash flows within a firm, it is argued that the low capacity of the SCF clients to absorb negative shocks can be implied when the SCF clients are unable to make frequent VAT payment. As such, it gives rise to the following hypothesis:

H3. The lower the frequency of making VAT payment by SCF clients, the higher the chance of their business failure.

From the OE perspective, firm age matters in the issue of business failure. Based on the summary from Cao and Huang (2012), three lines of thoughts exist to predict the relationships between the risk of business failure and firm age. In the first line of thought (Stinchcombe, 1965), the younger enterprises are believed to have higher chance of business failure due to the liability of newness (such as deficiency of resources and capabilities). In the second line of thought, it is believed that enterprises' risk of business failure follows an inverted U-shape pattern. The major explanation is that new born enterprises have no experience and reputation at first, but will gradually lower their risks of business failure since the "adolescence." In the third line of thought, the older enterprises gradually increase their chance of business failure due to inability to adapt to the rapidly changing business environment (Hannan, 1998).

Based on the above discussion, it is reasonably assumed that the chance of business failure increases with younger age due to limited resources and capability constraints faced by the younger firms. It is anticipated that young SCF clients have lower capacity to absorb negative shocks. Thus, it gives rise to the following hypothesis:

H4. The younger the firm age of new SCF clients, the higher the chance of their business failure.

As mentioned in Figure 1, the likelihood of business failure of SCF clients can also be attributed to low responsiveness to customer budget sensitivity and retention, as many customers have faced limited resources and shrinking budgets since the global financial crisis in 2008. From the OS perspective, business failure is associated with internal inadequacies in coping with external threats (Argenti, 1976). Whether the SCF clients are able to cope with threats depends much on how well they can maintain consistent cash flows by retaining customers. Since their downstream customers value mostly with the value of their offerings, it implies that the increased amount for which the downstream customers (who are also VAT taxpayers for private consumption expenditure) finally pay will lead to a decrease in their purchase commitment, subsequently reducing the sales turnover of SCF clients. Thus, it gives rise to the the following hypothesis:

H5. The higher the VAT paid by the SCF clients, the higher the chance of their business failure.

In the unified framework, which is shown in Figure 1, we argue that there is a positive relationship between low adaptability to supply chain relationship and business failure. Our argument is predicated on the assumptions that the SCF clients are more

vulnerable to business failure if they have high dependence on a few core downstream customers. From the OE perspective (Bauum and Singh, 1994; Hannan and Freeman, 1978), when the mutual interactions within and among organizational populations become negative, the SCF clients are becoming difficult to fit into natural selection process. Given that the downstream customers need to obtain the VAT invoices, the smaller the number of counterparty (i.e. downstream customers) for VAT invoice issued by SCF clients, the high the dependence on the business relationship with their downstream customers. As such, it gives rise to the following:

H6. The smaller the number of counterparty for VAT invoice issued by new SCF clients, the higher the chance of their business failure.

Since all the VAT input values of downstream customers should be supported by VAT invoice issued by SCF clients (EU SME Center, 2012), lower frequency of VAT invoice issuance implies lower frequency of transactions with downstream customers. When the transactions are less frequent, the new SCF clients tend to be more reliant on particular business relationships or business deals. As such, it is reasonably argued that when the VAT invoice are less frequently issued, these SCF clients will be more vulnerable to business failure. Based on the above argument, it gives rise to the following:

H7. The lower the frequency of VAT invoice issued by new SCF clients, the higher the chance of their business failure.

From the IO perspective, the environment conditions typically have long-term effects on business failure (Swaminathan, 1996). Various IO scholars have argued that the drastic changes in demand structure, technology and industrial order will lead to the discontinuance of incompetent firms (Anderson and Tushman, 2001; Slater and Narver, 1994). Fine (1998) introduced the concept of clockspeed to capture the rate of industry change promoted by technological and competitive factors. While it appears that clockspeed will influence the business failure or survival, previous research has found mixed results on clockspeed in determining business success or failure. As it is generally agreed in the financial discipline that higher opportunities are typically associated with higher risks, we believe that new SCF clients in higher clockspeed industries tend to have higher chance of business failure. Thus, it gives rise to the following:

H8. The higher the industry clockspeed of new SCF clients, the higher the chance of their business failure.

Research methodology

Data

The big data set, originating from the sources of a reliable and big Chinese information provider, represents data from 18 Chinese industries and 206,149 enterprises operating in China. As this paper emphasizes the clockspeed, which is the rate of industry changes (Fine, 1998), we select the best appropriate industries based on Chinese standard industrial classification. It finally comes with 12 Chinese industries and 203,335 sample companies operating in China for big data analysis. Table III shows the sales revenue and industry distribution of sample companies in 2014 Q4. Accordingly, 62.15 percent of them are high clockspeed enterprises while 37.85 percent of them are low clockspeed enterprises.

As shown in Table III, our sample covers a spectrum of companies having different levels of sales revenues and can be stratified into five categories according to sales

Sales revenues in 2014 Q4 (in million CNY)								
Number of sample/ proportion (%)	Below 0.1	0.1 to <0.5	0.5 to <1	1 to <5	5 or above	Total	Types of clockspeed	Percent in total (%)
Manufacturing	30,268/ 14.89	25,281/ 12.43	18,288/ 8.99	34,200/ 16.82	16,873/8.3	*124,910/ 61.43*	High clockspeed	*62.15*
Information services, computer and software	14/0.01	5/0	6/0	15/0.01	30/0.01	70/0.03		
Wholesaling and retailing	20/0.01	15/0.01	5/0	6/0	3/0	49/0.02		
Financial services	210/0.1	202/0.1	174/0.09	387/0.19	224/0.11	1197/0.59		
Renting and business services	38/0.02	33/0.02	27/0.01	43/0.02	15/0.01	156/0.08		
Farming, fishing, forestry, herding	894/0.44	394/0.19	268/0.13	464/0.23	198/0.1	2,218/1.09	Low clockspeed	*37.85*
Mining	377/0.19	62/0.03	65/0.03	145/0.07	84/0.04	733/0.36		
Electricity, gas and water supply	335/0.16	597/0.29	218/0.11	306/0.15	252/0.12	1,708/0.84		
Architecture	68/0.03	76/0.04	89/0.04	263/0.13	179/0.09	675/0.33		
Transportation, warehousing and postal services	18,887/ 9.29	14,913/ 7.33	10,017/ 4.93	18,551/ 9.12	9,228/4.54	71,596/ 35.21		
Hotel and dining	7/0	0/0	0/0	5/0	9/0	21/0.01		
Housing and Land development	2/0	0/0	0/0	0/0	0/0	2/0		
合计	*51,120/ 25.14*	*41,578/ 20.45*	*29,157/ 14.34*	*54,385/ 26.75*	*270,95/ 13.33*	*203,335/ 100*		

Table III. Sales revenues and industry distribution of sample companies in 2014 Q4

revenue in 2014 Q4. The five categories include: quarterly sales revenue of below 0.1 million CNY (representing 25.14 percent of total); quarterly sales revenue of between 0.1 million CNY and 0.5 million CNY (representing 20.45 percent of total); quarterly sales revenue of between 0.5 million CNY and 1 million CNY (representing 14.34 percent of total); quarterly sales revenue of between 1 million CNY and 5 million CNY (representing 26.75 percent of total); and quarterly revenue of more than 5 million CNY (representing 13.33 percent of total). From the table, we find that the sample companies are evenly distributed among the above five sales revenue categories, with the medium to large firms (in term of sales revenue) having a slightly bigger share. Our analysis of the industry distribution of sample companies indicates that manufacturing sector ranks at the top of distribution (61.43 percent of total).

Dependent variable

In this paper, we use the discontinuance of reporting tax (Y) as a strong signal of business failure because it is essential for SCF clients to file tax return until they cease to operate in China. In our measurement, the discontinuance of reporting tax is measured by the number of times the firms report part-quarterly (monthly) to the Chinese tax office for the three months in 2014 Q4. In the normal situation, a typical firm should report to the tax office monthly for three times. If the number of times the firms report to the tax office is 0-1, it indicates that the firms fail to maintain the continuance of reporting tax and tend to discontinue the operations.

Predictor variables

Taxable sales revenue ($X1$) reflects the ability of firms to make sales in 2014 Q4. Enterprise income tax ($X2$) is a direct tax on the remaining gross income. The taxable income is derived from gross income after deducing the real and reasonable expenses associated with income generating activities, as well as allowable loss carryforwards and relevant non-taxable and tax-exempted income. Both the taxable sales revenue ($X1$) and the enterprise income tax ($X2$) reflect the profitability of firms operating in China in 2014 Q4.

Frequency of making VAT payment ($X3$) means the number of times each year the SCF clients pay VAT. It generally reflects stability of cash flow operations in 2014 Q4. Firm age ($X4$) is the duration of the SCF clients in 2014 Q4.

VAT paid ($X5$) is the indirect tax imposed on the final private consumption expenditure. It reflects the reductions in value generated in the supply chain processes in 2014 Q4. Number of counterparty for VAT invoice ($X6$) reflects the number of downstream customers in 2014 Q4. Frequency of VAT invoice issued ($X7$) reflects the frequency of transactions in 2014 Q4. Both the number of counterparty for VAT invoice ($X6$) and frequency of VAT invoice issued ($X7$) reflect the extent to which the SCF clients depend on downstream customers. Industry clockspeed ($X8$) captures the rate of industry change in 2014 Q4.

Table IV illustrates the descriptive statistics of variables in the big data analysis.

Results

Figure 2 illustrates a model for predicting the business failure of SCF clients. In this model, eight hypotheses (*H1-H8*) are developed to predict the probability of business failure of SCF clients.

Logistic regression is deployed as our dependent variable (Y) is discrete not continuous. We set dependent variable (Y) as a dummy variable (1 = business failure happens, 0 = otherwise), and use the logistic regression procedure to estimate the predicted probabilities. According to Hosmer and Lemeshow (1989), logistic regression can solve the major problems with using linear probability model such as heteroskedastic and not normally distributed error terms, as well as difficulty in interpreting predicted values.

The logistics regression model, as shown in the following equation, fits the log odds (Logit) of business failure by a linear function of the predictor variables including Taxable sales revenue ($X1$), Enterprise income tax ($X2$), frequency of making value-added tax (VAT) payment ($X3$), firm age ($X4$),value-added tax (VAT) paid ($X5$), number of counterparty for value-added tax (VAT) invoice issued ($X6$), frequency of value-added tax (VAT) invoice issued ($X7$) and industry clockspeed ($X8$). Maximum likelihood estimation is used to estimate the coefficients of the model:

$$\text{Logit}(P|Y = \text{probability of business failure}) = B0 + B1X1 + B2X2 + B3X3 + B4X4 + B5X5 + B6X6 + B7X7 + B8X8 \quad (1)$$

Before conducting detailed diagnosis of business failure, we base on the descriptive statistics of variables presented in Table IV and further conduct two tests – the likelihood ratio test (in Table V) and the ROC curve analysis (in Table VI). The likelihood ratio test, which is a test of the significance, helps us compare the likelihood of the data under the full model against the restricted model. Meanwhile, the ROC curve

Table IV.
The descriptive statistic of variables in the big data analysis[a]

Variables	Mean value/mode	SD/median	*Y*	*X*1	*X*2	*X*3	*X*4	*X*5	*X*6	*X*7
Y	0[b]	0[b]								
*X*1	2,989,325.687	2,3533,712.476	−57.503c**							
*X*2	1,588.201	5,6539.469	−10.516c**	0.013**						
*X*3	1.21	0.912	−686.600c**	0.031**	−0.005*					
*X*4	10.19	4.968	−16.801c**	0.016**	−0.004	−0.008**				
*X*5	62,411.087	61,9741.663	−45.260c**	0.663**	0.013**	0.079**	0.022**			
*X*6	12.75	59.431	−97.307c**	0.612**	0.001	0.133**	0.033**	0.672**		
*X*7	50.23	300.569	−75.773c**	0.388**	0.004	0.092**	0.024**	0.360**	0.489**	
*X*8	1[b]	1[b]	303.917 d**	−3.180c**	7.375c**	27.005c**	22.961c**	7.467c**	−10.123c**	−16.373c**

Notes: *Y* and *X*8 are categorical variables. The corresponding statistics are mode and median. *Y* and *X*8 are dummy variables. *X*1, *X*2, *X*3, *X*4, *X*5, *X*6 and *X*7 are continuous variables, and *t* test (*t*-statistic) is applied;. *Y* and *X*8 are categorical variables. Pearson χ^2 is used as the test statistic because the minimum expected count is 10,011.63 (i.e. the expected count of less than five accounts for less than 20 percent) and the sample size $n > 40$. *,**Correlation is significant at the 0.05, 0.01 levels (two-tailed)

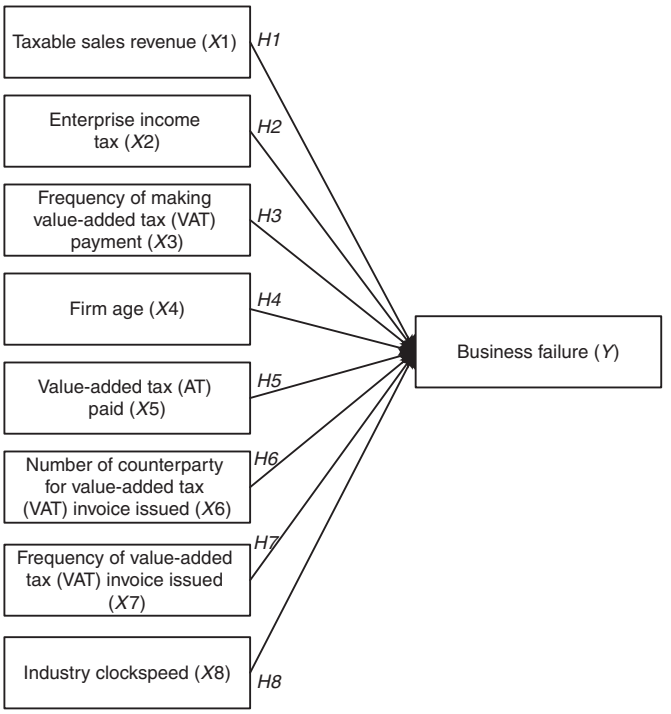

Figure 2.
Model for predicting the business failure of SCF clients

Independent variables	B (SE)	Exp (*B*)	Wald
Taxable sales revenue (*X*1)	−105.023 (2.688)	0.000	1,526.146***
Enterprise income tax paid (*X*2)	−0.123 (0.071)	0.884	3.048
Frequency of making VAT payment (*X*3)	−3.095 (0.092)	0.045	1,136.777***
Firm age (*X*4)	−0.192(0.010)	0.825	376.562***
Value added tax paid (*X*5)	6.208 (0.617)	496.490	101.222***
Number of counterparty for VAT invoice issuance (*X*6)	−54.243 (2.143)	0.000	640.968***
Frequency of VAT invoice issuance (*X*7)	−19.470(2.482)	0.000	61.554***
Industry clockspeed (*X*8)	0.760(0.020)	2.139	1,457.926***
Constant	−31.747(0.473)	0.000	4,495.268***
−2 Log likelihood	61,093.130		
χ^2(df)	96,116.483***		
Odds ratio for business failure/Odds ratio for organizational survival (%)	87.5/93.4		
Overall odds ratio (%)	92.6		

Note: ***Correlation is significant at the 0.001 level (2-tailed)

Table V.
Logistic regression predicting business failure of SCF clients

analysis is to quantify how accurately our diagnostic test can actually discriminate between SCF clients having business failure problems and normal SCF clients (Swets, 1986). If the area under the ROC curve is 1, it implies a perfectly discriminating test – a test having 0 false positives and 0 false negatives (Hajian-Tilaki, 2013).

To justify our decision to include the proposed predictor variables (i.e. *X*1 -*X*8), we use a stringent *p*-value ($p = 0.01$) threshold for the likelihood ratio test. Analysis

reveals that the observed value (i.e. 96,116.48) of our model is much greater than χ^2's ($p = 0.01$, df = 8) critical value (i.e. 20.09). Given that the stringent p-value ($p = 0.01$) threshold has passed, we have high confidence that the eight independent variables, which include $X1$-$X8$, are justified and the Logit P regression is statistically sound.

To further justify the effectiveness of the model, we use ROC curve for diagnosis (Table VI). Our result shows that the area under ROC curve is 0.966, which is greater than the acceptable threshold of 0.5, suggesting that the predictability of our model is acceptable. Therefore, we justify the proposed model as our final model.

Table V shows the logistic regression predicting the business failure of SCF clients. The regression measures the effect of independent variables (i.e. $X1$-$X8$) on the probability that the SCF clients would have business failure. The slope coefficient (B) is the rate of change in the "log odds" as a respective X variable changes. A positive slope coefficient demonstrates the positive effect on the business failure of SCF clients, and vice versa. All coefficients of $X1$-$X8$, except $X7$, are statistically significant at p value (Wald statistic) less than 0.001. To make the interpretation of the logit coefficient more intuitive, we try to evaluate the effect of the independent variable ($X1$-$X8$) on the "odds ratio" (exp B) , which is the probability of the business failure of SCF clients divided by the probability of the business survival. As shown in Table V, the probability of business failure is 87.5 percent while the probability of business survival is 93.4 percent, giving an odds ratio of 92.6 percent. Based on our preliminary analysis, it appears that our model powerful in predicting the business failure of the SCF clients.

Table VII illustrates the hypotheses results from the big data analysis. All hypotheses except (*H2*) are statistically significant at p value less than 0.001.

Discussion

The importance of taxpaying behavioral variables

In the knowledge economy, intellectual capabilities, which means having the ability to comprehend and create knowledge derived from manpower, creativity, innovation,

Area	SE[a]	Test result: odd values Asymptotic Sig.[b]	Asymptotic 95% confidence interval Lower bound	Upper bound
0.966	0.000	0.000	0.965	0.966

Notes: [a]Under the nonparametric assumption; [b]null hypothesis: true area = 0.5

Table VI. Area under the curve

Hypothesis	Proposed direction	Outcome
H1: taxable sales revenue→chance of business failure	Negative	Supported
H2: enterprise income tax (EIT) paid→chance of business failure	Negative	Rejected
H3: frequency of making VAT payment→chance of business failure	Negative	Supported
H4: firm age→chance of business failure	Negative	Supported
H5: value added tax (VAT) paid→chance of business failure	Positive	Supported
H6: number of counterparty for VAT invoice issued→chance of business failure	Negative	Supported
H7: frequency of VAT invoice issued→chance of business failure	Negative	Supported
H8: industry clockspeed→chance of business failure	Positive	Supported

Table VII. Hypotheses result for the big data analysis

organizational structure or relevant parties, is regarded as the integral part of success (Powell and Snellman, 2004; Shaikh, 2004; Shih *et al.*, 2010). In order to optimize the use and disposal of intellectual capabilities, an increasing number of organizations emphasizes the assessment of creditworthiness. Our results reveal that several taxpaying behavioral variables, including the frequency of making VAT payment (*H3*), the number of counterparty for VAT invoice issuance (*H6*) and the frequency of VAT invoice issuance (*H 7*) are negatively correlated with business failure of SCF clients. Our results suggest that the SCF financial institutions should avoid lending SCF loans to those exhibiting poor taxpaying behavior as it reflects poor creditworthiness of SCF clients.

From the OE perspective, the instability of cash flow operations can be regarded as a factor in determining the business failure of SCF clients because it reflects the possibility that the SCF clients may have some hidden management issues. From the OE perspective, it appears that the SCF clients are at the high risk of over-relying on a few key customers since other organizations can play a crucial role in determining the chance of failure of an organization (Mellahi and Wilkinson, 2004). Our results suggest that the SCF financial institutions should better choose a healthier SCF client who has diversified its customer base to better secure the revenue streams and bargaining power.

The importance of tax amount, firm age and industry clockspeed

Our results show that the VAT paid are positively correlated with the risk of business failure (*H5*) while taxable sales revenue (*H1*) are negatively correlated. There is no statistically significant relationship between the EIT paid and the probability of business failure (i.e. *H2* rejected).

The probability of business failure of SCF clients increases with greater VAT paid (i.e. *H5* supported). Based on the evolutionary economics discussed in Hodgson (1998), business failure can be viewed as the inability of the enterprises to transform the organizational memory to "add values" to the internal business operations and market processes. In this sense, VAT tax, as being an extra cost burden to customers, can be argued to be a detrimental factor of organizational survival because it reduces the "value for money" of SCF clients' customers, subsequently affecting the customer retention. The financial institutions, therefore, should pay attention to the VAT paid by the SCF clients.

The probability of business failure of new SCF clients increases with lower taxable sales revenue (*H1*) (i.e. *H1* supported). As previously discussed, lower profitability implies lower capacity of SCF clients to absorb negative shocks. The financial institutions, therefore, should carefully analyze the profitability of SCF clients and determine the potential implementation barriers in their sales revenue cycles.

To survive in the knowledge economy, an increasing number of organizations are needed to adapt to the accelerated pace of technological advance, as well as fast obsolescence (Powell and Snellman, 2004). As such, in this paper, we investigate the effect of the firm and industry variables on business failure. Based on our findings, the firm age (*H4*) and industry clockspeed (*H8*) are confirmed to be negatively and positively correlated with their business failure, respectively. From the OE perspective, high probability of business failure happens when younger firms have inadequate intellectual capability to respond to the changed situations due to their organizational newness (Bruderl and Schussler, 1990; Staw *et al.*, 1981).

From the knowledge management perspective, the financial institutions are needed to keep adequately informed of the business cycles of all other industries since the financial industry is highly knowledge intensive (Shih *et al.*, 2010). Our results suggest

that the SCF financial institutions should target at more mature SCF clients operating in the less turbulent business environments unless they are highly familiar with those high clockspeed industries.

Conclusion

Early detection of business failure of SCF clients is critical to the success of SCF financial institutions. From the risk management perspective, the financial institutions will suffer from great loss when the SCF clients go for business failure. It is especially the case for Chinese financial institutions, which strive to achieve sustainable operations in the deregulated, increasingly global and highly commoditized domestic market. The results support the notion that the powerful financial institutions can develop the integrative and comprehensive big data analysis to expand the loan business in a progressive and risk-controllable manner. By identifying those SCF clients who are more vulnerable to business failure, we provide the financial institutions with managerial insights on how to screen out the risky SCF clients and target less risky ones. The customer segmentation, driven by big data, enables financial institutions to target the less risky SCF clients by providing more competitive SCF loan packages.

Our paper highlights the importance of internal and external factors on the early identification of the business failure of the SCF clients. As discussed in Anheier (1996), business failure can be viewed in multiple aspects, such as organizational, political, structural and cognitive aspects. Based on the review of literature, however, the institutional, social and business ethic indicators for organizational survival are rarely discussed. In future, we should investigate the above indicators and transform the multi-dimensional big data sets into better prediction outcomes.

Our paper focusses on the individual characteristics and industry clockspeed. Future research may consider incorporating the collaborative performance of supply chain networks to better determine the business risks inherent in the supply chain transactions and potential supply chain failure. By incorporating the collaborative performance into the predictive model, both the financial institutions and SCF clients may further exploit the value of relationship capital, which refers to all relations between all relevant members and stakeholders, for higher returns in the interconnected knowledge economy.

Our paper extends the applicability of several perspectives, including OS perspective, IO perspective and OE perspective, to the development of a financial client risk assessment model. It triggers a more extensive discussion of big data in financial industry and its implications for cross-disciplinary management research.

Last but not the least, our paper helps to develop the knowledge economy in China as the major constraints (such as the poor credit environment in China and the vulnerability of SMEs) for SCF clients accessing and for financial institutions allocating the SCF money in the lending market are mitigated by the intellectual capital accumulated through the deployment of the predictive model for business failure. By collaborating with external information providers, the SC financial institutions can develop the collective intellectual capital to reduce credit risks and create profits, thus being more capable of providing the SMEs with adequate funds to fulfill their financial needs. The new waves of innovation-led, entrepreneur-oriented growth in the knowledge economy can be promoted through the significant reduction of business failure uncertainty and increasing the prevalence of the internet enabled, big data driven business-to-business network environment. As the financial institutions are enabled with information, skills and intellectual capabilities to screen out the financially distressed

SCF clients, the remaining clients are generally more willing to connect and contribute to the interconnectedness and transparency of the financial supply chain networks. The resultant change of knowledge processing environment will catalyze the sort of development that encourages all parties within a financial supply chain to embrace the knowledge economy.

Our paper implies that it is possible to transform the intellectual capabilities of different parties together into bigger intellectual capital to support the development of big data driven knowledge economy. As the value of our model can be applied to financial service risk management pursuits, the idea of this paper can be served as a starting point for the Chinese government to develop the best financial services risk management practices through the development of the open data platform for the benefits of network members (e.g. banks, insurance companies, credit agencies, internet financing providers and governmental departments) related to the financial industry.

Acknowledgments

This work described in this book was substantially supported by the Major Program Grant (Nos 71090403/71090400), the Major International (Regional) Joint Research Project (No. 71420107024) of the Natural Science Foundation of China (NSFC), National Natural Science Foundation of China (No. 71473087), Project of Chinese Ministry of Education (No. 14YJC630162) and two vertical projects of China (Nos x2jmN5140240, 2014HQPY04). It is also supported by the Institute of Supply Chain Integration and Service Innovation at South China University of Technology.

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