Multi-Objective Optimisation of Dynamic Short-term Credit Portfolio Selection: The Adoption of Third Party Logistics Credit for Financing Working Capital Constrained Small and Medium Sized Enterprises in Supply Chains

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Declaration

This statement and the accompanying publications have not previously been submitted by the candidate for a degree in this or any other university.

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Abstract

Many companies, especially small and medium sized enterprises, are faced with liquidity problems. The shortage of working capital in their businesses has prevented supply chains from achieving effectiveness and efficiency in management. Although they can access short-term loans from banks and suppliers, the willingness of these credit lenders to lend short-term capital is often restricted by the fact that they cannot monitor whether or how their customers will use the loans according to the agreements. In many cases, this fact makes it difficult for capital-constrained companies to obtain sufficient working capital from existing funding sources.

A business practice called Integrated Logistics and Financial Service has been developed, which can improve banks' monitoring of how their loans will eventually be used via the alliance of third party logistics companies and banks. The emergence of credit offered by third party logistics companies (termed as 3PLC) provides more choices for working capital constrained companies. Following on traditional bank overdrafts and trade credit, the new 3PLC became the third type of credit available to short-term working capital constrained companies. A new issue arising from this situation is how a working capital constrained company can determine a credit portfolio from multiple working capital sources. Current studies of credit portfolio management are still silent in considering 3PLC. Moreover, limited studies have integrated credit portfolio management into material flow management in supply chains. In light of the aforementioned discussions, this thesis aims to optimise dynamic credit portfolio management in supply chains to achieve the different business objectives of working capital constrained companies.

To achieve the above aims, this thesis firstly applies an analytic hierarchy process and linear programming model to optimise a single objective. It applies the analytic hierarchy process to evaluate the concerns of working capital-constrained companies in selecting credit. These concerns are identified through a thorough literature review focusing on the considerations of small and medium sized enterprises' in borrowing short-term credit. The analytic hierarchy process has been applied to determine the priority of the identified concerns and the preferences of borrowers for bank overdrafts, trade credit and 3PLC. A linear programming model has been developed based on the results obtained from the analytic hierarchy process model. It determines the maximum borrowing amount for a given period from multiple credit sources. To reflect the complexity of working capital constrained companies borrowing credit, this thesis has extended the model from single objective optimisation to multiple objectives optimisation. Consequently, a goal-programming model has been developed. This model provides the solution of optimizing two business objectives including overall cost and backorder penalty cost minimization. Numerical examples have been conducted to test and analyse all the mathematical models.

This thesis contributes the following aspects: 1) the new 3PLC together with bank overdraft and trade credit have been considered into credit portfolio management; 2) borrower's concerns and credit preferences relating to the three types of credit have been identified and evaluated; 3) mathematical models have been developed for credit portfolio selection over multiple periods.

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In loving memory of my grandfather

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List of Abbreviations

Term Abbreviations

Abbreviations	Full words
AHP	Analytic Hierarchy Process
ANP	Analytic Network Process
BL	Bank Loan
BO	Bank Overdraft
BPC	Backorder Penalty Cost
CI	Consistency Index
CR	Consistency Ratio
CSL	Customer Service Level
EOQ	Economic Order Quantity
EPQ	Economic Production Quantity
ILFS	Integrating Logistics Financial Service
GP	Goal Programming
LP	Linear Programming
MIP	Mixed Integer Programming
MILP	Mixed Integer Linear Programming
MOLP	Multi-Objective Linear Programming
MOO	Multiple-Objective Optimisation
NLP	Nonlinear Programming
OFT	Order Fulfilment Time
PQM	Product Quantity Management
RI	Random-Like Matrix
SBA	Small Business Administration
SC	Supply Chain
SCFF	Supply Chain Financial Flow
SCM	Supply Chain Management
SME	Small and Medium-sized Enterprises
TC	Trade Credit
3PL	Third-Party Logistics
3PLC	Third-Party Logistics Credit

Country Abbreviations

Abbreviation	Country
AT	Austria
BE	Belgium
BG	Bulgaria
CZ	Czech Republic
DE	Germany
ES	Spain
FR	France
GR	Greece
IE	Ireland
IT	Italy
NL	Netherlands
PT	Portugal
FI	Finland

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PART 1 INTRODUCTION AND LITERATURE REVIEW

Chapter 1 Introduction

The study aims to help small and medium sized entreprises (SME) to fulfil their working captial demands. This chapter aims to review working capital constrained problems in academic studies and industrial operations and address the importance of managing working captial flow in supply chains (SC). This chapter is structured as follows. Chapter 1.1 describes a brief background of the research. Chapter 1.2 dicusses and explains the research questions and objectives of this thesis and Chapter 1.3 presents and explains the structure of this thesis.

1.1 Working Capital Constraint in Supply Chains

The objective of supply chain management (SCM) is defined by Mentzer et al. (2001) as,

> *"To collaborate and coordinate several stakeholders to optimise the flow of materials, information, and finance along the entire supply chain."*

It can be infered that, material flow, information flow and financial flow should be given the same attention in both academia and industry and investigated in an integrated way (Thomas and Griffin, 1996; Comelli *et al.*, 2008). However, in academia, this has not been the case. The majority of studies related to SCM mainly focus on material flow management (Min and Zhou, 2002). Only limited studies have discussed how to integrate informational flow with material flow management (Hau *et al.*, 2000; Lee and Whang, 2000; Padilla and Pagano, 2000; Shore, 2001; Azadian *et al.*, 2012; Shi *et al.*, 2012; Wu, 2015). Moreover, the study of financial flow management in the context of supply chain management (SCM) has also been neglected in academic research (Pfohl and Gomm, 2009; Waters and Rinsler, 2014). Furthermore, the coordination of financial flow and material flow has also rarely been discussed in recent studies (Wuttke *et al.*, 2013a).

Practitioners in SC industry are required to coordinate three flows in SCM, especially in order to be aware of the stability of financial flow (Hendricks and Singhal, 2005; Rai *et al.*, 2006; Wuttke *et al.*, 2013a; Wuttke *et al.*, 2013b). A stable financial flow is reckoned to be the fundamental support for operating material flow and information flow (Song and Yao,

2013). To determine whether a financial flow is stable or not, the amount of working capital that is availabe to the company is selected as one criterion by SC practitioners (Gunasekaran *et al.*, 2001; Bichou and Gray, 2004; Gunasekaran *et al.*, 2004; Mitra and Bagchi, 2008; Liu and Lyons, 2011). It can be used to evaluate liquidity assets in SC financial flow (Cho *et al.*, 2012).

Working capital is important as it decides the survival of a firm (Estampe *et al.*, 2013). Stevenson and Waite (2010, p. 1663) defined working capital as:

> *"The capital of a business which is used in its day-to-day trading operations; calculated as current assets minus the current liabilities."*

On the one hand, from the perspective of a firm, Baños-Caballero *et al.* (2010), working capital management could affect a firm's profitability and consequently its value. On the other hand, from the perspective of SCs, Juttner *et al.* (2003), a stable supply of working capital would maintain the operations of entire SCs. Rai *et al.* (2006) described working capital as being important as it supports firms in SCs, and it also allows them to operate their material flow and information flow more efficiently. As a result, a SC with stable working capital financing has a better performance in material flow management (Melo *et al.*, 2009). On the contrary, a disrupted supply of working capital in a company affects the stability and efficiency of whole SCs (Fairchild, 2005; Dehning et al., 2007; Lai et al., 2009; Yang and Birge, 2013; Xu et al., 2015).

However, it may be not easy for many companies to maintain working capital stability. This problem can be understood as working capital constraint and it has been defined as:

> *"A liquidity shock on cash flow, which companies are insolvent and have no capitals for operating business."*
>
> Sato (2012)

In general, working capital constraint is a common problem which leads to companies finding it hard to cover their operation costs (Chan, 2014). This problem has been the most direct threat to every firm; especially due to the financial crisis, there has been an extra increase in the number of working constrained companies of late (Dan *et al.*, 2012).

To ensure the survival of working capital constrained companies in competitive markets and to maintain the stability of SCs, accessing financing is the priority of many working capital constrained companies, especially for small and medium sized enterprises (SME)

in SCs (Cook and Nixson, 2000; Mohammed, 2007). Heger and Rohrbeck (2012) described how SMEs developed their businesses not only by acquiring emerging information such as demands in new markets, but also through integrating stakeholders in order to obtain sufficient capital. However, raising enough working capital is much more difficult for SMEs than for large enterprises (Carpenter and Petersen, 2002). Compared to most large enterprises with sufficient collaterals, SMEs are less attractive to external financial supports due to having insufficient collateral, business history or credit history (Luo and Tung, 2007).

Since the global financial crisis of 2008, the problem of working capital constrained has struck many SMEs (Bricongne *et al.*, 2012; Ding *et al.*, 2013; Manova *et al.*, 2014). This situation led directly to disruption in many businesses and even in a whole SC. According to the European Central Bank (2014), the increased costs in labour and materials have exacerbated the working capital constraint in SMEs. During this period of financial crisis, a shortage of working capital directly limited the procurement and logistics activities of many SMEs' (Cornett *et al.*, 2011). Lee *et al.* (2015) investigated many companies including SMEs in the UK, and found they were pressed to access short-term credit to solve their working capital constraint problems. However it is often difficult to reach their credit demands due to the economy in the U.K. having not recovered to its pre-global financial crisis level (Cowling *et al.*, 2016). Some scholars find that these working capital constrained SMEs have smashed entire SCs. Apart from the negative effect on business operations and development, a working capital constrained SME may cause a domino effect in a SC, of which capital shortage would pose a threat to the activities of procurement, inventory, even logistics (Cornett *et al.*, 2011). The working capital constraint problem often appears in SMEs, but it may spread to whole SCs easily and negatively influence cash flow even causing interruption in SCs (Uta, 2005).

The negative influence of the working capital constraint problem has been addressed to both individual companies and entire SCs. Wang et al. (2003) discussed the fact that working capital constraint led to retailers experiencing difficulty in selecting their suppliers. This problem resulted in these retailers having to select local suppliers to save costs. Abdel-Malek et al. (2004) stated that working capital constraint imposed more pressure on procurement and inventory management. For example, companies, which are short of working capital, are often under pressure to replenish stock. Gomm (2010) stated SMEs with working capital constraint were weak in their operational ability. Their business

operations such as procurement, manufacturing, even their communication with upstream and downstream business partners are all in jeopardy. Insufficient working capital in SC cash flow may lead to some delays even default repayments between companies, and it results in unexpected losses in both these companies and their suppliers (Brealey *et al.*, 2012). Therefore, solving working capital constraint has become a highly important issue in SCM (Moussawi-Haidar et al., 2014).

1.2 Short-term Credit Borrowing for Small and Medium Sized Enterprises

Since fulfilling the working captial demand is recognised as a way of enhancing SC operations and development (Hendricks and Singhal, 2005; Rai *et al.*, 2006; Wuttke *et al.*, 2013a), accessing external short-term credit is an efficient approach to financing the liquidity shortage (Cornett et al., 2011; Acharya and Naqvi, 2012; Banerjee and Duflo, 2014). For external short-term credit, Gomm (2010), Yang and Birge (2013) asserted that bank overdrafts (BO) and trade credit (TC) were the two common external financial approaches for SMEs to raise working capital, respectively. In practice, BO, and other major types of BL, are lent by banks absorbing savings from the public and then lending parts of the capital to companies for short periods (Rosenberg, 1993), while TC works on a contract between sellers (suppliers) and buyers (retailers). TC allows repayments to occur after buyers have received their required products or service and repayment is set over an acceptable period according to their contracts (Kouvelis and Zhao, 2012).

BO and TC are treated as the two main mature financing options for solving the working capital constraint problem. Dimelis et al. (2015) described BO as one of the main types of short-term credit in bank loans (BL). It enables companies accessing short-term credit to operate business. TC is different from BO. TC finances companies based on the trust between sellers and buyers (Wilson and Summers, 2002). TC guarantees buyers to operate business by providing products or services instantly (Kouvelis and Zhao, 2012). Moreover, for SMEs with a short credit history, it offers them a chance to raise working capital (Petersen and Rajan, 2002). More than 80% of UK companies relies on TC for operating their business-to-business transactions (Wilson and Summers, 2002) and a similar amount of companies in the US also conducted TC transactions. TC has been treated as the main source where working capital constrained companies to access capital from. Particularly

for SMEs and some companies with limited access to BO, TC is another main credit source available for financing products or services (Yang and Birge, 2013).

However, it may not be fully guaranteed that working capital constrained SMEs can have access these two types of short-term credit. Berger and Udell (2002) stated that, compared with large enterprises, SMEs found it hard to access short-term credit. Many SMEs are restricted to only being able to access short-term credit due to the different barriers of banks and sellers. In other words, they are still having difficulty in raising sufficient working capital from a single source in practice (Howorth and Westhead, 2003; Torre et al., 2010; Zhao and Xiong, 2014). Figure 1.1 demonstrates the difficulty that SMEs in the European area face when accessing short-term credit from banks. Apart from high rejection and cost, these SMEs are limited by their capital-borrowing amount or discouraged by their capital application results. As The European Central Bank (2014) stated, SMEs in Europe were not fully guaranteed to access sufficient capital from banks. 82% of SMEs in Germany (DE) were successful in accessing short-term credit from banks. However, they could only obtain part of the requested amount. Some other countries were far worse than Germany, such as The Netherlands (NL) and Greece (GR), the accessibility of short-term credit from banks sharply decreased to 25% and 33% during 2013 to 2014 (European Central Bank, 2014).

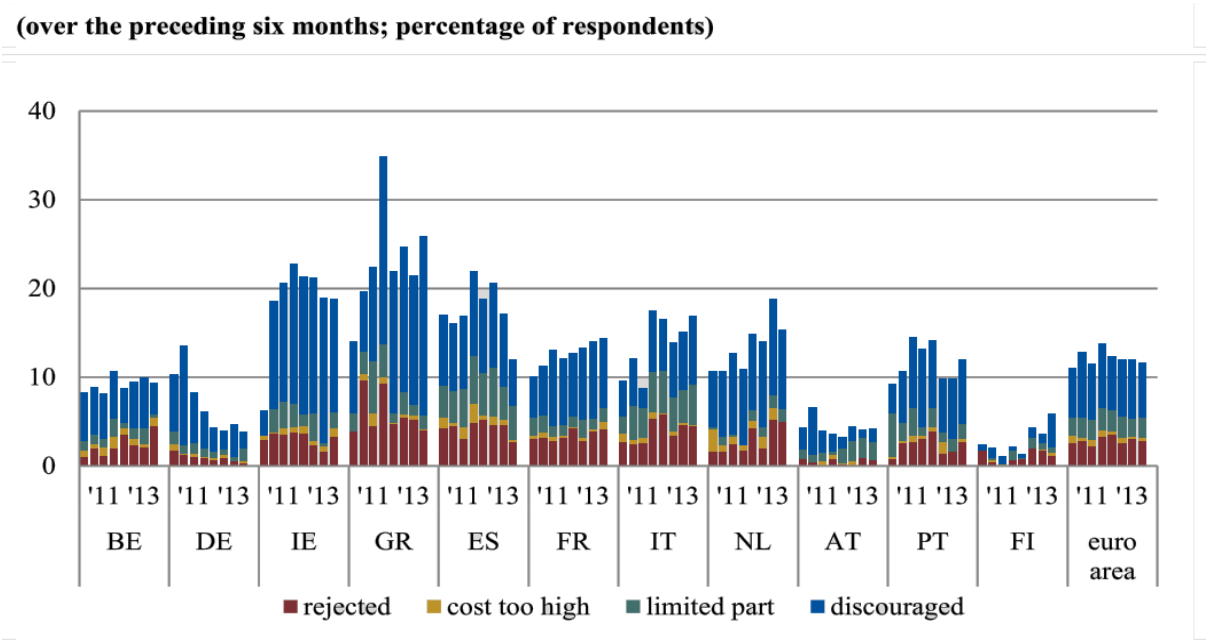

Figure 1.1. SMEs access BL in the European Economic Area from 2010 to 2014

(European Central Bank, 2014)

(The abbreviation of each country has been presented in Page ix)

Figure 1.2 shows the application results of SMEs in Europe borrowing BO from 2010 to 2014. Although many SMEs got their required capital amounts, significantly, a large portion of applicants were discouraged by the disappointing results, such as achieving limited borrowing amounts, being rejected in applications and even having to abandon because of excessive costs.

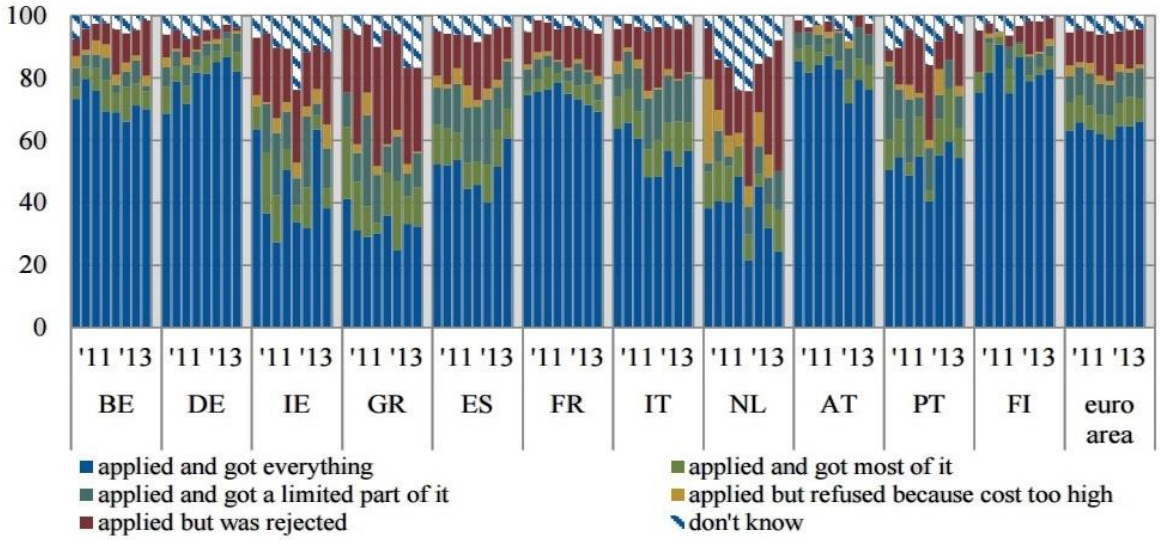

Figure 1.2. SMEs in the European Economic Area applied BO from 2010 to 2014

(European Central Bank, 2014)

Similarly, some SMEs are also struggling to access TC. An early study by Blasio (2005) stated that TC became a working capital source alternative to banks. This has been the primary choice of SMEs solving their working capital shortage. However, Giannetti et al. (2011) found that applying TC often required a close relationship between lenders and borrowers. Thus, for SMEs without strong relationships in a business network, applying for TC is harder than applying for BO.

According to the European Central Bank (2014), due to insufficient credit history and weak collateral, the number of SMEs accessing BO and TC were decreasing (as shown in Figure 1.3).

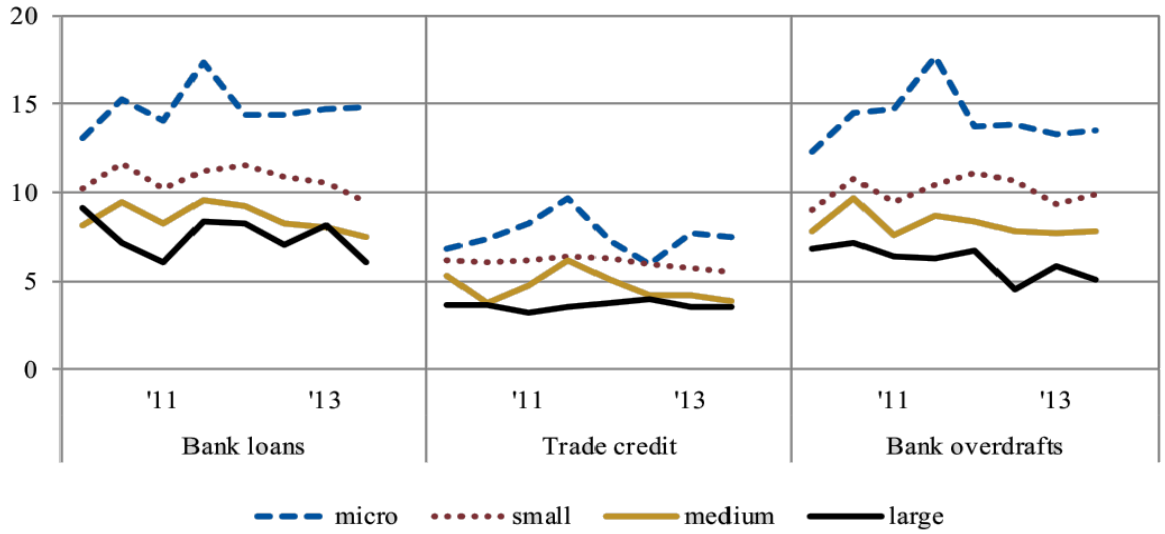

Figure 1.3. The situation of receiving commercial credits for SMEs in Europe (European Central Bank, 2014)

Currently, obtaining short-term credit from financial institutions and sellers is getting more difficult. Following on from the shock of the financial crisis in 2008, banks and suppliers have taken high risks in lending working capitals due to a severe business decline in the market. Banks have raised their approval criteria for working capital borrowing to control risk taking (Jiménez *et al.*, 2013). They have the unwillingness to lend unsecured loans and require more collateral from their borrowers (Filippo *et al.*, 2016). Casey and O'Toole (2014) stated that the occurrence of the financial crisis affected the willingness of sellers lending TC. Because of the heightened lending requirements of BO, TC is also restricted so that it is only provided to companies in business cooperation (Berger and Udell, 1998; Pike *et al.*, 2005; Lee and Rhee, 2011). This situation has increased the difficulty of SMEs in accessing BO and TC, it has also worsened the financial flow in related SCs.

Some studies suggest that BO and TC have limited ability in monitoring borrowers. In other words, banks and suppliers find it difficult to ascertaining how borrowers will use the credit once they receive it from lenders (Blasio, 2005; Chen and Cai, 2011). Wilner (2000) stated TC suppliers were stuck with limited real-time information from their borrowers. Some companies are likely to use their borrowed loans in other business projects to chase higher profits, which may be highly risky (Giannetti *et al.*, 2011). Ortiz-Molina and Penas (2007) pointed out that, due to defective and hysteretic business information, banks and suppliers vacillated in lending working capital to SMEs. In this regard, symmetrical communication

of information was needed in SC financial flow management. This facilitates low-risk lending for working capital suppliers, meanwhile, it increases the possibility of working capital constrained SMEs to access short-term credit (Houston *et al.*, 2010).

In response to the deficiency of BO and TC, especially difficulty of access for SMEs, an innovatie practice named integrated logistics and finance service (ILFS) has been proposed (Chen and Cai, 2011). In the framework of ILFS, third party logistics (3PL) industry aims to involve information exchange into the logistics service (Zacharia *et al.*, 2011) and share the information of borrowers' logistics activities with banks to control the credit default risk. Therefore, banks will use the information provided by 3PL companies to decide whether to lend working capital to SMEs. Chen and Cai (2011) discussed an actual case of ILFS and pointed out that 3PL companies have advantages over banks and suppliers in monitoring short-term credit usage of borrowers. Some studies were based on ILFS and modeled 3PL companies providing a new type of short term credit to working capital constrained retailers in SCs. This short term credit, which was termed as 3PLC, allows retailers to access products without instant payment and pay a discounted amount for the logistics service (Chen and Xie, 2009; Chen and Cai, 2011; Xia *et al.*, 2014).

In the current market, multiple working capital sources are available to SMEs. The European Central Bank (2014) presents that SMEs in the European area were heavily reliant on BO and TC as their solution to releasing working capital constraint and they were expected that more working capital would be provided as of 2014 (as shown in Figure 1.4). With the financing of BO and TC, some current studies attempt to discuss how working capital constrained SMEs borrow BO or TC (Chen and Wang, 2012; Abdesamed and Wahab, 2014; Cobb and Johnson, 2014; Comeig *et al.*, 2015; Serrano, 2016).

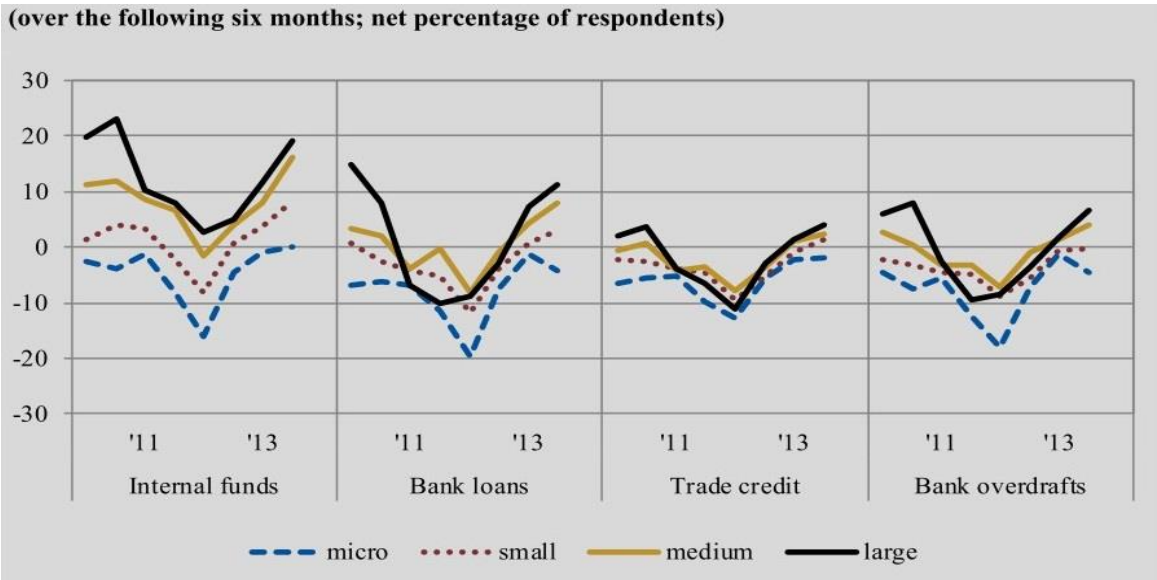

Figure 1.4. SMEs' expectation regarding the availably of external financial supports (European Central Bank, 2014)

In light of increasing popularity of BO and TC in solving working capital constraint for SMEs, some studies have discussed and compared BO and TC in financing SCM, respectively (Cook, 1999; Blasio, 2005; Behr and Sonnekalb, 2012; Kouvelis and Zhao, 2012; Engemann *et al.*, 2014; Psillaki and Eleftheriou, 2015). Nwankwo and Osho (2010) suggested how SMEs could effectively manage their working capital by borrowing BO. Chen and Wang (2012) analysed how TC could be used to create benefits for the entire SC and how they could coordinate SCM. Some scholars compared the difference between both in financing in SC inventory management. Lee and Rhee (2011) believed that, due to the time value of money, delaying payment of TC encourages borrowers to increase the quantity of orders and keep more inventories. Kouvelis and Zhao (2012) compared the differences of BO and TC in financing newsvendors, and determined the optimal TC contract for achieving maximum profit for SCM. Zhong and Zhou (2013) developed a model for TC in financing SC inventory control with the aim of improving SC performance. Similarly, some studies focused on comparing BO and TC, discussing especially the substitution between the two types of short-term credit (Pike *et al.*, 2005; Lee and Rhee, 2011; Zhong and Zhou, 2013; Psillaki and Eleftheriou, 2015; Lorentz *et al.*, 2016). The study by Chen and Cai (2011) might be the only one that both involves 3PLC and compares it with BO and TC with regard to cost difference. Although 3PLC have been involved, their study was not realistic in considering the difficulties that working capital constrained SMEs have when accessing short-term credit.

In real business, the working capital demand of SMEs are hardly ever satisfied from a single source because of high rejection rates or limited borrowing amounts (Padachi, 2006). According to the description of Bannier *et al.* (2012), lenders selection is a process influenced by both tangible and intangible factors and the first priority of a company is to evaluate their consideration in selecting credits. Furthermore, companies in practice consider their credit selection as a multiple sourcing problem instead of a single selection (Levenson and Willard, 2000a). In other words, companies always borrow some of their credit from one source and some from another, in order to avoid the risk of rejection. Therefore, few scholars have suggested that these working capital constrained SMEs should borrow from BO and TC by developing short term credit portfolios (Coleman and Carsky, 1999; Blasio, 2005). By applying for short-term credit from multiple sources, the possibility of receiving sufficient working capital will be increased. In addition, these studies stated that borrowing via a credit portfolio consisting of BO and TC would help working capital constrained SMEs to reduce their overall costs. By introducing 3PLC into SCM, working capital constrained SMEs can not only select BO and TC, but also include 3PLC. This new working capital source whereby 3PL companies issue TC has piqued the interest of few scholars. Relatively few studies have attempted to discuss 3PLC in comparison with BO and TC (Chen and Zhu, 2005; Erik, 2009; Chen and Cai, 2011).

In academia, since 3PLC is a new credit source, it is still rare to discuss working capital in SCs when considering BO, TC and 3PLC together (Chen and Zhu, 2005; Chen, 2008; Chen and Xie, 2009; Pfohl and Gomm, 2009; Chen and Cai, 2011; Jin *et al.*, 2014). Current studies consider credit portfolios only consisting of BO and TC (Cook, 1999; Wilson and Summers, 2002; Fisman and Love, 2003; Kouvelis and Zhao, 2012). Although Chen and Cai (2011) developed a model of a 3PL company lending 3PLC to a SME in the SC, their study has not considered the credit portfolio management from BO, TC and 3PLC.

Apart from the involvement of 3PLC, current studies rarely discuss the influence of multiple factors in the credit selection of working capital constrained SMEs. In detail, credit borrowing decisions and credit portfolios have different variants in different working capital constrained companies (Aouni *et al.*, 2014). The process of determining an optimal credit portfolio is influenced by various factors when multiple short-term credit sources are involved. Some studies investigated the influence of one or some of the factors.

Ramiah *et al.* (2014) investigated the working capital borrowing behaviours of SMEs from multiple sources using an empirical approach. Their investigation stated that many factors affect the treasurers' short-term credit selection and borrowing. The study by Ramiah *et al.* (2014) emphasized that short-term credit borrowing is influenced by various factors. Some relevant studies have also concluded that certain factors significantly influence companies' credit portfolios or selections. For instance, Beck and Demirguc-Kunt (2006) focused on different firm sizes and addressed the difficulty SMEs faced when accessing external finance. Huyghebaert (2006) stated that start up business preferred to apply for TC as companies in this stage were short of credit history. Behr et al. (2011) investigated the relationship between micro-lenders and their borrowers. The result shows the benefit of longer relationships on the information symmetric transfer, which will help borrowers to access small capital easier. Apart from these factors, decision making procedures (Romano *et al.*, 2001), information sharing and distance (Carling and Lundberg, 2005), managers' genders (Bellucci *et al.*, 2010) and other factors which significantly influence capital constrained companies' selection are also addressed. These samples present various factors and discuss their influence. However, it is hard to locate a study that integrates all these factors and analyses their influence.

Based on the above-mentioned limitations of current studies, there is still a gap in terms of optimising credit portfolio management. The main issue to be addressed is how a short-term credit portfolio can be managed to improve the efficiency of SCM. In other words, short-term credit portfolio management should be coordinated with material flow management in SCM (Kouvelis and Zhao, 2012).

In detail, the problems with some current studies on SC short-term credit borrowing have reflected the main gap described above. These problems are presented as follows.

1. How various factors influence working capital constrained SMEs' borrowing from multiple short-term credit sources?

Despite some studies mentioning the influence of some certain concerns on the working capital borrowing result, such as the distance of the lender-borrower (DeYoung *et al.*, 2008), the relationship between lenders and borrowers (Dass and Massa, 2011), ownership (Roberts and Yuan, 2010) and even gender issues (Storey, 2004; Marlow and Patton, 2005; Bellucci *et al.*, 2010; Agier and Szafarz, 2013), there is no clear evidence that neither

summarises these concerns nor analyses their priorities to working capital constrained SME in their credit portfolio management.

2. How can 3PLC be used to finance working capital constrained SMEs?

Current studies have introduced BO and TC, which are discussed and studied as two main short-term credit sources in various studies (Cook, 1999; Blasio, 2005; Yang, 2011; Lin and Chou, 2015). 3PLC has not been discussed widely in academia as the concept was only defined recently. The study by Chen and Cai (2011) may be the first one to consider 3PLC and compare it with BO and TC. Apart from this study, 3PLC has not been studied as a working capital source.

3. How do working capital constrained SMEs manage short-term credit portfolios involving BO, TC and 3PLC?

Past studies have discussed the portfolio selection of BO and TC. These two working capital sources have been discussed in relation to how they finance SMEs in SCs. For instance, Chen and Kang (2010) developed the vendor-buyer model to investigate TC financing. Kouvelis and Zhao (2012) compared the difference between BO and TC in financing a newsvendor. However, none of these studies have considered 3PLC. Most of them only considered one funding source for short-term credit financing instead of multiple credit sources.

This thesis will design research questions based on these three main problems mentioned above. In the study, working capital constrained SMEs' concerns will be summarised and analysed; 3PLC, new working capital sources, will be considered as an option to credit portfolio management with multiple objectives. Section 1.3 will develop the research objectives and research questions of this thesis in order to address these aspects and fill any research gaps.

1.3 Research Objectives and Research Questions

Section 1.1 and 1.2 summarised the working capital constraint problem in SCs and the situation of SMEs accessing short-term credit, respectively. To be brief, three academic trends can be inferred from the above content; these trends need to be addressed and

conducted in the thesis. This study has been developed based on the research opportunities identified in previous studies.

1. Credit borrowing in SCM should be integrated with material flow (Kouvelis *et al.*, 2006). When credit borrowers design their borrowing schedule, material flow including product purchasing, manufacturing, distribution and other logistics activities should be considered into the borrowing activity (Shi and Zhang, 2010). Successful credit borrowing in SCM refers to running SC operations with a good financial flow (Silvestro and Lustrato, 2014);

2. BO and TC has become more costly and difficult to access for SMEs (Yang, 2011). Thus, many working capital constrained companies are not choosing one type of credit and resorting to BO and TC both finance working capital constrained companies in SCs. Moreover, with the fast development of 3PL financial service in practise, 3PLC will be an alternative credit source in future short-term credit markets (Chen and Zhu, 2005; Berger and Nakata, 2013). For solving the low availability of working capital, companies can access from multiple credit sources rather than a single source, thus credit portfolio management is important for working capital constrained companies when they are facing multiple short-term credit options.

3. Most of the studies relating to SC financial management rely on empirical analysis (Levenson and Willard, 2000a; Black and Strahan, 2002; Fisman and Love, 2003; Giannetti *et al.*, 2011; Dimelis *et al.*, 2015). However, the studies of applying mathematical models to investigate the working capital constrained problem in SCs are rather limited. In particular, few studies have integrated financial flow and material flow in their models.

In recognition of these three trends, the aim of this study is to analyse the borrowing concerns of working capital constrained companies in SCs, and to help them to access working capitals from various multiple short-term credit sources.

To achieve this aim, the following research objectives have been designed:

1. To clarify 3PLC that combine logistics with financial services;
2. To identify the issues considered by credit borrowers in the process of applying for credits;
3. To rate the priority of these concerns according to the impact on borrowers' credit selection;
4. To develop an optimal solution for allocating credit borrowing amounts in dynamic periods;
5. To optimize credit portfolio selection with multiple objectives for multiple periods from multiple credit sources.

Based on these aims and objectives, this research will address the following questions.

1. **What are borrowers' concerns when determining their short-term credit borrowing options from multiple working capital sources?**
2. **How do working capital borrowers determine their borrowing portfolio when applying for maximising borrowing amount in dynamic periods?**
3. **How do working capital constrained borrowers determine the credit portfolio with multiple objectives for multiple periods?**

1.4 Outline of the Thesis

The research is presented as eight chapters. For better understanding the structure of the thesis, is summarized in Figure 1.5.

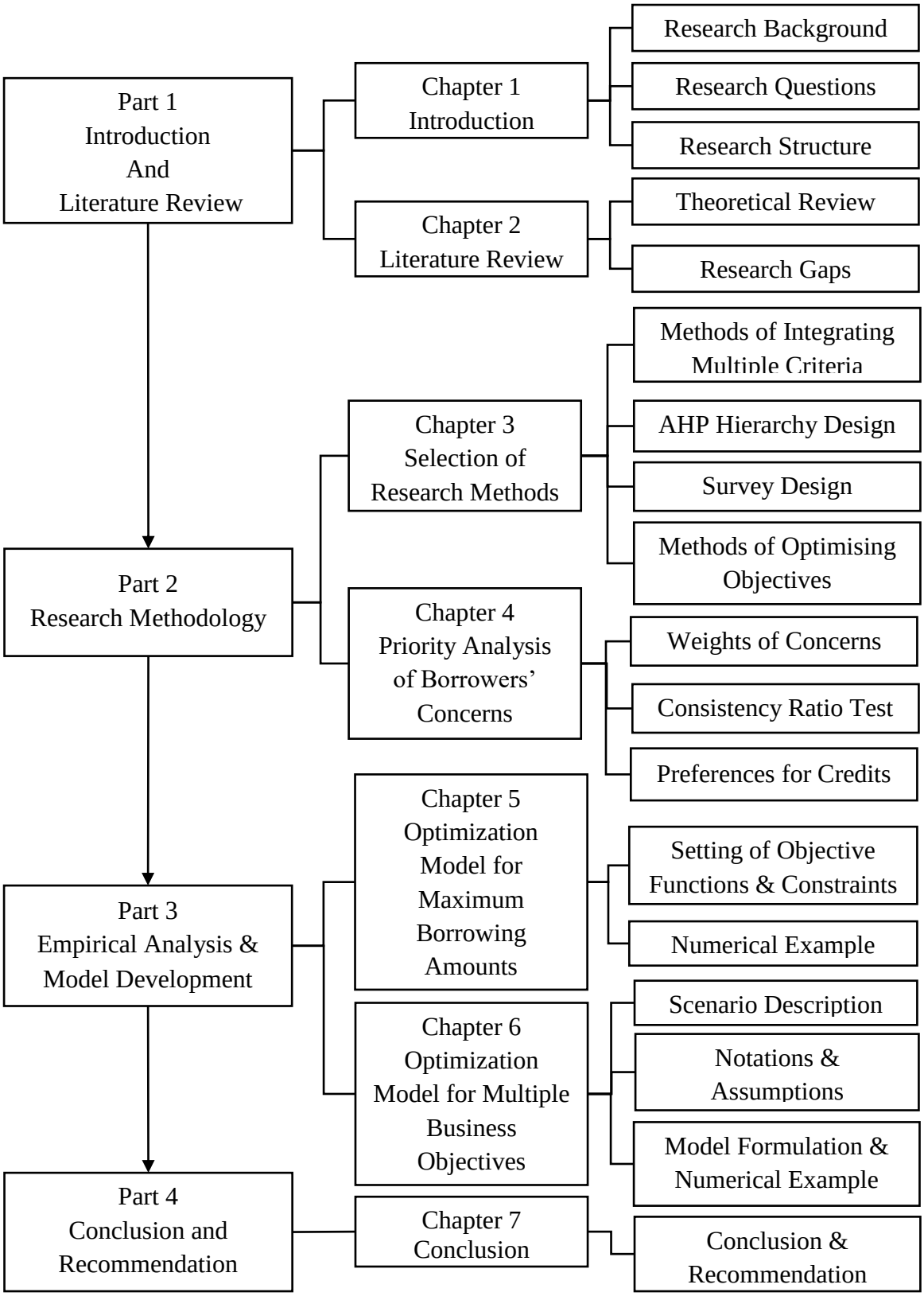

Figure 1.5. The framework of the thesis

Figure 1.5 presents the four main sections of the thesis, which include Part 1, the introduction and literature review, Part 2, the research methodology, Part 3, empirical analysis and model development and Part 4, the conclusion and recommendations.

In Part 1, Chapter 2 reviews the relevant literature, and critically emphasizes the academic gaps that this research aims to fulfil. Simply, these gaps refer to the silence of studying 3PLC, the partial summary on borrowers' concerns and their objectives in short-term credit portfolio management.

In Part 2, Chapter 3 discusses the research methodology. It develops a review of methodologies that have been applied when evaluating working capital constrained SMEs' concerns and objectives. Based on this, the analytical hierarchy process (AHP) was chosen and a survey designed specifically with ethical awareness in mind. In addition, another methodological review was developed to conduct an understanding of the methods being applied in optimising objectives.

Chapter 4 applies AHP as a method to evaluate the appointed criteria, which refers the specific SMEs' concerns and conducts a result of how these SMEs choose from alternative short-term credit sources regarding important concerns.

In Part 3, Chapter 5 presents the results of the concerns' priorities and SMEs' preferences to alternative financing options. Based on these results, a LP model will be developed which simulates short-term credit portfolio management in a working capital constrained company. This LP model provides an optimal working capital portfolio which maximises the short-term credit borrowing amount for a working capital constrained retailer.

Chapter 6 simulates a SC with the problem of working capital constraint. It applies the GP model to determine dynamic credit portfolio management. The model will optimise the overall cost minimisation and backorder penalty cost minimisation. A numerical example will be designed to suggest a procurement schedule and a credit portfolio at each period.

Chapter 7 draws conclusions from the analysis and discussion in the thesis. This chapter summarizes and discusses the major contributions and limitations of the research. Moreover, the implications for further research are also presented in this chapter.

Chapter 2 Literature Review

This chapter presents a literature review in short-term credit borrowing and SC financial management. The review aims to build up an understanding of the following issues: types of short- term credit, the development of 3PL financial service and working capital constrained companies' objectives and considerations in credit borrowing.

Section 2.1 introduces some main types of commercial credits including bank loans (BL), bank overdrafts (BO) and trade credit (TC). Specifically, it summarizes their pros and cons. Section 2.2 reviews the literature on studying companies with a capital-constraint problem, and concludes that there is a new short-term credit demand apart from BO and TC. Section 2.3 describes the financial role of the 3PL industry in SCM. In addition, this section reviews a few studies which innovate and promote the 3PL industry in its ability to provide for financial service SCs. Section 2.4 applies a systematic literature review and presents the concerns and business objectives of working capital constrained companies in the process of applying for credit. Section 2.5 summarises the contributions and research limitations of past studies. Section 2.7 provides a summary for this chapter.

2.1 Main Commercial Credits in the Market

Credit has various meanings. Stevenson and Waite (2010, p. 336) provide two types of definition:

> *"1, the ability of a customer to obtain goods or services before payment, based on the trust that payment will be made in the future."*
>
> *"2, money lent or made available under such an arrangement."*

All the above refer to a financial transaction between lenders and borrowers. Moreover, Moro and Fink (2013) define commercial credit as：

> *"Capital issued by financial organizations, mainly used for financial business trading or manufacturing operations."*

Capital constrained companies can access different types of commerical credit depending on their aims (Jayaratne and Wolken, 1999). Bank Loan (BL) is the most traditional form of commerical credit. BO is the most common short- term BL used to satisfy the demands of working capital (Raghavan and Mishra, 2011). TC is very commonly used between sellers and buyers with a long standing business relationship (Yang, 2011). This section

will focus on discussing BL and TC. Meanwhile, it will also outline some studies which introduce popular commercial credit, with the aim of discussing their strengths and weaknesses. This section will also address the difficulty SMEs have when accessing these credits.

2.1.1 Bank Loan

Bank loan (BL) is one of the main types of traditional credit source, which is comprised of diverse types used for different purposes. It is widely adopted by most capital -constrained companies (Cook, 1999). The concept of BL was developed to aid businesses with insufficient capital to finance business activities. BL was defined as:

> *"An amount of money lent by banks with interest for a certain period."*
>
> Anderson (1917, p. 15)

The concept of BL has not changed significantly in the modern business era, it is defined as:

> *"An amount of money that commercial banks absorb savings from the public and lend parts of the capital to enterprises, commercial organizations or natural persons."*
>
> Rosenberg (1993, p. 35)

Generally, BL can be understood as the capital lent by commercial banks. This amount of capital aims to finance commercial institutes or individuals. In return, commercial banks require borrowers to pay back the capital with a specific interest rate within a certain timeframe. To solve the capital-constraint problem, BL have played an important role.

Banks are servicing capital-constrained companies through different types of BL (Black and Strahan, 2002). In the banking system, BL can finance capital-constrained companies through guarantee schemes (Cook, 1999). For instance, the credit guarantee scheme, defined by Gozzi and Schmukler (2016, p. 1) as:

> *"A mechanism which a third party, normally a guarantor, pledges to repay some or the entire loan amount to the lender in case of borrower default."*

This scheme motives financial institutions, especially banks to lend to SMEs (Levitsky and Prasad, 1987, p. 1). This scheme works under a specific guarantee agreement, which

ensures these SMEs achieve capital even without providing adequate collateral or suitable creditworthiness (Department for Business Innovation & Skills, 2013). Levitsky and Prasad (1987, p. 3) state that the main purpose of a credit guarantee scheme is to provide loans for fix asset investment. While it also guaranteed working capital for SMEs.

Apart from the credit guarantee scheme, individuals also can apply for another type of BL, known as a personal guarantee loan for developing their own business. Personal guarantee loans are defined by Evans and Evans (2007) as :

> *"A type of credit guaranteed by a biological individual life who has the right to legally own its business, and establish commercial organisations."*

Pritchard (2016) described that personal guarantee loans were mainly prepared with the purpose of financing capital constrained SMEs. Different to credit guarantee loans guaranteed by a third party, described as:

> *"It allows a business owner to borrow by putting his or her personal finances on the line. It is lent without involving anybody's personal assets."*

In comparison with personal guarantee loans, Allen *et al.* (2015, p. 1) introduced individual entrusted loans, defined as:

> *"A type of loan made by a non-bank party, such as an industrial firm, to another. It uses a bank as a servicing agent."*

This type of loan involves a third party in credit lending and borrowing activities. A bank receives a fee by providing funds and it transfers the credit default risk to other parties (Li and Lin, 2016). Moreover, Terry (1995) described a type of BL known as a discounted noted loan which is the same as factoring. This type of loan is defined as

> *"A note sold to a bank by a merchant for less than its face value, in order to convert it into cash."*
>
> Terry (1995, p. 88)

Similarly, Yang *et al.* (2014) also suggested another type of commercial BL for financing SMEs by calling for intellectual property as the collateral. This type of BL aims to service SMEs with insufficient creditability (Wang and Yang, 2016a, p. 75). In line with the heightened importance of intellectual property in recent years, in order to apply for relevant amounts of capital, SMEs can pledge their intellectual property instead of using fixed assets as collateral to banks. This advantage has attracted the interest of both SMEs and commercial banks in many countries (Hao and Li, 2014). Finally, Yescombe (2002, p. 1)

introduced the project development loan, which is also known as project finance, it is defined as:

> *"A long-term capital financing for major projects."*

BL can be also classified in different ways according to their detailed contract designs (Phillips, 1931). They can be classified as secured and unsecured loans. In practice, around 70% of businesses in the US and European countries utilised secured loans. The main difference between these two types of loan is whether they are protected by collateral or not (Filippo *et al.*, 2016). From the perspective of the bank, taking collateral as the security is favourable. Jimenez *et al.* (2006) found that more and more banks gradually promoted secured loans to businesses rather than offering unsecured loans. Choi *et al.* (2015) stated that banks aimed to make their lending secure by requiring more collateral. Regarding taking collateral as security, Fabbri and Menichini (2016) stated that the secured loan made banks safer and that more banks had raised their collateral requirement and also limited the amount of borrowing for unsecured loans.

Compared with secured loans, Farag *et al.* (2013) stated that an unsecured loan to a business might have higher risks than secured loan as the latter is more predictable. Aside from requesting collateral, the lending amount of secured and unsecured loans is also different. The former is normally larger than the latter due to the required collateral (Cowling, 2010). In this situation, Sharifi and Flores (2013) described how most SMEs with low-income or low-value generally found it impossible to access an unsecured BL directly from the bank.

Moreover, BL can also be classified in different ways according to the contract length with the borrowers. Based on different time periods, they can be classified as short-term, medium-term and long-term BL. Bank overdraft (BO) is a representative credit product in short-term loan which is mainly used to finance daily business operations (Sharifi and Flores, 2013). From the perspective of accounting, BO is defined as:

> *"An amount of money overdrawn from banks."*
>
> Siddiqui (2014, p. 223)

Moreover, GOV.UK (2016) described BO as:

> *"A credit facility a business agrees with a bank. It allows the business to temporarily spend more than it has in its account to cover short-term financing needs."*

BO works in two different ways including authorised and unauthorised, for which the main difference is the monthly charges adhered to working capital constrained borrowers by the

former, but the latter charges them daily (Sharifi and Flores, 2013). Apart from BO, invoice finance is also a type of short-term BL. Ranaldo and Wrampelmeyer (2016) introduced an example of invoice finance, which allowed working capital constrained companies to sell their invoices to banks.

Medium-term and long-term BL provide financing to capital constrained companies. However, both no longer meet companies' needs for working capital. The purpose of these medium-term and long-term loans is to provide capital for purchasing and investing in fixed assets (Laeven and Valencia, 2013). For medium-term loans, Van Rixtel and Gasperini (2013) described that they had been operated under different terms during a one- to seven-year period. Medium-term loans normally have a fixed or variable interest rate and are mainly used to invest on some fixed assets, including property or machinery. Similarly, long-term loans are also provided to capital-constrained companies to finance their commercial premises, such as a mortgage. Therefore, the repayment for long-term loans normally spans over 15 years (Qian and Yeung, 2015). A project development loan is a typical long-term loan. This loan has developed rapidly in last twenty years. From 2001, nearly $190 billion in capitals was invested in different projects through project finance (Yescombe, 2002). Esty (2004) also described how in the USA, almost 10% to 15 % of projects relied on project capital financing.

In practice, SMEs may raise enough working capital through different sources. Although BO is treated as a popular short-term credit type, some other informal avenues including loans from directors, loans from friends or families and other third parties are accepted by SMEs (BIS, 2012). Whilst accessing sufficient finance is important for working capital constrained SMEs, Figure 2.1 lists the majority of capital resources for UK SMEs, and presents a summary of the distribution ratios regarding SMEs raise working capitals from these resources in 2011. According to this figure, nearly half of SMEs relied on the financial supports from banks, including BO, credit cards or mortgages. In detail, 28% of SMEs surveyed prefer BO than other types of capital sources. This ratio is significantly higher than invoice finance and loans from other third parties (Apart from TC), which has clearly stated BO is the prior resource for SMEs to raise their working capital. However, around half of SMEs, which was 51%, borrowed their working capitals from informal sources, such as their suppliers or retained earnings.

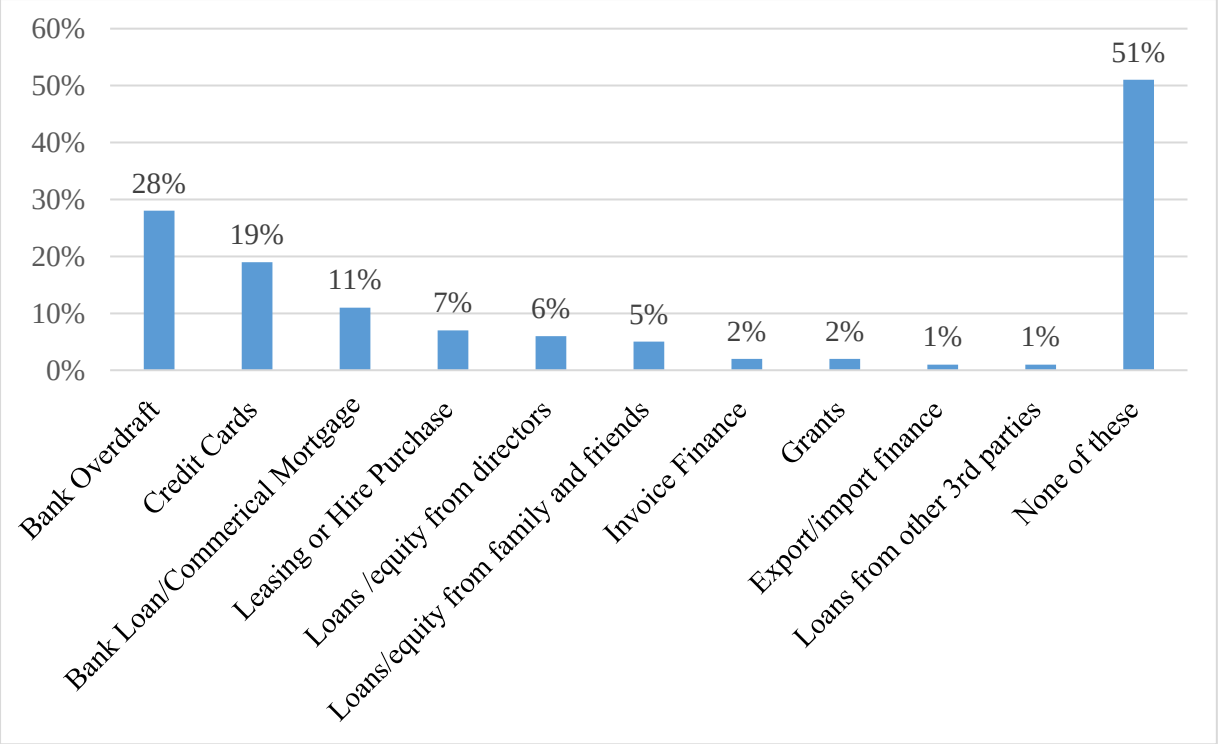

Figure 2.1. The approaches of UK SMEs raising capitals in 2011

(BIS, 2012)

Even though BO are a first choice for working capital constrained SMEs, these SMEs are still required to take a complex assessment. The reason behind banks strengthening assessment is to reduce the risk of credit default (Petersen and Rajan, 2002). Richard (2007) summarised the basic steps of working capital constrained companies applying for BO from banks. This procedure includes filling out a BO application, requiring additional information, obtaining credit history, approving the application and informing the applicant of the result. In practice, applicants' results are significantly affected by loan officers' decisions. Heider and Inderst (2012) thought the current assessment process of banking systems might make it hard for SME's to obtain sufficient working capital. They pointed out that 'soft information', which refers to unstructured, unquantifiable, or hard to transmit information (Giannetti and Ongena, 2009), would impact the loan officers' decision making. Due to the different levels of 'soft information acquisition' in banks, SMEs are more or less under an impact on their borrowing from banks (Ogura and Uchida, 2014). Figure 2.2 presents the procedure of BL applications as summarised by Richard (2007).

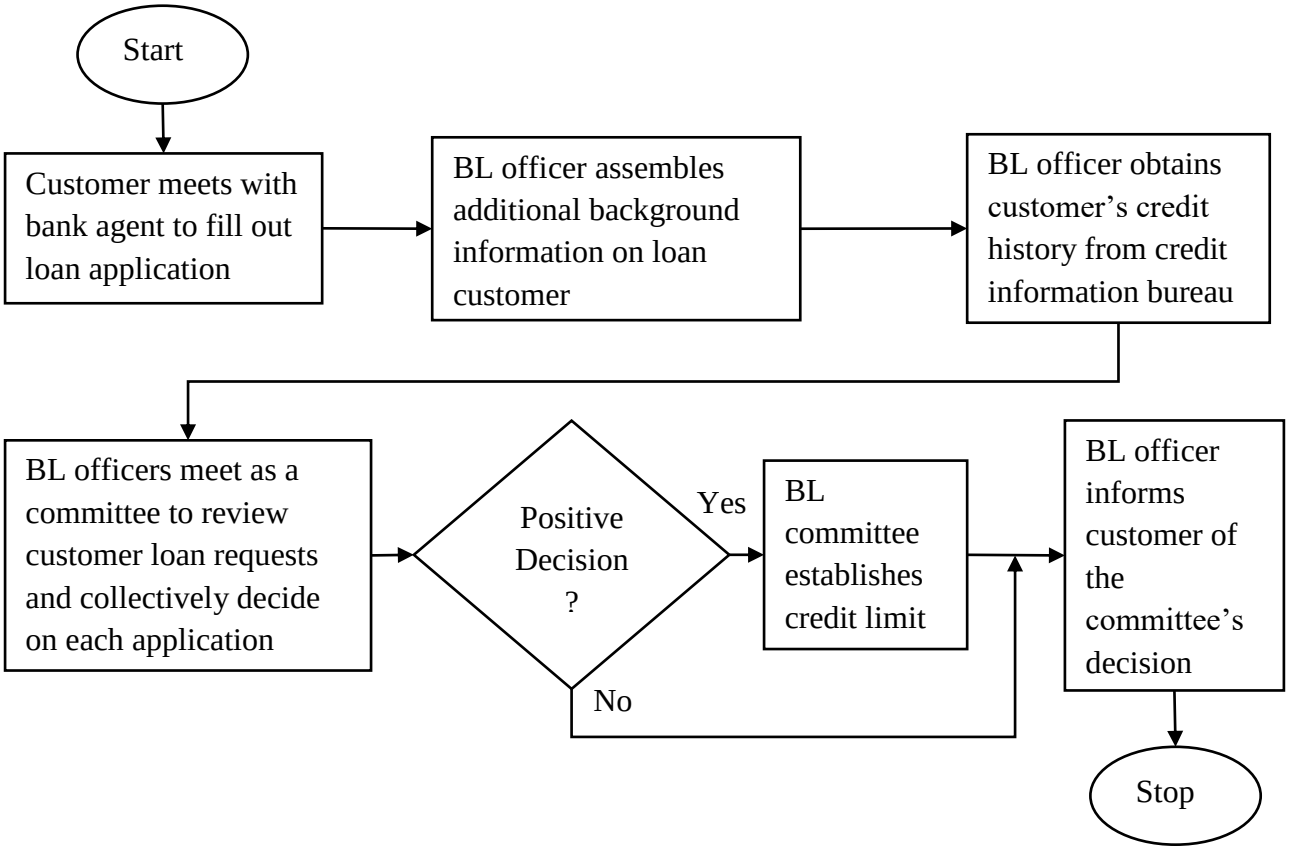

Figure 2.2. The approval process of bank loan
(Richard, 2007)

Only some SMEs are successful in completing the above complex assessment. These SMEs are success as they benefit from a long-term relationship with a bank. Binks and Ennew (1997) described how a long-term relationship with a bank created a higher success rate when accessing working capital. However, for most SMEs, especially for many start-up businesses, a long-term relationship with a bank is not realistic (Haron *et al.*, 2013). Therefore, working capital constrained SMEs have no alternative but to access other capital sources when they have difficulty obtaining a BO.

2.1.2 Trade Credit

Some SMEs have difficulties when accessing working capital from banks. TC has become another option for SMEs to increase their working capital. According to Petersen and Rajan (1997), trade credit is the credit form in which buyers are allowed to receive products or services first and then pay later according to their contracts. The most intriguing parts of TC are its flexible repayment periods and flexible interest rates. In addition, it directly links

buyers and sellers, allows easy transfer of credit requirements, products prices, quality and other information to each other (Wilson and Summers, 2002).

Many companies, especially in the manufacturing industry, have a high dependence on TC financing. TC is an alternative credit source; providing financial support to many companies. Compared with BL, TC is considered as a better option for many start-up companies keen to access credit (Fisman and Love, 2003). Interestingly, Blasio (2005) discussed whether TC can substitute BL. He used firm-level data of Italian manufacturing companies, SMEs and companies, which did not pay dividends and preferred to use TC instead of BO to solve their tight liquidity problems. Similarly, Ge and Qiu (2007) investigated private companies in China on their selection of BL and TC and found this type of company find it hard to access BL and more often use TC.

Research suggests that TC makes a significant contribution to solving the financial problems of working capital constrained companies. Petersen and Rajan (1997) discussed the contribution of TC to SMEs whose lack of credit history might hinder their ability to apply for a BL. Their research found that TC could help working capital constrained SMEs to achieve their manufacturing or selling goals. Moreover, the repayment period of TC is more flexible than BO. Sellers set no interest charge for the deferred payment of buyers' in this period, but the payment for these products must be completed in the time specified on the contract (Chang and Byong-Duk, 2011). Teng and Lou (2012) and Pal *et al.* (2014), have both discussed how to optimise the TC repayment period in order to reduce inventory costs.

If buyers cannot pay back TC on time, they have to pay extra interest, which is also known as a penalty (Klapper *et al.*, 2012). This kind of operation - the basic model of TC - only requires the buyer to negotiate with the seller; this effectively accelerates the communication between suppliers and retailers, as well as stabilizes the cooperative relationship between them (Yang and Birge, 2013). However, Teng *et al.* (2012) stated that the floating demands of the market made forecasting more difficult for retailers. In order to fulfil market demands, they always tend to borrow extra TC to hold excessive inventories due to the low financial costs of TC. This not only increases the costs of working capital constrained companies in managing inventories, but also heightens the credit default risk.

In international trade, there are two different types of TC: buyer's credit and supplier's credit (Manova, 2008). Buyer's credit is defined by Manova *et al.* (2014, p. 579) as:

> *"A short- term credit extended to an importer by overseas lenders to finance the purchases of goods or services and other items".*

Buyer's credit normally requires a bank to provide a guarantee. As normally it is rare for the importer to pay cash (in international trade), few exporters have the capacity to lend credit directly to their importers without any guarantee (Manova, 2008). Therefore, banks are involved in buyer's credit. A bank normally based in the importer's country offers the guarantee to the importer. Meanwhile, a bank in the exporter's country assists the exporter in issuing the credit to the importer (Levit, 2005).

For buyer's credit, in the operating process, there are two ways of issuing credit. The first way is that the exporters' bank will issue trade credit to the importers' bank and then the importers' bank could transfer this credit to importer (As shown in Figure 2.3). The second way is that the exporter's bank can transfer the TC to the importer directly after receiving the guarantee from the importer's bank (As shown in Figure 2.4).

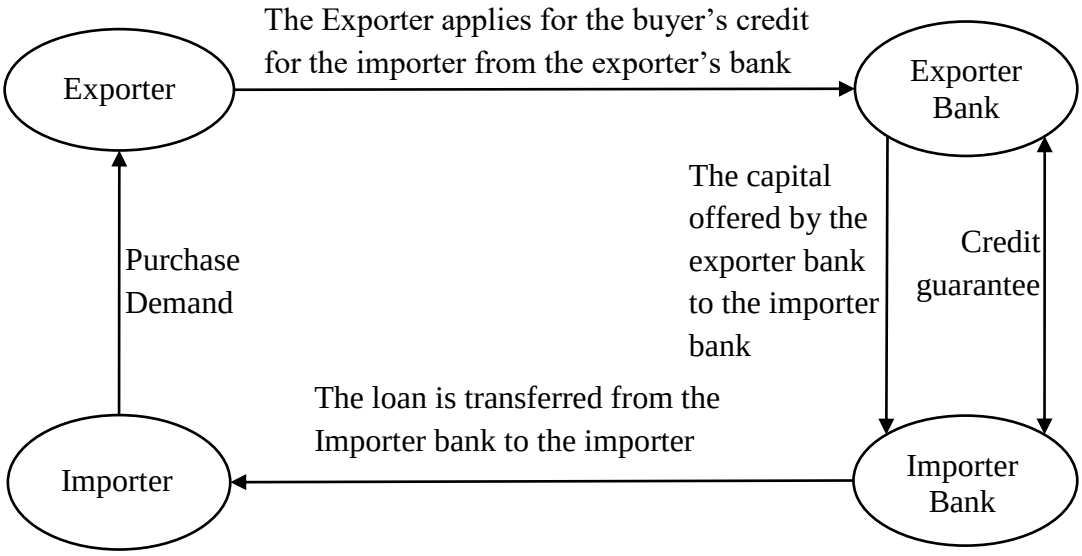

Figure 2.3. The credit transfer from exporter bank to import bank in buyer's credit (UK Export Finance, 2013b)

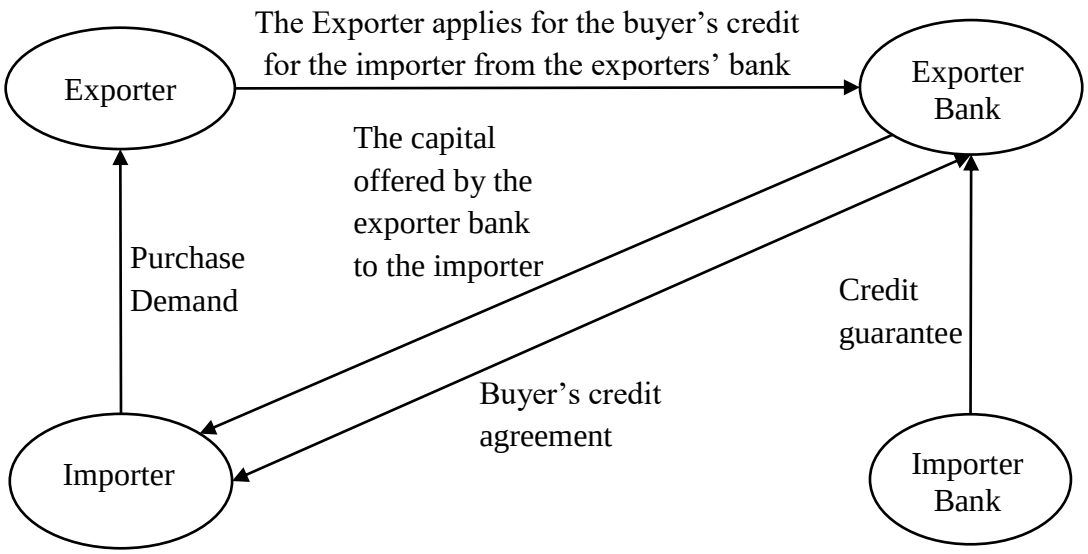

Figure 2.4. TC direct from exporter bank to importer in buyer's credit

(UK Export Finance, 2013b)

Suppliers' credit is another type of TC used in the international trading business. In the UK, HM Revenue & Customs (2012, p. 33) defined this type of credit as:

> *"A credit to an overseas buyer to finance the procurement of capital goods and services from a UK importer. It covers payments due under bills of exchange or promissory notes purchased by a bank from this exporter."*

The exporter as the supplier receives the loan from it's local bank and then lends it to the importer (UK Export Finance, 2013a). Specifically, Sloman *et al.* (2012) stated that this type of credit was different from buyer's credit. It guarantees that the exporter's bank can receive the amounts due under the bills of exchange, promissory note from the importer's bank rather than the full payment with interest in buyer's credit. Figure 2.5 presents the procedure of supplier's credit in trading.

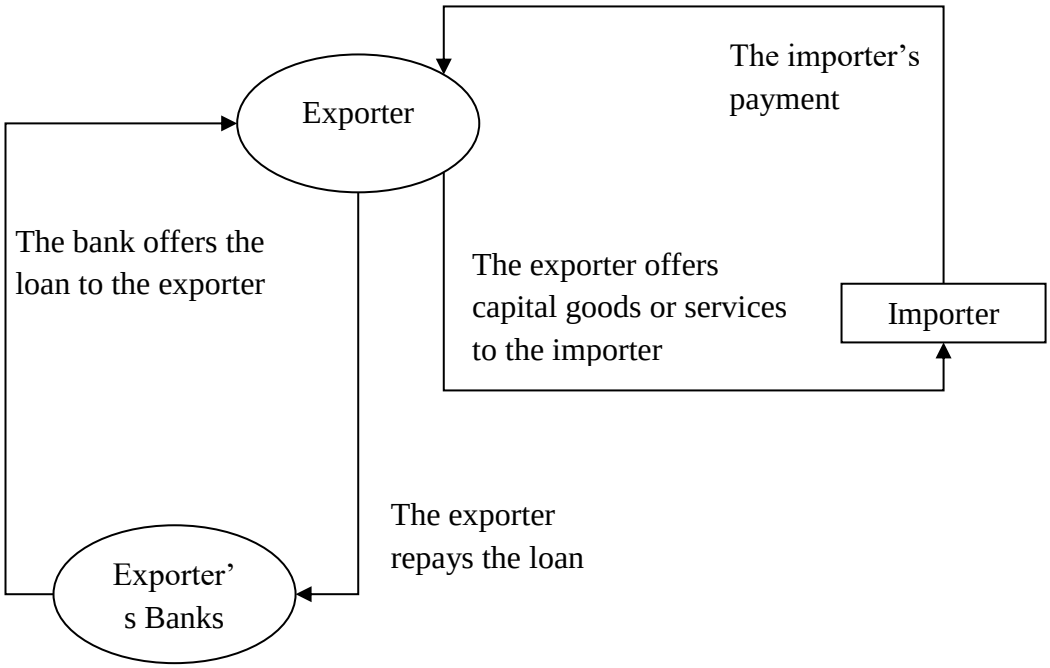

Figure 2.5. The operation of seller's credit

(UK Export Finance, 2013a)

Based on the above information, there are some differences between supplier's credit and buyer's credit. García Menéndez and Feo Valero (2009) illustrated the differences in the view of international trade, concluding that the main differences are as follows:

1. **The borrowers are different**: the borrower of buyer's credit is the buyer, or a bank entrusted by the buyer, whilst the borrower of supplier's credit is the supplier.

2. **The guarantee is different**: as for buyer's credit, the guarantee is normally taken by the bank entrusted by the buyer, after the buyer - or the bank entrusted by the buyer - has signed agreements with the exporter (seller)'s bank. As for seller's credit, the guarantee is based on contracts which are made by the sellers and the entrusted banks.

3. **The repayment exchange rate is different**: as the importer directly receives credit from the exporter's bank, there is no need for the exchange rate to be taken into consideration when the buyer repays the credit. As for the seller's credit, the loan will be repaid to the bank according to the contract, meanwhile, the buyer can utilize their domestic currency to pay for the goods. This will lead to the seller having to consider the exchange rate.

4. **The difference in risk taking**: based on the above information about varying exchange rates for repayment, and considering that sellers (exporters) need to take into account the exchange rate, there are potential risks involved. Meanwhile, when sellers become the loan borrower, there is also an interest rate risk. For the buyer (importer)'s credit, the seller will take less risks since there is no exchange rate risk. The borrower of buyer's credit is the buyer, therefore sellers (exporters) do not need to take all risks mentioned above.

In short, seller's credit and buyer's credit are the two forms of TC. The purpose of these credit arrangements is to fulfil the borrowers' capital demand with a certain agreement. This agreement allows borrowers to postpone their payment for purchasing and receiving their products or service first (Ferris, 1981). In practice, increasingly more working capital constrained SME's are willing to apply for TC (Ebenezer and Asiedu, 2013; Engemann *et al.*, 2014). They believe that their supplier is more informed than the bank and in addition, trade credit is more flexible than a bank loan in terms of interest rates and repayment periods, since these issues can be negotiated between the lenders and borrowers (Giannetti, 2012). Under TC, normally lenders will evaluate the length of cooperation with borrowers, and then decide how they will lend the credit to the borrowers. This type of lending, formed through a cooperation or trust, is also called relationship lending (Johan and Wu, 2014). Through relationship lending in trade credit, it it likely that the relationship between suppliers (lenders) and retailers (borrowers) will be enhanced, unlike BL (Biais and Gollier, 1997).

2.1.3 Other Credit Categories

Aside from the banks, sellers and suppliers that are involved in any credit lending and borrowing activity, some governments also provide financial help to capital constrained companies, especially providing various kinds of credit to SMEs. For instance, Small Business Administration (SBA) in the U.S. is a successful example of state government financing SMEs (Levenson and Willard, 2000b). In other words, SBA is a government department which aims to maintain the U.S national economy by supporting the development of SMEs (Cole, 2013).

SBA guarantees to support SMEs in accessing commerical loans from banks, credit unions or other lenders (Mills and McCarthy, 2014). SBA establishes different loan lending programs to fulfill different requirments of capital constrained companies. Gallagher (2015) introduced the loans issued by SBA which mainly include guarantee loan, fixed asset loan, micro loan and disaster loan. The guarantee loan is a type of secured loan with which SBA provides a guarantee to capital constrained SMEs. While different from the other types of guarantee, SBA does not provide a full guarantee to borrowers, it only offers part of the guarantee and increases the guarantee by 10 precent according to the loan size (Hyra *et al.*, 2014). A fixed asset loan aims to support capital constrained SMEs when investing in property such as real estate and other facilities (Gallagher, 2015). This loan is partly funded by non-profit certified development companies but fully guaranteed by SBA (Brown and Earle, 2015). A micro loan is issued to finance a small amount of capital to SMEs (Wang and Yang, 2016). A disaster loan is a specific long-term loan used by SMEs to rebuild their business or repair damages after a disaster (Josephson and Marshall, 2014).

SBA as a governmental financial organisation provides loans to capital constrained companies in the U.S. This type of joint financial support by government and financial institutions is also popular in other centuries. 'SME Access to Finance Schemes' launched by the Department of Business Innovation and Skills in the U.K are another example similar to SBA. Cowling (2010) stated that this scheme provides more opportunities for capital constrained SMEs in the U.K to access funding. According to the introduction by the Department for Business Innovation & Skills (2013), it introduced seven types of credit to support the development of SMEs in the U.K.

Scheme	Type of Intervention	Aim
Funding for Lending Scheme	Cheaper borrowing for banks & building societies	More or cheaper loans and mortgages (consumers and businesses)
National Loan Guarantee Scheme	Government guarantees on unsecured borrowing by banks	Cheaper business finance by reducing the cost of bank loans under the scheme by up to 1 percentage point.
Community Development Finance	Loans to a specific disadvantaged geographic	Varies by institution. Can include loans to start-up companies, individuals and established enterprises

	area or disadvantaged group	from within that area or community who are unable to access finance from more traditional sources (for example banks).
Enterprise Finance Guarantee	Loan guarantee to SMEs	Enterprise Finance Guarantee Loan guarantees to facilitate additional lending to viable SMEs lacking the security or proven track record for a commercial loan.
Business Finance Partnership (BFP)	Increase supply of capital through nonbank channels	First tranche of BFP funds will be lent to midsized businesses, helping to diversify the channels of finance available to them.
Business Finance Partnership: Small Business Tranche	Increase supply of capital through nonbank channels for small businesses.	Increase non-traditional finance such as peer-to-peer platforms, supply chain finance and mezzanine finance for businesses with a turnover below £75m.
Start-up Loans	Loans to young people (18-30) to start a small company	Open up finance to those who would not normally be able to access traditional forms of finance due to a lack of track record or assets.

Table 2.1. Financial support from Department for Business Creation and Skills (Department for Business Innovation & Skills, 2013)

Moreover, governments in some countries such as in Canada (Branch, 2002), Sweden (Cressy and Olofsson, 1997), Malaysia (Wonglimpiyarat, 2011) and South Africa (Fatoki and Smit, 2011) also provide similar financial support to SMEs. Governments in these countries all establish their own schemes to provide commercial loans to capital constrained SMEs. Generally, Beck *et al.* (2011) state that many countries provide financing to SMEs in order to maintain their national economies. However, Xie *et al.* (2010) stated that not all working capital constrained SMEs have access to financial support from their governments. For example, Hadjimanolis (1999) investigated the government financing in Cyprus, and

found around 50% of the companies had not obtained any governmental financial support, especially in terms of of financing innovations.

To conclude, BO and TC are the two main credit sources in the market. Although they succeed in financing short-term credit to working capital constrained companies (Jansen, 2016), some problems have obstructed working capital constrained SMEs from achieving credit from both credit forms. Some scholars have begun to consider the weaknesses and problems of both forms of credit (Blasio, 2005; Pike *et al.*, 2005; Ioannidou and Ongena, 2010; Torre *et al.*, 2010; Iyer *et al.*, 2014; Lin and Chou, 2015). Sharifi and Flores (2013) thought that working capital constrained SMEs were influenced by stringent assessment criteria and collateral requirements, which has hindered many applications from SMEs, especially start-up companies. In detail, some of the issues are summarised as follows.

1. BO and TC do not always satisfy the demands of working capital-constrained companies, especially for SMEs. As working capital constrained SMEs are in a hurry to access capital (Graham *et al.*, 2015), the onerous loan approval criteria in banks can be a formidable barrier to these SMEs accessing sufficient working capital.

2. Many banks use 'good reputation' as an assessment criterion when evaluating loan applications (Chemmanur and Fulghieri, 1994). These soft criteria serve to disadvantage newly formed organisations, especially start-up companies. TC, similar to BL, is restricted in that it is only able to provide for business operations (Wheelock and Wilson, 2000; Berger and Udell, 2002; Berger, 2003).

3. For both BO and TC, credit monitoring problems and risk management systems can also discourage both from granting loans to companies with limited credit history (Berger and DeYoung, 1997). As the two main traditional forms of commerical credit available nowadays, BL and TC have been closely examined, revealing weak monitoring systems and supervisory infrastructures (Glass *et al.*, 2010). This problem has been identified as one of the main problems which weakens their competitive positions in offering loans to SMEs (Vera and Onji, 2010; Wilcox and Berkely, 2011).

In light of the above discussions, many working capital constrained SMEs have difficulty accessing sufficient credit from a single source. To help these SMEs raise credit, as

indicated by Harrison (2014), credit portfolio management can be used to to facilitate SMEs in obtaining sufficient capital as opposed to to borrowing from a single credit source. To manage a credit portfolio that only involves BO and TC, Yang (2011) compared the difference between BO and TC in financing SC inventory management, but suggested thatnworking capital constrained SMEs might achieve a cheaper cost from multiple sources. Kouvelis and Zhao (2012) promoted an optimal credit portfolio consisting of BO and TC, which was able to finance newsvendors in SCs. However, apart from raising sufficient capital, these SMEs still consider satisfying their other business objectives through their working capital portfolios, such as profit maximisation (Song and Yao, 2013).

BO and TC play a key role in financing working capital constrained SMEs in SCS. However, from the perspective of SMEs, over the last 20 years, banks and suppliers are less willing to engage in short term lending agreements. This decreased willingness is caused by one particular reason. In the banking industry, to reduce the credit default risk, banks are required to invest in systems which mirror symmetric information and monitor borrowers' investment behaviour (Black and Strahan, 2002). However, this investment lead to banks struggling with a wide gap between high technical expenditures and low returns (Fiordelisi and Mare, 2014). Compared with banks, suppliers have the advantage of being able to track the market or product demands; also they have more opportunities to acquire their borrowers' business operations (Wilson and Summers, 2002). However, as a long-term business relationship is often required by suppliers, many SMEs, especially new start-ups, face barriers in obtaining TC from suppliers.

2.2 The Role of Third Party Logistics (3PL) Industry

The 3PL industry has been widely discussed within academia. Mentzer et al. (2001) defined 3PL industry as:

"Performing logistic activities between two establishments."

The main responsibility of the 3PL industry is to provide logistics services to SCs. Traditionally, the logistics services have included transportation, warehousing, packaging amongst others (Vasiliauskas and Jakubauskas, 2007). In order to service the multiple flows of SCM, 3PL industry has extended traditional logistics activities to a wider scope by offering value- added services (Rahman, 2011).

Apart from core logistics services, the 3PL industry has evolved to create competitive advantages to other companies by sharing information, reducing inventories and investing in new technologies (Allesina et al., 2010). These new value added activities have promoted the 3PL industry to consolidate information management into material flow management (Zacharia *et al.*, 2011). With transmitting information, the 3PL industry is recognized as being able to remedy the limitations of banks in monitoring business activities in SCs (Pietro *et al.*, 2013). This advantage has promoted the discussion on the 3PL industry providing short-term credit in SCs (Chen and Cai, 2011; Xia *et al.*, 2014; Singh *et al.*, 2015).

2.2.1 3PL's Financial Service in Business Practice

The majority of studies related to the 3PL industry still focus on traditional logistics services, e.g., transportation (Rahman and Wu, 2011), network optimization (Azadian *et al.*, 2012), inventory management (Song *et al.*, 2014) and shipment planning (Dong *et al.*, 2015). In comparison to these studies, current studies on discussing the financial services of the 3PL industry are still very limited. Juho *et al.* (2012) stated that financial services had not been widely implemented by 3PL companies in SCM. Indeed, the 3PL financial service is currently still operated by few leading 3PL companies.

Developing a financial service is an innovation in 3PL industrial research and development (Chapman *et al.*, 2003). From the perspective of financial flow management, Coe (2014) stated that 3PL companies might have an insight into problems in SC operations through managing logistics. Moreover, developing a financial service is also a way to maintain the stability of SCs in response to the decreasing willingness of banks' and suppliers' to lend BO and TC (Pike *et al.*, 2005). Few scholars attempt to seek another type of short-term credit to support the working capital demands of SMEs (Chen and Zhu, 2005; Chen and Cai, 2011; Zacharia *et al.*, 2011; Xia *et al.*, 2014). Chen and Zhu (2005) discussed the role of the 3PL industry and promoted the concept of a logistics finance service, which enables the financing of inventory management in SCs. Erik (2009) studied the benefit of logistics service providers financing inventory management. It highlighted the revenue enhancement under logistics service providers' financing.

3PL financial service is different to a traditional logistics service. According to the definition of a 3PL financial service,

"A service to help companies to get commercial loans and relax their budget constraints."

Chen (2008)

ILFS is a practice of 3PL financial services, in which some 3PL companies cooperate with banks to finance commercial credit in SCs (Cai and Chen, 2011). Within ILFS, 3PL companies benefit from synchronizing information to banks which in turn will alter banking governance, enhance monitoring of SMEs' operational activities and evaluate risks in credit lending. To achieve this aim in practice, some scholars have presented the business cases of 3PL companies operating financial services (As shown in Table 2.2). These cases explain how 3PL companies form alliances with banks in joint monetary transactions, to provide financial solutions to working capital constrained companies in SCs.

Author(s)	**3PL Company**	**Financial Institution**	**Financial Service**
Chen and Cai (2011)	AIMS Logistics	U.S. National Bank	These 3PL logistics companies help their banking partners to design financial solutions for capital-constrained companies in SC. For example, a bank lends short-term credit to a SME with the 3PL company's monitor of product transactions.
	Schneider Logistics	U.S. Bank	
	China National Foreign Trade Transportation Group Corporation (SINOTRANS)	Industrial and Commercial Bank of China (ICBC)	
Large *et al.* (2013)	LINC	DNB (Norway's largest financial service group)	LINC provides a system to the banking partner. This system helps the bank tracking material flow in SC. It also enables LINC to manage payment from customer companies to the banking partner.

Table 2.2. 3PL companies corporate with banks to manage financial flow in SCs

In business practice, some strong 3PL companies use their expertise in controlling material and informational flow to help banks monitor credit usage and track monetary transactions. Due to the integration of material, information and financial flow, 3PL companies are able to share real-time information both up and downstream. Moreover, financial institutions can receive transparent information on SC transactions through 3PL companies (Trappey *et al.*, 2011).

The initial study by Chen and Cai (2011) , explained 3PLs' financial service by presenting ILFS. ILFS is a business practice formed by FedEx with its cooperating bank. As the presentation in Figure 2.6 shows, FedEx and the bank develop an internal financial cooperation. BO will be lent to the working capital constrained company under the monitoring of FedEx. Through ILFS, FedEx has integrated the logistics service, information management and monetary transaction. The clients in this SC not only receive the logistics service from FedEx, but also achieve working capital from the bank with assistance from FedEx.

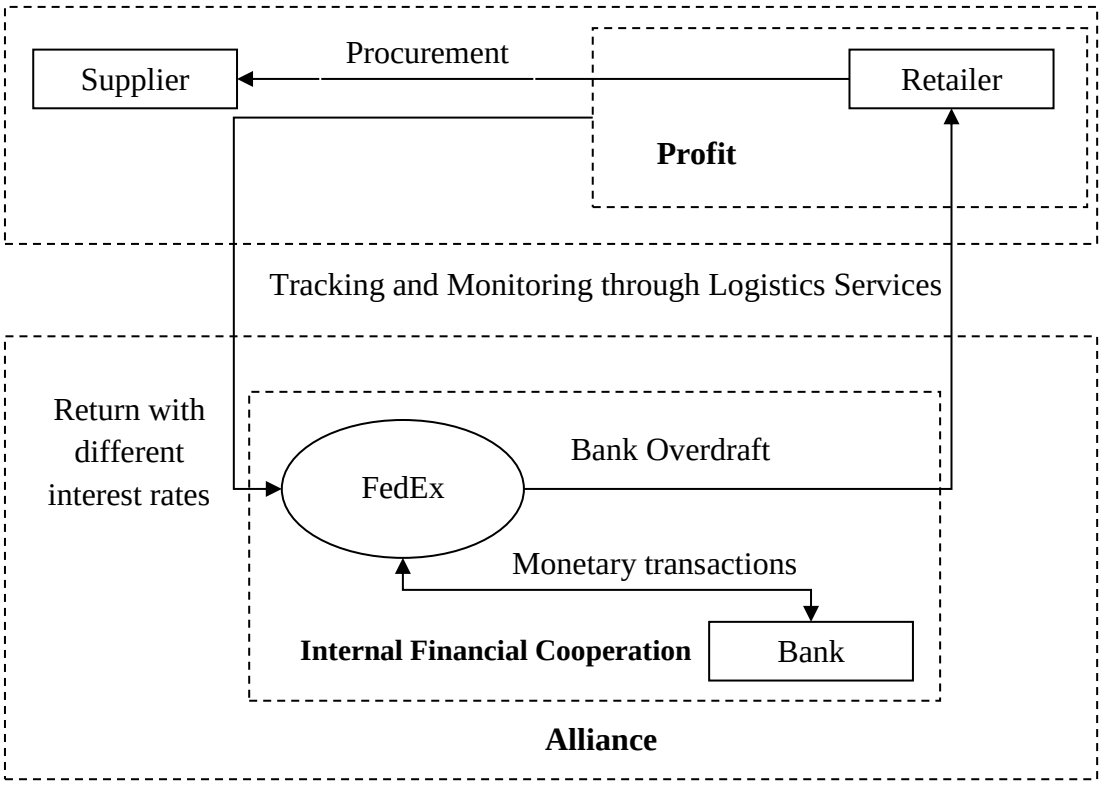

Figure 2.6. Integrated Logistics and Financial Service
(Cai and Chen, 2011)

Some studies have discussed the benefits of 3PL companies operating ILFS in SCs (Trappey et al., 2011; Huemer, 2012; Juho et al., 2012; Silvestro and Lustrato, 2014). To evaluate the adoption of ILFS in business practice, Chen and Xie (2009) described that ILFS created a more secure approach for banks in terms of lending BL to working capital constrained companies in SCs. Trappey *et al.* (2014) emphasized that banks in ILFS could lend short-term credit in a more transparent information sharing environment. This would also enhance the security and reliability of monetary transactions between banks and companies.

The discussion of the benefits of ILFS, raises a new question of whether or not 3PL companies could directly lend credit to working capital constrained companies in SCs. To satisfy the increasing working capital demands of SMEs, a new form of credit named 3PLC was developed. Chen and Cai (2011) tested the feasibility of a logistics company financing a company and compared this with BO and TC. Their study determined that 3PLC could contribute a lower total cost associated with a cheaper interest rate to working capital constrained companies. Trappey *et al.* (2016) presented a theoretical model which assumed a 3PL company being able to transfer materials, share information and transmit cash to a working capital constrained SC. As a result, the security of the bank is enhanced due to transparent information flow. To elaborate on this point, the following section reviews relevant studies on 3PL industry lending short-term credit, it also introduces the supposed 3PLC.

2.2.2 The Definition of 3PL Credit

It is rare to find a discussion about 3PL companies lending short-term credit in current studies. Furthermore, 3PLC has also not been clearly defined, so much so that few studies describe it as a new form of short-term credit in SCs (Chen and Xie, 2009; Chen and Cai, 2011). An initial study by Chen and Cai (2011) has commented on banks and suppliers having difficulty accessing accurate real-time information on monetary transactions in SCs. Moreover, their study applied ILFS, which based on cooperation between a 3PL companies and the bank, is appointed as a solution to reduce the risk of credit default (Chen and Cai, 2011), however they introduced ILFS and discussed the feasibilty of a 3PL company lending short- term credit in a SC. This type of short-term credit was given the term 3PLC. It aims to provide an extra short-term credit source in SCs apart from BO and TC and also

to fulfil working capital demands from small businesses. According to Chen and Cai (2011), 3PLC is defined as:

> *"3PL companies provide both logistic services and trade credit to retailers."*
>
> Chen and Cai (2011)

This definition has expanded the scope of 3PLs' service. 3PLC has changed the role of 3PL companies in financial services, they are transferred from being a bank partner to a short-term credit lender. In order to explain 3PLC, Chen and Cai (2011) assumed a SC which included a 3PL company, a working captail constrained retailer and a supplier. Figure 2.7 explains the relationship among these three roles from the perspective of material flow management.

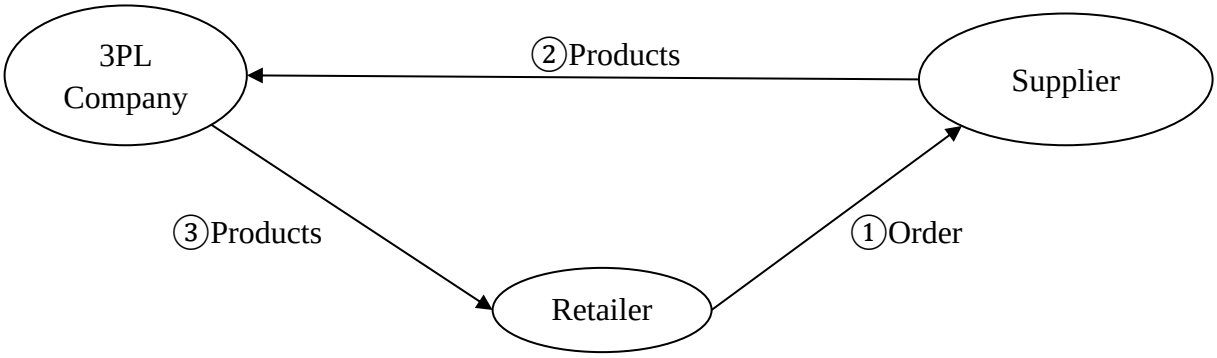

Figure 2.7. The logistics flow in supply chains
(Chen and Cai, 2011)

Figure 2.7 presents the material flow in the assumed SC. Process ① refers to the retailer ordering products from the supplier and the 3PL company is to provide logistics service indicated by process ② and ③. Process ① to ③ depict a typical logistics service provided by a 3PL company. Whereas in the scenario designed by Chen and Cai (2011), the 3PL company has been assumed to lend a type of special TC to a working capital constrained retailer. Figure 2.8 presents this scenario.

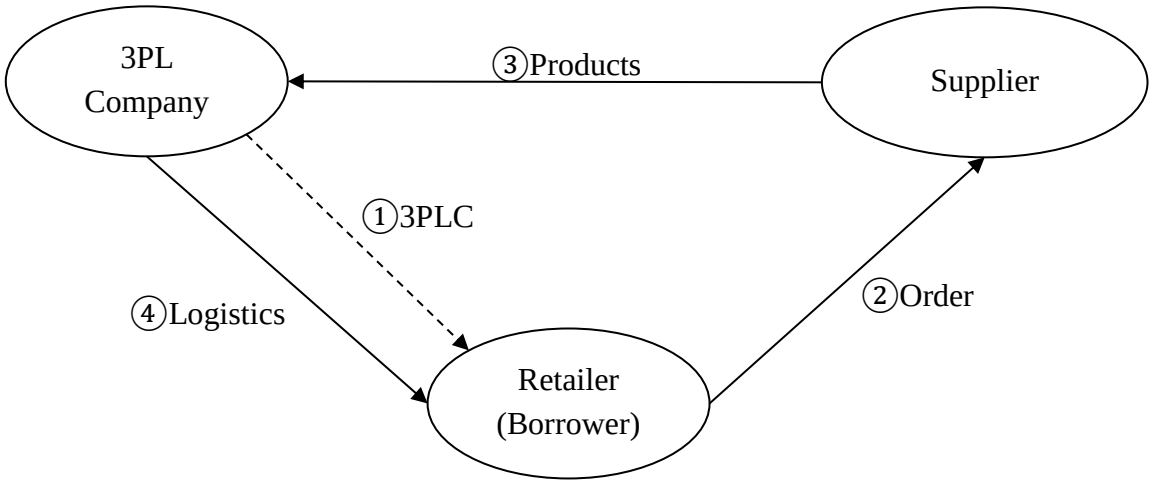

Figure 2.8. The 3PL company issues credit to the retailer

(Chen and Cai, 2011)

The description in Figure 2.8 presents how a 3PL company can lend 3PLC which is similar to TC to a working capital constrained retailer. While it is slightly different to a traditional TC, Chen and Cai (2011) explained that 3PLC lent by a 3PL company allows the late payment on logistics serivce and products.

Figure 2.9 visualises a 3PL company operating a logistics service and 3PLC in the SC. Process ① is the certain amount of orders placed by the working capital constrained retailer to the supplier without payment. This part of product will be delivered by the supplier by to the 3PL company in the process ②. The 3PL company will replace the retailer in paying the supplier in advance for the products and will receive payment for the logistics service from the supplier (Process ③ and ④). Meanwhile, the 3PL company will issue 3PLC to the working capital constrained retailer in process ⑤, which will allow the products and logistics service to be received without instant payment. Process ⑥ happens after the working capital retailer has completed the product sale. The retailer will pay back the 3PLC in the contract provision time.

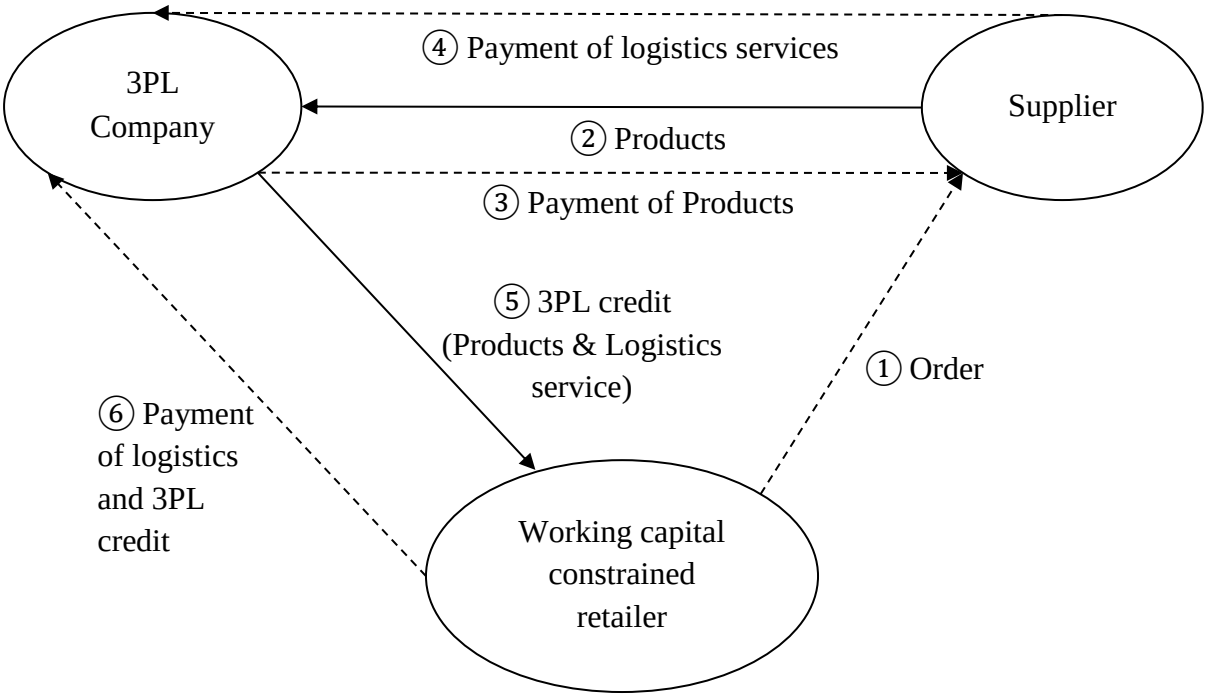

Figure 2.9. The 3PL company provides 3PLC in TC approach in the SC (Chen and Cai, 2011)

3PLC is also explained by Xia *et al.* (2014). Similarly, their study attempts to integrate a short-term credit lending business into a 3PL company. Thus, this 3PL company is assumed to provide a traditional logistics service and also offer short-term credit to working capital constrained companies in a SC. Different to the study by Chen and Cai (2011), Xia *et al.* (2014) described how 3PLC was similar to TC but not the exactly same as TC. Although they modelled 3PLC following the definition of Chen and Cai (2011), the 3PLC in their study works differently to the explanation in Figure 2.9 and it is designed as a capital which can be used for procurement and other payments. According to the explanation by Xia *et al.* (2014), 3PLC is similar to TC and lent before the working capital constrained retailer places the order. Thus, the procedure of a 3PL company operating 3PLC is different to the process in Figure 2.9. Figure 2.10 presents 3PLC modelled by Xia *et al.* (2014).

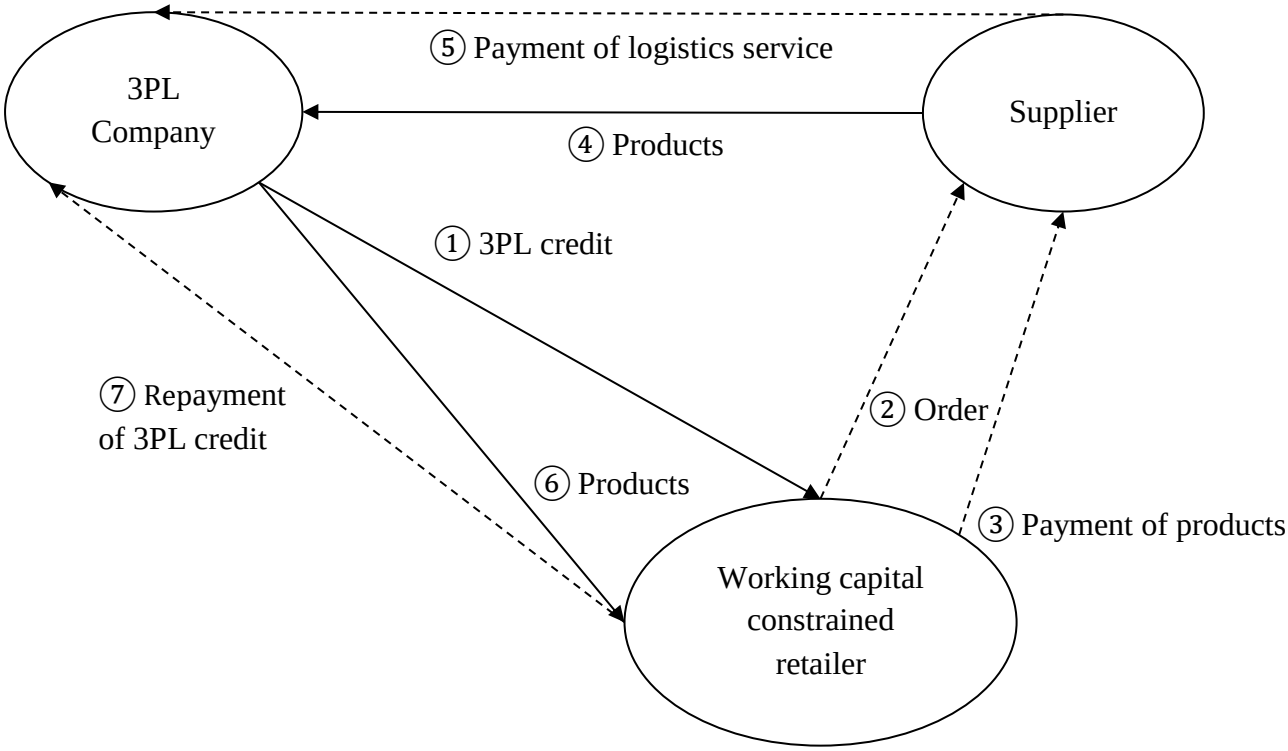

Figure 2.10. The 3PL company lends another type of 3PLC in a SC
(Xia *et al.*, 2014)

Based on Figure 2.10, the 3PL company is designed to provide 3PLC for the working capital constrained retailer. According to the description by Xia et al. (2014), process ① happens when the working capital constrained retailer needs procurement. Once the retailer has received 3PLC, the order will be placed to the supplier with instant payment (Processes ② and ③). The procured products will be delivered by the supplier to the 3PL company. Meanwhile, payment for the logistics service will also be paid to the 3PL company (Processes ④ and ⑤). These procedures are same as processes ② and ④ in Figure 2.9. The product will be delivered by the 3PL company to the retailer (Process ⑥). After sales, the retailer will repay 3PLC to the 3PL company as in process ⑦.

Compared with Figure 2.9 and Figure 2.10, the studies by Chen and Cai (2011) and Xia et al. (2014) both mentioned how a 3PL company operates 3PLC for a working capital constrained SC. The main difference between these two studies is in how they identify how 3PLC works in SCs. In detail, the study by Chen and Cai (2011) described how 3PLC worked in a similar way to TC. This mode assumed that 3PL company pre-purchased certain products from the supplier and offered them to the working capital constrained retailer without instant payment (as the process ⑤ in Figure 2.9). Whereas the study by

Xia et al. (2014) described how 3PLC was working capital lent by the 3PL company to the retailer to pay business operations, including procurement from the supplier (as in processes ① and ③ in Figure 2.10).

This difference in defining 3PLC means that these two studies present different models for presenting the operations of 3PLC. Cai and Chen (2011) assumed a working capital constrained retailer could obtain three types of short-term credit from a bank, a supplier and a 3PL company. From the perspective of the retailer, their study compared the difference of a working capital constrained retailer using BO, TC and 3PLC. By following the description in Figure 2.9, the working capital constrained retailer is assumed to obtain a discount on the logistics services by using 3PLC. Whereas the retailer will be charged the original logistics service price when using BO and TC. Thus, in the scenario, compared with BO and TC, a working capital constrained retailer using 3PLC has lower overall costs. Rather than using the same perspective as Cai and Chen (2011), Xia et al. (2014) discussed the benefit of issuing 3PLC to a 3PL company. Their study stated how lending 3PLC creates a larger income for the 3PL company as opposed to only providing a logistics service. In addition, 3PLC enhances credit safety in the SC, in which a 3PL company can use the pledge or control the stock if the retailer is unable to repay the credit.

Through these two studies, 3PLC has been defined clearly. Although Xia et al. (2014) slightly changed the operations of the 3PL company lending 3PLC; both studies confirmed that it is feasible for a 3PL company to lend short-term credit to working capital constrained companies. Regardless of the differences in servicing 3PLC procedures in the two studies, the purpose of 3PLC is to solve the working capital constraint problem in SCs. It supports working capital constrained companies to invest in procurement, logistics services and other business operations (Xia *et al.*, 2014). Based on the two studies, a clear picture of 3PLC emerges which should guarantee working capital constrained companies to be able to operate their business (Chen and Xie, 2009; Chen and Cai, 2011; Chen and Wan, 2011). Therefore, referring to the studies by Chen and Cai (2011) and Xia et al. (2014), 3PLC is actually a short -term credit which finances working capital constrained companies to enable them tp operate their material flow and allow them to obtain a discounted logistics service with late payment.

2.3 Borrowers' Credit Portfolio Selection

In early studies related to the working capital constraint problem, many scholars thought short-term credit lenders played the dominant role in the debtor-creditor relationship (Berger and Udell, 1995; Saidenberg and Strahan, 1999; Udell, 2008). Thus, the topic of working capital management has been studied extensively from the perspective of credit lenders (Dahiya *et al.*, 2003). There are numerous studies focusing on improving benefits for credit lenders, such as minimising credit default risks (Dierkes *et al.*, 2013), maximizing lending profit (Wu *et al.*, 2014), improving SC multi-flow integration (Goetschalckx *et al.*, 2002; Crespo Marquez *et al.*, 2004; Yang, 2011; Silvestro and Lustrato, 2014).

However, according to the description by Baños-Caballero *et al.* (2010),

> *"Much less attention has been given on studying working capital management in current studies."*

Indeed, studies on working capital constrained companies are limited. Some studies discussed how to borrow working capital from a single source (Guiso, 1998; Dan *et al.*, 2012; Teng *et al.*, 2012; Sharifi and Flores, 2013; Banerjee and Duflo, 2014; Murfin and Njoroge, 2014; Pal *et al.*, 2014; Wang *et al.*, 2014b; Barrot, 2015). However, the facet that working capital constrained SMEs is currently facing is that they are hardly able to access sufficient BO or TC by borrowing from a single short-term credit source (Berger and Udell, 2002; Bădulescu, 2010). To obtain sufficient capital, borrowing from multiple credit sources has been suggested rather than borrowing from a single source (Michalski, 2007). Michalski (2007) thought that credit portfolio management was useful to assist working capital constrained companies in maximising their benefits. As the first priority is to borrow a sufficient amount, Banerjee and Duflo (2014) stated that working capital constrained companies might hover between different types of short-term credit and they could easily switch credit choices if they have trouble to accessing current credit.

In addition, decision-making on credit borrowing and credit portfolio management is understood as being affected by both internal and external factors. Wilson and Summers (2002) addressed the importance of firm sizes in applying for TC. Their investigation shows that start-up SMEs, are limited by their firm sizes and blank relationship with suppliers, which makes it difficult for them to access TC. Blanchflower *et al.* (2003) stated that SMEs were not treated equally when they applied for short-term credit and that discrimination

might occur due to different firm sizes, development and other issues. Bannier *et al.* (2012) explained how credit borrowers' selection is affected by different concerns or considerations. These factors impact how working capital constrained companies are selected for short-term credit and how the borrowing amount is determined. Aouni *et al.* (2014) described some objectives of working capital constrained borrowers, such as profit maximisation, risk of loss minimisation, return on investments maximisation and others. These objectives influence borrowing amounts of each credit in the credit portfolio, especially when they have multiple conflicting objectives.

Current studies have not focused on analysing the influence of factors or objectives of credit portfolio management. Huyghebaert et al. (2007) was one of few studies analysing start-up companies' choice of BL and TC. It considered only a few factors' influencing decision-making on borrowing, such as company size and number of employees. The study by Huyghebaert *et al.* (2007) is an example explaining certain factors that may lead to different credit portfolios for working capital constrained companies. In terms of objectives, Aouni *et al.* (2014) discussed how credit portfolios could be different with regard to the considerations of single and multiple objectives. In addition, their study suggested considering how a single objective would not really reflect reality. Considering multi-objective could better reflect how a working capital constrained company decide their borrowing amounts to fulfil different purposes via a credit portfolio.

Therefore, this section attempts to identify all the possible factors influencing working capital selection or borrowing activities, meanwhile, it summarises the objectives of that borrowers are aiming to achieve. To conclude these two aspects, this section adopts a systematic literature review to go through previous studies., Brereton et al. (2007) suggested that a specific procedure be followed in order to aggregate empirical evidence. Therefore, following their suggested procedure as shown in Figure 2.11, the primary stage aims to address specific research questions. The first research question aims to determine concerns of working capital constrained companies in their credit borrowing from short-term credit sources. The second research question supposes a credit portfolio management to maximise OBA over multiple periods. The last research question supposes a dynamic credit portfolio management to optimise the minimisation of overall costs and BPC minimisation.

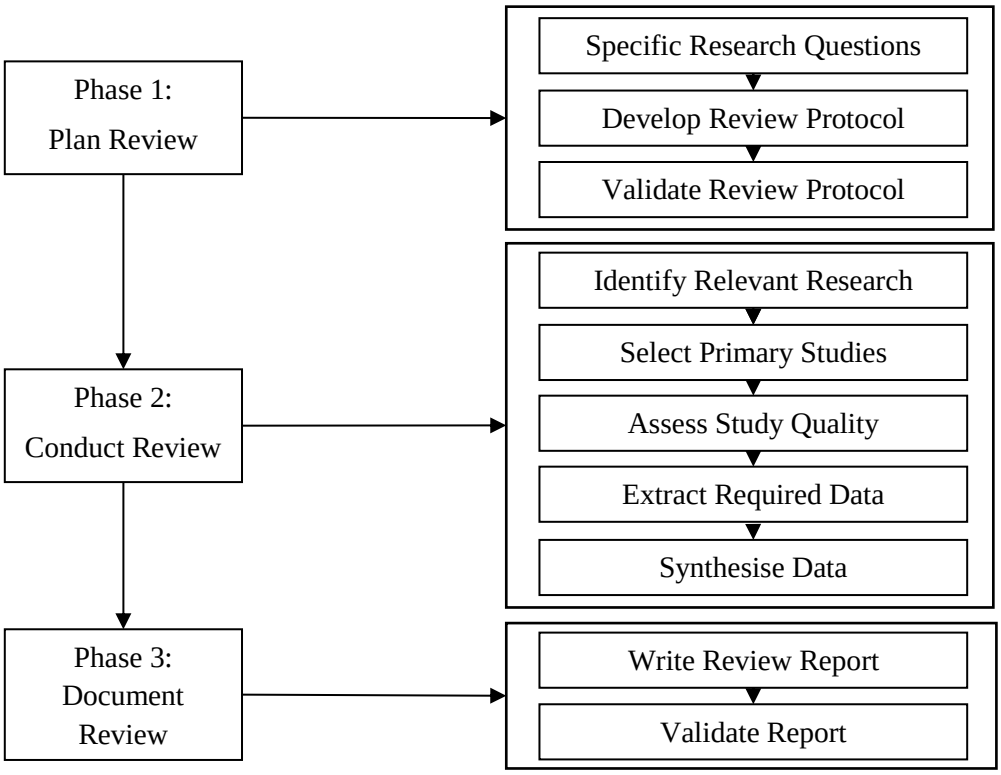

Figure 2.11. Systematic literature review process (Brereton et al., 2007)

Through narrowing down these research questions, two key aspects of content can be identified, which are the concerns and business objectives of working capital constrained companies. The following section attempts to aggregate the related studies by searching within these two aspects.

2.3.1 Borrowers' Concerns in Selecting Short-term Credits

In reality, working capital constrained companies may be influenced by their concerns, or affected by various external restrictions when they applying for short-term credit (Wilner, 2000; de Janvry *et al.*, 2010). Hubbard *et al.* (2002) described how many borrowers might be unsure whether they could be granted certain credits due to the influence of some certain factors. Studies have been conducted on how firm size (Minetti and Zhu, 2011), business ownership (Voordeckers and Steijvers, 2006), and firm age (Cowling *et al.*, 2012) directly influence the results of borrowers' credit applications. Dietrich (2010) stated that large sized firms held stronger negotiation power than SMEs which benefited them a lower interest rate. (Lin *et al.*, 2013) thought that family owned business, which are normally SMEs, have to suffer higher interest rates than large sized enterprises. Oh and Johnston

(2014) stated that firm age, significantly influenced the probability of companies' being successful when accessing short-term credit and also impacted their interest rate.

Moreover, apart from the above listed factors, some other factors have been addressed, including interest rate (Drobetz *et al.*, 2013), credit approval time (Behr *et al.*, 2011), collateral (Faia and Monacelli, 2007; Ono and Uesugi, 2009) and borrowing capacity. These factors have been studied as influencing the credit borrowing choices of working constrained companies from multiple credit sources, as well as their credit borrowing amounts. However, many of these factors have only been discussed individually in current studies. No significant studies have been found to consider all these potential factors together. It is also blank in the knowledge of analysing the influence of these factors on the credit selection of working capital constrained companies from multiple credit sources. Therefore, to fill this gap, this section attempts to conduct a summary of borrowers' concerns and external restrictions by reviewing relative studies.

To clarify these factors, which include concerns and external restrictions, this section applies a systematic process to first classify the literature review. By following the procedure in Figure 2.11, it selects journal articles from 1996 to 2016. The searching scope is restricted to firm related studies and the key search terms are set as "firms' concerns", "influencing factors" and "short-term credit borrowing". As a result, apart from some low-cited and repeatedly cited papers, 135 journal papers have been collected and reviewed. This section will go through these papers in terms of their suggested concerns. The summary of borrowers' concerns is presented in Table 2.3.

Category of Borrowers' concerns	**No.**	**Borrowers' Concerns**	**Explanation in respect to credit borrowing**	**Author(s)**
Concerns about credit conditions	1	Interest rate	The amount charged as a percentage of principal by a lender to a borrower for taking out a loan.	Angelini et al. (1998), Brau (2002), Johnson and Kriz (2005), Güner (2006), Ortiz-Molina and Penas (2007), Dehejiaa *et al.* (2012), Lin *et al.* (2011), Huston (2012), Jimenez *et al.* (2012), Dietrich (2010), Drobetz *et al.* (2013), Alesina *et al.* (2013), Kirschenmann (2015)
	2	Repayment period	The period in which credit lenders allow credit borrowers to use credit. At the end of this period, credit borrowers are expected to pay off all the borrowed loans.	Hand and Henley (1997), Godquin (2004), Derban *et al.* (2005), Klapper (2006), Huyghebaert (2006),

				Giannetti *et al.* (2011), Psillaki and Eleftheriou (2015), Kirschenmann (2015)
	3	Borrowing capacity	The maximum credit amount that a firm can borrow from the lender.	Jappelli and Pagano (2002), Berger *et al.* (2005), Rice and Strahan (2010), Agier and Szafarz (2013), Casey and O'Toole (2014), Kaya *et al.* (2014), Kjenstad *et al.* (2015)
	4	Transaction cost	A type of financial cost generated in the process of lenders delivering credit and borrowers collecting credit. The transaction cost is charged depending on the short-term credit amount and exchange rate.	Bhatt and Tang (1998), Bonaccorsi di Patti and Gobbi (2001), Hubbard *et al.* (2002), Cheng and Pike (2003), Huyghebaert (2006), Mihir *et al.* (2007), Hosseini *et al.* (2012), Lin *et al.* (2013)

	5	Credit approval time (Approval Time)	The time needed for a credit application to be assessed by the lender.	Frame *et al.* (2001), Blanchflower *et al.* (2003), Glennon and Nigro (2005), Wu *et al.* (2007), Beck *et al.* (2008), Behr *et al.* (2011)
	6	Credit discount	A discount offered by lenders to decrease interest payments	Marotta (2005), Drucker and Puri (2005), Dass and Massa (2011)
	7	Credit delivery time	The time it takes for credit to be transferred from the lender to the borrower.	Wilson and Summers (2002), Javed *et al.* (2006), Jiménez *et al.* (2009), Moro and Fink (2013), Iyer *et al.* (2014), Agarwal *et al.* (2015)
	8	Administration expenditure in managing credit borrowing (Administration Cost)	The administration cost incurred in the process of borrowing credit, which includes the credit source search, the application, negotiation, monitoring and management.	Cole (1998), Cook (1999), Cheng and Pike (2003), Johnson and Kriz (2005), Huyghebaert *et al.* (2007),

				Vos *et al.* (2007), Craig *et al.* (2007), Saunders and Steffen (2011), Berg *et al.* (2015)
Concerns about the relationship with lenders	9	Debtor-creditor distance (Distance)	The geographic distance between enterprises and their credit lenders (Bank)	Petersen and Rajan (2002), Degryse and Ongena (2005), DeYoung *et al.* (2008), Jiménez *et al.* (2009), Agarwal and Hauswald (2010), Rauterkus and Munchus (2014)
	10	Debtor-creditor relationship (Relationship)	The cooperating period of financial institutions and organizations that are engaged in lending and borrowing.	Berger and Udell (2002), Farinha and Santos (2002), Brau (2002), Elsas (2005), Chakraborty and Hu (2006), Udell (2008), Bharath *et al.* (2011), Berger and Black (2011), Dass and Massa (2011), Oh and Johnston (2014)

	11	Borrowing history	A record of a firm's credit borrowing and repayment to date.	Jayaratne and Wolken (1999), Kallberg and Udell (2003), Bharath *et al.* (2007), Bellucci *et al.* (2010), Ioannidou and Ongena (2010), Bharath *et al.* (2011)
	12	Firms' openness (Openness)	The degree to which firms accept their credit lenders' screening and monitoring on credit utilization.	Foglia *et al.* (1998), Berger and Udell (2002), Kallberg and Udell (2003), Carling and Lundberg (2005), Luoto *et al.* (2007), Agarwal and Hauswald (2010), Jimenez *et al.* (2012), Abdesamed and Wahab (2014), Oh and Johnston (2014)
Concerns about own business conditions	13	Business ownership (Ownership)	The owner of a business, organization or firm	Coleman and Carsky (1999), Haynes *et al.* (1999), Sapienza (2004), Voordeckers and Steijvers (2006)

	14	Gender difference (Gender)	Gender difference may influence a company's abilty to access commercial credit.	Storey (2004), Marlow and Patton (2005), Treichel and Scott (2006), Constantinidis *et al.* (2006), Coleman (2007), Coleman and Robb (2009), Bellucci *et al.* (2010), Agier and Szafarz (2013)
	15	Human capital	Employees who are professional in searching credit sources, applying for credit and managing credit in a firm.	Binks and Ennew (1996), Åstbro and Bernhardt (2005), Niskanen and Niskanen (2006), Coleman (2007), Li *et al.* (2008), Minetti and Zhu (2011), Abdesamed and Wahab (2014), Khang and King (2015)
	16	Firm size	The classification of organizations according to their level of human capital, economic growth and profit achievement.	Berger and Udell (1998), Robert and Mark (1998), Saidenberg and Strahan (1999), Dhawan (2001),

				Cavalluzzo *et al.* (2002), Gelos and Werner (2002), Biesebroeck (2005), Cull *et al.* (2006), Rice and Strahan (2010), Dietrich (2010), Minetti and Zhu (2011), Chodorow-Reich (2014)
	17	Firm age	The lemgth of time a firm has been established.	Martinelli (1997), Robert and Mark (1998), Harhoff and Körting (1998), Cull *et al.* (2006), Firth *et al.* (2009), Cowling *et al.* (2012)
	18	Business stage	The business development of a firm in the market.	Cassar (2004), Bates (1997b), Bates (1997a), Atiya (2001), Denis and Mihov (2003), Berkowitz and White (2004) ,

				Huyghebaert *et al.* (2007), Graham *et al.* (2009), Lu *et al.* (2015)
	19	Decision making procedure (Decision Making)	The process of determining credit borrowing by firm owners or management levels from alternative credit sources.	McNamara and Bromiley (1999), Romano *et al.* (2001), Frame *et al.* (2001), Romano *et al.* (2001), Vaaler and McNamara (2004), Brown and Zehnder (2007), Karlan and Zinman (2009), Haron *et al.* (2013)
	20	Project investment	The project in which the firm wishes to invest credit in.	Guiso (1998), Jonathan and Jonathan (2003), Gill *et al.* (2010)
	21	Social connection	Firms operate commercial transactions through social networks by exchanging resources.	Uzzi (1999), Coulson and Monks (1999)
	22	Collateral	The assets in a firm that can be pledged to the lender.	Elsas and Krahnen (1998), Gelos and Werner (2002),

				John *et al.* (2003), Hur *et al.* (2006), Faia and Monacelli (2007), Ono and Uesugi (2009)

Table 2.3. The summary of categories of concerns in the firm level

Based on the listed concerns and restrictions in Table 2.3, there are 22 types of factors identified in the relative studies. These factors are divided into three main categories, which include concerns about credit conditions, concerns about the relationship with lenders and concerns about their own business conditions. Following these three categories, Figure 2.12 summarises the number of studies in term of each specific factor and organises these factors into each category by presented in different bars.

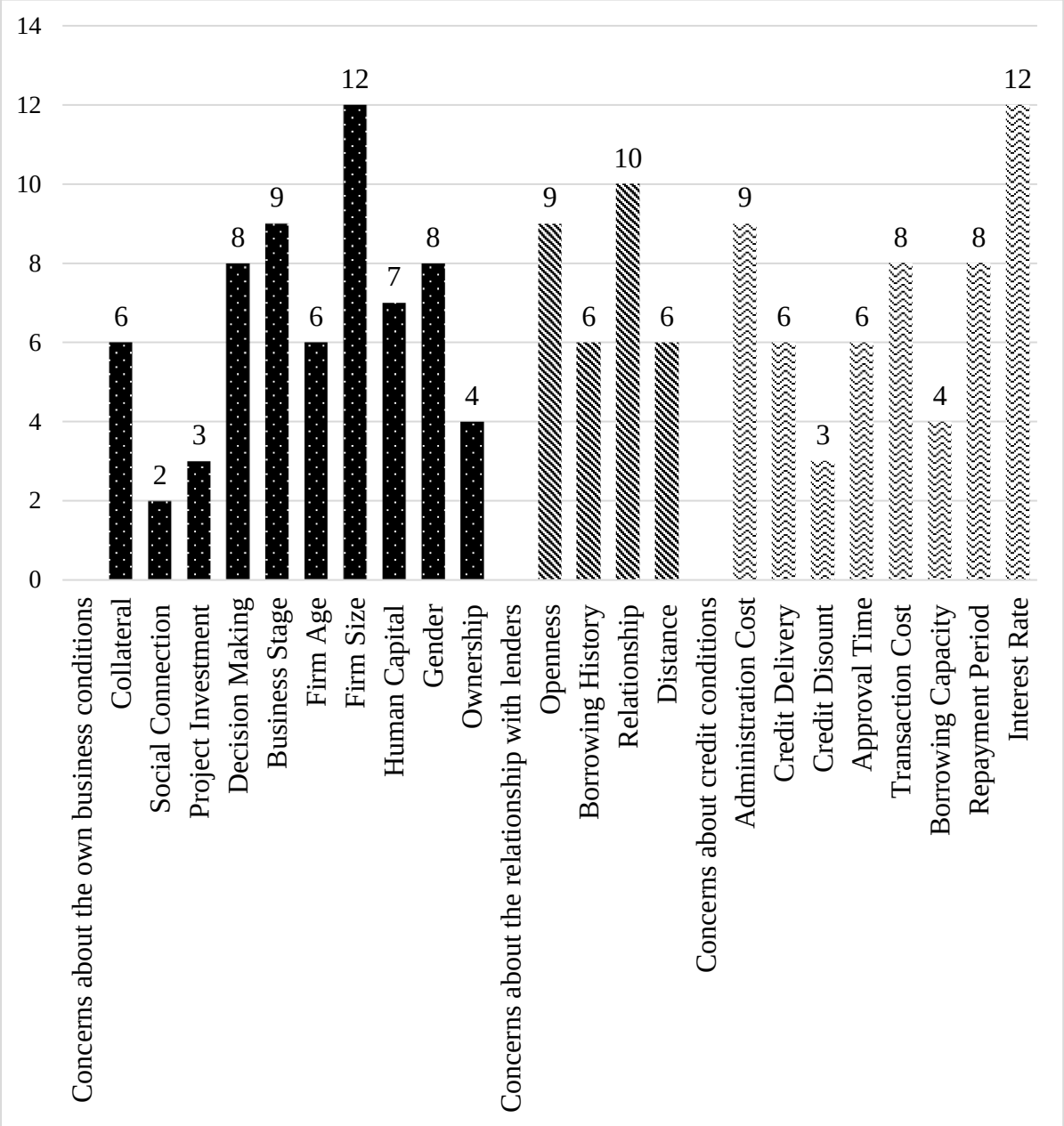

Figure 2.12. The numbers of papers in describing each borrowers' concern

All these 22 concerns are studied by a different number of studies. To provide a clear understanding, some widely discussed concerns in each category are presented. In the category of concerns about credit conditions, interest rate is one of the most frequently mentioned factors. Dehejiaa *et al.* (2012) described how interest rate significantly impacted a firms' borrowing costs. In practice, short-term credit borrowers consider high interest rates as a burden. Some SMEs are reluctant to accept a high interest rate when they apply for short-term credit from multiple credit sources.

Apart from interest, borrowing costs also consist of transaction costs and administration costs. Freund and Spatafora (2005) explained that transaction costs occured when short-term credit was delivered. Jappelli and Pagano (2002) described that administrative costs happen in the process of companies applying for credit, searching for new credit lenders, building up information, communication and exchange. These two types of cost significantly influence working capital constrained companies' borrowing decision (Hosseini *et al.*, 2012). Many private companies are normally subject to higher borrowing costs than large enterprises (Saunders and Steffen, 2011). Hence, many working capital constrained companies normally continue to search for credit with lower costs (Banerjee and Duflo, 2014).

Some other indirect factors may also increase the borrowing cost. Credit delivery time is also discussed in many papers (As shown in Figure 2.12). For example, TC borrowers specifically focus on credit delivery time as it is actually the time of product delivery (Giannetti *et al.*, 2011). In other work, the borrowing cost of using TC partly depends on when the credit will arrive. Murfin and Njoroge (2014) measured the waiting time for TC delivery and concluded that a longer waiting time would increase costs for the borrower.

Regarding the concerns about relationships with lenders, relationships are one of the most noticeable factors influencing borrowers' credit selection. Briefly, a close business relationship is always advantageous for working capital constrained companies in terms oftheir credit borrowing (Bharath *et al.*, 2011). A special lending approach known as relationship lending has been highlighted in some studies (Berger and Udell, 1995; Elsas and Krahnen, 1998; Berger and Udell, 2002; Behr *et al.*, 2011; Giannetti, 2012). It is described as a type of lending which relies on a close relationship between lenders and borrowers. It is also thought to benefit many working capital constrained SMEs (Berger

and Udell, 1995). Memmel *et al.* (2007) found many SMEs had difficulty in accessing BO, while they could achieve TC easier by taking advantage of their closer relationship with suppliers. Additionally, the duration of the relationship also affects the borrowing amount of working capital constrained companies. The duration of the relationship actually stands for the level of trust (Angelini *et al.*, 1998). A long-term relationship can better convince credit lenders to provide a large amount of credit (Dass and Massa, 2011) and also make it more likely for working capital constrained companies to be able to negotiate their repayment period and interest rates with lenders (Oh and Johnston, 2014).

However, the development of a close relationship depends on various factors. Some academics have discussed certain factors, such as distance (DeYoung *et al.*, 2008; Jiménez *et al.*, 2009; Agarwal and Hauswald, 2010). It represents geographical distance between credit lenders and their borrowers (DeYoung *et al.*, 2008). Thus, a far distance normally makes maintaining a stable business relationship between lenders and borrowers more challenging, it also brings higher transaction and administration costs (Petersen and Rajan, 2002; Carling and Lundberg, 2005; Degryse and Ongena, 2005).

Moreover, Behr *et al.* (2011) stated that geographical distance influences more than just costs. They stated that this factor would influence the relationship between lenders and borrowers and the empirical result described how lenders' willingness to lend credit significantly depended on the depth of the relationship. Accordingly, Lenders are more willing to lend credit to borrowers who have a closer business relationship. Obviously, a closer distance should promote the formation of a closer business relationship (Cotugno *et al.*, 2013).

Apart from distance, openness indeed influences the development of lender-borrower relationships (Carling and Lundberg, 2005). A firm's openness is defined as:

> *"A level or a degree to which that firm open to the market for control."*
>
> Ferreira and Laux (2007)

Berger and Udell (2002) stated that information protection in some companies caused difficulty in credit monitoring. Thus, credit lenders will raise interest rates or reduce loan sizes in order to mitigate lending risks (Kallberg and Udell, 2003). What is even worse is that without sufficient capital financing, investment in information exchange is restricted (Drechsler and Natter, 2012). In this case, companies will struggle with their market

campaigns, intellectual property protection and competition, which would make them more closed (Doblas-Madrid and Minetti, 2013). On the contrary, the expedite information communication can promote the development of a good relationship between lenders and borrowers and male it more possible for borrowers to access credit (Jappelli and Pagano, 2002; Kallberg and Udell, 2003; Behr and Sonnekalb, 2012).

Openness is sometimes limited as some companies attempt to hide their borrowing history. Some studies have indicated that companies are sensitive about their borrowing history (Jayaratne and Wolken, 1999; Kallberg and Udell, 2003). When a financial institution assesses a borrower, a good history is likely to increase the level of trust. On the contrary, a company with poor history has to face a series of strict assessments from lenders and may even have to sign up to some stringent arrangements to minimize lenders' risks (Bharath *et al.*, 2007). Bellucci et al. (2010) stated that borrowing history was very important in determining whether lenders will issue credit. For credit lenders, monitoring borrowers' credit usage and setting up strict assessment procedures regarding borrowers' credit history are both effective ways to minimize credit risks (Bharath *et al.*, 2011).

In terms of credit borrowing and selection, working capital constrained companies also consider their own business conditions (Banerjee and Duflo, 2014; Eurosystem, 2014; Ilat and Pontoh, 2014). In the category of concerns about own business conditions, the main factors include firm size, business stage, decision-making procedures and gender (As shown in Figure 2.12).

Firstly, firm size have been debated with regard to difference between SMEs and large enterprises in applying for short-term credit. Moro and Fink (2013) stated that SMEs were likely to select a credit lender with low costs. Secondly, the business stage is believed to influence companies' credit borrowing (Bates, 1997a; Atiya, 2001; Denis and Mihov, 2003). Compared with mature companies, start-up companies are experiencing difficulty in accessing BL (Bates, 1997a). In addition, credit borrowing capacities are different in each business stage. A start-up company, which is restricted by a short or even blank business operating history, normally achieves smaller credit amounts than a mature company does from their credit lenders (Martinelli, 1997). Moreover, credit lenders require these start-up companies to only undertake safe projects, in order to avoid some profit-driven companies investing in other high risk projects (Robert and Mark, 1998). Firth et al.

(2009) determined how business stage even influenced trust building between lenders and borrowers in their initial relationship development. As described by Cowling *et al.* (2012), under circumstances in which firms are of a similar size, financial institutions tend to offer larger credit amounts to mature, more established companies, whilst companies in the start-up stage or bankruptcy are frequently rejected.

Thirdly, Vaaler and McNamara (2004) stated that credit borrowers tried to build a structured decision-making process with clear objectives, a series of criteria and reasonable expectations. However, making credit-borrowing decisions depends on the structure and ownership of a company, in particular the decision maker in a firm has more power when it comes to making decisions about credit selection (Storey, 2004; Marlow and Patton, 2005; Coleman and Robb, 2009; Bellucci *et al.*, 2010; Agier and Szafarz, 2013). This situation is more significant for SMEs and some family-owned businesses. Credit borrowing decisions in family-owned businesses closely relates to the business owners' preference for credit sources (McNamara and Bromiley, 1999).

Thus, the final concern about gender is also discussed. Storey (2004) stated that female entrepreneurs might be discriminated against in credit applications. It seems that a great number of female-owned firms have been rejected in their attempts to borrow short-term credit (Constantinidis *et al.*, 2006). Marlow and Patton (2005) stated that female entrepreneurs had less financial support compared to male entrepreneurs. Treichel and Scott (2006) investigated some female-owned companies and found that, compared to the BL applications by male-owned companies, female-owned companies had more difficulty in successfully accessing BL.

Collateral, which is also discussed widely, heavily depends on some certain factors discussed above. The choice on collateral is subject to a company's size, business stage and lender-borrower relationship (Elsas and Krahnen, 1998; Elsas, 2005; Ono and Uesugi, 2009). Compared with large sized enterprises, it may be too costly for SMEs to implement extra management when applying for and administering their short-term credit, especially in the start-up stage. Abdesamed and Wahab (2014) stated that due to the strict requirements on collateral and credit history, less than 10% of SMEs were willing to apply for BL. This situation was the opposite for large enterprises. Jiménez et al. (2009) explained how a long-term relationship with lenders might benefit borrowers with a low level of

collateral. Regarding company size, most large enterprises own sufficient assets and therefore find it easier to provide collateral than SMEs (Degryse et al., 2012).

In addition, Biesebroeck (2005) stated that large enterprises were believed to be more reliable and stable when repaying credit. Compared to SMEs in the start-up stage, these companies are keener to pay back credit in order to enhance their reputation and asset value Comeig et al. (2015). While as this concern closely depends on other factors, it is normally discussed in combination with the listed concerns.

2.3.2 Borrowers' Objectives in Credit Borrowing Activities

> *"A business objective is what a commercial organization aims to achieve at the end of business"*
>
> Greenbank (2001)

Lenders' objectives have been widely discussed in some studies of credit portfolio management (Seifert et al., 2013). Maximising profit (Berlin and Mester 1998; Reinke, 1998) and minimising credit default risk (Thomas, 2000; Atieno, 2001; Shi and Zhang, 2010; Dierkes *et al.*, 2013) are examples considered from the perspective of credit lenders. The latter objective has also been discussed from the borrowers' perspective in some current studies (Cornett *et al.*, 2011; Teng and Lou, 2012; Boissay and Gropp, 2013).

Understanding the objectives of working capital constrained companies will help them better allocate credit portfolios from current multiple credit sources. Current studies have briefly addressed a few borrowers' objectives in short-term credit borrowing. Achieving a sufficient amount of capital has been identified as a direct objective of most working capital constrained companies (Jensen, 2001; Becchetti and Trovato, 2002). Additionally, these companies also aim to achieve other objectives, include maximization of profit (Alexander Tedeschi, 2006) or minimization of borrowing costs (Christian, 2007).

However, the objectives of working capital constrained borrowers have not been discussed systematically (Dierkes *et al.*, 2013), especially in short-term credit portfolio management. Apart from the two objectives mentioned above, some others were also addressed in a few studies. Thus, the following attempts to review business objectives which have been mentioned in related literature. Similar with the procedure of summarizing borrowers'

concerns, it follows the same systematic literature review process as Figure 2. 11. The reviewing protocol plans to select journal articles from 1996 to 2016. To better identify the relative papers, some key words including "credit/loan borrowing", "business objectives/aims" and "credit borrowers" and were selected. By following these steps, Table 2.4 presents the summary of credit borrowers' business objectives.

No.	Business Objectives	Description	Author(s)
1	To minimise credit default	In order to get refinanced, credit borrowers aim to ensure they can receive payment from other peers and repay credit on time.	Armendáriz de Aghion (1999)
2	To extend the credit period	Credit borrowers want to borrow long term with the possibility of default.	Hall (2001)
3	To maximise profit	Credit borrowers wish to receive a low interest rate in order to reduce the cost. Decreasing the borrowing cost will increase borrowers' profits.	Brown and Zehnder (2007), Wittenberg-Moerman (2008), Fishman (2009), Puro *et al.* (2010)， Acharya and Naqvi (2012)
4	To maximise the credit- borrowing amount	Borrowers want as much capital as they can possibly achieve.	Jimenez *et al.* (2006)， Cull *et al.* (2009)， Puro *et al.* (2010)， Banerjee and Duflo (2014)
5	To minimising borrowing cost	Borrowers monitor different banks in order to reduce the credit borrowing cost.	Blackwell and Winters (1997)， Elsas and Krahnen (1998)， Gehrig (1998)， Ghatak and Guinnane (1999)， Kang *et al.* (2000)， Sapienza (2002)，

			Hansmann *et al.* (2006)， Han *et al.* (2009)， Goss and Roberts (2011)， Wu and Chua (2012)， Dehejiaa *et al.* (2012)
6	To minimising time taken to receive credit	Borrowers receiving the credit in default at the time may cause the default of credit repayment.	Özçelik and Taymaz (2008)， Jiménez *et al.* (2009)

Table 2.4. Credit borrowers' business objectives in borrowing credits

Table 2.4 presents six types of business objectives considered by credit borrowers. Minimising borrowing costs is a widely discussed topic. To reduce borrowing costs, working capital constrained companies normally hover between different credit sources (Blackwell and Winters, 1997), in order to find an optimal credit portfolio (Han *et al.*, 2009). Hence, some key factors, such as transactions, interest payments, and even monitoring fees play a key role in influencing borrowers to make their decisions when choosing a credit portfolio (Berg *et al.*, 2015).

Business objectives are closely linked with the concerns of credit borrowers. Similar to minimisation of borrowing costs, some other objectives including maximisation of the borrowing amount and optimisation of business cycle time, are also discussed with regard to the influence of some certain factors (Gill et al., 2010; Acharya and Naqvi, 2012; Banerjee and Duflo, 2014). In detail, Gill *et al.* (2010) stated that firm sizes significantly influenced the borrowing amount. Banerjee and Duflo (2014) found that the default rate, which stands for a borrower's loan repayment performance, could influence the borrowers' credit achievement. Wang *et al.* (2014a) considered the relationship between TC repayment and business cycle time and attempted to determine an optimal credit period to minimise the loss caused by product deterioration. Consequently, other concerns identified in Table 2.3 also influence different borrowers' objectives. For example borrowing capacity significantly influences the credit borrowing amount (Rice and Strahan, 2010) and lender-borrower's distance and credit delivery time also impact the time it takes for borrowers to receive their TC (Agarwal and Hauswald, 2010; Moro and Fink, 2013). As in the

description by Denis and Mihov (2003), multiple concerns and certain business objectives would influence the credit selection of working capital constrained companies and also credit borrowing amounts from various credit sources. However, current relative studies have not yet addressed this point. The study of credit portfolio management is rarely discussed from the perspective of the borrower considering their concerns and business objectives together.

2.4 Research Gaps

Theoretically, the isue of working capital constrained companies adopting credit portfolio management has been widely discussed in academia, but credit portfolio management has rarely been studied from the borrowers' point of view. There are even less studies in the context of SCM. To review the numbers of studies on borrowers' credit portfolio management. Table 2.5 lists the numbers of relative journal articles that have been reviewed between 1996 and 2016 and organizes them by classified subject.

Academic Subject	**Journal**	**Numbers of Papers**
Accounting	Journal of Accounting and Economics	1
	Journal of Business Finance and Accounting	2
Economics, Econometrics and Statistics (Economics)	American Economic Review	1
	Review of Economic Studies	1
	Review of Economic Studies	2
	Economic Journal	1
	Journal of International Economics	1
	Journal of the European Economic Association	1
	Journal of Economic Dynamics and Control	1
	Journal of Economic Behaviour and Organization	3
	Economic Development and Cultural Change	2
	Economic Policy	1
	Journal of Development Economics	6
	World Bank Economic Review	1

	International Review of Economics and Finance	2
	Applied Economics	2
	Managerial and Decision Economics	1
	Research in Economics	1
Finance	Journal of Financial Economics	8
	Review of Financial Studies	7
	Journal of Finance	8
	Journal of Corporate Finance	1
	Journal of Financial Intermediation	6
	Journal of Money, Credit and Banking	4
	European Financial Management	1
	Journal of Banking and Finance	21
	Journal of Financial Research	1
	Review of Corporate Finance Studies	1
Innovation	Research Policy	1
Information Management	Decision Support Systems	1
International Business and Area Studies (International Business)	International Business Review	1
Entrepreneurship and Small Business Management (Entrepreneurship)	Journal of Business Venturing	5
	Journal of Small Business Management	5
	International Small Business Journal	1
	Small Business Economics	8
	Family Business Review	2
	Journal of Small Business and Enterprise Development	3
	Venture Capital: An International Journal of Entrepreneurial Finance	2
	International Journal of Entrepreneurial Behaviour and Research	1

Organization Studies	Organization Science	1
General Management, Ethics and Social Responsibility (General Management)	Academy of Management Journal	1
	Business Horizons	1
Social Sciences	American Sociological Review	2
	World Development	4
Sector Studies	Transportation Research Part E: Logistics and Transportation Review	1

Table 2.5. Journals Classification and Summary by Subjects

Based on the numbers of journal articles summarized in Table 2.5, Figure 2.13 summarizes the overall number of papers in each subject as follows.

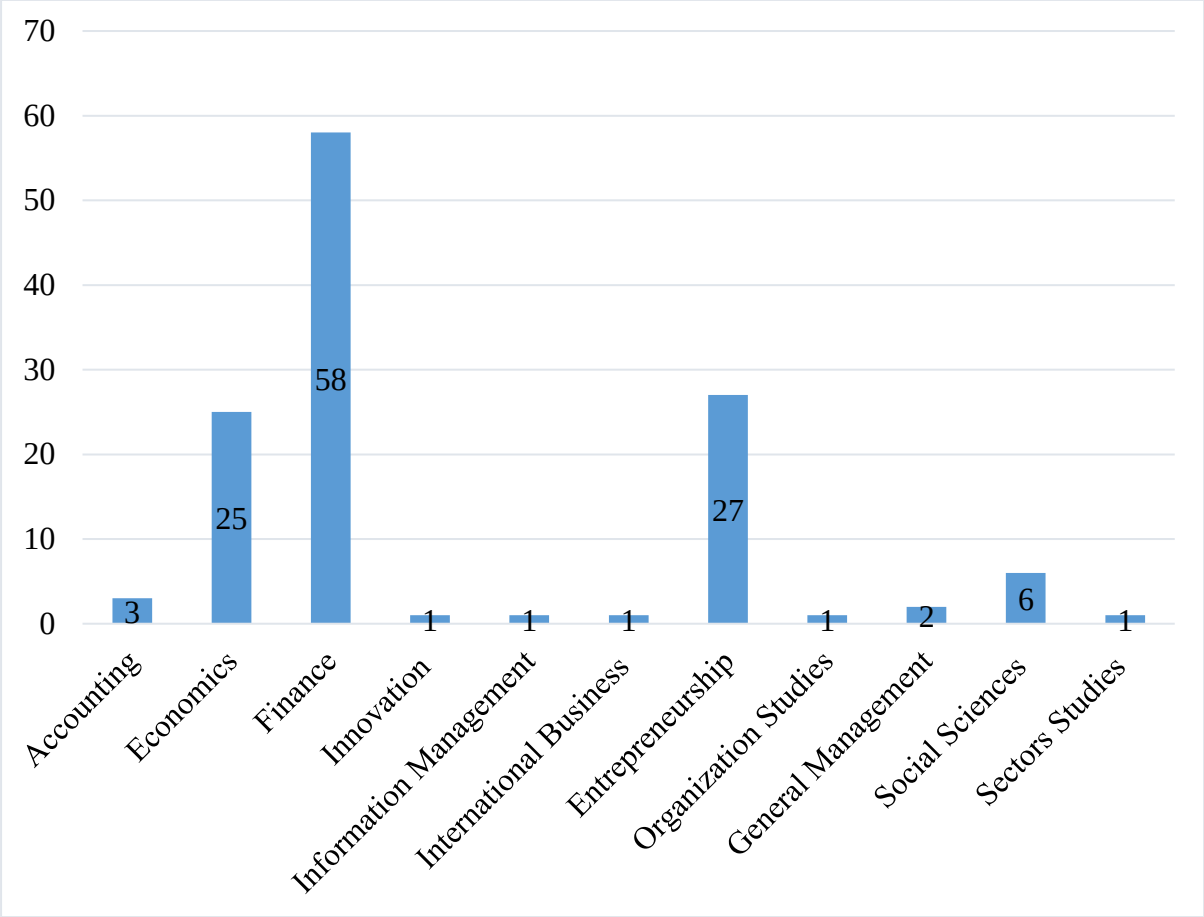

Figure 2.13. The Numbers of Journals in each Subject

Figure 2.13 clearly shows that the journal articles from the subjects of finance and economics are the main source of studying borrowers' concerns and business objectives, with amounts of 58 and 25 respectively. Additionally, the subject of entrepreneurship is the secondary source contributing 27 papers. Specifically, many papers in this subject focus on solving SMEs' capital constraint problem. However, aside from the subject of entrepreneurship, other subjects in business management are quite limited in discussing credit borrowers' business objectives and concerns.

Single short-term credit financing is a popular topic in the subject of SCM, covering TC improving the efficiency of SCM (Kouvelis and Zhao, 2012) and BO borrowing based on economic ordering quantity (Moussawi-Haidar *et al.*, 2014). However, studies on credit portfolio management are still limited. Some existing discussions on credit portfolio management mainly focus on TC and BO, such as minimisation of borrowing cost through a credit portfolio (Chen and Wan, 2011), financing of inventory management through BO and TC (Jing and Seidmann, 2014). BO and TC are the two main roles in current credit portfolio management.

While, 3PLC has not been widely studied in SCM, neither has credit portfolio management as a solution to the working capital constraint problem in SCs been considered. Some studies including Chen (2008), Chen and Xie (2009), Chen and Cai (2011) and Shi *et al.* (2016) have developed the comparison between 3PLC and BO or TC. Chen and Xie (2009) stated a clear definition of 3PLC and Chen and Cai (2011) improved 3PLC and compared it with both BO and TC. Compared with other papers addressing 3PLC, these two papers might be the first to provide a definition of 3PLC. Moreover, they hold more value as they provide a theoretical description of how 3PLC can be operated in SCs by applying mathematical modelling.

Indeed, modelling credit portfolio management considering 3PLC is limited in current studies, it is especially rare for it to be considered from the point of view of working capital constrained companies in SC. Few studies applies modelling when determining an optimal credit portfolio. Dietsch and Petey (2002) modelled credit portfolio management and aimed to develop an optimal credit portfolio with a minimum credit default risk. This is similar to the study of Anagnostopoulos and Mamanis (2010), their study aims to suggest an optimal credit portfolio to mitigate credit risk and improve lending security. However, these studies

are all discussed from the lenders' perspective rather than from the borrowers' side. Aouni *et al.* (2014) contributed a systematic review and suggested goal programming (GP) to help working capital constrained companies optimising multiple objectives in credit portfolio management. However, their study has not explained how to optimize a credit portfolio for multiple objectives.

Methodologically, the method adopted when studying credit portfolio management mainly focuses on developing a mathematical solution. The methodological review focuses on two aspects, including: the methods applied when integrating multiple borrowers' concerns and the types of mathematical modelling in SCFF studies. To highlight these two aspects, the key journal papers from 1996 to 2016 have reviewed and each aspect has been summarised.

As for the methods applied when integrating multiple borrowers' concerns, although current studies have not systemically analyzed these concerns, some similar studies have considered multiple criteria problems in SCM. Ghodsypour and O'Brien (1998) studied the problem of optimal supplier selection in a SC. Selecting an optimal supplier is a problem influenced by multiple criteria, including both qualitative and quantitative factors. In their study, the analytic hierarchy process (AHP) was adopted to determine the best supplier from a range of choices. Apart from it's use in this study, AHP has been used to solve other multiple criteria problems including quality evaluation (Lee and Kozar, 2006), group decision making (Pedrycz and Mingli, 2011), resource allocation (Caputo *et al.*, 2013), strategy design (Quezada and López-Ospina, 2014) amongst others. Appendix III provides a summary of these studies applying AHP to multiple criteria problems.

Briefly, AHP benefits scholars by enabling them to consider both qualitative and quantitative criteria. It is able to incorporate objectives, different categories of criteria and alternative options into a multi-level hierarchical framework (Galvez *et al.*, 2015). The pairwise comparison can help to determine the degree of importance of these criteria, and generate an evaluation of the alternatives (Saaty, 2013). In general, AHP provides an approach which enables researchers to solve complex problems that are influenced by qualitative and quantitative factors.

Looking at the types of mathematical modelling in SCFF studies, regardless of the research topics, the studies related to SCFF from 1996 to 2016 mainly adopted an optimization

technique, such as LP, GP and NLP. For example in studies concerning SC production and transport planning. Mula *et al.* (2010) focused on these two topics and reviewed the relevant academic journals from the last 20 years. They concluded that the majority adopted LP or MILP as the research methods. As shown in Appendix IV, LP and MILP are indeed selected as research methods in many SCM studies. Table 2.6 presents modelling methods applied in relative key journal papers from 1996 to 2016.

No.	Author	Research Subject	Perspective of Analysis	Modelling Method	Contributions to Research /Recommendations
1	Ghodsypour and O'Brien (1998)	Decision support system to maximise purchasing value in the supplier selecting process	From the perspective of a company	AHP and Linear programming (LP)	The study contributed an approach of integrating AHP and LP. This integration aims to help a company considering both tangible and intangible factors in supplier slection through applying AHP. Meanwhile, it can determine the best supplier by maximizing this company's purchasing value while considering various constraints.
2	Vidal and Goetschalckx (2001)	Transfer pricing and Transportation cost allocation in global SC	From the perspective of a company	LP	The current model considers the selection of different transportation modes. Each transportation mode has a specific transportation price and price tax. Further model development can consider the influence of profit repatriation and import quotas on profits.
3	Goetschalckx *et al.* (2002)	The determination of production-distribution allocations with different transport prices	From the perspective of an entire supply chain	Mixed integer programming (MIP)	Two models are developed. The first one sets the objective as maximizing profit for a company. This model aims to determine the cheapest transport prices to achieve the objective. The second model focuses on determining production and distribution allocation to fulfil customers' demands. This model set the objective as minimizing costs

					for an entire supply chain. These two models are subject to different constraints.
4	Das and Abdel-Malek (2003)	The influence of ordering quantities and lead-times on procurement costs	From the perspective of a retailer	MIP	The model is simulated on a supply chain with uncertain demands. This model is under the constraints of a suppliers' lead-times and the ordering amount of a retailer. The objective of the model is to evaluate the flexibility between different suppliers and the retailer. The flexibility is measured through procurement costs from all potential suppliers. The result proves a highly flexibile supplier-retailer relationship, has low deterioration in the procurement costs and penalties under different suppliers.
5	John and Rachel (2004)	Bank credit finance inventory management	From the perspective of a bank and a set of retailers	LP	The model simulates a bank offering bank credits to retailers with different interest rates. Compared with a traditional inventory model with a single interest rate bank financing, multiple interest rate bank financing can benefit the bank and the retailer with a joint consideration. In this joint consideration, the credit lending is issued taking into consideration the amount of inventory. With a clear realization about the inventory, the bank will be at the lowest

					risk for lending credit and retailers will receive a low interest rate due to good inventory management.
6	Burnetas and Ritchken (2005)	Retail price options in downward-sloping demands	From the perspective of a retailer	MIP	When the demand curve is downward sloping, lowering the retail price can promote the slae of extra products. When the demand is highly uncertain, it accelerates the increase of the wholesale price, but decreases the retail price. This hurts the retailer's profit.
7	Guillén *et al.* (2005)	Multiple objective optimization within an uncertain SC	From the perspective of an entire supply chain	Multi-objective stochastic model	The model considers various potential uncertainties. These uncertainties include both material flow and financial flow, such as suppliers' delay and insufficient purchasing capital. The model aims to minimize these uncertainties through measuring the net present value (NPV) of the investment. Through this model, the risk of NPV can be reduced by reducing the probability of receiving low income from the investment.
8	Comelli *et al.* (2008)	A combined financial and physical flow evaluation	From the perspective of a company	Activity Based Costing (ABC) modelling	The research suggested that ABC modelling could be integrated into financial flow management in future. The integration will benefit the efficiency of SC working. Moreover, exchange rates should be considered in further study. This extends the integration into a global SC. The

					extension increases the collaboration with other SC partners. It will improve the possibility of value creation.
9	Lai *et al.* (2009)	The impact of financial constraint on supply chain efficiency	From the perspective of an entire supply chain	Stackelberg model	Without financial constraint, the supplier prefers to select the consignment mode. In this mode, the supplier holds all stocks and transfers the products to the retailer when there is demand in the market. The supplier takes full inventory risk. In financial constraint, the suppler selects the combination mode. In this mode, the supplier sells part of the stock to the retailer. The retailer needs to pre-order products according to the forecast on market demand. The inventory risk is shared by the supplier and the retailer. The combination mode is the most efficient way to solve the financial constraint problem in the supply chain.
10	Franca *et al.* (2010)	Financial risk caused by poor suppliers' quality in supply chain outsourcing	From the perspective of a company	Multi-objective stochastic model	The financial risk decreases as the Sigma level increases. In other words, seeking a lower defect supplier can increase thr outsourcing quality and decrease the financial risk. However, even for the same multiple objectives, the selection of supplier may vary if the variables were changed.

11	S. Raghavan and Mishra (2011)	Short term financing in a capital constrained supply chain	From the perspective of a lender	Non-linear programming (NLP)	The model shows that a lender is motivated to finance both a manufacturer and a retailer. In this situation, the lender has two options for lending credit. One is making an independent decision on the credit lent to the supplier and the retailer. Another one is developing a joint decision which requires the lender to consider the capital demand of the whole supply chain. Through a numerical example, in order to maximise the lender's profit, a joint decision is a better option for to finance the manufacturer and the retailer.
12	Gupta and Dutta (2011)	Financial flow in the supply chain	From the perspective of an entire supply chain	NLP	The model is developed based on inventory management. It aims to solve the problem of dynamic credit borrowing and payback in a capital constrained SC. The model considers two scenarios. The first one designs a situation in which the arrival of invoices is dynamic, but the receipt of capital is known. In the second situation both the arrival and receipt are unknown.
13	Kouvelis and Zhao (2012)	BL and trade credit for financing a newsvendor	From the perspective of an entire supply chain	Stackelberg model	The model assumes a supply chain which includes a supplier and a retailer. In this model, the retailer has to order a single type of product from the supplier to fulfil uncertain demand.

					The retailer is working capital constrained and can access capital from bank credit or trade credit. The supplier provides trade credit with an early payment discount scheme. From the perspective of the supplier, the retailer that makes an early payment has interest-free or low interest rate. While the retailer which delays payment is charged at the full rate. From the perspective of the retailer, with an optimal trade credit contract, the retailer prefers to use trade credit rather than bank credit. Furthermore, in an optimal trade credit contract, both the supplier's profit and the SC efficiency can be improved. However, the retailer's profit may be improved under bank financing.
14	Pattnaik (2013)	A single item economic ordering quantity with space limitation	From the perspective of a company	NLP	The model considers a limited inventory space for a single type of product. To achieve the minimum cost, the company manager should reduce the cost when maintaining the production system. In addition, as the inventory space is limited, reducing ordering times and ordering quantity each time also helps to decrease the overall costs.

15	Tamiz *et al.* (2013)	Credit portfolio selection from international funds	From the perspective of a company	Goal programming (GP)	The paper designed a model to select a portfolio of international funds. The selection is influenced by three factors. These three factors are defined as Macroeconomics, regional and country preferences. There is a benefit from the result of the model, which is that investors can optimize their credit portfolio selections with regard of considering various factors.
16	Yang and Birge (2013)	Trade credit for financing SC with uncertain demands	From the perspective of an entire supply chain	Newsvendor model	In a financially stressful supply chain, when a supplier offers trade credit to a retailer, this supplier can balance its influence on the financial flow of the supply chain. The supplier will realize the financial stress and provide a financial source for the retailer. For the retailer, trade credit is an option for which they can access capital. The retailer can use a portfolio of these credits including cash, trade credit, and bank loans to solve their financial problems.
17	Wu *et al.* (2014)	Determining credit period in trade credit	From the perspective of a retailer	Economic Ordering Quantity (EOQ) model	The model simulates a scenario only including a supplier and a retailer. The supplier provides TC to the retailer and the retailer provides TC to the customers. In this model, the trade credit offered by the retailers can increase sales and revenue. Meanwhile, it also increases opportunity cost and default risk.

18	Wang *et al.* (2014a)	The denervation of credit period and cycle time to maximise the lifetime of deteriorating items	From the perspective of a supplier	EOQ model	The model is developed to help a supplier determine the credit period. In this model, the credit invested is defined as zero if the retailer can payback within the specified credit period. The model finds that deteriorating products in the SC continue to deteriorate. This kind of product has a maximum lifetime. Increasing the credit period can bring more demands, but also increases default risks.
19	Gelsomino *et al.* (2016)	Dynamic discounting in supply chain finance	From the perspectives of a supplier and a retailer	Analytical model	The model presents a dynamic discounting contract between a supplier and a retailer. In this contract, the supplier offersa discount to the retailer when an early payment occurs. In this discounting contract, the benefit for the retailer is that the financial cost can be reduced using the discount. In addition, early payment can enhance the cash flow management of the supplier.

Table 2.6. The summary of mathematical modelling in SCFF studies

So far, the studies on credit portfolio management in SCM have some limitations from both theoretical and methodological perspectives. In terms of the theoretical gaps, some limitations are summarised as follows.

1. **Few studies address the integration of credit borrowing in conjunction with typical SCM activities such as procurement, inventory control, transportation, etc.**

   Short-term credit borrowing is quite a new subject in the study of SCM. There are many studies exploring debt-credit relationships in banking and financing, but relatively few in SCM, especially in supply chain financial study. Moussawi-Haidar *et al.* (2014) stated that financial SCM is still a fresh area in supply chain research. Specifically, there are very few studies focusing on credit portfolio selection in SCs. With the integration of material flow, information flow and financial flow in SCM, the importance of discussing financial activities has been raised in order to keep pace with academic trends in SCM (Gelsomino *et al.*, 2016).

2. **Few studies consider 3PLC in credit portfolio selection.**

   The role of the 3PL industry in servicing material flow, financial flow and informational flow has attracted some scholars' attention. However, the studies discussing the feasibility of 3PLC and the practice of 3PLC are limited; therefore, more research needs to be undertaken.

3. **Insufficient studies discuss credit lending and borrowing from the perspective of borrowers.**

   There are numerous studies discussing the lending of commercial credit from a financial organization's perspective. These studies cover minimizing the credit default risk (Dierkes *et al.*, 2013), improving information asymmetry in credit lending (Lin *et al.*, 2012), maximizing lending profits (Reinke, 1998) and other subjects directly related to the credit lenders' interests. However, there are insufficient studies focusing on credit lending and borrowing from the perspective of a capital -constrained company. One representative SCFF study presented by Chen and Cai (2011) firstly discusses 3PLC in credit lending and borrowing in SCM and examines how to minimize borrowing costs from the perspective of a capital -constrained retailer. However, most studies still approach the subject from a credit lender's perspective.

In terms of methodological gaps, the limitations include the following aspects.

1. **The integration of empirical analysis and mathematical modelling is rarely used in SCFF study.**

   Empirical studies are widely used as a research method in SCFF studies, especially in developing an understanding of how capital -constrained companies select a credit lender and what categories of commercial credit are applied. However, there are comparatively few studies integrating empirical analysis with mathematical modelling. One of the objectives of this thesis is to understand how borrowers' considerations influence their credit selections. To address this question, mathematical modelling could be applied to analyze the results obtained from the empirical study (AHP).

2. **Multiple-objective modelling is less common for credit portfolio management.**

   In the previous studies about credit lending activity, mathematical modelling has been adopted, in order to help scholars to solve a specific problem, such as risk minimization, cost reduction or other single objectives from a lender's perspective. However, the use of mathematical modelling is rather limited in the study of credit-borrowing activity. Due to most existing studies focusing on single objectives, multiple objectives are not commonly considered when studying credit-borrowing activity through mathematical modelling.

In summary, theoretically, credit portfolio management should be highlighted as an effective approach for solving the working capital constraint problem in SCs. Moreover, 3PLC should be considered as a new credit source as the existing studies only address TC and BO. Meanwhile, various business objectives should be considered as this is more realistic than a single business objective (Min and Zhou, 2002). Methodologically, an empirical approach is better for investigating the business objectives and concerns of working capital constrained companies in SCs, but it is weak when it comes to determining an optimal credit portfolio to satisfy certain business objectives and concerns. To achieve this, it is still necessary to to apply mathematical modelling (Chan and Chan, 2004). In addition, the model needs to reflect the dynamic nature of lending, repayment, inventory and demand fulfilment (Franca *et al.*, 2010).

2.5 Summary

The literature review has uncovered some new theoretical trends. The importance of studying SCFF, especially in relation to working capital borrowing, has been highlighted due to the

integration of multiple flows management in SCs. However, short-term credit borrowing, as a new area in the study of SCM, should be paid attention in academia. Apart from some studies considered from a loan lender's perspective (Reinke, 1998; Frame *et al.*, 2001; Berger and Udell, 2002; Cole *et al.*, 2004; Bennardo, 2010; Casey and O'Toole, 2014), there are still far fewer studies discussing short-term credit borrowing from the perspective of a working capital constrained company.

Another trend has been addressed: working capital constrained SMEs are facing multiple options of short-term credit. A single credit source is no longer a reasonable assumption. By introducing 3PLC, there are at least three types of short-term credit that can be selected by SMEs. Thus, credit borrowing is no longer a single selection from banks or suppliers. It also covers 3PLC provided by 3PL companies.

By shifting from a single-credit source to a multi-credit source, the credit borrowing issue becomes a problem of portfolio management. In past studies, most studies have adopted an empirical analysis to investigate the different categories of borrowers' concerns. Based on these results, working capital constrained companies have been identified as having various concerns when selecting and borrowing short-term credit. However, this has not been widely discussed in the field of credit portfolio management. This fact has motived this research to contribute a conclusion about what types of concerns influence borrowers' credit portfolio management.

Methodologically, the thesis aims to fulfil two objectives in studying SMEs' credit portfolio management, which include the integration of empirical study and mathematical modelling in credit portfolio management and the consideration of multiple objectives and dynamic periods. The following chapter will outline the research methods used to address the above-mentioned problems. This chapter will introduce the research setting and explain the rationale for choosing the specific methods used in the thesis.

PART 2 RESEARCH METHODOLOGY

Chapter 3 Selection of Research Methods

3.1 Introduction

An appropriate research methodology is important as it significantly influences the quality of the research and it is required to answer research questions properly (P.H.Jarvinen, 2000). One of the research objectives in this thesis aims to rate the influence of all borrowers' concerns which is concluded in Section 2.4.1. Thus, a method is required to not only integrate these concerns into a framework, but also to systemically evaluate their levels of influence on credit selections.

To satisfying the above request, this chapter is organised as follows. Section 3.2 reviews some SCM problems considering multiple criteria and mainly focuses on methods for solving these problems. This review highlights the role of AHP in the analysis of multiple criteria problems. Section 3.3 presents a brief introduction of AHP. This introduction covers the procedure of applying AHP combined with the borrowers' concerns. In detail, it firstly identifies and structures the borrowers' concerns based on the review in Section 2.4.1 and then introduces the pairwise comparison and consistency ratio test which are the two main evaluation procedures in AHP. Section 3.4 presents the survey design which has two aims, to investigate the influence of borrowers' concerns and evaluate their preferences for BO, TC and 3PLC with regard to important concerns. Section 3.5 reviews the methods being applied to optimise business objectives, and Section 3.6 provides a summary of this chatper.

3.2 The Method of Integrating Borrowers' Concerns

Working capital constrained companies hold a variety of concerns concerning their credit selection. This makes any credit borrowing activity a multiple criteria problem (Berger and Udell, 2002). The credit borrowing process is significantly influenced by all these factors. However, current studies are still silent in analysing these multiple concerns in credit borrowing activities.

While studying this multiple criteria problem is not new in academia. Some past studies have already discussed other multiple criteria problems. Such as the subject of supplier selection.

Ghodsypour and O'Brien (1998) considered how the problem of supplier selection is influenced by multiple criteria; including both qualitative and quantitative factors. Their study applies AHP and integrates all the factors together helping the decision maker to determine the best supplier. Other studies also focus on this subject by considering different criteria (Eon-Kyung *et al.*, 2001; Liu and Hai, 2005; Gencer and Gürpinar, 2007). Apart from supplier selection, some SCM subjects are also discussed as multiple criteria problems in academia. Similarly, AHP has been adopted widely in solving these multiple criteria problems. Table 3.1 presents a brief summary of studies which apply AHP to solve certain multiple criteria problems.

Author (s)	**Subject**	**Objective (s)**	**Criteria**
Mohamed *et al.* (1996)	Supplier selection	Total cost minimization	1) Cost 2) Quality 3) Delivery
Ghodsypour and O'Brien (1998)	Supplier selection	Maximisation of total purchase value	1) Cost 2) Quality (Defects, Process capability) 3) Service (On-time delivery, Base of Communication, Response to changes, Process flexibility)
Badri (1999)	Global facility location allocation	AHP: Select the best location	1) Political situation of foreign country 2) Global competition and survival 3) Government regulations 4) Economic related factors
Yahya and Kingsman (1999)	Vender rating	Giving the highest rating for different vendors	1) Quality 2) Responsiveness 3) Discipline 4) Delivery 5) Technological capability management 6) Financial position 7) Past performance attitude 8) Communication system 9) Desire for business

Eon-Kyung *et al.* (2001)	Supplier selection	Determining the best supplier	1) Quality 2) Cost 3) Delivery 4) Service
Hafeez *et al.* (2002)	Determining the key capabilities of a firm	The evaluation of financial performance contribution and non-financial performance contribution	Financial aspects: 1) Sales growth 2) Operating profit 3) Return on capital employed Non-financial aspects: 1) Market share 2) New product introduction 3) Customer satisfaction
Yang and Kuo (2003)	Facilities layout design problem	Evaluate and select a good layout design generator.	1) Flexibility 2) Accessibility 3) Maintenance
Albayrak and Erensal (2004)	Human performance improvement	How human performance can be improved effectively	1) Conditional Factor (Physical workplace, Organization of work) 2) Managerial factors (Leadership, Participation involvement, Company culture) 3) Individual factors (Human performance capability, Attitude in human performance)
Bayazit (2005)	Flexible manufacturing systems (FMS) selection	FMS evaluation	1) Advantages 2) Risks 3) Disadvantages 4) Opportunities
Liu and Hai (2005)	Supplier selection	Best supplier selection (Total ranking comparison)	1) Quality 2) Responsiveness 3) Discipline 4) Delivery 5) Financial 6) Management 7) Technological capability

			8) Facilities
Lee and Kozar (2006)	The effect of website quality on e-business success	Choice of the most preferred website	1) Information quality 2) Service quality 3) Systems quality 4) Vendor- specific quality
Gencer and Gürpinar (2007)	Supplier selection	Determine the best supplier	1) General information of the supplier 2) Organization profile of the supplier 3) Financial status of the supplier 4) Equipment status of the supplier 5) Manufacturing capability of the supplier 6) Material delivering capability of the supplier 7) Quality system certificate of the supplier 8) Quality system documentation of the supplier 9) Quality system application of the supplier
Tugrul *et al.* (2012)	3PL providers selection	Deciding on which 3PL to consider	1) Cost of service 2) Service level performance and quality 3) Comprehensive global capabilities 4) Information technology capabilities and integration 5) Expertise and experience specific to the respondent's industry 6) Strong local presence and capability

Ordoobadi (2013)	Advanced manufacturing evaluation	Measure performance of all advanced technologies with respect to risks and benefits	1) Flexibility 2) Quality 3) Increased productivity 4) Use of technology 5) Promotion of strategic objectives 6) Competitive strengths 7) Customer satisfaction 8) Market opportunities 9) Case of operation 10) Employee relations
Sonal K. Thengane *et al.* (2014)	Hydrogen production technologies comparison	Cost minimization	1) Greenhouse gas emissions 2) Raw material & utility consumption 3) Scalability 4) Energy efficiency 5) Waste& non-GHG emissions
Zietsman and Vanderschuren (2014)	Multiple airport system assessment	Matching different passengers' levels	1) Socio-economic development: 2) Spatial and urban planning 3) Transportation improvement, efficiency and provision 4) Environmental preservation 5) Financial viability
Govindan *et al.* (2014)	The implementation of green supply chain management	Barrier analysis of green SCM implementation	1) Involvement and support 2) Financial 3) Technology 4) Knowledge 5) Outsourcing
Quezada and López-Ospina (2014)	Strategy map design	AHP: Identify a strategy map LP: 1) To reduce the number of relationships selected. 2) To increase the accumulated	1) Finances 2) Clients 3) Internal processes 4) Growth and learning

		importance of those relationships selected	
Shad *et al.* (2014)	Supplier development under uncertainty	Develop a realization about customers' requirements on suppliers' characteristics	1) Cost 2) Conformity 3) Punctuality 4) Efficacy 5) Lead time
Galvez *et al.* (2015)	Reserve logistics network design	AHP: Evaluate the preferences of stakeholders involved in the network LP: minimize all the costs associated with waste treatment	1) Cost 2) Crossed distance 3) Durability 4) Feasibility

Table 3.1. The summary of studies employing AHP in the methodology

Table 3.1 lists the samples of multiple criteria studies in SCM. It can be seen that AHP has often been used to solve these multiple criteria problems. Additionally, it is remarkable that some studies combined AHP and Linear programming (LP) together to solve multiple criteria problems (Peidro *et al.*, 2010; Kannan *et al.*, 2013; Quezada and López-Ospina, 2014). Quezada and López-Ospina (2014) state that important criteria in AHP represent the high influence on selections. These criteria should be considered when decision makers attempt to achieve business objectives. LP can assist them in transferring important criteria as a set of objective constraints, which is able to limit business objectives being optimized from a certain range of feasible alternatives (Sierksma, 2001). In other words, LP actually generates an optimal solution which satisfies the business objective and the requirements of the criteria.

3.3 The Procedure of Applying AHP

According to Saaty (1990), AHP is defined as

> *"A multiple criteria decision-making procedure which arranges various factors in a hierarchical structure."*

This definition determines that AHP integrates a group of factors, both qualitative and quantitative, in order to develop an overall view of the importance of these factors in decision making (Saaty, 1990). Tugrul *et al.* (2012) state that a complex problem is influenced by multiple factors. These factors have their own levels of influence which are being considered by decision makers. AHP is able to structure these factors hierarchically and then evaluate their influence on the decision makers' preference for alternatives, thus offering an optimal selection from all alternatives. In this research, applying AHP contributes to the systematical framework. This framework structures all determined borrowers' concerns, then provides an evaluation to rank their importance in terms of influencing borrowers' credit preferences.

To apply AHP, a certain procedures should be followed in order to develop this systemical framework. Bayazit (2005) presents a brief procedure including three basic steps:

1. Structuring the hierarchy.
2. Performing paired comparisons between elements and decision alternatives.
3. Synthesizing results.

In this research, this basic procedure has been extended using more steps as follows, which are:

1. Selecting the proper borrowers' concerns in choosing credit as criteria.
2. Summarizing these criteria into main criteria.
3. Designing a AHP hierarchy structure.
4. Questioning the credit borrowers.
5. Comparing the weight of the criteria .
6. Deciding on which credit to consider.

As the research still lacks a clear determination of criteria, the first step attempts to list all the possible criteria based on the review in Section 2.3.1. The second step aims to classify these concerns by different types and arrange them into a hierarchical structure, which is the third step. An investigation is established in the forth step, which aims to evaluate the importance of these concerns in influencing credit borrowers' selections. The fifth step pairs these concerns (criteria in the framework) and compares them with each other, in order determine the dominant

criteria. These criteria stand out as being more important and need to be considered in the decision-making process. In other words, these criteria, which represent certain concerns, significantly influence the decision makers' preference over alternative options. Lastly, by using the weight of these criteria, all alternatives can be evaluated to select the overall priority and find the optimal alternative option.

3.3.1 Identification of Borrowers' Concerns

The purpose of this section aims to identify the borrowers' concerns in order to structure the AHP hierarchy framework. Section 2.4.1 has identfied a series of concerns by reviewing some current studies. However, these concerns are disorganised and need to be classified in order to be able to be set into the framework. Saaty (1990) states a baseline for identifing and organising criteria into the AHP hierarchy structure, which includes the following two aspects.

1. It should consider as many influencing factors as possible.
2. The criteria should link with the goals and aim to directly identify a solution.

Therefore, based on these two aspects, this section re-organises the content in Section 2.4.1, and lists the following criteria for the AHP hierarchy framework.

1. Interest Rate: interest is levied by credit lenders, and paid by borrowers. It is treated as the main cost incurred by borrowers. Dietrich (2010) considers the influence of interest rate on credit borrowers' behaviour. The borrower becomes less willing when they face a high interest rate. A high interest rate is hardly accepted by borrowers. Moreover, borrowers are sensitive to the interest rates of their selected loan and always prefer to transfer their choice to a cheaper one (Dehejiaa *et al.*, 2012; Ching-Chung Lin *et al.*, 2015). Adams and Nehman (1979) mention that the interest rate clearly affects a borrowers' credit selection and low interest payments often attract the interest of more credit borrowers. Borrowers constantly seek lower interest rates, and actually aim to reduce their costs (Banerjee and Duflo, 2014). A higher interest rate can increase borrowing costs which will discourage borrowers in applying for credit (Michael Firth *et al.*, 2013).

2. Administration Fees: Arena and Dewally (2012) state that the administration fees spent on managing a loan should not be ignored. Borrowers need to invest in labour and facilities to manage their loan carefully, in order to avoid fault expenditure (Tennent, 2012).

3. Transaction Cost: Transaction cost is a part of the borrowing costs (Adams and Nehman, 1979). It normally includes two different types. The first type of cost refers to unavoidable costs which are paid as one fee using a credit transacting service. The second type of cost sometimes occurs in international trade. Due to the involvement of different currencies in international trade, credit borrowers need to repay their loans using the currency type designated by lender. In this process, some costs may occur when exchanging from one currency to another (Cristina Martínez-Sola *et al.*, 2012). Generally, exchange rates change over time and additional costs may incur when the exchange rate increases (İlhan Eroğlu and Eroğlu, 2012).

4. Openness of information: Openness of information in the debt-credit relationship refers to whether and to what extents borrowers are willing to share business information with their lenders, such as through a credit history check. Dass and Massa (2011) analyse trust management in BO and find that borrowers' credit selection is influenced by whether or not the lender requires their information to be shared. Lenders wish to ensure the safety of their capital by knowing more information about the borrowers, while lenders requesting more information may potentially infringe on the information privacy of borrowers (Moro and Fink, 2013). Borrowers may abandon their credit application from lenders who have requested more monitoring and controlling of information.

5. Borrowing Decision Making Procedure: The credit borrowing decision making procedure refers to the procedure of comparing and evaluating different credit sources with the aim of selecting suitable credit to fulfil the captial demands (Siddiqi, 2006). The procedure may vary in different companies due to different companies having different borrowing objectives (Lin *et al.*, 2011). The efficiency of credit evaluation and decision making may actaully be controlled and impacted by an organizational struture. Fan *et al.* (2013) find that a pyramid structure in one organization has more remarkable feature in in this aspect. As high level practitioners make credit borrowing decisions, this differs from some decentralized companies in terms of the time spent comparing credit and waiting for borrowing confirmation.

6. Credit Analyst: A credit analyst is a professional who is in charge of comparing and evaluating different credit sources (Bar-Isaac and Shapiro, 2011). An analyst can give an evaluation on the benefits and disdvantages of each credit. In the process of selecting credit, analysts are able to search for credit with a low interest rate and a suitable credit period which matches the borrowers' requirements (Huston, 2012). Credit analysts may be limited in how

much say they have over the final decision on credit selection, while their suggestions and evaluation about credit analysis can affect decision-making.

7. Historical business information: Historical business information may include sales records, cooperation between organisations, even past social performance (Oikonomou *et al.*, 2014). Credit borrowers want to present their business history in a good light to show their past performance to lenders. They believe that a good business history represents a good reputation and it can persuade lenders to build trust with borrowers (Paul Robsona *et al.*, 2013). In addition, borrowers often prefer to use their good business history to negotiate benefits such as a lower interest rate (Johan and Wu, 2014).

8. Distance: Communication is the core for establishing a debt-credit relationship as it is essential for lenders and borrowers to exchange their lending conditions and borrowing requirements. Arena and Dewally (2012) described that communication is a bridge linking both sides, aloowing them to exchange their consideration and aims. However, distance is a barrier to communication. Thus, DeYoung *et al.* (2008) and Dass and Massa (2011) investigated how distance influences borrowers' credit selection and found that borrowers would like to choose close lenders. DeYoung *et al.* (2008) claimed that a far distance often delays credit assessment and approval. Arena and Dewally (2012) also pointed out that a far distance does not only potentially increase costs on both sides, but also decreases the efficiency of communication; despite technology having already speeded up the efficiency of information exchange. Nishant Dass and Massa (2011) addressed how a short distance between lenders and borrowers could enhance communication, contributing to the formation of a lending relationship.

9. Borrowing History: Borrowing history refers to a borrower's experience in managing and repaying their loans. Although this term has an indirect impact on determining a borrower's credit selection, it will still help borrowers to reduce waiting time when lenders assess their applications (Lin *et al.*, 2012). On one hand, a good borrowing history presents a borrower's willingness to build up loyalty with the lenders, which would strengthen lenders' trust for borrowers taking credit obligation (Vuyisani Moss et al., 2013). On the other hand, it benefits borrowers when negotiating a lower interest rate.

10. Approval Time: Approval time is the time needed for the loan to be approved. Behr *et al.* (2011) found that there is a significant difference between the time taken to approve the first loan and the time taken to approve the second loan. In other words, if the borrower continuously

applies to the same lender, the approval time will be much shorter than if applying from a new lender. Many borrowers, such as new start-up SMEs are in a difficult situation as they face a long approval time for their first application, which may delay the time taken to achieve credit and cause loss (Levenson and Willard, 2000a). Consequently, they prefer to select one credit lender with the shortest approval time from multiple sources, or apply credit from the lenders they used to apply (Srisai Chilukuri and Rao, 2014).

11. Credit Period: The credit period is the time within which borrowers need to pay back their loans (Wu *et al.*, 2014). Peltoniemi and Vieru (2013) analysed the credit period as being a variable in credit borrowing activities. It significantly influences a borrower's interest payments. Borrowers normally consider both credit periods and interest rates together when selecting credit (Marc Cowling and Siepel, 2013).

12. Maximum Borrowing Volume: Bo Becker and Ivashina (2014) mentioned that borrowers are concerned about the maximum amount of credit they can obtain from lenders. Therefore, the maximum lending volume is the metric which should be considered by working capital constrained companies.

13. Credit issuing time: Borrowers are passive for waiting for their loan to be issued. Therefore, it significantly influences the willingness of a working capital constrained firm to borrow funds. Doh-Shin Jeon and Lovo (2013) found that a borrower's satisfaction is proportional to the waiting period. Credit issued on -time may help a borrower to overcome their working capital constraint. In the event of financial crisis, the earlier companies can obtain commercial credit, the more opportunity they will have to survive (Santiago Carbó-Valverde *et al.*, 2012).

Through the above brief review, some scholars contributed these borrowers' concerns to their studies. However, with regard to to these concerns, it is impossible to cover all those relating to credit selection, for example some scholars described how gender also has an influence. It is trying to offer a general definition to involve borrowers' concerns as much as possible. For instance, human capital has been widely defined, it covers personal education levels, position in a company and gender. Therefore, it could treat these concerns satisfy the principles of setting criteria in AHP hierarchy structure mentioned by Saaty. Table 3.2 lists the relevant main borrowers' concerns with regard to credit selection and using these concerns it explains the design of AHP hierarchy structure.

Internal Section
1. Interest Rate
2. Administration Fees
3. Transaction Cost (Exchange rate)
4. Information Openness/ Asymmetry
5. Ownership
6. Human Capital
7. Business Duration
External Part
1. Distance
2. Approval Time
3. Repayment Period
4. Lending Volume
5. Credit Issued
6. Borrowing History

Table 3.2. The summary of sub criteria in AHP hierarchy structure

3.3.2 Setting of the Main Criteria

Setting the main criteria is a procedure involved in designing the AHP hierarchy structure. While deciding how to better design the main criteria for the structure, Saaty (1990) suggested that the criteria can be summarized into different categories according to their differences and similarities. Albayrak and Erensal (2004) described that setting the main criteria is similar to distinguishing the difference between qualitative and quantitative information. The criteria can be categorized according to their nature. Such as human knowledge, human abilities, cultural background and human capabilities can all be categorised as human performance in business management. Therefore, in this research, the criteria listed in Table 4.1 can also be distinguished and summarized in the same way as the main criteria. In the internal section, the sub-criteria from No.1 to 3 all relate to monetary issues. In other words, borrowers should consider how much money they needs to spend on borrowing and managing credit. Therefore, these sub-criteria can be summarized as the main criteria for setting the hierarchy structure in AHP. Based on Table 4.1, the criteria from No.1 to 3 are summarized as the main criterion of Cost. No.4 to 7 are the criteria which describe the basic information of an enterprise, for example criterion No. 4 is the information openness of one company. This is a term used to describe the operating

situation of one company. It is similar to criteria No.5, No.6 and No. 7. They are all terms used to introduce the basic situation of one company. Therefore, criteria No. 4 to No. 7 can be summarized as the main criterion of an Organizations' Situation.

In the external section, criteria No.1 and No. 6 are the two metrics used to describe the geographical and physical relationship between the credit borrowers and lenders. No.1 is a term used to evaluate how credit borrowers' feel about the distance between themselves and lenders. It is the geographical factor which makes the credit borrower consider how far a distance between themselves and the lenders they are able to accept. No.6 is a term used to evaluate the credit borrowers' concern over their own debt-credit history. It means that, in order to increase the possibility of accessing credit the credit borrowers also consider their owb borrowing history before selecting credit lenders,. Therefore, these two criteria are constraints for credit borrowers' when selecting credit. They are summarized as the main criteria of Borrowing Constraints. Finally, external criteria No.2 to No. 5 are four metrics used to describe the borrowers' requirements with regards to credit. The borrower normally inquires how long they need to wait before their application is approved and the credit can be issued, when they need to repay and how much they can lend. Therefore, approval time, credit issue, repayment period and lending volume are actually the four basic things that credit borrowers require from thier lenders. These four metrics can be summarized as Credit Borrowing Requirements.

In conclusion, the previous chapter identifies sub- criteria, and it also introduces the process of setting main criteria. All the main criteria and the corresponding sub-critieria are shown in Table 3.3.

Main Criteria	**Sub- Criteria**
Costs	1. Interest Rate
	2. Administration Fees
	3. Transaction Cost (Exchange rate)
Borrowers' Internal Situation	4. Information Openness/ Asymmetry
	5. Borrowing Decision Making Procedure
	6. Credit Analysis
	7. Historic Business Information
Borrowers' External Situation	8. Distance
	9. Borrowing History

Borrowing (Capital) Requirements	10. Approval Time
	11. Credit Period
	12. Lending Volume
	13. Credit Issued

Table 3.3. Summary of main criteria and sub criteria in AHP hierarchy structure

3.3.3 Design of the Analytic Hierarchy Structure

After the determination of criteria and sub- criteria in Section 3.3.1 and 3.3.2, these main criteria and sub-criteria can be organised and structured into the AHP hierarchy framework. According to the procedure of setting the hierarchy framework by (Palma-Mendoza, 2014), the standard AHP hierarchy framework should include the following levels, the objective (first level), main criteria (second level), sub-criteria (third level) (optional) and alternative options/solutions. Thus, combined with the research to help working capital constrained companies in selecting proper short-term credit, this objective will be set at the first level. This objective will be linked with the main criteria presented in Table 3.3 on the second level and then linked with the sub-criteria in Table 3.3 on the third level. The alternative options including BO, TC and 3PLC will be linked with the third level. Therefore, following the above description, the AHP hierarchy framework can be structured in the following Figure 3.1.

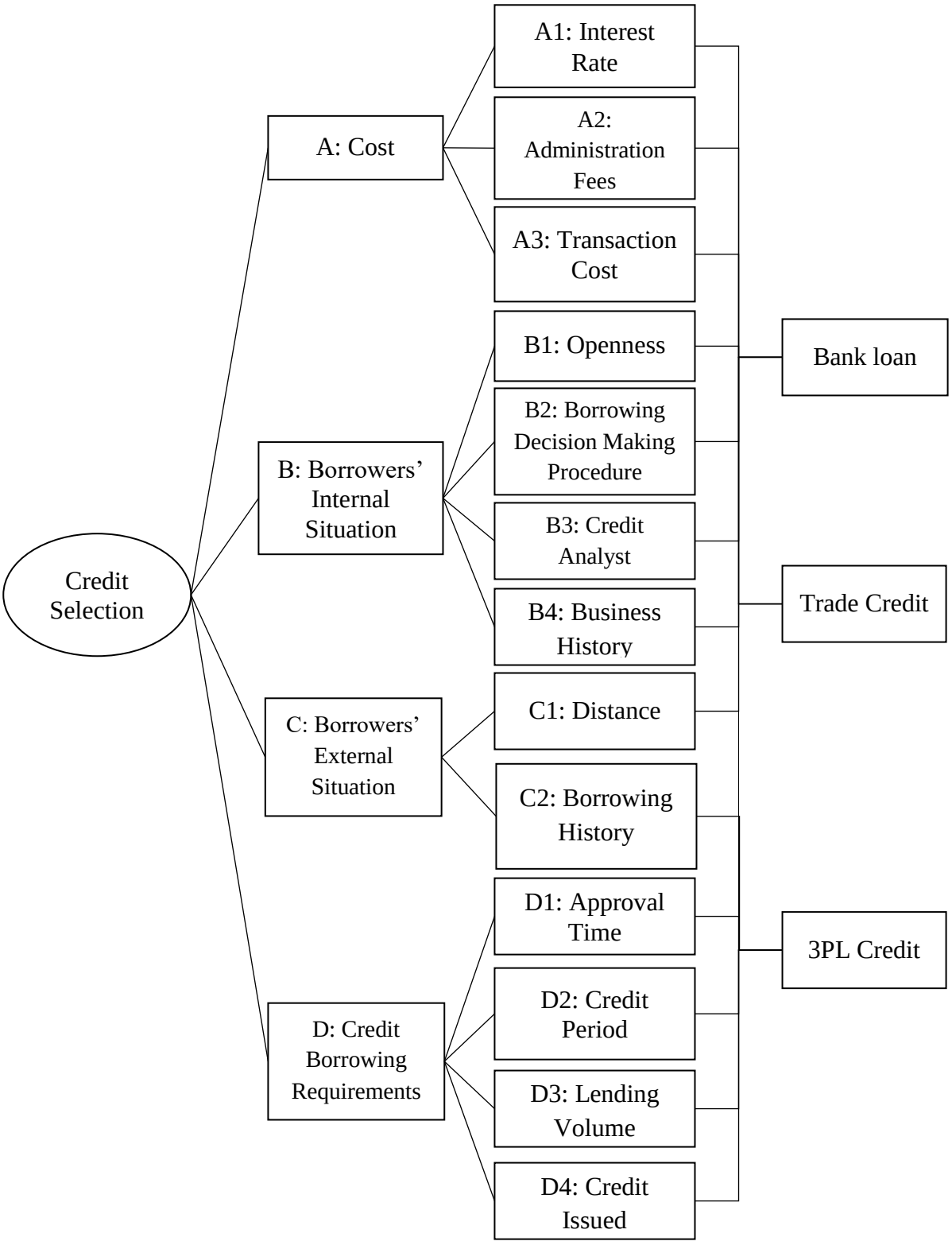

Figure 3.1. The AHP hierarchy structure

3.3.4 Weight of Criteria and Consistency Ratio Test

In the above AHP hierarchy structure, all selected criteria were structured in order to calculate their weight in terms of borrowers' credit selection. According to the introduction of AHP by Saaty (1990), the weight of each criterion should be marked in order from top to bottom using pairwise comparison, weights should be marked on a scale from 1 to 9 presented and explained in Table 3.4. These 9 levels of importance refer to 9 different intensities of importance, which start from the minimum level 1 to maximum level 9.

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two factors contribute equally to the objective.
2	Equal to moderately	When compromise is needed
3	Moderate Important	Experience and judgement slightly favour one over the other.
4	Intermediate Moderate Importance	When compromise is needed
5	Strong Importance	Experience and judgement strongly favour one over the other.
6	Intermediate Strong Importance	When compromise is needed
7	Very much more important	Experience and judgement very strongly favour one over the other.
8	Intermediate Demonstrated Importance	When compromise is needed
9	Extreme Importance	The evidence favouring one over the other is of the highest possible validity.

Table 3.4. AHP rating scale from 1 to 9
(Saaty, 1990)

Participants will mark criteria via pairwise comparison following the marking scale in Table 3.4. The criteria will be marked through questionnaires. These questionnaires are answered by specific professional accountants. First stage marking is used to calculate the weight of criteria

which have an impact on lender selection. The higher weighted criteria in the ranking are then;/selected to measure the borrower's preference for alternative credit.

The calculation of criteria in AHP structure follows pairwise comparison (Saaty, 1990). Pairwise comparison is a method used to compare the priority of two items. For example if an issue is influenced by item i and item j, pairwise comparison aims to evaluate their importance in influencing the issue. When item i compares with item j, it is actually comparing whether item i holds more or less importance than item j. If it assumes that the importance marking of i and j are w_I and w_j, respectively, the result of the pairwise comparison of item will be $\frac{w_i}{w_j}$. Following the above idea, the main criteria of Figure 3.1 have been compared. The corresponding matrix is shown in Table 3.5.

	A	**B**	**C**	**D**
A	$\frac{w_A}{w_A}$	$\frac{w_A}{w_B}$	$\frac{w_A}{w_C}$	$\frac{w_A}{w_D}$
B	$\frac{w_B}{w_A}$	$\frac{w_B}{w_B}$	$\frac{w_B}{w_C}$	$\frac{w_B}{w_D}$
C	$\frac{w_C}{w_A}$	$\frac{w_C}{w_B}$	$\frac{w_C}{w_C}$	$\frac{w_C}{w_D}$
D	$\frac{w_D}{w_A}$	$\frac{w_D}{w_B}$	$\frac{w_D}{w_C}$	$\frac{w_D}{w_D}$

Table 3.5. The pairwise comparing matrix for main criteria

According to Table 3.5, supposing a participant has been asked to compare criterion A to criterion B, the participant has determined the importance of Criterion A w_A and also the importance of criterion Bw_B. According to the rating scale in Table 3.4, the participant should mark the pairwise comparing result of the two main criteria from one of intensities of importance. Therefore, the result of the pairwise comparison for comparing Criterion A to Criterion B is $\frac{w_A}{w_B}$. The matrix in Table 3.5 presents the results of the pairwise comparisons for all of the main Criteria A, B, C and D.

The results of the pairwise comparisons for all of the main criteria can be used to calculate the weight of each criterion. The weight of each criterion is calculated through the equation which is presented as follows:

$$\frac{w_i}{\sum_{i=1}^{n} w_i} \qquad (1)$$

According to Equation (1), there are four main criteria in the AHP structure, which stands for n=4. Therefore, based on Equation (1), the weight of Criterion A in column A is equal to $\frac{\frac{w_A}{w_A}}{\frac{w_A}{w_A}+\frac{w_B}{w_A}+\frac{w_C}{w_A}+\frac{w_D}{w_A}}$.

The corresponding weight of A in column B is $\frac{\frac{w_A}{w_B}}{\frac{w_A}{w_B}+\frac{w_B}{w_B}+\frac{w_C}{w_B}+\frac{w_D}{w_B}}$.

The corresponding weight of A in column C is $\frac{\frac{w_A}{w_C}}{\frac{w_A}{w_C}+\frac{w_B}{w_C}+\frac{w_C}{w_C}+\frac{w_D}{w_C}}$.

The corresponding weight of A in column D is $\frac{\frac{w_A}{w_D}}{\frac{w_A}{w_D}+\frac{w_B}{w_D}+\frac{w_C}{w_D}+\frac{w_D}{w_D}}$.

Therefore, according to Equation (1), it can calculate the weight of criterion A, B, C and D in each column.

	A	**B**	**C**	**D**
A	$\frac{\frac{w_A}{w_A}}{\sum_{n=A,\dots,D}\frac{w_n}{w_A}}$	$\frac{\frac{w_A}{w_B}}{\sum_{n=A,\dots,D}\frac{w_n}{w_B}}$	$\frac{\frac{w_A}{w_C}}{\sum_{n=A,\dots,D}\frac{w_n}{w_C}}$	$\frac{\frac{w_A}{w_D}}{\sum_{n=A,\dots,D}\frac{w_n}{w_C}}$
B	$\frac{\frac{w_B}{w_A}}{\sum_{n=A,\dots,D}\frac{w_n}{w_A}}$	$\frac{\frac{w_B}{w_B}}{\sum_{n=A,\dots,D}\frac{w_n}{w_B}}$	$\frac{\frac{w_B}{w_C}}{\sum_{n=A,\dots,D}\frac{w_n}{w_C}}$	$\frac{\frac{w_B}{w_D}}{\sum_{n=A,\dots,D}\frac{w_n}{w_C}}$
C	$\frac{\frac{w_C}{w_A}}{\sum_{n=A,\dots,D}\frac{w_n}{w_A}}$	$\frac{\frac{w_C}{w_B}}{\sum_{n=A,\dots,D}\frac{w_n}{w_B}}$	$\frac{\frac{w_C}{w_C}}{\sum_{n=A,\dots,D}\frac{w_n}{w_C}}$	$\frac{\frac{w_C}{w_D}}{\sum_{n=A,\dots,D}\frac{w_n}{w_C}}$
D	$\frac{\frac{w_D}{w_A}}{\sum_{n=A,\dots,D}\frac{w_n}{w_A}}$	$\frac{\frac{w_D}{w_B}}{\sum_{n=A,\dots,D}\frac{w_n}{w_B}}$	$\frac{\frac{w_D}{w_C}}{\sum_{n=A,\dots,D}\frac{w_n}{w_C}}$	$\frac{\frac{w_D}{w_D}}{\sum_{n=A,\dots,D}\frac{w_n}{w_C}}$
SUM	$\frac{w_A}{w_A}+\frac{w_B}{w_A}+\frac{w_C}{w_A}+\frac{w_D}{w_A}=\sum_{n=A,\dots,D}\frac{w_n}{w_A}$	$\frac{w_A}{w_B}+\frac{w_B}{w_B}+\frac{w_C}{w_B}+\frac{w_D}{w_B}=\sum_{n=A,\dots,D}\frac{w_n}{w_B}$	$\frac{w_A}{w_C}+\frac{w_B}{w_C}+\frac{w_C}{w_C}+\frac{w_D}{w_C}=\sum_{n=A,\dots,D}\frac{w_n}{w_C}$	$\frac{w_A}{w_D}+\frac{w_B}{w_D}+\frac{w_C}{w_D}+\frac{w_D}{w_D}=\sum_{n=A,\dots,D}\frac{w_n}{w_D}$

Table 3.6. The weight of each criterion in columns

Based on Table 3.6, the final weight for all of the main criteria can be calculated through averaging their weights in each column. Thus, the final weight of criterion A is the value below.

$$\sum_{n=A,\ldots,D} \frac{w_n}{w_A}$$

Next, thes weight of Criterion A in column A, B, C and D can be averaged out to calculating the final weight of criterion A, which is also the priority of criterion A (Triantaphyllou and Mann, 1995). Similarly, the priority of Criterion B, C and D can be calculated following the same procedure. All of the priorities of the criteria should be measured by the consistency ratio (CR) in order to check their validity (Ghodsypour and O'Brien, 1998). The CR test aims to evaluate the trustworthiness of participants' judgements. If the value of the CR is more than 0.1 (10%), this means the judgements are untrustworthy. That is because the participants may have not given a true judgement and will thus lead to a valueless result. To conduct a CR test, the equation is presented as follows:

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}} \qquad (2)$$

Equation *(2)* will be used to test the CR of all markings of respondents, where CI represents consistency index and RI represents consistency ratio. To calculate the CI, the Principle Eigen value denoted by λ_{max} is needed. The Principle Eigen value λ_{max} is obtained from averaging the summation of all Eigen vectors. Each Eigen vector is calculated through dividing the criterion's weigh sum vectors (WSV) by this criterion's weight. To calculate each criterion's WSV, the values of each criterion's final weight need to be summed and multiplied by the correspondent intensity of importance in the row.

To test all the priorities of criteria by consistency ratio (CR), According to Table 3.6, the comparison matrix presents weights of criterion A in column A, B, C and D. It could achieve the overall markings for the main criteria, which only need to plus the marking in each column. For example the overall marking of main criterion A is:

$\mathrm{SUM\ (A)} = \frac{w_A}{w_A} + \frac{w_B}{w_A} + \frac{w_C}{w_A} + \frac{w_D}{w_A}$.

It could get the overall markings for the rest B, C and D by following the above method, which is SUM (B), SUM (C) and SUM (D). The marking in each column is then divided by the overall marking of each criterion, such as the $\frac{w_A}{w_A}$ / SUM (A). The rest of the criteria can follow the equation: $\frac{w_i}{\sum_{i=1}^{n} wi}$, i=A, B, C and D. Therefore, it could produce the following Table 3.7 on the weights of criteria.

	A	B	C	D
A	$\frac{w_A}{w_A}$/SUM (A)	$\frac{w_A}{w_B}$/SUM (B)	$\frac{w_A}{w_C}$/SUM (C)	$\frac{w_A}{w_D}$/SUM (D)
B	$\frac{w_B}{w_A}$/SUM (A)	$\frac{w_B}{w_B}$/SUM (B)	$\frac{w_B}{w_C}$/SUM (C)	$\frac{w_B}{w_D}$/SUM (D)
C	$\frac{w_C}{w_A}$/SUM (A)	$\frac{w_C}{w_B}$/SUM (B)	$\frac{w_C}{w_C}$/SUM (C)	$\frac{w_C}{w_D}$/SUM (D)
D	$\frac{w_D}{w_A}$/SUM (A)	$\frac{w_D}{w_B}$/SUM (B)	$\frac{w_D}{w_C}$/SUM (C)	$\frac{w_D}{w_D}$/SUM (D)
SUM	$\frac{w_A}{w_A}+\frac{w_B}{w_A}+\frac{w_C}{w_A}+\frac{w_D}{w_A}$	$\frac{w_A}{w_B}+\frac{w_B}{w_B}+\frac{w_C}{w_B}+\frac{w_D}{w_B}$	$\frac{w_A}{w_C}+\frac{w_B}{w_C}+\frac{w_C}{w_C}+\frac{w_D}{w_C}$	$\frac{w_A}{w_D}+\frac{w_B}{w_D}+\frac{w_C}{w_D}+\frac{w_D}{w_D}$

Table 3.7. The weights of criteria

In order to achieve the final weight of each main criterion, it needs to average the weights in each row, for example the weight of criterion A is:

Average $[\frac{w_A}{w_A}/SUM\ (A) + \frac{w_A}{w_B}/SUM\ (B)\ +\ \frac{w_A}{w_C}/SUM\ (C)\ +\ \frac{w_A}{w_D}/SUM\ (D)]$

Therefore, the final weight of main Criterion A equals: Average $[\ \frac{w_A}{w_A}/SUM\ (A) + \frac{w_A}{w_B}/SUM\ (B)\ +\ \frac{w_A}{w_C}/SUM\ (C)\ +\ \frac{w_A}{w_D}/SUM\ (D)]$. For the rest of other main criteria, their weight can be achieved by following the above calculation.

However, not all of the weights of the main criteria are valid until they are tested by the consistency ratio (CR). The value of the CR is equal to $\frac{\text{CI}}{RI}$. Before doing the CR test, the definition of the Principal Eigen Value (λ_{max}) needs to be realised. This value is obtained from the summation of items between each element of Eigen vector and the sum of the columns of

the reciprocal matrix. The λ_{max} calculation, should first calculate the weight sum vector (WSV), which is equal to the weight of each criterion × marks in each row.

For example the WSV of A

$$= Average\left[\frac{\frac{w_A}{w_A}}{SUM}(A) + \frac{\frac{w_A}{w_B}}{SUM}(B) + \frac{\frac{w_A}{w_C}}{SUM}(C) + \frac{\frac{w_A}{w_D}}{SUM}(D)\right] \times \frac{\frac{w_A}{w_A}}{SUM}(A) +$$

$$Average\left[\frac{\frac{w_B}{w_A}}{SUM}(A) + \frac{\frac{w_B}{w_B}}{SUM}(B) + \frac{\frac{w_B}{w_C}}{SUM}(C) + \frac{\frac{w_B}{w_D}}{SUM}(D)\right] \times \frac{\frac{w_A}{w_B}}{SUM}(B) +$$

$$Average\left[\frac{\frac{w_C}{w_A}}{SUM}(A) + \frac{\frac{w_C}{w_B}}{SUM}(B) + \frac{\frac{w_C}{w_C}}{SUM}(C) + \frac{\frac{w_C}{w_D}}{SUM}(D)\right] \times \frac{\frac{w_A}{w_C}}{SUM}(C) +$$

$$Average\left[\frac{\frac{w_D}{w_A}}{SUM}(A) + \frac{\frac{w_D}{w_B}}{SUM}(B) + \frac{\frac{w_D}{w_C}}{SUM}(C) + \frac{\frac{w_D}{w_D}}{SUM}(D)\right] \times \frac{\frac{w_A}{w_D}}{SUM}(D) \quad (3)$$

Calculating the WSV of A aims to produce new values. The new values are calculated through WSV divided by the weight of each criterion.

$$\text{Such as the new value of A} = \frac{WSV\ of\ A}{\text{Average}\left[\frac{\frac{w_A}{w_A}}{SUM}(A)+\frac{\frac{w_A}{w_B}}{SUM}(B)+\frac{\frac{w_A}{w_C}}{SUM}(C)+\frac{\frac{w_A}{w_D}}{SUM}(D)\right]} \quad (4)$$

It could follow Equation (3) and (4) to get new values for the rest of main criteria B, C and D. Then the values of λ_{max} are equal to the average results of all of the new values ofA, B, C and D. The value of CI can be achieved through the equation$\frac{\lambda_{max}\text{-n,}}{\text{n-1}}$, where n is the number of criteria. If the value of CI needs to be calculated, it should realize the value of RI. The values of RI are shown in Table 3.8.

n	1	2	3	4	5	6	7	8	9	10	11	12
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48

Table 3.8. The values of RI

(Saaty, 1990)

Therefore, the value of the CR can be calculated through CI/RI. If the value of the consistency ratio is smaller or equal to 10%, inconsistency is acceptable. If the consistency ratio is greater than 10%, the subjective judgment needs to be revised. Thus far, the evaluation of the importance of borrowers' concerns and the preferences using AHP is finished.

3.4 Investigation into the Importance of Borrowers' Concerns

In the process of seeking a method to investigate the importance of credit borrowers' concerns, many approaches have been considered such as examining secondary sources, observation and

interviews including both semi-structured and structured. Based on the selection of research methods in Section 3.3, the research mainly uses surveys to investigate how company's concerns rank by level of importance. Robson (2002) commented that questionnaires as a research method worked with standardised questions and could minimise influence created by intepretation and interruption. Gill and Johnson (2002) also recommended that questionnaire be used for descriptive and explanatory research. These two types of research focus more on realzing options, organizational practises in descriptive research and relationships between variables in explanatory resarch.

According to the recommendation by Gill and Johnson (2002), considering the aim of investigating the importance of borrowers' concerns, a method that can both examine and explain the relationships between borrowers' concerns and also evaluate their importance should be found. Therefore, it could be decided to to use questionnaires as the method of investigation.

3.4.1 The Choice of Questionnaire

The questionnaire aims to investigate important concerns considered of borrowers when selecting short term credit. The result of this questionnaire should be able to answer the first research question addressed in Section 1.3. To achieve this aim, the questionnaire is designed to evaluate all concerns appointed in the hierarhcy structure (As shown in Figure 3.1). The hierarchy structure is formed using 4 main catergories and 13 types of concerns and links to 3 different alternative options. According to the pairwise comparison in AHP (Saaty and Vargas, 2012), questions in the questionnaire will be developed so as to pair each two concerns and compare any two (in one category) one by one.

To ensure that the results of the questionnaire are accurate, sample size as a component of planning a questionnaire has been discussed in some studies (Francis *et al.*, 2010; Zikmund *et al.*, 2013; Rowley, 2014). Saaty (1994) has not pointed out any specific requirements with regard to sample size in AHP. However, his study determined that an approiate sample size depends on the requirements of margin errors. For instance, for a margin error of 5%, Yang and Kuo (2003) tested the results of diffrerent samples using the AHP method. For large groups (400 respondents) and small groups (19 respondents), the results were very stable. In AHP, the accuracy of the results depends on the development of the hierarchical structure rather than the sample size, meanwhile, participants' judgement of variables (Concerns of this research) can

also influence results (Saaty and Vargas, 2012). Thus, the AHP questionnaire for this study will be developed based on the AHP framework in Figure 3.1.

An appropriate questionnaire should be able to fulfil the purposes of a survey. The purpose of the questionnaire aims to compare the criteria listed in Figure 3.1, investigate their priorities in terms of how they influence credit selection and realise participants' preferences for each type of credit. In this context, the key to designing a questionnaire is to determine which type of questionnaire. Catergories commonly used in questionnaires include self-admininstered and interviewer-administered (Saunders *et al.*, 2009), the main difference between them is whether the questionnaire is completed by the respondents or not. In this research, self-administrated questionnaires allow participants to evaluate the selected criteria by themselves rather than the interviewer. In this regard, they are more suited to this investigation.

Dillman (2007) suggests a guide to help scholars develop their questionnaires in the right style. Primarily, the development of the questionnaire should follow research questions. Besides, this guide addresses some aspects to be covered in the questionnaire development, which include:

1. The role of the respondents in collecting data.
2. The method of reaching the respondents.
3. The importance of the respondents being distorted.
4. Size sample needed for the research.
5. Types of questions to be asked.
6. Numbers of questions to be asked.

Based on the above understanding of the six principles of choosing a questionnaire, the investigation for this research aims to invite some professional respondents who have experience in applying for commerical short-term credit. To expand the number of participants and increase response rates, a group of self-administrated questionnaires will be deliveried via the internet and via post. Web- based questionnaires can be considered as an effective and low cost approach and the response rate for this approach can also be improved via post (Sauermann and Roach, 2013). Other methods of reaching participants, such as using delivery and collection questionnaires will be abandoned due to thier reliance on hand to hand delivery and collection which is strongly limited by geographical distance and time. Oppenheim (2000) addressed the advantages of web-based surveys and postal questionnaires. The main advantages of using these two methods ae that the quantity of feedback can be guarenteed. The former can cover respondents who are computer-literate individuals by using email. The latter can cover literate

individuals by using post with a clear destination.Furthermore, as the questionaire is sent by email, the former can also guarantee the quality of feedback. Both these two types can be geographically dispersed, which in turn can maximize the quantity of feedback. According to research by Hewson *et al.* (2003) about the likely response rate in these two types of questionnaire, an almost 30% response rate can be achieved via intranet and an 11% response rate via internet questionnaires. In postal questionnaires, the likely response rate is 30%.

With regard to the sample size, Saaty and Vargas (2012) addressed that AHP might be applied to the responses of both large and small groups. However, sample size should depend upon the problems and response rates of participants. In other words, a large sample size may be no different to small group of participants.The study of Paolo and Leandro (2016) discuss an appropriate sample size with which to run the AHP method, it found that in a common acceptable margin error and an alph level, which is 5% and 0.05, there is no significant difference when determining important alternatives from 19 to more than 400 samples. Thus, by following the same margin error and alph level, this research is going to use the maximum number of participants with regards to their availability.

3.4.2 Questionnaire Development

In this research, data will be collected through said questionnaire. This part of the data aims to answer the first research question defined in Section 1.3, which is *'What are borrowers' concerns when determining their short-term credit borrowing from multiple working capital sources?'* To answer this question, the research aims to clarify two kinds of information, including,

What is the priority of borrowers' considerations in choosing short term credit?

How does the priority of borrowers' considerations influence their preferences for the alternative credit?

These two questions cover the core information which should be obtained from the questionnaire. Based on the suggestion by Brace (2008), some key procedures can assist the questionnaire to be designed with more reliability. Brace (2008) determined that a standard questionnaire design should start from the question design. In other words, it is suggested that researchers should determine what questions they want to ask in their questionnaire. In addition to determining the questions, Saunders *et al.* (2009) suggested a typical procedure for developing a questionnaire. Four basic steps are involved, and they are summarized as follows.

1. **Question development.**

   Questions should be clear and easily understood by the participants. They should be specified to reflect the research domain value. Moreover, Oppenheim (2000) emphasized that questions should be defined in reference to related literature, in order to ensure the validity of the contents. Therefore, through referencing literature, especially when studying the approach of defining questions, enables questionnaires to achieve the information expected from the investigation.

2. **Scale determination.**

   Measurement scales are used by respondents/participants to answer the questions. In the current questionnaire design, Saunders *et al.* (2009) has summarised four basic scales, which include nominal, ordinal, interval and ratio. The difference between these four scales are in what they are used measure. For example, a nominal scale is used to define names, genders and other categorical data. An ordinal scale, such as Likert scale, is applied when measuring elements with an order. An interval scale is similar to an ordinal scale, but it is mainly applied for evaluating information which is split equally. In other words, the difference between the results of two evaluations is same as the difference between another set of results from two different evaluations. Ratio is similar to an interval scale, but it also allows for the existence of value 0 in the scale.

3. **Respondent identification**

   A key procedure in questionnaire development is identifying respondents. Scholars need to to determine certain features of respondents, including who is going to be selected to participate in the investigation and how many of the respondents are appropriate. The group of selected participants, which is the sample, should be able to represent the population.

4. **Questionnaire test**

   The final step is the test questionnaire. Testing the questionnaire is a procedure which requires the scholar to develop a questionnaire by organising all the questions together in the correct ordering and with an appropriate layout. The questionnaire should be operated through a pilot test in order to improve any shortfalls.

This thesis follows the procedures suggested above. In order to develop an appropriate questionnaire, the definition of the questions will be discussed in the rest of this chapter. As a key procedure in questionnaire development, Ghauri and Gronhaug (2005) suggested that

defining questions could follow the aim of the research questions, questions in the questionnaire should support the investigation and answer the research questions. In other words, question can be defined based on certain research questions in order to assist the scholar in achieving their original aims. Therefore, the first research question of the thesis, "**What are borrowers' concerns when determining their credit borrowing from multiple credit sources?**" discusses working capital borrowing activities and requires the development of an understanding about borrowers' concerns in this activity. Moreover, this first research question not only aims to find out borrowers' concerns. There are also two sub-research questions that have been raised which are "**What is the priority of borrowers' considerations in choosing credit? And how does the priority of borrowers' considerations influence their preference for alternative credit?**" These two research questions aim to investigate two aspects in terms of the priorities of borrowers' concerns and the influence of their concerns on borrowers' preferences.

As the types of borrowers' concerns have already been clarified through reviewing relevant literature, this questionnaire aims to investigate the importance of these concerns instead of their definitions and categories. To achieve this aim, the questions in questionnaire should be able to evaluate the importance concerns. Referring back to the AHP hierarchy structure (Figure 3.1) in Section 3.3.3, there are 13 types of concerns are presented and need to be compared. Based on the AHP technique of pairwise comparison, all these concerns will be compared in pairs. In other words, the questions will evaluate and compare the concerns to each other two at a time within the questionnaire.

Section 3.3.4 introduced that if using pairwise comparison to evaluate these 13 concerns, at least 23 questions should be prepared for the respondents. The variables, which stand for the different borrowers' concerns, actually ask the respondents' opinion in terms of evaluating their priority. Therefore, these variables can be understood as a type of opinion data (Dillman, 2007). When using opinion data, the most common methods are rating questions and ranking questions (Corbetta, 2003). A Likert-style rating scale, such as agree, tend to agree, tend to disagree and disagree is often used. However, rating questions should not be confused with rating scales (Corbetta, 2003). As the scales in the questionnaires will follow the AHP scale in Table 3.4, this questionnaire will therefore use ranking questions. Ranking questions can ask the respondents to place their opinions in rank order. This satisfies the aim of the questionnaire which wishes to evaluate the importance of borrowers' concerns. Therefore, ultimately this research decided to use ranking questions to develop the questionnaire.

To developing the questionnaire using a ranking questionnaire and in order to avoid misleading the respondents, the questions in the questionnaire are set as "select first then rank". Taking two main criteria in the AHP hierarchy structure as an example, if setting the main criterion Cost (A) and the main criterion Organization's situation (B) as the variables in the question, the question will ask the respondents to select which one is more important, A or B, rather than let them rank how A is more (less) important than B. Therefore, the question about evaluating the importance of A and B is set as follows,

> *"Which does your company consider more in borrowing commercial credit, the aspect of costs? Or the aspect of own business conditions? And how important of this factor in the consideration? (A: B)".*

The above template can be used by further questions to evaluate the importance of other criteria. The questionnaire development is shown as Question List 1 in Appendix I.

As the questionnaire aims to evaluate the importance of borrowers' concerns and also evaluate how these concerns influence the credit borrowers' preference for alternative credits, thus the second part of the questionnaire will investigate the borrowers' preference for credit with the highly important concerns. The first part of the questionnaire should collect the borrowers' rating on the importance of concerns and as the result, this data can be analysed and produce a ranking according to importance arranged by maximum to minimum value. This ranking will be used in developing the second part of the questionnaire.

Based on the sub-research question "How does the priority influence the credit borrowers' preferences for the alternative credits?" The priority achieved in the first part of questionnaire will be refined to select the highly important criteria and these criteria will be set as the conditions for the second part of the questionnaire. For example, if the approval time is an important concern for credit borrowers, when evaluating the borrowers' preference for bank loan and trade credit, the question will be set as follows,

> "*Borrowers are all willing to go through a shorter approval time in their application in order to obtain credit. For bank overdrafst and trade credit, the participants have the experience and realization about their approval time. Therefore, in the following question, the respondent will rate credit sources according to which one has a shorter approval time.*

Q: Comparing bank loan with trade credit, which one has a shorter approval time in the application process? (BO: TC)"

This question aims to ask the respondents to choose which has a shorter approval time, bank loans or trade credit in order to identify the participants' preference for bank loan and trade credit when considering the approval time. For the other highly important concerns, the setting of the questions will follow the above logic and the second part of questionnaire will evaluate the participants' preference for BO, TC and 3PLC. This part of questionnaire is designed as Question List 2 in Appendix I.

Before using the questionnaire to conduct official data collection, Saunders *et al.* (2009) suggested it is better to conduct a pilot test. The purpose of the pilot test is to refine the questionnaire and ensure that respondents will have no problem in understanding and answering the questions.

Initially, there was a group of accounting trainees in one company invited to do the pilot test. The number of participants and number of pilot tests will be based on the progression of the research and the capital invested. As a small-scale questionnaire, there is no time limitation for the respondents to answer the questions. By ignoring time limitation, the time taken for respondents to answer the questions can be evaluated (J.Bell, 2005). In the pilot test for the questionnaire, four issues were cleared up and realized, which are shown as the following.

1. The time taken for the questionnaire to be completed.
2. The clarity of the instructions
3. Whether the questions are clear or not and easily understood.
4. Whether the layout of the questionnaire is clear and attractive or not.

These four issues were asked after each respondent finished and all the comments they provided were used to improve the quality of the questionnaire.

3.4.3 Focus Group and Collecting Procedure

After developing the questionnaire and doing the pilot test, the questionnaire is ready to be used for data collection. As the aim of sending the questionnaire is to evaluate the priority of borrowers' concerns and preference over the alternative alternative credit sources. Therefore, the focus group should be familiar with credit borrowing activities. The preferred focus group is credit borrowers. For this part of participant, it aims to select professional accountants in working capital constrained companies. These working capital constrained companies should have experience in using commercial credit, or should be using commercial credit currently. There is no specific requirement for the locations of these companies. In order to increase the

quantity of respondents, the questionnaire was also emailed or posted to different countries. The translation of the questionnaires will be introduced in the following section.

With the aim of increasing the quantity of respondents, the questionnaire will be translated into Chinese. Based on the suggestion of Usunier (1998), in order to guarantee the accuracy of description and expression the translation of this questionnaire should follow three basic principles. The translating work should focus on the lexical meaning, the idiomatic meaning and the experiential meaning. These three meanings require the questionnaire to pay attention to the translation of individual English to Chinese words. For example, the Chinese definition of 'credit', 'credit' in the original questionnaire refers to a commercial loan rather than reputation, faith or other meanings in Chinese. In terms of idiomatic meaning, the translator should pay attention on a group work. For example, 3PLC should be correctly translated as a type of credit offered by 3PL companies by following the definition in Section 2.3.2. The final point that should be paid attention to is the experiential meaning. Translators are required to translate professional or academic terms into easy and understandable language, for example 3PL needs to be clearly explained as a professional company that is in charge of delivering, transporting, packaging, warehousing and other logistics services.

Based on these translation requirements, in order to guarantee the accuracy of the translated questionnaire, this research decided to use a mixed translating technique to translate the questionnaire. Usunier (1998) explained that a mixed technique could ensure a best match between the original language and the target language. Although it is costly in time and translators, it can maximize the accuracy of the questionnaire. Therefore, the author invited one professional English-Chinese translator to carry out this work and additionally, the thesis required the translator to examine the original English version of the questionnaire, in order to guarantee the correct of grammar and syntax.

After finishing the translation and proofreading the questionnaire, the questionnaire is ready to be emailed and posted. In order to ensure the maximum response rate, each postal questionnaire was delivered by pre-paid return standard post. It is also followed the suggestion by Witmer *et al.* (1999), each email questionnaire is delivered with a cover page to explain the approach towards reading the AHP hierarchy structure and rating the importance, a receipt was also requested for the receipt after the respondents receive it.

3.4.5 Research Ethics of the Investigation

One issue should be addressed before sending the questionnaire for data collection. Research ethis are an important factor that should be paid attention to when conducting this research. Data collection is achieved through email and postal questionnaires, therefore, some specific ethical issues should be considered to protecting the privacy of participants (Bell, 2014). To clarify the awareness of risks that arise in the research, some important elements will be addressed regarding each stage in the data collection procedure.

Regarding the procedure of developing data collection, this research has four stages; Stage one -data collection design, Stage two - data collection, Stage three- data storage nad Stage 4 - data analysis. These four stages are divided according to the data collection process. In each stage, some key ethical issues should be discussed before proceeding to formal data collection.

In the first stage, the participants have been told the aims of the research, their privacy rights and their rights in accessing the results of the data analysis. These three issues aim to let the participants know what kind of research they will be taking part in (Robson, 2002).

In the second stage, ethical issues should be divided into researcher's ethics and participants' ethics (Saunders *et al.*, 2009). However, as the questionnaires are posted and emailed, there is no need for the researcher to request absence from university and no other safety risks. It is only necessary to mention the participants' rights before collecting the data. The participants were all made aware of their right to withdraw their attendance before any data collection took place and they all guaranteed to maintain confidentiality.

In the third stage, data storage, the research followed the suggestions of Cavana *et al.* (2001), the questionnaire of each participant was kept in its own individual folder and these folders were marked only with a code and a date rather than the names of the participants or organizations. The participants kept a copy of the questionnaire introduction and a signed agreement of attendance, in addition, they also kept the contact information of the researcher, for any further processing of the results of the data analysis.

In the fourth stage, during the data analysis process, all of the results were posted or emailed back to the participants so that they could store them as they wished. This action aims to maintain their right to be informed, which was announced in the first stage. In a research output,

any identifiable information used in the results of the data analysis, including details of the participants or organization will never be quoted.

All the ethical issues mentioned above will benefit the research by providing accurate responses in the data collection. The announcement prior to the investigation will guarantee that all participants understand the aims of the research, their roles and their rights in the investigation. Meanwhile, this research also confirms the right of using these data for further research freely and fully.

3.5 Method for Optimising Business Objectives

Generally, in order to reduce their financial stress, most working capital constrained companies attempt to control their costs; including borrowing costs (Che and Sethi, 2014). Cost minimisation has drawn the attention of many scholars' in academia. However, business objective optimisation in managing credit borrowing portfolios from the perspective of working capital-constrained companies is still rarely discussed.

Credit borrowing activity is under the influence of various factors, thus, different credit borrowing portfolios may vary in how they achieve business objectives (Stango and Zinman, 2013). Based on the presentation in Chapter 2.3, abundant studies mention how certain business objectives are considered in credit borrowing activities, for instance, maximising the credit-borrowing amount (Jimenez *et al.*, 2006; Puro *et al.*, 2010; Banerjee and Duflo, 2014), and minimising the credit borrowing cost (Dehejiaa *et al.*, 2012; Wu, 2015). More broadly, in academia, some other business objectives are also considered regardless of credit borrowing activity, such as lead time minimisation (Kazim, 2015), backorder level (Sarkar *et al.* (2014), even multiple objectives including inventory levels, labour levels and backorder levels (Wang and Liang, 2005).

On this basis, regardless of a single objective or multiple objectives, this section aims to review the methods applied in past studies and also aims to identify an appropriate method to optimise business objectives addressed in Chapter 2.3. Table 3.9 summarises some studies which focuses on optimising certain business objectives.

Author(s)	Study Design	Subject	Contributions
Mason-Jones and Towill (1999)	Simulation	Minimising total cycle time in SCs	Minimising the total cycle time not only enables the retailer to hold smaller stock levels but also aids stock control. This improvement in inventory performance will benefit the retailer by making costs cheaper.
Spitter *et al.* (2005)	Linear Programming	Minimising the size of backorders	The development of two LPs aims to optimise the production plan, in order to achieve a minimum inventory cost and the cost caused by backorders.
Wang and Liang (2005)	Probable Linear Programming	Minimising three business objectives including: Inventory levels, Labour levels and Backorder levels	A probable LP model is designed to optimise multiple objectives, including maximising the possibility of achieving lower total costs and minimising the risk of higher total costs. This probable LP model adjusts overtime production rates, inventory levels, labour levels and the rate of backorders to optimise the two objectives
Roberts and Yuan (2010)	Empirical analysis	The influence of institutional structure on the cost of corporate borrowing bank credit	The study determines how some variables in one corporation may influence loan borrowing costs. These variables include market share, corporate size, total return, investment, sigma and turnover.
Lin *et al.* (2011)	Empirical analysis	Different ownership structures impact on the cost of corporate borrowing	There are five main variables which influence the corporate borrowing cost; borrower ownership, cash flow rights, borrower characteristics, loan characteristics and macroeconomic factors. These main variables contain 36 variables which have significant influence on borrowing costs.
Karjalainen (2011)	Regression analysis	Audit quality affects the borrowing cost	The quality of auditing significantly influences borrowing costs. A responsible auditor can contribute to a decreased borrowing cost.

Sanchez-Ballesta and Garcia-Meca (2011)	Regression analysis	The influence of ownership concertation and shareholder identity on the borrowing cost	This study discusses the influence of ownership from the perspective of both banks and firms. The investigation assumes that borrowing costs relate to both the structure of bank ownership and firm ownership. The analysis proves that firms with government ownership have lower borrowing costs.
Schmitt (2011)	Mathematical modelling	Risk of disruption caused by high total costs	This model tries to minimize the total cost by reducing disruption in the SC. The model aims to design a back-up inventory amount in order to fulfil any uncertain customer demands.
Arena and Dewally (2012)	Regression analysis	The influence of firms' location on borrowing costs	The study found that rural firms face higher borrowing costs. Banks are normally unwilling to spread credit to rural firms and they have less interest in attracting SMEs. Relationship banking is an effective approach to ensure that these kinds of firms can access enough capital.
Wu and Chua (2012)	Empirical analysis	Gender difference affecting the cost of bank loans	Female and male entrepreneurs encounter different costs in credit borrowing. The study found that commercial credit lenders charge female entrepreneurs more than males.
Chevallier (2012)	Stochastic Modelling	Emissions trading affecting the costs of banks and firms	This study discussed the costs of banks and borrowers in EU carbon trading markets. The result shows how a flexible borrowing schedule is associated with discounted interest and repayment rates.
Baghalian *et al.* (2013)	Mathematical modelling	Maximising fill rates to reduce the risk of disruption and maximise SC profit	Two objective functions are developed which aim to maximise SC profit and minimise the risk of disruption. A distribution schedule is created to optimise these two objectives.

Sawik (2014)	Empirical analysis	Maximising fill rate to meet customers' demands	This study develops two models with the objective of minimising expected worst-case cost and maximising expected worst-case CSL. Optimal order scheduling from both single and multiple product sources is created to achieve these two objectives.
Sarkar *et al.* (2014)	Simulation	Minimising backorder level in SCs	This study applies the EPQ model to formulate a single-type product purchasing SC. It focuses on controlling backorders to aid production which can minimise backorder costs and inventory levels over a single period.
Moussawi-Haidar *et al.* (2014)	Modelling	Total SC cost reduction through delayed repayment and discounted interest rates	The study proposed a coordination solution to minimise the total cost in a SC. With the help of permissible delay in repayments and discounted interest rates, using trade credit can benefit the whole SC by providing minimum costs associated with an optimal inventory.
Sawik (2015)	Mathematical Modelling	Fulfilling customers' demands on time	The model develops two objectives. The first objective is to maximise CSL by controlling unfulfilled demands and the second objective is to minimise the total cost. An optimal production schedule is created to achieve these two objectives.
Kazim (2015)	Stochastic modelling	Reducing lead-time in SCM	The model aims to minimise the lead-time in SCM. Through improving errors in inventory information, the lead-time can be reduced for the whole SC. As a result, this model benefits the SC by creating cheaper total cost and an increased CSL.

Table 3.9. Cost minimisation in Credit borrowing studies

Table 3.9 provides a summary of some past studies related to multiple types of business objectives in SCM. These papers provide an insight into how scholars determine and optimise each business objective. Based on this review, two points can be concluded including:

1. Mathematical modelling has been applied to the study of SCM.
2. Both single objective and multiple objective problems can be optimised through developing appropriate mathematical models.

According to the description of Luca Mattia *et al.* (2016), in terms of methodology, the adoption of mathematical modelling will be required more in future studies. Their study listed three main reasons why modelling is necessary for the study of credit borrowing activities in SCM. Firstly, the data and results achieved through this empirical approach are not strong enough to study financial flow operations in SCs. Secondly in practice, empirical analysiscontributes less towards improving credit portfolio management.

Indeed, mathematical modelling is a tool used to complement other methods in SCM study. According to the description by Min and Zhou (2002), models of optimization are normative and aim to formulate the best solution to a problem. Models of simulation, on the other hand, are descriptive and aim to describe how a SC operates in a given set of circumstances. In this way, applying a mathematical model can test a SCM problem and provide a reasonably accurate prediction or improvement plan (Aissaoui *et al.*, 2007). Furthermore, mathematical modelling benefits scholars by providing a systemic analysis with repeatable results. The model also can be refined by changing the variables (Comelli *et al.*, 2008).

3.6 Summary

The first part of this chapter introduces the approaches of AHP and the survey. The AHP introduction explains the three main aspects, including how AHP organises borrowers' concerns into the hierarchy structure; how the priority of these concerns is measured based on the markings collected by the survey; and how a CR test is used to evaluate the validity of the measurements.

In the survey design section, four aspects explain how the thesis investigates in detail the markings of capital constrained companies on the selected concerns. The first part introduces how the type of questionnaire was selected based on the suggestions of other scholars. Secondly, it develops the questions in the questionnaire following the AHP hierarchy framework. Thirdly, it states how the respondents are selected and explains how the survey will be conducted. The

investigation was conducted based on ethics requirements. Ethical issues follow the suggestions of some scholars and are presented in the final section.

Moreover, this chapter also develops a review of the methods used to optimise business objectives. The review of relevant studies provides an insight into how other studies conduct the optomisation of business objectives. Modelling has been employed to observe the impact of appointed concerns on borrowers' credit preferences and to optimize different objectives in dynamic credit portfolio selection. Specifically, credit portfolio management is no longer an individual activity in SCM. As a part of financial flow management, credit portfolio management should link with material flow management in SCs (Gjerdrum *et al.*, 2002; Erik, 2009; Yang and Birge, 2013; Pal *et al.*, 2014).

Based on the introduction of AHP and the survey, the following chapter will adopt the AHP method to evaluate the markings collected by survey. The result of the evaluation should present the ranking of all concerns in the framework in order of importance, which refers to the level of influence of credit borrowers' concerns regarding their preference for alternative credit sources. In chapter 4, the markings collected by the certain respondents will be analysed using the AHP measurement.

PART 3 EMPIRICAL ANANLYSIS AND MODEL DEVELOPMENT

Chapter 4 Analysis of Credit Borrowers' Concerns Using AHP

4.1 Introduction

Working capital constrained companies apply for credit from multiple credit providers simultaneously. Some current studies suggest that the credit-borrowing problem has been widely extended to become a multiple sourcing problem. Many scholars have not been limited to single credit sourcing. Murfin and Njoroge (2015) investigated some large retailers using trade credit from their small suppliers. Their study found that the slow repayment of borrowers was caused by small financial investment from suppliers. This action may mean that suppliers have to endure a longer wait time before they can see a profit, it may also make suppliers less willing to offer trade credit. Therefore, for a large working capital constrained borrower, multiple credit sources can guarantee them access to enough capital. Lin and Chou (2015) continued to compare BL and TC for working capital constrained companies. Their study investigated both large enterprises and SMEs in using BL and TC. It found that supply and utilization of TC were decreasing. More working capital constrained companies are likely to access both to raise sufficient capital.

Intuitively, when facing multiple types of short-term credit, working capital constrained companies will need to determine the borrowing amount from a particular credit provider based on their requirements and multiple factors. The literature review highlighted the importance of studying credit borrowers' concerns. Meanwhile, to understand how these concerns influence borrowers' credit portfolio selection, this chapter proposes a framework to optimise borrowing amounts under the influence of different multiple factors. To achieve this aim, the study first employs the analytical hierarchy process (AHP) to determine the priority and the relative importance of multiple factors influencing borrowers' decision-making and then uses linear programming (LP) to optimise the borrowing amount based on the priority ranking. The effectiveness of the proposed framework is verified in a numerical case presented at the end of the study.

4.2 Empirical Analysis and Results

4.2.1 Profiles of the Respondents

In the initial stage, 25 questionnaires were sent out and 23 returned. These 23 questionnaires were all tested using the consistency test required by the AHP pairwise comparison. Only 17 questionnaires passed the consistency test. The profiles of the respondents are listed in the following Table 4.1.

Company Category	Company Size	Development Phase	Credit History	Number of Respondents
Service industry (Private)	SME	Maturity	No bad debt	5
Mining facilities industry (Private)	SME	Maturity	No bad debt	2
Manufacturing industry (Private)	SME	Maturity	No bad debt	3
Publishing industry (State-owned)	SME	Maturity	No bad debt	1
Publishing Industry (Private)	SME	Rapid growth	No bad debt	1
Service industry (Private)	SME	Decline	With bad debt	1
Manufacturing industry (Private)	SME	Rapid growth	No bad debt	3
Construction industry (Private)	SME	Start-up	With bad debt	1

Table 4.1. The information of the respondents in answering the questionnaire

4.2.2 Weight of Criteria in AHP Structure and Consistency Ratio Test

Following the procedure designed in the methodology, the questionnaire was sent out for data collection. To answer the question addressed in Section 3.4.2, the collected data will be evaluated to provide two kinds of information, including priorities of borrowers' considerations in choosing short-term credits, and their preferences for the alternative credits. The questionnaire collected data from 17 companies. In the first stage of data collection, the feedbacks present the respondents' marks in the comparison. These marks denote the importance of the marked criterion comparing with another one. The participants marked each criterion with following the marking scale in Table 3.4. In order to explain how calculating the

weights of criteria through pairwise comparison, a respondent has been selected as the example to explain calculation process.

The AHP hierarchy structure in Section 3.3.3 (Figure 3.1) was first introduced and explained to the respondent. Presenting the AHP hierarchy structure aims to guide the respondent to understand the objectives and the achievement. The respondent firstly reviewed the AHP hierarchy structure and then compared the importance from main criteria to sub criteria. The comparison follows the pairwise sequence, in which A compares with B, C and D, respectively. The rest of the main criteria follow the same pairwise comparison sequence. As a result, based on the rating scale, the importance of the main criteria is marked in the following way Table 4.2.

	Main Criteria			
	A	**B**	**C**	**D**
A	1.000	3.000	7.000	2.000
B	0.333	1.000	3.000	0.500
C	0.143	0.333	1.000	0.200
D	0.500	2.000	5.000	1.000
Sum	1.976	6.333	16.000	3.700

Table 4.2. The marking of one respondent for main criteria

Table 4.2 indicates that the respondent first compares Criterion A (costs) and Criterion B (organizations' conditions). The result of the comparison between these two criteria is presented in Table 4.2. Following the marking scale in Table 3.4, marking 3 indicates that for the respondent, cost evaluation is of moderate importance. In other words, costs are a moderately important criterion, it will be considered as a priority by the respondent when selecting short-term credit. Based on this logic, the marks of A compared with B, C and D are 3, 7 and 2, respectively. After the respondent has marked all the main criteria, the weight of these main criteria can be calculated. The calculation uses an equation to measure the weight, presented as Equation (1) (Page 111). As a result, the collective weight of main criteria can be calculated as in Table 4.3.

	A	B	C	D	Weight	Priority
A	0.506	0.474	0.438	0.541	0.48944	1
B	0.169	0.158	0.188	0.135	0.16230	3
C	0.072	0.053	0.063	0.054	0.06037	4
D	0.253	0.316	0.313	0.270	0.28789	2

Table 4.3. The weights of main criteria

In Table 4.3, the respondent compares the importance of the criteria one by one. It achieves different weights by comparing them with different criteria, for example A is compared with A to get a weight of 0.506 and A is compared with B to get a weight of 0.474. To calculate the final weight of A, it should average all these weights which A compares with each criterion. This produces a final weight of A which is 0.48944. Therefore, the weights of B, C and D can be achieved by averaging out all the values in each row. The weights of B, C and D are 0.16230, 0.06037, and 0.28789 respectively. It can be seen that costs (A) are the most important consideration influencing lender selection.

However, before confirming the validity of the weight of these criteria, the consistency ratio (CR) should be measured. Measuring the CR aims to evaluate the trustworthiness of the respondent's judgement. In this context, the value of the CR is equal to $\frac{\text{CI}}{RI}$, where CI stands for consistency index and RI is random-like matrix. The CI is achieved through the equation $\frac{\lambda_{max}-\text{n}}{\text{n}-1}$, where λ_{max} is the average of the division of the weighted sum vector (WSV). To calculate the WSV, which is equal to the weight of each criterion × marking in each row (as shown in Table 4.2), such as the WSV of A = 0.48944 × 1 + 0.16230 × 3 + 0.06037 × 7 + 0.28789 × 2 = 1.974707. Values of the WSV for the remaining three criteria give 0.650499, 0.241967, and 1.159057, respectively.

To achieve λ_{max}, first divide the values of the WSV by the corresponding weight of each criterion as shown in Table 4.3, such as the division of Criteria A = 1.974707/ 0.48944 = 4.034649. The others can be calculated as 4.007978, 4.008158, and 4.026001. Thus, the mean of these values is 4.019197 and that is the estimate for λ_{max}. As the value of λ_{max} is known, the value of CI could be calculated through the equation$\frac{\lambda_{\text{max}}-\text{n},}{\text{n}-1}$, where n is the number of criteria. As a result, CI = 0.006399. Using the CR equation, value of RI can be found. The values of RI are shown in Table 4.4.

n	1	2	3	4	5	6	7	8	9	10	11	12
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48

Table 4.4. The values of RI

(Saaty, 1990)

Based on Table 4.4, it can be seen that the value of RI is 0.90 where n is 4. The value of CR can then be calculated through $\frac{CI}{RI}$. The CR is 0.00711 which is smaller than 10%. This therefore proves that the respondent's judgements are trustworthy and confirms the validity of the weight of the main criteria. The whole data analysis procedure is presented as shown in Appendix II. The rest of the respondents' feedbacks were analysed by following the same procedure.

The issued questionnaire (as shown in Appendix I) collected information on borrowers' concerns from 17 respondents. In the first round of questioning, the respondents offered their marks in evaluating considerations when selecting loans and the weights of all the relative criteria were thus calculated in Table 4.5.

A	0.48944	D1	Approval Time	0.28466
		A2	Administration Fees	0.19720
		D4	Accuracy of Credit	0.15817
D	0.28789	D3	Lending Volume	0.13346
		D2	Repayment Period	0.12885
		A1	Interest Rate	0.09143
B	0.16230	B1	Openness	0.04933
		B3	Human Capital	0.04866
		C2	Debt-Credit Relationship	0.04180
C	0.06037	A3	Transaction Cost	0.04076
		B4	Business Duration	0.03691
		C1	Distance	0.03206
		B2	Organizational Structure	0.01243

Table 4.5. The ratings of criteria

Table 4.5 lists the value of importance of the considerations influencing borrowers' credit selection. It could be utilized as a way to compare the weight rating of these three categories of credit. In addition, these values are also utilized to calculate the rating of alternative credits.

The second round of data collection was designed as an investigation to find credit with a shorter approval time, lower administration fees, higher credit accuracy, a larger lending volume, more flexible repayment period and a lower interest rate. To achieve this aim, question list for a second round of data collection was established, which is shown as Question list 2 in Appendix I.

D1	Approval Time
A2	Administration Fees
D4	Accuracy of Credit
D3	Lending Volume
D2	Repayment Period
A1	Interest Rate

Table 4.6. Top 6 for influencing selecting consideration

4.3 Borrowers' Preference for Alternative Credits

Based on the result of Question List 1 in Appendix I, in all selected criteria which aim to measure their weights in influencing borrowers' borrowing consideration, the first round of AHP analysis confirms the weight ratings of these criteria and will select important criteria to measure the alternative credits' ratings (BL, TC and 3PLC). Therefore, in the second round of data collection, the borrowers' preference for alternative credit will be calculated taking into consideration the criteria of high importance from the first round.

	Bank Overdraft	**Trade Credit**	**3PL Credit**
Approval Time *	0.09632	0.27958	0.62410
Administration Fees *	0.10689	0.26581	0.62731
Accurate of Credit	0.14452	0.25063	0.60485
Lending Volume	0.12203	0.22679	0.65117
Repayment Period	0.12135	0.27084	0.60781
Interest Rate *	0.08564	0.29661	0.61776
Overall Rating	***0.11279***	***0.26504***	***0.62217***

Table 4.7. The Borrowers' Preferences for Alternative Credit

Table 4.7 provides an evaluation of borrowers' preferences for alternative credit. This evaluation is based on the survey which considers the criteria of the selected important concerns

in Table 4.6. The result of this evaluation presents the overall ratings of borrowers' preferences for these three credit sources. It can be seen that credit borrowers have a higher preference for 3PLC than for BO or TC when considering these six certain concerns. The ratings of BO and TC indicate that working capital constrained companies are less willing to select BO and TC. This result is similar to the description in the literature review depicting a demand for new credit sources.

4.4 Summary

Based on the responses to this survey, this chapter uses the AHP method to analyse the priority of borrowers' concerns. The AHP integrates the selected possible concerns into the hierarchy structure. Meanwhile, a survey is developed to measure the influence of these concerns by investigating professional accountants in working capital constrained companies. The marking from these respondents are used to measure the influence of the concerns on credit borrowers' credit selection, and concludes the six concerns with the highest priority. These concerns are important in influencing the credit selection of working capital constrained companies. Another survey was developed to investigate borrowers' preferences over BL, TC and 3PLC. This investigation measures borrowers' preferences while taking these concerns into consideration. The investigated respondents compare these credit sources and record their preferences. As a result, out of theoverall ratings of BO, TC and 3PLC it can be concluded that 3PLC has more preference for the respondents.

This chapter first contributes the priorities of all selected concerns. By considering the concerns with a high priority, this chapter also conducts the preferences of some companies for BO, TC and 3PLC. These results develop an understanding on working capital constrained companies about their preferences to certain types of short-term credit. This understanding will be applied when answering the second research question, which aims to help borrowers to schedule their borrowing amounts in order to maximise borrowing amounts in dynamic periods. The following chapter will develop a model by adopting the LP technique. This model asseses concerns with a high priority and the preferences of borrowers for credit and then transfers them as components into the LP model.

Chapter 5 A Dynamic Solution to Optimise Credit Borrowing Quantities

5.1 Introduction

To get credit from various short-term credit sources, working capital constrained SMEs often obtain an optimal credit portfolio. However, whether a credit portfolio is influenced by the concerns of working capital constrained companies (Dehejiaa *et al.*, 2012; Erica Field *et al.*, 2012; Banerjee and Duflo, 2014). Thus, to determine a credit portfolio, important borrowers' concerns which have significant influence, it is necessary to involve the borrower's concerns with a signf be involved into the consideration (Lu *et al.*, 2013).

Chapter 4 has evaluated these concerns and summarised the most important concerns with a higher priority rating. These important concerns influence whether or not working capital constrained companies can access borrowing amounts from BO, TC and 3PLC. Additionally, different credit borrowing allocations may impact how working capital constrained companies achieve thier business objectives. Therefore, two questions have arisen: How can companies access borrowing amounts from BO, TC and 3PLC while considering these important concerns and how can business objectives be optimised through creating a credit portfolio. The following study aims to help a working capital constrained company to answer the above two questions.

To achieve this aim, this chapter aims to design a LP model to simulate the borrowing activity of a working capital constrained company in a SC. This LP model is able to access borrowing amounts from short-term credit sources. Meanwhile, certain concerns (As shown in Table 4.6) are considered and business objective of maximising the borrowing amount for a working capital constrained company is set.

5.2 The Setting of Objective Function and Constraints in the LP Model

This section describes a scenario modelling credit portfolio management. A LP model will be developed according to this scenario, those concerns of high importance will be set as constraints of this model. To develop this LP model, the following sections provide a description of the scenario, notation determination, objective functions and constraints.

5.2.1 The Description of Assumptions

In order to simplify the problem of credit portfolio management, this section assumes that a working capital constrained retailer exists in a SC. Apart from the retailer, this SC also includes a bank, a supplier and a 3PL company. As the retailer has zero initial capital, it needs to access a certain amount of capital in each period, so as to continue a business contract with the supplier to fulfil fixed market demands.

In this SC, the retailer can access BO, TC and 3PLC from the bank, the supplier and the 3PL company, respectively. The retailer aims to develop a credit portfolio that consists of these three types of working capital, in order to maximise the overall borrowing amount (OBA) to operate procurement in each period. However, the determination of a credit portfolio is influenced by the series of concerns mentioned in Table 4.6. These concerns, including approval time, administration fees, credit issued time, lending volume, repayment period and interest rate, have been shown to significantly influence the retailer's preferences for credit sources and affect the borrowing amounts. Thus, an optimal credit portfolio should satisfy the retailer's business objective of maximising OBA, meanwhile, it should be able to address the concerns.

To simplify this scenario, the items are delivered instantly once the payment has been made by the supplier. In addition, the main role of the 3PL industry is to provide 3PLC to the retailer, logistics services are not a responsibility of the 3PL due to the instant delivery.

5.2.2 The Setting of Notations

The objective of the LP model is to maximise OBA. As this objective depends on the borrowing amounts and preference for credit sources, the model determines the borrowing amount from each credit source as the variable and the preferences as the coefficients. The variables should be subject to the concerns listed in Table 4.6. This LP model will be transferred into a mathematical equation by using the following notations.

i: The type of short-term credit (1= BO, 2= TC, 3= 3PLC)

n: Number of days in each period

m: The number of period (m=1…, T)

v_i: Maximum lending volume of i^{th} type of short-term credit

t_i^m: Approval waiting period of each borrowing from i^{th} type of credit in m^{th} period

f_i^m: Percent of administration cost in each borrowing from i^{th} type of credit in m^{th} period

r_i^m: Interest rate of i^{th} type of short-term credit in m^{th} period

p_i: Repayment period of i^{th} type of short-term credit

o_i^m: Occurrence rate of i^{th} lender issued credit inaccurately in m^{th} period

d_i^m: Extra waiting period when i^{th} type of credit issued delay in m^{th} period

b_i^m: Binary variables equal 1 if the i^{th} type of credit is borrowed in m^{th} period

e_i^m: Binary variables equal 1 if the repayment of i^{th} type of credit is due in m^{th} period

C_1: Maximum acceptable rate of waiting cost in overall borrowing

C_2: Maximum acceptable rate of administration cost in overall borrowing

C_3: Maximum acceptable rate of interest payment in overall borrowing

C_4: Fixed borrowing setup cost in each time credit borrowing

C: Daily waiting cost of the borrower

A_m: The amount of capital left at the end of m^{th} period (Available for $m^{th} + 1$ period)

S_1: Unit product purchasing price from the supplier

S_2: Unit product selling price to the market

D_m: Fixed market demand of the product in each period

T: The period of a contract (T≥m)

B: A value equals infinity

5.2.3 The Objective Function

The objective of the LP model is to maximise the OBA of a working capital constrained retailer. In this model, maximising OBA is supposed to support the retailer in accessing sufficient short-term credit from the credit sources through a credit portfolio. Adams and Nehman (1979) stated that it should be a priority for borrowing activity to fully satisfy the capital demands. However, an unplanned borrowing can increase borrowing costs, for example through extra interest payments (Peters and Westerheide, 2009). This will be a burden to working capital constrained companies rather than benefit them, it could even directly damage business operations (Huston, 2012). Through an optimal credit portfolio, a company is able to access the overall borrowing amount through multiple credit sources satisfying certain business objectives (Banerjee and Duflo, 2014; Berg *et al.*, 2015). Thus, the credit portfolio in this model is going to provide a maximum working capital amount to a retailer, and then full fit concerns.

Using the results of the AHP, the important concerns are set as constraints of conditions. Optimal borrowing allocation refers to maximising OBA for working capital constrained retailer. To develop the objective function, a decision variable is introduced as follows:

x_i^m: Borrowing quantity for i^{th}type of short-term credit in the period m

With this notation, the objective function is to maximize the sum of the borrowing quantities from each type of short-term credit in all contract periods. Therefore, the objective function and its constraints in the linear model are designed as follows.

$$Maxmize\ (OBA) = \sum_{i=1}^{3} \sum_{m=1}^{T} x_i^m \qquad (5)$$

The constraints of the LP model should be set follow the results of AHP analysis, in which the rating of the weight of each criterion actually refers to the retailer's concerns when selecting a loan. Therefore, in order to design the constraints for this LP model, the priority should be to calculate the weight of all criteria and then sort these results in order of importance according to how they influence the retailer's concerns.

5.2.4 The Constraints

Working capital constrained companies apply for credit in order to fulfil their capital demands. While in the process of credit application, these credit borrowers compare and evaluate their credit sources, so as to determine one optimal credit portfolio selection. (Lu *et al.*, 2013) stated that the selection of an optimal credit portfolio should fulfil working capital constrained companies' business objectives and satisfy their various concerns. This section proposes to formulate each concern which achieved in AHP to the constraints of the objective function. Based on the above notations, the formula of each constraint in the model can be described as follows.

Approval Time & Credit Issued: Approval time is different and depends on the lender. Thus, the retailer needs to consider that the lenders' assessment may prolong waiting time and delay business operations. This period of time should be considered as a cost for the retailer's business activities. t_i^m refers to approval waiting time of i^{th} type of credit; the daily cost of the approval waiting period, is set as C.

The retailer should consider that lenders might occasionally be delayed in issuing credits with an occurrence rate o_i^m. Delays increase the waiting time t_i^m of the retailer and any extra waiting time is set as d_i^m. The cost of the overall waiting time should be less than the value of the maximum acceptable rate of overall waiting time for borrowing quantities from i^{th} type of credit. Therefore, approval time and credit issued should be considered together as a constraint, shown as the following Equation *(6)*.

$$\sum_{i=1}^{3}\sum_{m=1}^{T} C\ [t_i^m(1-o_i^m) + \ (t_i^m + d_i^m)o_i^m] \le C_1 \sum_{i=1}^{3}\sum_{m=1}^{T} x_i^m \qquad (6)$$

Administration Fees: Administration fees are handled by the retailer managing the credit and are also collected according to the borrowing quantity. f_i^m refers to what percentage of administration costs are in each borrowing quantity from ith credit source, ie: the borrower should pay $f_i^m x_i^m$ administration fees if they achieve x_i^m quantity of credit from i^{th} credit source in m^{th} month. The overall administration fees have been set as C_2. Therefore, this constraint is:

$$\sum_{i=1}^{3}\sum_{m=1}^{T} f_i^m x_i^m < C_2 \sum_{i=1}^{3}\sum_{m=1}^{T} x_i^m \qquad (7)$$

Lending Volume: x_i^m refers to the borrowing amount of the retailer from i^{th} type of credit in m^{th} month. As the assumption, which maximum lending volumes of each credit source is v_i. Therefore, this constraint is:

$$\sum_{i=1}^{3}\sum_{m=1}^{T} x_i^m \le v_i \qquad (8)$$

Apart from the above constraints, the retailer also has to consider the product procurement from the supplier in their first month. As the retailer has zero initial capital; thus, the borrowing amount for the first month cover the product procurement from the supplier, which is shown as Equation *(9)*.

$$\sum_{i=1}^{3}\sum_{m=1}^{T} x_i^m \ \ge \ S_1 D_m\,, m = 1 \qquad (9)$$

Credit Period and Interest Payment: Credit borrowing activity should include borrowing and repayment procedures. The retailer needs to consider repaying the lenders with certain interest

at the end of each credit period. The amount of interest depends heavily on the length of credit period. To calculate how the credit period influences the interest amount, the principal credit formula can be used, it is also recognized as a formula to calculate minimum interest payments (Broverman, 2010). Broverman (2010) stated some notations for organizing this formula.

r : Interest rate

n : Number of credit periods

PV : Credit amount of a borrower achieved from the credit source

C : Overall interest amount should be paid

By following the above notations, the formula used to calculate the overall interest amount can be presented as Equation *(10)*.

$$C = \frac{PV(1+r)^n r}{(1+r)^n - 1} \tag{10}$$

p_i is defined as the credit repayment period of i^{th} type of credit, and T is the number business period which refers to the period of requiring credit. Thus, the result of T being divided by p_i is the number of credit periods from i^{th} credit source. Therefore, $\frac{T}{p_i}$ replaces n in Equation *(10)* as the number of credit periods. Based on the known notations, x_i^m represents the credit borrowing quantity from i^{th} credit in m^{th} month, and r_i^m is the interest rate of i^{th} credit in m^{th} month, the overall interest payment to i^{th} credit can be displayed as the:

$$\sum_{i=1}^{3}\sum_{m=1}^{T}\frac{x_i^m(1+r_i^m)^{\frac{T}{p_i}}r_i^m}{(1+r_i^m)^{\frac{T}{p_i}}-1} \tag{11}$$

In this constraint, the maximum acceptable rate of interest payment in overall credit borrowing has been set as C_3 and the overall credit amount for the retailer is B. So C_3 times B is the maximum acceptable expenditure of the retailer paying interest to lenders. Combined with Equation *(11)*, the overall interest payment of the retailer to all lenders should not exceed the maximum acceptable interest payment. Therefore, this constraint can be developed as follows:

$$\sum_{i=1}^{3}\sum_{m=1}^{T}\frac{x_i^m(1+r_i^m)^{\frac{T}{p_i}}r_i^m}{(1+r_i^m)^{\frac{T}{p_i}}-1} \leq C_3\sum_{i=1}^{3}\sum_{m=1}^{T}x_i^m \tag{12}$$

Meanwhile, the retailer needs to repay the loan using profits from product sales. The fixed market demand for each month is D_m and the unit product selling price is S_2, so the income of the retailer for each month is $S_2 D_m$. As credit periods are different among these three types of

credit, the retailer needs to consider the due date of the repayment. p_i stands for the credit repayment period, which p_i divided by n $\left(\frac{p_i}{n}\right)$is the due date for credit repayment. Thus, credit should be re-paid from the retailer's income. In addition, the retailer should pay for the credit borrowing setup costs which occur when the retailer borrows from i^{th} credit in m^{th} period. Equation *(13)* presents the available capital amount of $m+1^{th}$ period after the retailer has repaid the loan and deducted borrowing setup costs.

$$S_2 D_m - \sum_{i=1}^{3}\sum_{m=1}^{T} x_i^m (1+r_i^m)^{\frac{p_i}{n}}\, e_i^m - C_4 \sum_{i=1}^{3}\sum_{m=1}^{T} b_i^m = A_{m+1} \qquad (13)$$

In addition, the relationship between x_i^m and b_i^m is presented as the Equation *(14)*,

$$x_i^m - B b_i^m \leq 0,\ \ b_i^m \in \{0,1\} \qquad (14)$$

5.3 Numerical Examples of Optimising Borrowing Quantities

5.3.1 The Scenario of Numerical Example

To test the model developed in Section 5.2, this section describes a scenario using numerical data. In this scenario, the retailer arranges a procurement plan from a supplier for 6 months. The procurement of the retailer aims to satisfy the demand for a single type of product in a market, which is 8,500 units per month. Based on the contract, the retailer needs to fulfil the market demand by providing a fixed amount each month. The retailer can purchase products from the supplier at a price of £197 per unit and sell to the market at £310 per unit. To simplify the model, each month consists of 30 days.

As the retailer is working capital constrained, there are three types of short-term credit provided to the retailer, in order to support product procurement from the supplier. A fixed borrowing setup cost is £30,000. This applies to each of the loans. In other words, borrowing from one credit source in a month will cost the retailer £30,000 another loan in the same month will double this cost. In the process of managing the credit portfolio, the maximum acceptable administration cost for the retailer takes up 20% of the credit-borrowing amount and the maximum acceptable interest payment takes up 35% of the credit-borrowing amount. Specifically, the approval time would cost the retailer £300 per day and the maximum acceptable rate for the approval time takes 3% of each credit-borrowing amount. As the

business contract lasts 6 months, the retailer must repay the loan with the required interest at the end of 6th month.

The details about interest rates, repayment periods and maximum lending volumes of these three credits are introduced as the following Table 5.1.

	BO	**TC**	**3PLC**
Interest Rate/month r_i^m	6.15%	6.00%	5.80%
Repayment Period (Days) p_i	90	60	30
Monthly Maximum Lending Volume (Million) v_i	1.1	0.9875	0.8
Occurrence Rate of Inaccurate Credit (per month) o_i^m [Extra Waiting Time t_n]	0.010% [3]	0.015% [2]	0.013% [2]
Percent of Administration Fees f_i	2%	1.7%	1.5%
Approval Length (Days) t_i	4	3	3

Table 5.1. The basic information of each credit source

5.3.2 Optimisation Allocation for Borrowing Quantities

Following the numerical data presented in Section 5.3.1, the objective function and constraints in Section 5.2 can be written as the following equations:

$$Max.OBA = x_1^1 + x_1^2 + x_1^3 + x_1^4 + x_1^5 + x_1^6 + x_2^1 + x_2^2 + x_2^3 + x_2^4 + x_2^5 + x_2^6 + x_3^1 + x_3^2 + x_3^3 + x_3^4 + x_3^5 + x_3^6$$

Subject to,

Overall Waiting Costs:

$6 \times \{300 \times [4 \times (1 - 0.01\%) + 0.01\% \times (4 + 3)]\} \leq 3\%(x_1^1 + x_1^2 + x_1^3 + x_1^4 + x_1^5 + x_1^6)$,

$6 \times \{300 \times [3 \times (1 - 0.017\%) + 0.017\% \times (3 + 2)]\} \leq 3\%(x_2^1 + x_2^2 + x_2^3 + x_2^4 + x_2^5 + x_2^6)$,

$6 \times \{300 \times [3 \times (1 - 0.015\%) + 0.015\% \times (3 + 2)]\} \leq 3\%(x_3^1 + x_3^2 + x_3^3 + x_3^4 + x_3^5 + x_3^6)$,

Administration Fees:

$0.02(x_1^1 + x_1^2 + x_1^3 + x_1^4 + x_1^5 + x_1^6) + 0.017(x_2^1 + x_2^2 + x_2^3 + x_2^4 + x_2^5 + x_2^6) + 0.015(x_3^1 + x_3^2 + x_3^3 + x_3^4 + x_3^5 + x_3^6) \leq 0.20(x_1^1 + x_1^2 + x_1^3 + x_1^4 + x_1^5 + x_1^6 + x_2^1 + x_2^2 + x_2^3 + x_2^4 + x_2^5 + x_2^6 + x_3^1 + x_3^2 + x_3^3 + x_3^4 + x_3^5 + x_3^6)$,

Maximum Lending Volume:

$x_1^1 + x_1^2 + x_1^3 + x_1^4 + x_1^5 + x_1^6 \leq 1{,}100{,}000,$

$x_2^1 + x_2^2 + x_2^3 + x_2^4 + x_2^5 + x_2^6 \leq 987{,}500,$

$x_3^1 + x_3^2 + x_3^3 + x_3^4 + x_3^5 + x_3^6 \leq 800{,}000$

Interest Payment: based on the Equation *(12)* which is:

$0.55(x_1^1 + x_1^2 + x_1^3 + x_1^4 + x_1^5 + x_1^6) + 0.37(x_2^1 + x_2^2 + x_2^3 + x_2^4 + x_2^5 + x_2^6) + 0.20(x_3^1 + x_3^2 + x_3^3 + x_3^4 + x_3^5 + x_3^6) \leq 0.35(x_1^1 + x_1^2 + x_1^3 + x_1^4 + x_1^5 + x_1^6 + x_2^1 + x_2^2 + x_2^3 + x_2^4 + x_2^5 + x_2^6 + x_3^1 + x_3^2 + x_3^3 + x_3^4 + x_3^5 + x_3^6),$

Credit Demand in Each Month

Month 1: $x_1^1 + x_2^1 + x_3^1 \geq 8{,}500 \times 197,$

Month 2: $x_1^2 + x_2^2 + x_3^2 + A_2 \geq 8{,}500 \times 197,$

Month 3: $x_1^3 + x_2^3 + x_3^3 + A_3 \geq 8{,}500 \times 197,$

Month 4: $x_1^4 + x_2^4 + x_3^4 + A_4 \geq 8{,}500 \times 197,$

Month 5: $x_1^5 + x_2^5 + x_3^5 + A_5 \geq 8{,}500 \times 197,$

Month 6: $x_1^6 + x_2^6 + x_3^6 + A_6 \geq 8{,}500 \times 197$

Available Credit Amount for the Following Month

Month 1: $8{,}500 \times 310 - x_3^1(1 + 5.80\%) - 30{,}000\ (b_1^1 + b_2^1 + b_3^1) = A_2,$

Month 2: $8{,}500 \times 310 - x_2^1(1 + 6.00\%)^2 - x_3^2(1 + 5.80\%) - 30{,}000\ (b_1^2 + b_2^2 + b_3^2) = A_3,$

Month 3: $8{,}500 \times 310 - x_1^1(1 + 6.15\%)^3 - x_2^2(1 + 6.00\%)^2 - x_3^3(1 + 5.80\%) - 30{,}000\ (b_1^3 + b_2^3 + b_3^3) = A_4,$

Month 4: $8{,}500 \times 310 - x_1^2(1 + 6.15\%)^3 - x_2^3(1 + 6.00\%)^2 - x_3^4(1 + 5.80\%) - 30{,}000\ (b_1^4 + b_2^4 + b_3^4) = A_5,$

Month 5: $8{,}500 \times 310 - x_1^3(1 + 6.15\%)^3 - x_2^4(1 + 6.00\%)^2 - x_3^5(1 + 5.80\%) - 30{,}000\ (b_1^5 + b_2^5 + b_3^5) = A_6,$

Month 6: $8{,}500 \times 310 - x_1^4(1 + 6.15\%)^3 - x_2^5(1 + 6.00\%)^2 - x_3^6(1 + 5.80\%) - x_1^5(1 + 6.15\%)^2 - x_2^6(1 + 6.00\%) - x_1^6(1 + 6.15\%) - 30{,}000\ (b_1^6 + b_2^6 + b_3^6) = A_7\ ,$

Therefore, based on the above objective function and constraints, this LP can be simplified to the following context.

$$Max.OBA = x_1^1 + x_1^2 + x_1^3 + x_1^4 + x_1^5 + x_1^6 + x_2^1 + x_2^2 + x_2^3 + x_2^4 + x_2^5 + x_2^6 + x_3^1 + x_3^2 + x_3^3 + x_3^4 + x_3^5 + x_3^6$$

Subject to,

$240{,}018 \leq x_1^1 + x_1^2 + x_1^3 + x_1^4 + x_1^5 + x_1^6 \leq 1{,}100{,}000,$

$180{,}020.4 \leq x_2^1 + x_2^2 + x_2^3 + x_2^4 + x_2^5 + x_2^6 \leq 987{,}500,$

$180{,}018 \leq x_3^1 + x_3^2 + x_3^3 + x_3^4 + x_3^5 + x_3^6 \leq 800{,}000,$

$0.75(x_1^1 + x_1^2 + x_1^3 + x_1^4 + x_1^5 + x_1^6) + 0.54(x_2^1 + x_2^2 + x_2^3 + x_2^4 + x_2^5 + x_2^6) +$

$0.35(x_3^1 + x_3^2 + x_3^3 + x_3^4 + x_3^5 + x_3^6) \leq 0.55(x_1^1 + x_1^2 + x_1^3 + x_1^4 + x_1^5 + x_1^6 + x_2^1 +$

$x_2^2 + x_2^3 + x_2^4 + x_2^5 + x_2^6 + x_3^1 + x_3^2 + x_3^3 + x_3^4 + x_3^5 + x_3^6),$

$2{,}635{,}000 - 1.058x_3^1 - 30{,}000\ (b_1^1 + b_2^1 + b_3^1) = A_2,$

$2{,}635{,}000 - 1.1236x_2^1 - 1.058x_3^2 - 30{,}000\ (b_1^1 + b_2^1 + b_3^1) = A_3,$

$2{,}635{,}000 - 1.1961x_1^1 - 1.1235x_2^2 - 1.058x_3^3 - 30{,}000\ (b_1^1 + b_2^1 + b_3^1) = A_4,$

$2{,}635{,}000 - 1.1961x_1^2 - 1.1235x_2^3 - 1.058x_3^4 - 30{,}000\ (b_1^1 + b_2^1 + b_3^1) = A_5,$

$2{,}635{,}000 - 1.1961x_1^3 - 1.1235x_2^4 - 1.058x_3^5 - 30{,}000\ (b_1^1 + b_2^1 + b_3^1) = A_6,$

$2{,}635{,}000 - 1.1961x_1^4 - 1.1236x_2^5 - 1.058x_3^6 - 1.1268x_1^5 - 1.06x_2^6 - 1.0615x_1^6 -$

$30{,}000\ (b_1^1 + b_2^1 + b_3^1) = A_7,$

$x_1^1 + x_2^1 + x_3^1 \geq 1{,}674{,}500,$

$x_1^2 + x_2^2 + x_3^2 + A_2 \geq 1{,}674{,}500,$

$x_1^3 + x_2^3 + x_3^3 + A_3 \geq 1{,}674{,}500,$

$x_1^4 + x_2^4 + x_3^4 + A_4 \geq 1{,}674{,}500,$

$x_1^5 + x_2^5 + x_3^5 + A_5 \geq 1{,}674{,}500,$

$x_1^6 + x_2^6 + x_3^6 + A_6 \geq 1{,}674{,}500,$

$x_i^m - B\ b_i^m \leq 0$, m=1…,6 and i =1, 2, 3

$b_i^m \in \{0,1\}$

$x_i^m \geq 0$

The above LP model assumes acredit portfolio for the retailer made up of BO, TC and 3PLC. The formulation of the LP model allows an optimal credit portfolio to be created, which helps the retailer to access borrowing amounts from three credit sources per month. Table 5.2 presents this credit portfolio management over a 6- month period.

Month	BO	TC	3PLC	Overall Borrowing	Available Capital	Capital Demand
1	286,657.35	587,842.65	800,000.00	1,674,500.00	888,600.00	1,674,500.00
2	803,040.36	-	-	803,040.36	1,674,500.00	785,900.00
3	-	-	300,222.17	300,222.17	1,674,500.00	-
4	-	-	-	-	1,674,500.00	-
5	-	-	624,291.12	624,291.12	1,674,500.00	-
6	-	987,500.00	800,000.00	1,787,500.00	141,850.00	-
Amount of Each Credit (£)	1,089,697.71	1,575,342.65	2,524,513.29	5,189,553.65		
OBA (£)	5,189,553.65					

Table 5.2. The optimal allocation of credit portfolios from BO, TC and 3PLC

5.4 Summary

This chapter helps one working capital constrained retailer to access borrowing amouts from multiple types of short-term credit with specific concerns. The integration of AHP and LP determines the importance of borrowers' concerns and then offers an optimal borrowing portfolio. This integrated method could be used to improve how borrowers select credit from multiple credit sources. AHP evaluates the importance of borrowers' concerns and their preferences for alternative credit. In this way, utilizing a LP model is a technique to consider important concerns into short-term credit portfolio management. In this chapter, a short-term credit portfolio management, which allocates borrowing amounts from different types of short-term credit, is not limited to one scenario. When considering more concerns, this solution can be utilized in more scenarios in the future.

Generally, this chapter gives an insight into borrowers' concerns and helps them to optimize the amount of credit they are able to borrow. The findings are as follows:

1. Both qualitative and quantitative borrowers' concerns have been considered. Utilizing AHP integrates these criteria into the same hierarchy structure, to avoid deviation which might happen when using two different systems.

2. The data from the questionnaire truly reflects the importance of borrowers' concerns.

3. Borrowers' concerns are identified and rated according to their importance. The ranking of concerns highlights those which are deemed to be of high importance.These concerns may vary depend on how working capital constrained companies aim to control their credit borrowing.

4. Integration of AHP and LP offers a strategy to optimise borrowing quantities. AHP provides constraints and coefficients of variables for LP and LP optimizes borrowing quantities. Changing the AHP criteria would transform thedifferent constraints in theLP model and form another scenario.

Chapter 6 Dynamic Credit Portfolio Design for Optimising Multiple Objectives

6.1 Introduction

Chapter 5 provides a solution on how to arrange a credit portfolio selection for a working capital constrained company. This solution integrates the highly important concerns of the company and can maximise the overall amount using various types of short-term credit. However, maximizing OBA as a single business objective is not always realistic. Many studies consider different objectives when credit-borrowing. In the early stage of the multiple objectives in credit borrowing study, Nichols *et al.* (2005) mentioned borrowers no longer only consider borrowing costs in their credit portfolio design. In reality, cost reduction may be not the first priority (De Meyer *et al.*, 1989). Apart from credit borrowing costs, more studies focused on a range of other objectives. For instance, reducing overall costs by controlling the inventory (Badu *et al.*, 2012; Agarwal *et al.*, 2015; Berg *et al.*, 2015), mitigating lenders' risks by optimizing repayment periods (Teng *et al.*, 2012; Yu *et al.*, 2012; Cotugno *et al.*, 2013) and improving supply chain performance by increasing supply chain efficiency (Berg *et al.*, 2015; Wu and Zhou, 2015).

Many working capital constrained companies attempt to obtain enough capital from multiple credit sources by using credit portfolio. Meanwhile, they are likely to fulfil various business objectives, which may be conflicting or interactive (Ponsich *et al.*, 2013). While a single business objective can be impractical, considering multiple business objectives is a challenge when determining credit portfolio selection. A question raised is what business objectives have been considered in current studies. In the existing literature, most studies on credit lending and borrowing activities are from the perspective of credit lenders. Moreover, minimizing the credit risk has been more frequently discussed as an objective. At the early stage of studying credit portfolio, the effect of providing credit portfolio to reduce the default risk was debated by some scholars (Andersson *et al.*, 2001; Duffee and Zhou, 2001). These studies contributed to identifying an optimal credit portfolio that performed well in terms of risk reduction. Hibbeln (2010) described detailed risk parameters and measured these risks in different credit portfolios. As a result a better credit portfolio was presented which could improve risks in credit lending. Chen *et al.* (2014) investigated credit portfolio management in Chinese banks. It was found that, in order to reduce risks, the bank industry maintains portfolio diversification by lending credit to corporations and private companies. Apart from minimizing credit risks, some recent studies

considered more business objectives, such as profit making (Aouni *et al.*, 2014), interest rate enhancement (Tamborini, 2014) and even information sharing (Doblas-Madrid and Minetti, 2013).

The previous studies mainly considered single objectives from the perspective of credit lender. To improve the setting of single objectives, this chapter aims to consider multiple business objectives from the perspective of working capital constrained SMEs. The need to consider multiple business objectives makes it harder for SME's when making decisions (Ponsich *et al.*, 2013), and also affects how they manage their short-term credit portfolios. Therefore, to optimise multiple objectives, a multiple objective optimisation (MOO) model will be designed. The purpose of this MOO model is to integrate different business objectives and to determine a credit portfolio for credit borrowers in dynamic periods. In particular, the MOO model is designed to contain two business objectives including overall cost (OC) minimisation and backorder penalty cost (BPC) minimisation.

This chapter is organized as follows. In the second section, some past studies are reviewed in order to explain the reasons for focusing on the total cost and customer service level. The third section presents the model assumptions and defines the notations in the MOO model. In the fourth section, two non-linear programming models were developed, which aim to minimize OC and minimize BPC. They were then formulated in the MOO model to optimise both business objectives via a dynamic credit portfolio. A numerical example was provided at the end of the chapter.

6.2 Business Objectives in Supply Chain Management

> *"Business objectives are the benefits of a commercial organisation aiming to achieve at the end of the business."*
>
> Greenbank (2001)

In each business period, companies aim to fulfil specific business objectives, such as profit, market shares and other areas of development (Li and Ma, 2015). Business objectives vary,and they have been designed in various ways in many studies. The majority of studies focused on a single objective, especially in relation to credit borrowing activity. The design of multiple objectives is rarely discussed in this field, which can be said to be slightly unrealistic. (El-Kholy, 2014).

The design of multiple objectives is not new in the study of SCM. Multiple objectives have been widely designed in some SCM subjects. Sabri and Beamon (2000) attempted to improve operational planning by considering multiple objectives including cost minimisation, customer service level (CSL) and flexibility. Their study concluded that considering these multiple objectives can provide a more comprehensive solution when designing a decision system. Kumar *et al.* (2004) discussed that a perfect supplier should satisfy three objectives, which include minimum net cost, net rejections and net late deliveries. Kainuma and Tawara (2006) studied performance measurements in lean and green SCM and state that two objectives should be evaluated,; maximising environmental performance and maximising customer satisfaction. Vachon and Klassen (2008) also discussed manufacturing performance in terms of environmental issues. Their study evaluates product quality and delivery in the manufacturing process, it also defines how a collaborative manufacturing process can lead to good environmental performance with high quality and fast delivery in SC. Liu and Papageorgiou (2013) studied the problems of production, distribution and capacity planning in global SCM. This study models a company providing a single product to its global customers. The best SCM should fulfil the company's requirements of total cost, total flow time and total sales lost. As a result, the study provides various solutions as to how this company can manage its production, distribution and inventory, but one of the solutions is optimal in achieving the lowest cost, shortest flow time and minimum total lost sales. Kannan *et al.* (2013) discussed the problem of supplier selection and order allocation in a green supply chain. The discussion aimed to provide a solution to maximise the total purchasing value and minimise the total purchasing cost.

The above studies present different multi-objective problems related to SCM. According to the main purpose of this chapter, to optimizing multiple business objectives in a dynamic credit portfolio, it is necessary to be aware of what borrowers consider when borrowing credit. However, abundant researches have discussed this issue from the perspective of the credit lenders. In the rare studies of that do describe credit borrowers' behaviour, some of them present thier business objectives in terms of credit lending and borrowing. The following content will define the business objectives considered by working capital constrained companies.

6.2.1 Cost management in Credit Borrowing Activities

The priority when borrowing short-term credit is to fulfil the capital demands of working capital constrained companies. Credit borrowers are willing to apply for credit with lower costs than other options (Banerjee and Duflo, 2014). Expensive borrowing costs significantly increase the

companies' overall cost. Berg *et al.* (2015) investigated the total cost of working capital constrained companies in terms of borrowing credit. For working capital constrained companies with low creditworthiness, they have to pay higher fees to persuade a lender to issue credit. Their study debated how higher fees charged when borrowing credit may cause financial stress in working capital constrained companies.

Apart from the above studies, borrowing costs have also been discussed in some previous studies. Reducing borrowing costs as a main objective attracts the attention of many scholars. Some past literature studies from the perspective of credit borrowers discuss what factors influence the borrowing costs of working capital constrained companies (Sanchez-Ballesta and Garcia-Meca, 2011; Arena and Dewally, 2012; Martínez and León, 2015). These studies focus on the borrowing costs of working capital constrained companies and debate the influence of certain factors on credit borrowing costs. Through reviewing the relevant literature, it can be seen that there are abundant fiannce and accounting studies discussing credit borrowing costs. However, in the field of business management there are limited studies considering borrowing costs. In particular, studies considering credit-borrowing costs in SCM are still rare.

With the combination of credit borrowing and SCM, borrowing cost reduction is no longer the premier objective of credit borrowers. These capital constrained companies aim to reduce all costs occurring in their SCM. Therefore, the overall cost should include credit borrowing costs and needs to be a new business objective of SC financial management. Overall cost minimisation has been set as a main business objective in many SC mathematical modelling studies, for example Nagurney (2010) discussed SC network design and attempted to optimize the processes of manufacturing, storage and distribution for a minimum total cost. Yang and Birge (2013) studied the inventory management of retailers financing in the SC. Their study considered reducing costs including inventory and credit borrowing costs through an optimal credit borrowing portfolio. Murfin and Njoroge (2015) stated that the aim of borrowing credit is to release financial pressure. Reducing borrowing costs is important but minimising the overall cost is more effective to avoid financial disruption.

6.2.2 Order Fulfilment and Backorder Level in Customer Service

Current studies related to SCM and logistics management, especially in inventory management, have addressed the importance of optimising customer service (F. Espino-Rodríguez and Rodríguez-Díaz, 2014; Shockley and Fetter, 2015). A system known as customer service level

(CSL) which measures what percentage of customer demand been satisfied, has been considered in SC performance evaluation (Bowersox *et al.*, 2002).

Some academics have explored the measurement of CSL from several perspectives. Commonly, CSL measurement focuses on certain aspects, such as backorder level (Gao *et al.*, 2010), overall order fulfilment (Tiemessen *et al.*, 2013), penalty cost due to backorders (Chung and Cárdenas-Barrón, 2012; Li and Muckstadt, 2013) and order cycle time (Sana, 2011; Wang *et al.*, 2014a). Specifically, some academics focus on minimising or managing backorder levels in certain SC models, for example Widyadana *et al.* (2011) aimed to minimise inventory costs in the Economic Order Quantity (EOQ) model while considering backorder level. Similarly, Chung and Cárdenas-Barrón (2012) compared the inventory costs in EOQ and Economic Production Quantity (EPQ) models while considering fixed backorder cost. Generally, backorder level and penalty cost due to backorders are considered to be significant factors which influence the overall cost of a SC and the customer wait time in SCM (Jin and Ryan, 2012; Kristianto *et al.*, 2012; Sieke *et al.*, 2012).

As mentioned above, CSL is measured from several perspectives. Fulfilling orders on time is treated as one of the primary goals in business management (Ramanathan, 2011) and it significantly influences SC performance and customer loyalty (Ramanathan, 2011; Lam *et al.*, 2015). In this regard, the order fulfilment ratio (OFR) (Meisel and Bierwirth, 2014; Lam *et al.*, 2015) and order fulfilment time (OFT) (Acimovic and Graves, 2014; Croson *et al.*, 2014) are two elements used to measure order fulfilment. In SCM, order fulfilment is defined as:

> *"The process from the point of sales to deliveries of products to customer."*
>
> Croxton (2003)

Based on the definition of order fulfilment, order fulfilment time (OFT) is the period in which a supplier fulfils the buyers requirements regarding delivery date and delivery amount (Farahani *et al.*, 2011, p. 164). Some studies includes Lambert and Cooper (2000), Gunasekaran et al. (2001), Boyaci and Gallego (2004), Farahani and Elahipanah (2008), Ramanathan (2014), Gligor et al. (2015) and Sawik (2015), have also stated the importance of OFT when influencing CSL. It has been indicated that the shortening of the OFT can contribute a better CSL (Hong and Lee, 2013; Mishra and Singh, 2013). In SCM, order fulfilment is under the influence of the demand quantity and delivery distance (Chiang and Hsu, 2014). As in the description of Barkaoui *et al.* (2015), the management behind order fulfilment is complex. To reduce OFT,

the SCM is required to decide on an optimal schedule of inventory amounts and delivery management.

Apart from OFT, backorder level is another criterion for measuring CSL (Biswas and Narahari, 2004). Backorder is described as,

> *"An order that cannot be filled when presented and for which the customer is prepared to wait for some time."*
>
> Wang and Liang (2004)

Abad (2003) pointed out that backorder levels significantly influence order fulfilment. As the occurrence of backordering lengthens the wait time of customers (Ouyang and Chuang, 2001); companies consider minimising backorders to reduce wait time (Biswas and Narahari, 2004). Thus, the level of backorders, which is the amount of orders waiting to be fulfilled, influences the CSL of a company and even a SC (Lee, 2005). However, a SC with backordering has become more complex than common inventory management without backorders (Widyadana *et al.*, 2011). Specifically, this SC is also constrained by its working capital shortage, which requires the SC to fulfil market demand and working capital demand over dynamic periods. Therefore, an optimal solution, to fulfil working capital demands and minimise backorder penalty costs via managing backordering level, is necessary to develop a good CSL.

6.3 Notations and Assumptions Setting in the Model

6.3.1 Model Assumptions

This section will model a dynamic credit borrowing schedule for a working capital constrained retailer in a SC. It assumes that this SC includes a working capital constrained retailer, a supplier, a bank and a 3PL company. The working capital constrained retailer purchases one type of product from the supplier. The procurement of the retailer aims to fulfil the fixed dynamic market demands. Since this scenario is dealing with a working capital constrained retailer, in order to pay for each procurement, it needs to borrow short-term credit from the bank, the supplier or the 3PL company.

Apart from the procurement in each period, the retailer also needs to pay for transportation and inventories because the logistics service is provided by the 3PL company. Trucks provided by the 3PL company are supplied at a fixed price, however, the retailer will not be charged for 'dead freight' when several deliveries are needed.

To solve the working capital constraint problem, the retailer has access to three credit sources in this SC, BO from the bank, TC from the supplier, and 3PLC from the 3PL company. These three types of credit are different in lending volume, interest rate, payment period and credit delivery time. Additionally, they are also different in terms of how credit is issued. In detail, BO is the capital directly injected into the retailer. This part of the capital can be diverted to pay for product procurement, logistics services or any other business expenditures. TC is the entity of the actual products. It is different to BO as it only transfers the actual products or equivalent capital to the retailer. Using TC allows the retailer to receive products without instant payment. However, in this scenario, to reduce the default risk of the supplier, TC can only be lent with certain percentages. According to the introduction of 3PLC in Chapter 2.4.3, 3PLC is a type of credit that not only provides capital to working capital constrained retailers, but also offers a discounted charge for logistics services when 3PLC is borrowed. The assumption of 3PLC is also consistent with the current two studies by Chen and Xie (2009) and Chen and Cai (2011).

With the help of these three types of short-term credit, working capital constrained retailers may be able to raise capital for procurement. However, the retailer is limited by the bank, the supplier and the 3PL company regarding the maximum borrowing amount. Specifically, apart from TC which varies depending on procurement, the borrowing amounts of BO and 3PLC are fixed. Therefore, borrowing from multiple types of short-term credit, which constitutes a credit portfolio, will benefit the retailer by creating a high possibility of raising sufficient working capital.

There is a possibility of a situation arising in which the working capital constrained retailer could gain insufficient capital amounts from credit sources. Insufficient capital leads to backordering causing the retailer to be unable to satisfy the market unable the working capital constrained retailer may wish to gain enough capital amounts demand. In this scenario, the retailer will take a penalty regarding the number of backorders. Apart from the cost issue, the wait time for fulfilling these backorders is considered as an influence on customer service level.

Regarding insufficient capital for procurement, indeed, accessing credit from multiple sources will make it more likely for the retailer to receive enough capital than they were accessing credit from a single source. Thus, a problem for the retailer is how to dynamically determine a credit

portfolio using the distinctive features and conditions of short-term credit. To simplify the assumptions, this business scenario covers the following key points.

1. The initial budget of working capital constrained retailer is zero.
2. The product is a single type
3. Each business period has a fixed time slot.
4. The market demand of each period is known and constant.
5. The 3PL company has infinite inventory space.
6. Product supplement is not received instantaneously in the market.
7. All borrowed short-term credit should be repaid at the end of each business period.
8. The scenario allows shortages in business periods. There are backorders apart from at the end of the business period and the market must wait for the next replenishment which happens in the following period.

The above assumptions involve various business activities in SCM, e.g. product procurement, logistics and credit borrowing. Both material flow and financial flow have been considered. Based on this assumption, Figure 6.1 briefly describes two routes which represent material flow and financial flow. The solid line refers to the flow of product purchasing and logistics activity, and the dotted line denotes to the flow of credit borrowing.

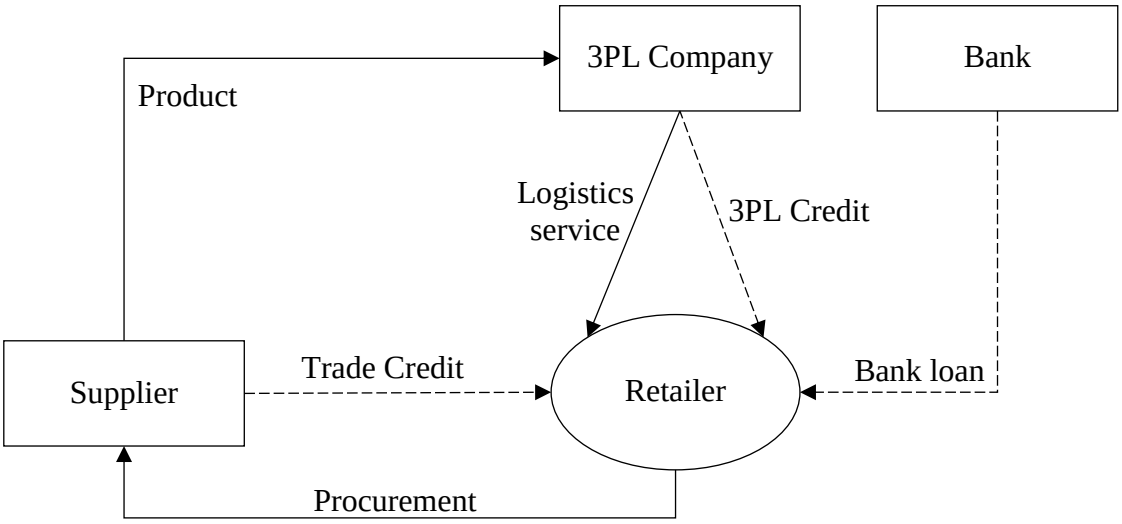

Figure 6.1. The description of model assumption

In Figure 6.1, the retailer purchases products from the supplier based on market demand. This SC follows the Production Quantity Management (PQM) model, which assumes that the market demand is deterministic and constant thus the retailer can plan the order quantity in advance. In the PQM model, the ordered items will arrive at a constant rate. This is significantly different to the EOQ model, in which the ordered items arrive instantly. The following Figure 6.2 presents the inventory level change over time in the PQM model. In the PQM model, the

ordered products are delivered gradually from the supplier to the retailer. The inventory will reach the maximum level in the 3PL company until the supplier delivers all products to the retailer. In the process of products being depleted, the retailer should place the order at the average inventory level. The new order begins to be delivered when the inventory in the previous order cycle is completely depleted. Therefore, the retailer needs to manage the credit application in advance, in order to guarantee enough capital to place a new order and pay other expenditures.

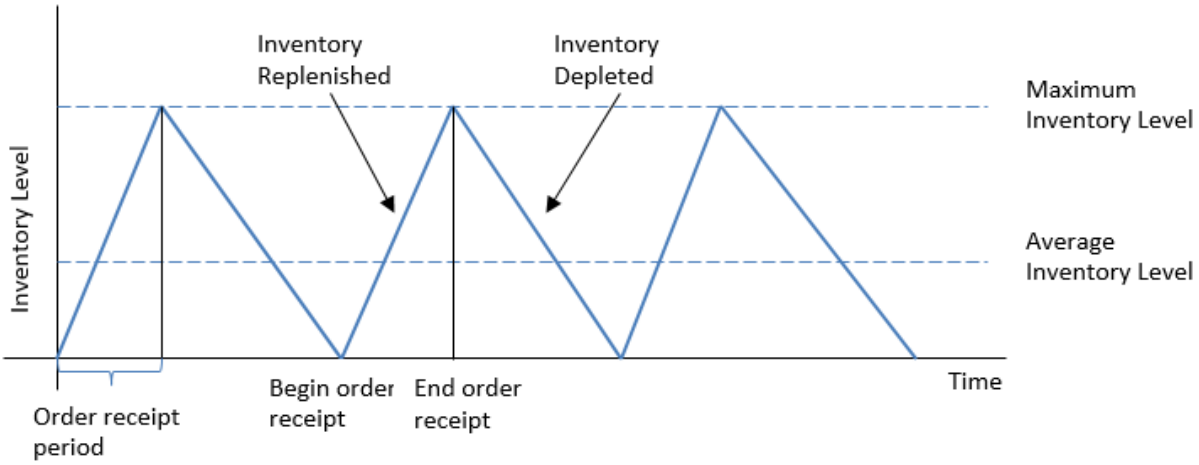

Figure 6.2. PQM Model

(Lee and Yao, 1998)

Using the PQM model, the market has a stable and constant demand of products in each period, e.g., each week. The demand is deterministic and known. According to the description of the PQM model, delivery is not instant but the arrival rate of ordered items is constant. Meanwhile, credit from the bank, the supplier and the 3PL company are different in terms of credit assessment and repayment. As per the requirements, the retailer should obey the settlement date and repay all fees and loans at the end of each credit period. Therefore, in order to minimise the overall cost and also minimise BPC via reducing the backordering level, the retailer has to schedule the credit borrowing time and also design credit portfolios by evaluating the terms and conditions of the credit.

The following section will present the notations for the modelling of this scenario. These notations are applied when designing non-LP (NLP) models, which can achieve these two objectives respectively through different dynamic credit portfolios. Furthermore, these NLP models are also used to formulate the MOO model in the following sections.

6.3.2 Notations

Based on the above description of the working capital constrained SC, in order to model this scenario, the following notations are defined. In all notations, the constants include:

t: A time horizon, where t = 1 to T

l: Number of the lender, $l = 1\ or\ 2\ or\ 3$.
1 represents bank overdraft (BO); 2 is trade credit (TC) and 3 is 3PL credit (3PLC)

Q^P: Overall product demand

d_t^P: Product demand in period t

D_1: Distance between the market and the retailer

D_2: Distance between the retailer and the supplier

R_t^C: Maximum lending rate in TC determined by the supplier

s^1: Setup cost of ordering products from the supplier

s_l^2: Setup cost of borrowing credit from l^{th} lender/type of short-term credit

s^3: Penalty cost due to lost sale for per unit of backorder

p^1: Ordering price for unit product from the supplier to the retailer

p^2: Selling price for unit product from the retailer to the market

d: Delivery fee charged based on distance and amount offered by the 3PL company

h: Holding cost for unit product per period by the 3PL company

r_l: The monthly interest rate of l^{th} lender

e.g. r_1: The monthly interest rate of BO

r_2: The monthly interest rate of TC

r_3: The monthly interest rate of 3PLC

R^h: Discount on holding cost if using 3PLC

R^d: Discount on delivering charge if using 3PLC

M_{lt}: Maximum lending amount of l^{th} lender in period t

E: The waiting time of receiving available products in the market

V: The Infinite value

A group of variables is defined as follows.

x_t^P: The procurement amount in period t

o_t: A binary variable; 1, if any product has been ordered in period t; 0, otherwise.

b_t: Amounts of backorders in period t

y_{lt}^{P}: The amount of short-term credit borrowed for procurement from l^{th} lender in period *t*

I_t^P: Inventory amount of product in period t

A_t^C: Available capital at the beginning of month *t+1*, such as A_0^C denotes the available capital in period 1

n_{lt}: A binary variable equal to 1 if any credit has been borrowed from l^{th} lender in period *t*

e.g. n_{1t}: BO is borrowed in period t if the variable equals to 1. 0, otherwise.

n_{2t}: TC is borrowed in period t if the variable equals to 1. 0, otherwise.

n_{3t}: 3PLC is borrowed in period t if the variable equals to 1. 0, otherwise.

6.4 Model for Multiple Objectives Simulation

In this section, two NLP models are developed, each of which will correspond to one of the two fore-mentioned business objectives. The first model aims to minimise the overall cost (OC) including operational and financial costs of the working capital constrained retailer. The second model aims to minimise BPC by reducing the level of backorders. Both models will lead the two different dynamic credit portfolios to satisfying their own objectives. In the last section, a MOO model is developed by adopting the GP method, which aims to develop a new dynamic credit portfolio to satisfy both OC minimisation and BC minimisation.

6.4.1 The PQM Model

The theory of the PQM model assumes a situation in which products are delivered gradually over time at a constant rate. Thus, the retailer receives the ordered products gradually correspondingly, whilst the inventory level is simultaneously being depleted. This situation can be depicted as Figure 6.2.

The PQM model aims to control the amount of inventory in the SC in order to minimise the overall cost. By solving this model, the optimal ordering quantity can be determined. Based on the introduction of the PQM model from Christopher (1992), this model can be presented by applying the following notations.

r: The production rate of the supplier

p: The ordering cost by the retailer

h: The inventory cost

d: The fixed demand in each period

D: The overall market demand

Q_{opt}: Optimal ordering quantity

Based on these notations, the equation to determine the optimal ordering quantity can be presented as follows:

$$\text{Optimal ordering quantity} = (Q_{opt}) = \sqrt{\frac{2p\,D}{\text{h}\left(1-\frac{\text{d}}{r}\right)}}$$

Following the theory of PQM, a model to minimise procurement and inventory costs can be developed. By applying the following notations, Equation *(15)* is designed to minimise the overall cost including procurement and holding inventory.

T: Planning horizon

t: A business period, t =1…, T

p: The production rate of the supplier

p_t: The ordering cost by the retailer in period t

h_t: The inventory cost in period t

d_t: The demand in period t

D: The overall market demand

Q_{opt}: Optimal ordering quantity

Based on the above notations, Equation *(15)* can be developed by applying the optimal ordering quantity, which can in turn help the retailer achieve a minimum overall cost. Equation *(15)* is presented as follows.

$$\text{Minimum TC} = \frac{p_t\,D}{Q_{opt}} + \frac{h_t\,Q_{opt}}{2} \times \left(1 - \frac{d_t}{p}\right) \qquad (15)$$

Through Equation *(15)*, the retailer can obtain a minimum total cost by ordering the optimal product quantity. Based on this equation, the section combines with the assumption described in Section 6.3.1 and develops an LP model by applying the notations in Section 6.3.2. This LP model can optimise the ordering quality in order to obtain a minimum total cost.

The LP formulation of the PQM model, which is shown as Equation (*16*), is presented as follows.

Minimise TC = Setup Cost + Inventory Cost

$$= \sum_t S_1 o_t + \sum_t h_t\,I_t^P \qquad (16)$$

s.t $I_t^P = x_t^p - d_t^P + I_{t-1}^P$, t = 1, … , T

$x_t^p \leq \mathrm{V}o_t$, t = 1, … , T

$0 \leq x_t^p \leq R_t^p$, t = 1, … , T

$\sum_t x_t^p \geq Q^P$, t = 1, … , T

$o_t \in \{0,1\}$, t = 1, … , T

The above LP model helps the retailer to minimise the total cost of product procurement and inventory in SCs. The results of this LP model should be able to determine an optimal ordering schedule over the whole business period.

Following the theory of the PQM model, the rest of the sections will model short-term credit borrowing activities by applying the assumptions and notations in Section 6.3. These models aim to optimise multiple objectives including OC minimisation and BPC minimisation.

6.4.2 A Model Used to Minimise Overall Cost

The first business objective is to minimise the overall cost in credit borrowing activities. Based on the model assumptions, the working capital constrained retailer has access to BO, TC and 3PLC. Meanwhile, it also needs to purchase products from the supplier by using a 3PL logistics service. The overall cost (OC) in this process includes the purchasing cost, purchasing setup cost, delivery cost, inventory cost, lost sale penalty caused by backorders, interest cost, and borrowing setup cost. Therefore, the objective function for minimising OC is presented as follows.

Minimise overall cost = Purchasing cost + Delivery cost + Inventory cost + Interest cost + Borrowing setup cost+ Purchasing setup cost

To simplify the narrative, a simple case has first been considered and formulated in which the working capital constrained retailer only borrows BO from the bank.

Minimise overall cost

$$= \sum_t x_t^P p^1 + \sum_t x_t^P d\,(D_1 + D_2) + \sum_t I_t^P h + \sum_t y_{1t}^P r_1 + \sum_t s^1 o_t + \sum_t s_1^2 n_{1t} \qquad (17)$$

For the constraints, procurement is influenced by the retailer's credit borrowing amount. Therefore, the borrowing amount should fulfil costs which the retailer spends on procurement, and any income at the end of the time slot, which consists of actual sales and available capital

from the previous period, should cover logistics services, setup costs and penalties from lost sales, and borrowing cost. The constraints of this NLP model are presented as follows.

Inventory amount：	$I_t^P = x_t^p + I_{t-1}^P - d_t^P + b_t - b_{t-1}$
Available Credit in Period 1：	$A_1^C = A_0^C + y_{1,0}^P + (x_0^P - I_1^P)p^2 - [x_0^p p^1 + s^1 o_0 + s_1^2 n_{1,1} + x_0^p d(D_1 + D_2) + I_1^P h]$
Available Credit from Period t：	$A_t^C = A_{t-1}^C + y_{1,t-1}^P + (x_{t-1}^P - I_t^P)p^2 - [x_{t-1}^p p^1 + s^1 o_{t-1} + s_1^2 n_{1t} + x_{t-1}^p d(D_1 + D_2) + I_t^P h] - y_{1,t-2}^P(1 + r_1)$, Where t = 2… T
Income should cover all the costs in period t	$A_{t-1}^C + \left(x_{t-1}^p - I_t^P\right)p^2 \geq x_{t-1}^P d(D_1 + D_2) + I_t^P h + s^1 o_t + s_1^2 n_{1t} + y_{1t}^P(1 + r_1)$
Fulfilling backorders should be less than the market demand in each period	$b_t - b_{t-1} \leq d_t^P$
Backordering amount should be zero when approaching in the final time slot	$b_t = 0$, where t = T
Overall Procurement Quantity	$\sum_t x_t^P \geq Q^P$
Overall BO amount should be able to pay the procurement	$\sum_t y_{1,t-1}^P \geq \sum_t x_t^P p^1 + \sum_t b_{t-1} p^1$
Borrowing amount is larger than 0 but limited by the maximum lending volume	$0 \leq y_{1t}^P \leq M_{1t}$
Procurement amount should less than the capital amount	$0 \leq x_t^p \leq \frac{y_{1t}^P}{p^1}$
Binary for procurement	$x_t^p \leq \mathrm{V} o_t$, V is the sufficient big value
Binary for borrowing	$y_{1t}^P \leq \mathrm{V} n_{1t}$
Inventory amount is larger than 0	$I_t^P \geq 0$
Backordering amount is larger than 0	$b_t \geq 0$
Available capital is larger than 0	$A_t^C \geq 0$
	$n_{1t} \geq o_t$

$$o_t \in \{0,1\}$$
$$n_{1t} \in \{0,1\}$$
$$t = 1\ldots, T$$

Once the model of BO borrowing in the PQM has been developed, some more credit sources can be considered into the credit borrowing problem. These newly introduced credit sources include TC and 3PLC. TC has an allowance relying on trust between borrowers and their suppliers. It allows companies to receive products or services first and then pay back within a specific period. Normally, suppliers only offer products or services as TC to borrowers, or the same amount of capital equivalent to products, or services. 3PLC is a type of credit offered by 3PL companies, it is similar to BO which can provide capital directly to borrowers, in addition, 3PL companies also offer a discount rate on logistics service charges to their 3PLC borrowers. By considering these two additional types of credit and combining them with BO, there are now three types of short-term credit are available to the retailer. In order to fulfil the fixed market demand each month, the retailer in this new model purchases products monthly from the supplier. Due to a working capital shortage, the retailer needs to access enough capital from these credit sources. In the process of scheduling borrowing, the retailer aims to minimise the overall cost. The overall cost mainly includes the procurement cost, delivery cost, inventory cost and borrowing cost. Specifically, in the situation of using 3PLC, the retailer can benefit from a discounted delivery charge and inventory service. Therefore, the model used to minimise TC should be modified taking 3PLC into account. A new non-LP model is developed considering borrowing from multiple short-term credit sources.

The objective function

Overall Cost = Procurement Cost + Delivery cost + Inventory cost + Interest cost + Purchasing Setup Cost + Borrowing setup cost

$$Min\ OC = \sum_t x_t^P p^1 + \sum_t x_t^P d\ (D_1 + D_2)(1 - R^d n_{3t}) + \sum_t I_t^P h(1 - R^h n_{3t}) + \sum_t \sum_l y_{lt}^P r_l + \sum_t s^1 o_t + \sum_t \sum_l s_l^2 n_{lt} \quad (18)$$

For the constraints, the retailers' overall credit borrowing amount should satisfy the capital demand in terms of operating procurement, delivery and inventory. Specifically, one feature of TC, is that the maximum lending amount of each period is equivalent to the product procurement price of each period. The constraints of this NLP model are presented as follows.

$$I_t^P = x_t^p - d_t^P + I_{t-1}^P + b_t - b_{t-1} \quad (19)$$

$$A_1^C = A_0^C + \sum_l y_{l,0}^P + (x_0^P - I_1^P)p^2 - x_0^P p^1 + s^1 o_0 + s_l^2 n_{l1} + x_0^p d(D_1 + D_2)\big(1 - R^d n_{3,0}\big) + I_1^P h\big(1 - R^h n_{3,0}\big)\,] \quad (20)$$

$$A_t^C = A_{t-1}^C + \sum_l y_{l,t-1}^P + (x_{t-1}^P - I_t^P)p^2 - [x_{t-1}^p p^1 + s^1 o_{t-1} + s_l^2 n_{l,t-1} + x_{t-1}^p d(D_1 + D_2)\big(1 - R^d n_{3,t-1}\big) + I_t^P h\big(1 - R^h n_{3,t-1}\big)] - \sum_l y_{l,t-2}^P (1 + r_l), \quad (21)$$

Where t = 2…, T

$$A_{t-1}^C + (x_{t-1}^P - I_t^P)p^2 \geq x_{t-1}^p d(D_1 + D_2)\big(1 - R^d n_{3,t-1}\big) + I_t^P h\big(1 - R^h n_{3,t-1}\big) + s^1 o_{t-1} + s_l^2 n_{l,t-1} + \sum_l y_{lt}^P (1 + r_l), \quad (22)$$

$$b_t - b_{t-1} \leq d_t^P \quad (23)$$

$b_t = 0$, where t = T (24)

$$b_t \geq 0 \quad (25)$$

$$\sum_t x_t^P \geq Q^P \quad (26)$$

$$\sum_t \sum_l y_{l,t-1}^P \geq \sum_t x_t^P p^1 + \sum_t b_{t-1} p^1 \quad (27)$$

$$0 \leq y_{lt}^P \leq M_{lt}, \quad (28)$$

$$\sum_l n_{lt} \geq o_t \quad (29)$$

$$0 \leq y_{2t}^P \leq d_t^P p^1 R_t^C \quad (30)$$

$$0 \leq x_t^p \leq \frac{y_{lt}^P}{p^1},\ and\ x_t^P \in \mathbb{Z}^+ \quad (31)$$

$x_t^p \leq \mathrm{V} o_t$, V is the sufficient big value (32)

$y_{lt}^P \leq \mathrm{V} n_{lt}$ (33)

$I_t^P \geq 0$ (34)

$A_t^C \geq 0$ (35)

$o_t \in \{0,1\}$ (36)

$n_{lt} \in \{0,1\}$ (37)

$l = 1, 2, 3$ (38)

Equation *(18)* aims to minimise the OC of the retailer. Constraint *(19)* is the inventory amount in Period t. Constraints *(20)* and *(21)* indicate the amount of available capital which can be used

for business operations in Period $t+1$, respectively. The amount of available credit plus income from product sales should be able to cover the retailer's expenditures on product delivery, inventory holding, all setup costs and borrowed capital with interest. This is described by Constraint *(22)*. Constraints *(26) and (27)* limit the overall procurement quantity and overall borrowing amount, in which the former should satisfy the market demand and the latter should satisfy the capital demand for procurement. As the supplier offers products as TC to the retailer, the retailer can only access an amount of short-term capital equivalent to the purchasing products. Therefore, the maximum amount of TC the retailer can borrow from the supplier is presented as Constraint *(30)*. As the initial budget of the retailer is zero, each procurement relies on borrowed working capital; thus, the procurement amount cannot exceed the overall borrowed working capital from three types of short-term credit, which is shown as Constraint *(31)*.

The above model formulates how the retailer schedules credit portfolio selection in dynamic periods. This model considers multiple credit sources and provides a solution to help working capital constrained retailers to schedule a dynamic credit portfolio from these credit sources. This model is based on the PQM model which assumes that market demand is fixed and known in each period. The retailer can schedule the credit portfolio in order to fulfil all the expenditure on procurement and logistics. As a result, the model enables the contribution of an optimal credit portfolio which in turn minimises OC.

In order to enhance performance and competitiveness, a working capital constrained retailer not only wants to minimise OC, but also attempts to minimise BPC.Another model used to minimise BPC will be developed in the following section. This new BPC minimisation model attempts to reduce the backorder level to cut down the penalty cost due to shortages.

6.4.3 A Model to Minimise Backorder Penalty Costs

The studies presented in Section 6.2.2 have considered backorder minimization as one business objective. Markets always expect that products can be manufactured and arrive on time. Both studies by Gunasekaran et al. (2001) and Bhagwat and Sharma (2007) pointed out that extra wait time due to backorders would lead to the dissatisfaction of customers, meanwhile, wait time brings extra costs for suppliers (Li and Muckstadt, 2013), such as penalty costs due to missing market demands.

In this research, following the assumption described in Section 6.3.1, the ability of the retailer to fulfil market demands depends on their levels of working capital. An insufficient level of working capital causes the retailer to be stuck when it comes to procurement and logistics payments. Thus, when considering minimizing the amount of backorders, in order to purchase the right amount of products or keep enough inventory for market demands, the retailer needs to obtain a sufficient amount of working capital via an optimal credit portfolio. Alternatively, in the situation of fulfilling backorders in a following period, credit borrowing activity should be considered into the model as the SC has a working capital constraint problem. This part of the activity can also be developed as a descriptive equation, which is presented as follows:

Credit borrowing = Credit scheduling based on the orders + Credit required for fulfilling backorders

Therefore, in this working capital constrained SC, two parts of activities run through the process of fulfilling orders in the market. These two parts of activities include the order supplement in material flow, and the credit borrowing in financial flow. However, the order placed in each period may be not satisfied by the inventory from the retailer; in another word, backorders may happen, the retailer needs to apply working capital for purchasing products from the suppliers. In this situation, the lead-time due to backorders increases the waiting time of the market, and negative influences CSL (Bielen and Demoulin, 2007); thus, minimising backorder level can improve CSL effectively regarding reducing the waiting time in the market. For a retailer, reducing backorder level cuts down the penalty cost due to the shortage directly. Therefore, a descriptive equation can be presented as follows:

Minimise BPC = Penalty Cost for waiting backorder fulfilment

Based on the above description and combined with the notations in Section 6.3.2, an objective function *(39)* aiming to minimise BPC is developed as follows:

$$Min\ BPC = \sum_{t} b_t s^3 \qquad (39)$$

To satisfy the demand in the market, the process time of backorders and short-term credit demands should be less than the expected wait time of the market. Equation (*39*) is subject to the following constraints,

$$b_t = I_t^P - x_t^p + d_t^P - I_{t-1}^P + b_{t-1} \qquad (40)$$

$$\sum_{t}\sum_{l} y_{l,t-1}^{p} \geq \sum_{t} x_t^P p^1 + \sum_{t} b_{t-1}\, p^1 \qquad (41)$$

$$A_1^C = A_0^C + y_{l,0}^P + (x_0^P - I_1^P)p^2 - [x_0^P p^1 + s^1 o_0 + s_l^2 n_{l1} + x_0^p d(D_1 + D_2)(1 - R^d n_{3,0}) + I_1^P h(1 - R^h n_{3,0}) + b_0 s^3] , \quad (42)$$

$$A_t^C = A_{t-1}^C + y_{l,t-1}^p + (x_{t-1}^P - I_t^P)p^2 - [x_{t-1}^p p^1 + s^1 o_{t-1} + s_l^2 n_{l,t-1} + x_{t-1}^p d(D_1 + D_2)(1 - R^d n_{3,t-1}) + I_t^P h(1 - R^h n_{3,t-1}) + b_{t-1} s^3] - \sum_l y_{l,t-2}^P (1 + r_l), \quad (43)$$

Where t = 2…, T

$$\sum_t x_t^P \geq Q^P \quad (44)$$

$$\sum_l n_{lt} \geq o_t \quad (45)$$

$$0 \leq x_t^p \leq \frac{y_{lt}^P}{p^1}, \ \ and\ x_t^P \in \mathbb{Z}^+ \quad (46)$$

$$0 \leq y_{lt}^P \leq M_{lt} \quad (47)$$

$$0 \leq y_{2t}^P \leq d_t^P p^1 R_t^C, where\ l = 2 \quad (48)$$

$$b_t - b_{t-1} \leq d_t^P \quad (49)$$

$b_t = 0$, where t = T (50)

$$E \leq T \quad (51)$$

$x_t^p \leq \mathrm{V} o_t$, V is the sufficient big value (52)

$$y_{lt}^P \leq \mathrm{V} n_{lt} \quad (53)$$

$$I_t^P \geq 0 \quad (54)$$

$$A_t^C \geq 0 \quad (55)$$

$$o_t \in \{0,1\} \quad (56)$$

$$n_{lt} \in \{0,1\} \quad (57)$$

$$l = 1,2,3 \quad (58)$$

6.4.4 Optimisation of Multiple Objectives

The working capital constrained retailer in this scenario considers two business objectives. These two objectives are total cost minimisation and BPC minimisation as have been presented in Chapter 6.4.2 and 6.4.3. The models for these two objectives will design two different dynamic credit portfolios. Based on these two non-LP models, the working capital constrained retailer can attempt to optimise these two objectives. In other words, a dynamic credit portfolio should be created which is able to satisfy both OC minimisation and BPC minimisation. However, one question raised is that of how to determine a dynamic credit portfolio to optimise these two objectives.

To answer this question, this chapter develops a MOO model to integrate these two objectives. Khorramshahgol (2012) stated that MOO is an optimisation technique which is regarded as an extension of linear programming. It is able to handle multiple objectives and provide a satisfactory solution to optimise various objectives. In the literature review chapter, many SCM problems have been studied by applying the MOO model. For example raw material procurement (Gao and Tang, 2003), supplier selection (Amid *et al.*, 2006; Amid *et al.*, 2009), production and distribution design in SC (Selim *et al.*, 2008) and green SC network design (Wang *et al.*, 2011). Many similar studies tried to optimise various objectives such as total cost minimisation, efficiency maximisation and other objectives. Therefore, this section will adopt the MOO model in order to integrate the two objectives of OC minimisation and BPC minimisation.

The adoption of MOO requires a solution in order to optimise the multiple objectives in the model. Ngatchou *et al.* (2005) introduced one approach to solving the MOO model in their study. The GP approach has been considered as it is able to find the minimum deviation from pre-specified goals. Lee *et al.* (2010) determined the GP approach as a technique which aims to minimise the deviations between the optimal solution and goals. Their study applied the GP model to design an optimal weapon system from various suppliers. It sets the GP model to optimise 19 different objectives which were evaluated and determined by AHP analysis. This study is representative of how introducing AHP and GP integrates the optimisation of a multi-objective problem.

Romero (2004) explained the general procedure of developing the GP model in order to adopt this approach when optimising OC minimisation and BPC minimisation. The first step of the procedure should specify a target for each objective. Ngatchou *et al.* (2005) presented a common formulation for developing the GP model. This common GP model is formatted as Equation *(59).*

$$Minimise\ Z = \sum_{j=1}^{N} w_j \mid f_j(\vec{x}) - T_j \mid \qquad (59)$$

Equation *(58),* T_j denotes the goal value set by the decision maker for objective j. w_j represents the priority / weight of the goal.

Combining the common formulation of GP, the following section aims to employ this method to optimise the two objectives set out in Chapter 6.4.2 and 6.4.3. To achieve this aim, this section introduces some new notations as follows.

Z: The sum of weighted deviational variables

$f_j\,(v)$: The j^{th} objective function with vector v

g_i: The target value (goal) of i^{th} objective

e.g. g_{OC}: The target value of OC cost that the retailer wishes to minimise

g_{CWT}: The target value of BPC that the retailer wishes to minimise

w_i: The relative weight of i^{th} objective

e.g. w_i^+: The positive relative weight of i^{th} deviation

w_i^-: The negative relative weight of i^{th} deviation

d_i^+: The positive deviation variable from i^{th} objective

d_i^-: The negative deviation variable from i^{th} objective

These notations are applied to develop the GP model. Based on the two objective equations *(18)* and *(39)*, it manifests as $f_1\left(x_t^P, y_{lt}^p, o_t, n_{lt}\right)$ referring to the objective function of OC minimisation and $f_2\,(\,b_t\,)$ representing the objective function of BPC minimisation. Combined with the notations above, the target value for each goal is presented as g_{OC} and g_{BPC}, which refer to the goal value of the overall cost and the goal value of BPC, respectively. Moreover, the weights of the two goals are denoted by the notations w_1 and w_2, which are the weights of the first and second goals. Therefore, based on Equation *(59)*, the GP model used to optimise the two objectives of this study can be developed as the following equation.

$$Minimise\ Z = \sum_{t=1}^{n} w_1 \mid f_1\left(x_t^P, y_{lt}^p, o_t, n_{lt}\right) - g_{OC} \mid + w_2 \mid f_2\,(b_t) - g_{BPC} \mid \qquad (60)$$

Equation *(60)* provides a GP model with a new objective of minimising deviation between the objectives and goals. Based on the introduction of the GP model by Chang (2007), the Equation *(60)* can be replaced by another Equation *(61)* applying the notations above. The replaced equation is presented as follows.

$$Minimise\ Z = \sum_{i=1}^{n} (w_i^+ d_i^+ + w_i^-\, d_i^-) \qquad (61)$$

The Equation *(61)* replaces Equation *(60)* as the GP model. This newly replaced GP model considers the weight of each deviation. Based on the AHP analysis in Section 4.2.2, the value of w_i^+ and w_i^-, can be solved. Therefore, the purpose of this GP model is mainly to minimise the sum of weighted deviational variables.

Chang (2007) introduced the multiple objective GP model in terms of t model development and solution. This study defined the typical mathematical formulation of GP models, especially in

designing objective functions and constraints. The constraints of the GP model considering the weights of the deviations are presented as below.

s.t $f_i(X) - d_i^+ + d_i^- = g_i$, which i = 1, 2, 3…, n

$d_i^+, d_i^- \geq 0$, which i = 1, 2, 3…, n

$X \in F$, which F is a feasible set

By following the above formulation of the GP model, the constraints of Equation *(61)* are designed as follows.

s.t $f_1\left(x_t^P, y_{lt}^p, o_t, n_{lt}\right) - d_1^+ + d_1^- = g_{OC}$,

$f_2(b_t) - d_2^+ + d_2^- = g_{BPC}$,

$d_i^+, d_i^- \geq 0$, which i = 1 and 2

$I_t^P = x_t^p - d_t^P + I_{t-1}^P + b_t - b_{t-1}$

$A_1^C = A_0^C + y_{l,0}^p + (x_0^P - I_1^P)p^2 - x_0^P p^1 + s^1 o_0 + s_l^2 n_{l1} + x_0^p d(D_1 + D_2)\left(1 - R^d n_{3,0}\right) + I_1^P h\left(1 - R^h n_{3,0}\right) + b_0 s^3]$,

$A_t^C = A_{t-1}^C + y_{l,t-1}^p + (x_{t-1}^P - I_t^P)p^2 - [x_{t-1}^p p^1 + s^1 o_{t-1} + s_l^2 n_{l,t-1} + x_{t-1}^p d(D_1 + D_2)\left(1 - R^d n_{3,t-1}\right) + I_t^P h\left(1 - R^h n_{3,t-1}\right) + b_{t-1} s^3] - \sum_l y_{l,t-2}^P r_l$,

Where t = 2..., T

$b_t - b_{t-1} \leq d_t^P$

$b_t = 0$, where t = T

$b_t \geq 0$

$\sum_t x_t^P \geq Q^P$,

$$\sum_t \sum_l y_{l,t-1}^P \geq \sum_t x_t^P p^1 + \sum_t b_{t-1} p^1$$

$0 \leq y_{lt}^P \leq M_{lt}$,

$$\sum_l n_{lt} \geq o_t$$

$0 \leq y_{2t}^P \leq d_t^P p^1 R_t^C, where\ l = 2$

$0 \leq x_t^p \leq \frac{y_{lt}^P}{p^1},\ and\ x_t^P \in \mathbb{Z}^+$

$x_t^p \leq \mathrm{V} o_t$,

$y_{lt}^P \leq \mathrm{V} n_{lt}$

$I_t^P \geq 0$

$A_t^C \geq 0$

$o_t \in (0,1)$

$$n_{lt} \in (0,1)$$

$$E \leq t$$

Therefore, Equation *(61)* and the above constraints form the GP model. This GP model aims to help this working capital constrained SC to optimise two objectives; namely OC minimisation and BPC minimisation. To test the feasibility of this GP model and also to compare its results with the NLP models in Section 6.4.2 and 6.4.3, the following section will develop a numerical example to simulate a working capital constrained retailer in a SC.

6.5 Numerical Example in Determining a Dynamic Credit Portfolio

This chapter assumes a numerical example to test the credit portfolio model. This example aims to offer a series of optimal credit portfolio management to satisfy the single objective and multiple objectives described in Section 6.4. To achieve this aim, Section 6.5.1 introduces the numerical examples by presenting the relative data and information. Section 6.5.2 discusses the solutions based on the description of the example.

6.5.1 The Scenario of Numerical Example

Based on the description in Section 6.4, this numerical example assumes that there is a three-level SC which includes a supplier, a working capital constrained retailer and a 3PL company. In addition, a bank exists outside the SC and provides BO to the retailer. The 3PL company in this SC is supposed to to provide logistics services for the retailer. The logistics service is designed to provide delivery and inventory for the retailer. To simplify the model, the 3PL's delivery service is operated by trucks with a fixed speed and capacity, which deliver from the supplier to the retailer, then to the market. Figure 6.3 presents this SC network.

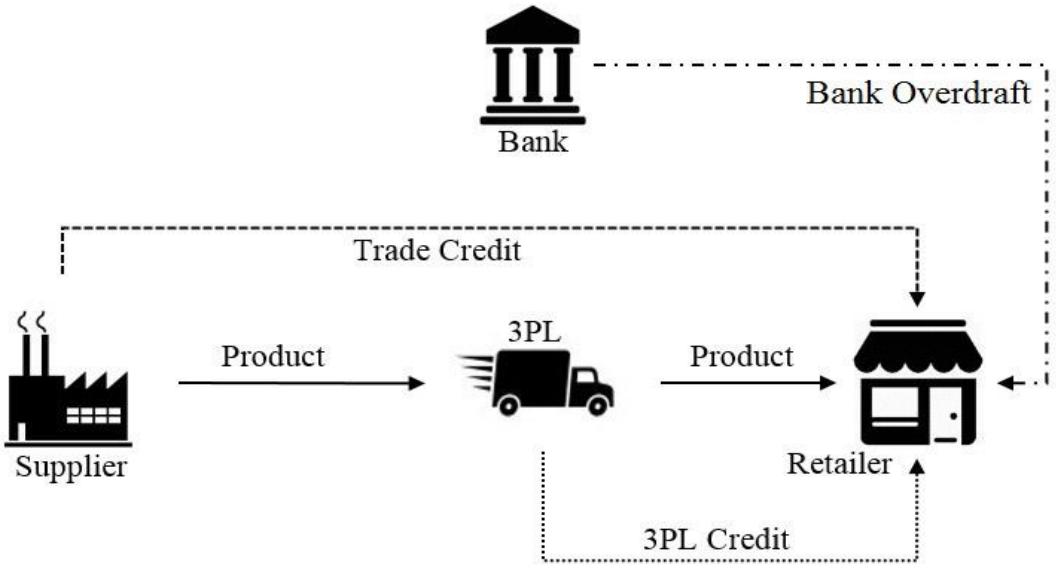

Figure 6.3. Description of the supply chain network

In this SC network, the retailer has been cooperating with the supplier for 6 months in order to fulfil the market demand. The market demand is fixed and known at the beginning of each month. Due to the fact that replenishment is non-instantaneous, the retailer should purchase the products from the supplier in advance, the order will be placed at the beginning of the previous month and received at the beginning of the new month. The purchased products will be delivered by the 3PL company and arrive at the beginning of each month.

The SC has multiple short-term credit sources which include BO, TC and 3PLC. The BO is offered by the bank and it is issued as capital to the retailer to pay for certain expenditures. TC is provided by the supplier. It allows the retailer to pay the purchasing fee later (Giannetti *et al.*, 2011). 3PLC is a new form of short-term credit offered by 3PL companies. It can provide capital to the retailer and charges a discounted logistics service fee (Chen and Cai, 2011).

To operate this 6-month business, the working capital constrained retailer attempts to borrow short-term credit from these credit sources. In order to raise sufficient capital, the retailer aims to manage a credit portfolio consisting of BO, TC and 3PLC. Meanwhile, this credit portfolio needs to optimise the two business objectives of the retailer, which are OC minimisation and BPC minimisation. Short-term credit benefits the retailer in different ways. In the scenario of using TC, the supplier allows the retailer to pay for the procurement delay, as the retailer can repay procurement at the time of the next order placement (At the end of each month). Regarding the logistics services offered by the 3PL company, in the scenario of using 3PLC, the retailer can receive capital and enjoy certain discounts on delivery and inventory services. To simplify the model, the settlement data of all the credit borrowing should be repaid at the

end of each month. All the information of this numerical example is summarised in the following Table 6.1.

Market Aspect			
Market Demand	2625 items in total	Contract Period	7 months
Product Price	£ 467/ item		
Supplier Aspect			
Lending Rate	85% / borrowing	Distance to the Retailer	100 miles
Retailer Aspect			
Purchasing Price	£ 178/ item	Distance to the Market	155 miles
Penalty Cost of lost selling due to backorder		£170/ item	
3PL company Aspect			
Inventory Fee	£ 50/item	Discount of Inventory	15%
Delivery Fee	£ 0.35/ item/ miles	Discount of Delivery	20%
Purchasing Setup Cost (Per Order)		£ 30,000	
Credit Source Aspect			
Borrowing Setup Cost of BO		£ 20,000	
Borrowing Setup Cost of TC		£ 18,500	
Borrowing Setup Cost of 3PLC		£ 17,500	
Maximum BO lending Volume (Per time)		£ 65,000	
Maximum TC lending Volume (Per time)		£ 60,075	
Maximum 3PLC lending Volume (Per time)		£ 55,000	
BO Interest Rate (monthly)		0.218	
TC Interest Rate (monthly)		0.221	
3PLC Interest Rate (monthly)		0.224	

Table 6.1. The information of numerical example

Table 6.1 introduces some basic information about the SC used in the numerical example. It presents detailed data in terms of the market demands, procurement of the retailer, supplement of the supplier, logistics services of the 3PL company and the credit information. Based on the information, Section 6.5.2 aims to apply the models which were developed in Chapter 6.4, in order to test their feasibility and design an optimal dynamic credit portfolio for the working capital constrained retailer.

6.5.2 Dynamic Credit Portfolios for Each Business Objectives

Firstly, by inputting the numerical data into the NLP model of overall cost minimisation, the NLP model can be formulated as follows.

$$\text{Minimise OC} = 178\sum_{t} x_t^P + 30{,}000\sum_{t} o_t + 0.35\sum_{t} x_t^P(100+155)(1-20\%n_{3t}) + 50\sum_{t} I_t^P(1-15\%n_{3t}) + \sum_{t}\sum_{l} y_{lt}^P r_l + \sum_{t}\sum_{l} S_l^2 n_{lt}$$

This objective function is subject to constraints *(19)* to *(38).* Meanwhile, the NLP model of BPC minimisation can be formulated as follows,

$$\text{Min BPC} = 170\sum_{t} b_t$$

This objective is subject to the constraints *(40)* to *(58).*

By following the NLP model of OC minimisation, dynamic procurements during these 7 months can be determined optimally, also the relevant credit portfolio for product purchasing in each month can be created. To formulate this NLP model in LINDO, a result is presented including a procurement schedule, credit portfolio and the amount of backorders. Table 6.2 gives the details of these parts of information.

Month	Demand	Capital Demand	Purchasing Amount	Purchasing Cost	Backorders	Backorder Purchasing
0	0	0	365	0.00	0	0
1	375	68500	309	65000.00	10	1750.00
2	375	80250	577	55000.00	76	13500.00
3	375	66750	0	102705.33	0	0.00
4	375	111045	634	0.00	249	44294.67
5	375	66750	365	112794.67	0	0.00
6	375	66750	375	65000.00	0	0.00
7	375	66750		66750.00	0	0.00
Overall	*2625*	*526795*	*2625*	*467250*	*335*	*59544.67*

Table 6.2. The procurement allocation of the retailer for OC minimisation

Table 6.2 allocates the purchasing amount of the retailer in each month. This procurement allocation is able to minimise the retailer's procurement costs. Meanwhile, the overall purchasing setup cost is also minimised. Specially, as there are backorders and due to the retailer having insufficient capital, market demand cannot be met in the fourth month. Thus, extra capital is required in the fifth month with an aim to purchase more and to make up for the shortage of the 4th month. By following this allocation, a credit portfolio has been created using three short-term credit sources. Table 6.3 presents the credit scheduling of each month.

Month	**BO Amount**	**TC Amount**	**3PLC Amount**	**BO Setup**	**TC Setup**	**3PLC Setup**
0	65000.00	0.00	0.00	20000	0.00	0.00
1	0.00	0.00	55000.00	0.00	0.00	17500
2	0.00	60075.00	51569.67	0.00	18700	17500
3	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	60075.00	55000.00	0.00	18700	17500
5	65000.00	0.00	0.00	20000	0.00	0.00
6	0.00	60075.00	55000.00	0.00	18700	17500
7						
Overall	*130000.00*	*180225.00*	*216569.67*	*40000*	*56100*	*70000*

Table 6.3. The allocation of credit borrowing in the 7-month period (OC Minimisation)

Apart from the procurement (P), purchasing and borrowing setup costs (S) and borrowing setup costs, the retailer has to pay a logistics service fee to the 3PL company. As 3PLC is used in some months, the retailer has the opportunity to obtain a discount on delivery (D) and inventory (I). All these costs constitute operation costs which consist of P, S, D and I. Moreover, the retailer needs to repay the loan with interest. Thus, Table 6.4 presents the operational costs and borrowing repayments with interest.

Month	**Inventory**	**3PLC Used (1) / Not (0)**	**Inventory Cost**	**Delivery Cost**	**Operation Cost**	**Interest Payment**
0	0	0	0	0	0	0
1	0	1	0.00	32591.29	82591.29	14170.00
2	0	1	0.00	22061.80	69561.80	12320.00
3	126	0	5361.52	41197.53	112759.05	24828.18

4	0	1	0.00	0.00	0.00	0.00
5	10	0	417.84	45244.61	111862.44	25596.58
6	0	1	0.00	32591.29	82591.29	14170.00
7	0		0.00	26775.00	92975.00	25596.58
Overall	*136*	*4*	*5779*	*173687*	***552341***	***116681***

Table 6.4. The operational cost and the borrowing interest payment (OC Minimisation)

Combining the results in Table 6.3 and 6.4, the overall cost can be calculated as:
Minimum Overall Cost = Interest Payment + Operation Cost = £669,022

The current product allocation and credit portfolio minimise the overall costs for the retailer. However, the above results are unable to minimise penalty costs due to backorders. In this regard, there are backorders presented in Table 6.5; meanwhile, the penalty costs are caused due to backorders.

Month	**Backorders**	**Backorder Penalty Cost**
0	0	
1	10	1700
2	76	12920
3	0	0
4	249	42330
5	0	0
6	0	0
7	0	0
Overall	*335*	***56950***

Table 6.5. The backorder penalty cost in the scenario of OC minimisation

Based on Table 6.5, the result of BPC is *£56,950*. As there are backorders, this result should not be the minimum BPC. Therefore, by inputting numerical data into the NLP model of BPC minimisation and based on this NLP model, it can be formulated in the LINDO. Through the optimization of LINDO, Table 6.6 allocates the procurement for the retailer in each month.

Month	Demands	Procurement	Backorders	Backorder Fulfilment Time
0	0	375	0	0
1	375	375	0	0
2	375	376	0	0
3	375	374	0	0
4	375	376	0	0
5	375	374	0	0
6	375	375	0	0
7	375			
Overall	*2625*	*2625*	*0*	*0*

Table 6.6. The procurement allocation of the retailer for BPC minimisation

Based on Table 6.6, procurement occurs each month and this allocation is different to the procurement in Table 6.2 in which the retailer aims to minimise the OC. As the procurement allocation changes, credit borrowing amounts from multiple credit sources also change. Compared with the credit borrowing allocation in Table 6.3, Table 6.7 presents the new credit allocation of the retailer to minimiseBPC.

Month	Capital Demand	BO Borrowing Amount	TC Borrowing Amount	3PLC Borrowing Amount
0	0	0.00	60075.00	8425.00
1	66750	65000.00	0.00	0.00
2	66750	0.00	60075.00	23436.54
3	66750	0.00	0.00	55000.00
4	66750	0.00	60075.00	5056.55
5	66750	23500.00	0.00	55000.00
6	66750	0.00	0.00	55000.00
7	66750	-	-	-
Overall	*467250*	*88500.00*	*180225.00*	*201918.09*

Table 6.7. The allocation of credit borrowing in the 7-month period (BPC minimisation)

Following the schedules of procurement in Table 6.7, the delivery time of backorders is zero due to the lack of backorders. This is different to the Minimum OC scenario presented in Table 6.2. Therefore, all products have been fulfilled and delivered to the market. Regarding backorders in '*Customer service level',* when the backorder amount reaches the minimum level, the retailer performs well in terms of satisfying market demand without any delay (Widyadana *et al.*, 2011). Table 6.8 presents the backorder level with regard to the above purchasing allocation (Table 6.6) and credit portfolio (Table 6.7).

Month	**Backorder Amount**	**Backorder Penalty Cost**
0	0	
1	0	0
2	0	0
3	0	0
4	0	0
5	0	0
6	0	0
7	0	0
Overall	*0*	***0***

Table 6.8. The penalty cost due to backorders (BPC minimisation)

Based on Table 6.8, the BPC is £0. This is the minimum BPC by adopting the purchasing allocation in Table 6.6 and the credit portfolio in Table 6.7, respectively. However, purchasing allocation and the credit portfolio in BPC minimisation cannot guarantee the minimum OC at the same time. Table 6.9 presents the operational costs and the borrowing repayment with interest regarding BPC minimisation.

Month	Inventory	3PLC Used (1) / Not (0)	Inventory Cost	Delivery Cost	Operation Cost	Interest Payment
0	0	1	0	0	0	0
1	10	0	417.84	27476.97	94094.80	15163.78
2	0	1	0.00	32591.29	82591.29	14170.00
3	75	1	3191.91	32137.40	101529.31	18526.36
4	9	1	386.43	22061.80	69948.23	12320.00
5	0	1	0.00	26125.80	92325.80	14409.24
6	66	1	2805.48	31488.20	101793.68	17443.00
7	0		0.00	22061.80	69561.80	12320.00
Overall	*160*	*6*	*6802*	*171881*	***611845***	***104352***

Table 6.9. The operational cost and the borrowing interest payment
(BPC Minimisation)

Based on Table 6.9, in BPC minimisation, the OC is *£716,197*. It is much higher than the overall costs in OC minimisation, which is *£669,022*. Regarding this increase of OC, the retailer needs new production allocation and credit portfolio in order to optimise both business objectives at the same time. The following section will solve this issue by adopting the GP model.

6.5.3 A Dynamic Credit Portfolio to Optimise Multiple Objectives

Currently, the retailer has two credit portfolios and is able to achieve a minimum OC and a minimum BPC, respectively. However, the retailer aims to achieve both business objectives at the same time. Thus, a dynamic credit portfolio is required to help the retailer to optimise these two objectives. Based on the results presented in Chapter 6.5.2, the backorder penalty cost in the scenario of OC minimisation is *£56,950*, and the overall cost in the scenario of BPC minimisation is *£716,197*. For the retailer, to optimise these two business objects to the target level, a new-targeted OC of £710,000 can be set and the original BPC of £0 can be maintained as a new targeted BPC whendeveloping a new credit portfolio.

To achieve these new business targets, Equation *(61)* provides a goal to optimise the above two business objectives for each certain goal. Before applying Equation *(61)*, the weights of the two objectives have to be calculated by referring to the AHP result in Table 4.5. Through reorganizing all the sub-criteria by cost and service time and adding up their weights, the overall

weights of cost and service level can be summarised which thus represents their priorities considered by the retailer. The result is presented in Table 6.10.

Cost		**Service Level**	
Administration Fees	0.19720	Approval Time	0.28466
Repayment Period	0.12885	Distance	0.03206
Interest Rate	0.09143	Business Duration	0.03691
Transaction Cost	0.04076		
Lending Volume	0.13346		
Overall	0.5917	**Overall**	0.35363

Table 6.10. The overall weights of objectives of cost and service level

Applying the weights presented in Table 6.10 into the Equation *(61)*, a new objective function of GP model can be developed.

$$Minimise\ Z = \sum_{i=1}^{n} (0.5917 d_1^- + 0.35363\, d_2^+)$$

This objective function aims to minimize the sum of weighted deviational variables. These variables represent the retailers' efforts to meet the new goals of OC minimisation and BPC minimisation. Specifically, when the backorder is empty, BPC will be at the minimum level; however, this may not guarantee a minimum OC. As minimising OC is more of a priority than minimising BPC, this GP model integrates these two priorities and aims to produce a new procurement allocation and a new credit portfolio to meet each business target. These two deviational variables are subject to the following main constraints.

$$178 \sum_t x_t^P + 30{,}000 \sum_t o_t + 0.35 \sum_t x_t^P (100 + 155)(1 - 20\% n_{3t}) + 50 \sum_t I_t^P (1 - 15\% n_{3t}) + \sum_t \sum_l y_{lt}^P r_l + \sum_t \sum_l S_l^2 n_{lt} - d_1^+ + d_1^- = 710{,}000,$$

$$170 \sum_t b_t - d_2^+ + d_2^- = 0$$

Combining this objective function and the new constraints with the LINDO models of OC minimisation and BPC minimisation, new procurement allocation and a credit portfolio it are achieved within a 7-month period. Table 6.11 presents the new procurement allocation of minimising OC to the targeted objective.

Month	Demands	Procurement	Purchasing Cost	Backorders
0		365	0	0
1	375	413	66750	10
2	375	359	68500	0
3	375	363	66750	0
4	375	395	66750	0
5	375	365	66750	0
6	375	365	66750	0
7	375		66750	0
Overall	*2625*	*2625*	*469000*	*10*

Table 6.11. Procurement allocation in GP model

As to the procurement has changed, credit borrowing from multiple sources needs to be re-allocated. Table 6.12 presents the new credit portfolio with regard to the procurement amount in each month.

Month	BO Borrowing Amount	TC Borrowing Amount	3PLC Borrowing Amount	BO-Setup	TC-Setup	3PLC-Setup
0	65000.00	0.00	0.00	20000	0	50000
1	0.00	60075.00	13509.33	0	18700	66200
2	65000.00	0.00	0.00	20000	0	50000
3	65000.00	0.00	0.00	20,000	0	50000
4	0.00	60075.00	11800.12	0	18700	66200
5	65000.00	0.00	0.00	20000	0	50000
6	65000.00	0.00	0.00	20000	0	50000
7						
Overall	*325000.00*	*120150.00*	*25309.45*	*100000*	*37400*	*382400*

Table 6.12. The credit portfolio in the 7-month period

Apart from the changing the borrowing amounts and borrowing setup costs, the other costs of the retailer have also been changed because of the procurement re-allocation. Table 6.13

presents the figures for operations costs and borrowing with interest regard to the new procurement and borrowing amounts.

Month	Inventory	Inventory Cost	Delivery Cost	Operations Cost	Interest Payment
0					
1	0	0.00	32591.29	82591.29	14170.00
2	29	1213.95	29516.41	96930.37	16302.66
3	12	609.10	32006.68	82615.78	14170.00
4	0	0.00	32381.51	82381.51	14170.00
5	20	835.67	28178.93	95214.61	15919.80
6	10	491.57	32591.29	83082.87	14170.00
7	0	0.00	32591.29	82591.29	14170.00
Overall	*70*	*3150*	*187266*	***605408***	***103072***

Table 6.13. The operations cost and the borrowing interest payment of the retailer

As the priority of the GP model is to minimise the OC of the retailer, the above tables including Table 6.9, 6.10 and 6.11 helped the retailer to achieve this goal by reducing OC to *£708,480*, which is lower than the target of £710,000. However, the satisfaction of this goal led to some backorders in Month 1 (As shown in Table 6.11). In this regard, the original procurement allocation and credit portfolio in Table 6.11 and Table 6.12 no longer reduce the BPC to the minimum target (£0). Due to the existence of backorders, the wait time of the market is extended which should consist of the fulfilling time of backorders. The procurement allocation and credit portfolio in this GP model lead to extra wait time which is presented in following tables.

Month	Demands	Procurement (P)	Backorders
0		365	0
1	375	413	10
2	375	365	0
3	375	365	0
4	375	404	0
5	375	365	0
6	375	365	0
7	375	0	0

Overall	*2625*	*2625*	*10*

Table 6.14. The allocation of procurement in GP model

Table 6.14 presents the backorder level regarding production allocation in Table 6.11. Due to these backorders, the retailer will take an extra penalty cost even though the current OC has reached the new target. The new BPC is presented in Table 6.15.

Month	**Backorder Level**	**Backorder Penalty Cost**	**Backorder Level in OC Minimisation**	**Backorder Penalty Cost in OC Minimisation**
0	0			
1	10	1700	10	1700
2	0	0	76	12920
3	0	0	0	0
4	0	0	249	42330
5	0	0	0	0
6	0	0	0	0
7	0	0	0	0
Overall	0	***1700***	*335*	***56950***

Table 6.15. Comparison between the targeted BPC and the BPC in OC minimisation

Therefore, based on the above tables, the original BPC is not minimised with regard to procurement allocation and new credit portfolio. Although the new BPC which is £1,700 has still exceeded the target, compared with the BPC in the scenario of OC minimisation, it has been cut down to a lower level.

Generally, compared with Table 6.2, 6.6 and 6.11, it can be seen that the retailer has a different procurement allocation for a single business objective and multiple objectives. Similarly, the credit portfolios are also different for different business objectives.

6.6 Summary

This chapter improves the LP model designed in Chapter 5, which imports multiple business objectives and replaces the original single business objective. In this section, the working

capital constrained retailer is able to optimise the multiple business objectives in dynamic periods. Meanwhile, through the GP model, the retailer is able to reach specific business targets via an optimal credit portfolio.

Compared with the LP model in Chapter 5, this chapter contributes a more realistic solution in terms of multiple business objectives optimisation. In detail, some findings can be summarized as follows.

1. Working capital constrained companies are allowed to consider multiple business objectives rather than a single objective. This design is close to a real business operation, in which companies may have more or even conflicting business objectives.

2. Working capital constrained companies can set their own business targets after they have achieved their current business objectives. Through the GP model in Chapter 6.4.4, these new business targets can be satisfied through new procurement allocation and a credit portfolio. Meanwhile, in cases where one or more of the multiple objectives is clearly far more important than the others, this GP model can initially focus on the most important target, and then the second target (Which can be applied more in further studies). Through the numerical cases, it can be seen that the model provides the optimal solution with respect to the first-priority goal and the second-priority goal. In some special cases, the model may suggest a penalty for working capital companies if the solution is hard to optimise for the second or other goals.

PART 4 CONCLUSION AND RECOMMENDATION

Chapter 7 Conclusion

7.1 Introduction

This thesis has so far contributed to filling some gaps in the study of SCM. An insight is provided has been provided into how credit borrowing activity can be integrated into SCM. This integration not only follows current SCM development, but also discusses credit borrowing management from the perspective of working capital constrained companies. The one main question that working capital constrained companies face is how they design static and dynamic credit portfolios from multiple credit sources in order to optimise different business objectives. By finding the answer to this question, working capital constrained companies should be able to analyse the concerns they consider in credit selection and how these concerns impact their credit portfolio. These concerns were determined through a systematic literature review. However, current literature rarely evaluates the influence of these concerns. Moreover, there are limited studies analysing credit borrowing portfolios that manage procurement and inventory in dynamic periods. Therefore, the objective of this thesis was to contribute to credit portfolio selection for working capital constrained companies by developing:

1. A solution to analyse the influence of concerns in credit borrowing activities.
2. A solution to schedule static credit selection from multiple credit sources in order to minimise the total costs while considering high important concerns.
3. A solution to generate a dynamic credit portfolio design to optimise multiple objectives of a working capital constrained company.

These three solutions support SC managers in making a choice from multiple credit sources. They enable the working capital constraint problem to be solved through well-designed credit portfolios. In this chapter, the thesis summarises the main findings, and discusses the contributions and limitations of the research. Some directions of this research will be conducted for future study at the end of this chapter.

7.2 Evaluation of Research Objectives and Main Research Questions

Looking at the structure of this thesis, Chapter 1 has addressed the necessity of studying the credit borrowing problem in SCM. The current developments in SCM integrate logistics, financial and information management. This development requires SC managers to carry out a

smooth financial transaction. However, the working capital constraint problem in most companies has hampered efficiency in financial performance. For those working capital constrained companies, borrowing credit is an efficient approach to solve financial pressure. Chapter 2 presents traditional commercial credit and introduces the features of traditional commercial credit in detail. In addition, this chapter addresses the problem of a lack of the credit monitoring in the usage of these types of credit. In light of growing demand for new credit sources, 3PLC has been promoted by many scholars because of its benefits of monitoring and low costs. Moreover, Chapter 2 views current studies and suggests that more emphasis should be placed on working capital constrained companies. Through the review, a group of borrowers' concerns are summarised. So far, for working capital constrained companies, credit borrowing is a process that includes multiple alternative credits and is under the influence of various concerns. Working capital constrained companies have to answer the research questions (Section 1.3) in order to solve this financial problem. The following sections will discuss the main findings of the thesis by answering each research question.

7.2.1 Research Question 1

What are borrowers' concerns when determining their credit borrowing from multiple credit sources?

This research question includes two sub- research questions, which are; what is the priority of borrowers' considerations in choosing credit sources? And how does the priority of borrowers' considerations influence their preference for the various forms of credit? The purpose of these aims is to determine the concerns of borrowers when considering credit selection and analyse how these concerns influence their preference for various credits. To achieve these two aims, Chapter 2 develops a systemic literature review to summarise borrowers' concerns. The review selected plenty of relevant studies which presented descriptions of borrowers' considerations. As a result, most concerns were identified but some were abandoned as they were discussed less frequently. These concerns are summarized for further analysis on the importance of influence.

To analyse the influence of these concerns, Chapter 4 applied the AHP method which enabled all of these concerns to be integrated into a hierarchical framework. Based on this framework, the thesis developed a survey to investigate the priority of these concerns. The survey was delivered to professional accountants and business owners who responded with their markings

related to the priority of their concerns. In Chapter 5, the thesis adopted the certain pairwise comparison method suggested in the AHP model. The comparison enabled the evaluation of the responses collected by the public. The result of the evaluation highlighted those concerns of high importance which included Approval Time, Administration Fees, Accuracy of Credit, Lending Volume, Repayment Period and Interest Rate. These concerns have more significant influence when working capital constrained companies are selecting their credit borrowing. Based on these concerns of high importance, the AHP also conducted another evaluation of credit borrowers' preference regarding multiple credit sources. As a result, taking into consideration these six important concerns, working capital constrained companies prefer 3PLC over BO and TC.

In the process of answering this research question, some findings have been confirmed. These findings include the following points.

1. A thorough literature review has been conducted to identify all the possible factors that may affect a borrower's credit selection.
2. In this study, all of these factors have been considered when selecting credit time by using the AHP method. In comparison to many of the existing studies where only individual factor has been considered when selecting credit; this dissertation's approch is more likely to facilitate a good decision being made regarding credit selection.
3. Real data has been collected to measure the relative importance of the factors affecting the choices of credit borrowers. To the best of our knowledge, no such result has been reported before.

Generally, a solution is provided to evaluate borrowers' concerns and preferences for multiple credit sources. It is first time that the various concerns of credit borrowers have been integrated into a systemic framework and also the first time that their importance in terms of how they influence preferences for multiple credit sources have been scientifically compared. This achievement provides an approach to evaluating the preference of working capital constrained retailers for different credit sources. In addition, the preferences are applied to help credit borrowers schedule the amount they borrow over a static period. This has been discussed when answering the second research question.

7.2.2 Research Question 2

How do working capital constrained borrowers determine their borrowing portfolio to maximise the borrowing amount in dynamic periods?

To answer this research question, in Chapter 5, a methodology to introduce LP into the objective optimisation was adopted. In the process of answering the first research question, a systemic literature review considered all the possible concerns that could influence borrowers' credit selection. The AHP determined the relative importance of these concerns and the borrowers' preference for different credit sources. Based on these findings, in Chapter 5 concerns of high importance and borrowers' preferences were used to input the LP model. This LP model was able to determine an optimal borrowing amount for each credit source.

A numerical example was presented in Chapter 5. This numerical example assumed that a working capital constrained retailer needed to borrow capital from three different credit sources for further procurement. The result of this example provided a solution to help this retailer schedule borrowing amounts from multiple credit sources. The following findings have been obtained in the process of answering this research question.

1. A solution has been provided to working capital constrained companies to schedule their credit borrowing amounts from various credit sources. This solution not only enables credit borrowers to optimise a single business objective, but also satisfies the various concerns of working capital constrained companies. The retailer in the numerical example maximises its borrowing value tby accessing a dynamic working credit borrowing amount from three credit sources. Meanwhile, this borrowing amount schedule also optimises the retailer's concerns about borrowing credit.

2. This solution integrates different methodologies including both survey and mathematical modelling. Real data collected by the survey has measured the importance of all the possible concerns affecting borrowers' credit choice. In the LP model, the design of the constraints is based on the analysis of the results of the real data. The setting of these constraints incorporates a real borrower's considerations into the modelling, which is much closer to reality. The adoption of surveys and LP modelling is limited in SCM studies, especially in studies regarding the subject of credit lending and borrowing study. Therefore, the mixed methods in answering this research question is a good example for future similar studies.

The two main findings above have developed through answering the second research question. A static schedule of borrowing amounts is provided to help the working capital constrained retailer maximise their borrowing amount. Furthermore, this dynamic solution maximises borrowers' single objective and also satisfies various concerns. Therefore, it is feasible for SC managers to schedule their borrowing amounts from different types of short-term credit sources.

7.2.3 Research Question 3

How do borrowers determine the credit portfolio for optimising multiple objectives in dynamic periods?

Chapter 5 provides a dynamic solution for maximising the borrowing amount of working capital constrained companies. This solution succeeds in credit portfolio selection of a single objective optimisation. However, in capital borrowing activity, businesses have other objectives aside from just the borrowing amount. Chapter 6 answers the third research question by considering a more realistic credit-borrowing problem. This chapter states that credit borrowing is still a dynamic procedure. Meanwhile, working capital constrained companies in this scenario have multiple objectives instead of the single objectives discussed in the second research question. Moreover, Chapter 6 integrates credit borrowing activity into the SCM, in which working capital constrained companies should consider both cash flow and logistics management. With the adoption of the MOO model, Chapter 6 has designed a dynamic credit portfolio for a working capital -constrained retailer in a SC. This credit portfolio is able to optimise two objectives which are overall cost minimisation and backorder penalty cost minimisation. In the process of answering this research question, some main findings have been addressed as follows.

Chapter 6 simulates credit borrowing in a working capital constrained SC. This assumption integrates credit-borrowing activity into SCM. The integration of credit borrowing and SCM is rare in past relevant studies. Many studies have discussed the credit portfolio problem in terms of financing and accounting, however most of these studies aim to reduce the credit default risk or maximise lenders' profit from the perspective of credit lenders. Chapter 6 studies the credit portfolio problem from the perspective of a working capital constrained retailer and presents findings about how this retailer can manage a procurement and inventory plan using multiple credit financing.

Although the problem of a single credit-financing inventory has been considered in a few studies, the subject of multiple credit financing of cash flow in SC's is rarely discussed. In Chapter 6, the working capital -constrained retailer can borrow credit from the bank, the supplier and the 3PL company finance its capital demand. The working capital -constrained retailer, has to manage both cash flow and material flow in order to avoid interruption of the whole SC.

The single objective designed in Chapter 5 has been improved. Based on the literature review in Section 2.5.2, working capital constrained companies may have various business objectives related to borrowing credits. The objective of minimisation of overall costs has replaced that of maximisation of overall borrowing amount in Chapter 5 and thus becomes as one business objective of credit borrowing activities in Chapter 6. However, along with integration of credit borrowing and procurement, another business objective of minimising backorder penalty cost is considered in Chapter 6. This business objective aims to improve SC responsiveness by controlling the level of backorders. Therefore, Chapter 6 has further developed multiple objectives instead of the single objective presented in Chapter 5.

After considering the multiple business objectives in Chapter 6, the optimal solution for satisfying the business objectives in Chapter 5 is no longer suitable in Chapter 6. Therefore, regarding the consideration of multiple objectives, two dynamic procurement schedules and credit borrowing portfolios have been achieved using the two NLP models. Each schedule can independently satisfy certain business objectives, although neither can optimise both business objectives at the same time. Therefore, the adoption of the GP model contributes a new portfolio in terms of product purchasing amounts and credit borrowing amounts. This portfolio not only satisfies the working capital demand of the retailer in each month, but also optimise both of business objectives designed for this SC.

Generally, compared with the LP model in Chapter 5, the scenario designed in Chapter 6 is more grounded in reality. The third research question is designed based on the integration of credit borrowing and SCM. Working capital constrained companies in SC's have various business objectives in addition to capital demand fulfilment. As per the scenario design in Chapter 6.2, minimising overall cost and maximising customer service level are both business objectives of the working capital constrained retailers. The consideration of multiple objectives allows credit borrowers to be flexible when selecting their credit portfolio. In addition, a

dynamic-period design requires the credit borrower to consider the time frame for the credit application, procurement and repayment.

7.3 Main Contributions to Knowledge

Based on the evaluation in Section 7.2, it is appropriate to conclude the contributions that this thesis has made. One main contribution to knowledge that this thesis makes is in terms of how working capital constrained companies can schedule their credit portfolios in a SC. These credit portfolios can be designed in various ways including single objective and multiple objective optimization, static and dynamic period consideration. In particular, the following main contributions are included in this thesis.

1. The clarification of 3PLC is made based on various descriptions of past studies. Some current studies have summarised business practice of 3PL industries and banks financing working capital constrained companies in a SC. However, these studies have not clearly defined 3PLC. Based on these studies, this thesis has clarified the financial services of the 3PL industry and defined 3PLC as a commercial credit issued by 3PL companies, which allows working capital constrained companies to receive capital and logistics services without the immediate payment.

2. The identification of working capital constrained companies' concerns is developed through a systemic literature review. Abundant studies in Chapter 2.5 listed many borrowers' concerns, but most of them only focus on analysing the influence of one certain concern. Through a systemic literature review, all these concerns are summarised and organised into the AHP framework. The adoption of the AHP method enables the priorities of all these concerns to be identified wit regard to how they influence borrowers' credit selection.

3. The LP model of maximising the credit borrowing amount is developed to fulfil the capital demands of working capital constrained companies. Using this model, a static credit portfolio is achieved. This type of credit portfolio helps working capital constrained companies to schedule credit borrowing amounts from BO, TC and 3PLC. Apart from achieving enough capital, this portfolio is a static solution that can help working capital constrained companyto minimise interest payments and administration.

4. The MOO model of optimising multiple business objectives was developed. This model suggests a credit portfolio which solves the SC working capital constraint problem in a dynamic period. Different to previous credit borrowing studies, the working capital constrained company in this model has to manage the logistics flow and credit portfolio selection in a dynamic period. Meanwhile, this credit portfolio fulfils two different objectives of working capital constrained retailers which are minimisation of overall costs and maximisation of customer service levels.

These four aspects are the main contribution to this thesis. There are some other perspectives that have been concluded such as a comparison of traditional commercial credit sources, clarification of the demand for new working capital sources in current SCM, integration of credit borrowing and SCM, a summary of the methodologies used in studies of credit borrowing activity and other contributions achieved through systemic literature.

7.4 Limitations of This Research

Although the thesis has contributed to knowledge from various aspects, several limitations should be concluded in this section. These limitations can be split into two areas; theAHP framework design and model practice.

This thesis adopted the AHP method to analyse the importance of possible concerns in terms of selecting credit. Although these concerns are summarised in a systemic literature review, reality it would be better to design a survey to investigate these concerns. In the systemic literature review, abundant relative studies were selected to conclude what types of concerns may affect working capital constrained companies in terms of credit selection. Through reviewing these studies, many studies have introduced various concerns based on surveys. In this thesis, these concerns were analysed according to the importance of the influence. It eliminated the process of investigating whether working capital constrained companies are still affected. The omission of this process may lead to an inaccurate design of the constraints in the LP model. Therefore, in an attempt to clarify borrowers' concerns, the thesis has attempted to summarise all the possible concerns mentioned in relevant studies. However, a few components may have been missed out due to the limitation of accessing databases.

In terms of model design, some certain assumptions restrict the model from being put in to practice. Firstly, the LP model based on the results of the AHP has limitations when considering

credit borrowing activity as a dynamic process. Through the analysis of the AHP method, interest rates and repayment periods have been addressed as having a significant influence on credit selection. The objective of the LP model is to maximise the borrowing value, ie. borrowing the maximum amount of credit with the lowest costs, however, it is difficult to see to what extent working capital constrained companies can reduce interest when only looking at a single period.

To improve this limitation, the MOO model designs credit borrowing activity as a dynamic process. The objectives in this MOO model consider multiple aspects including OC minimisation and BPC minimisation. The objective of OC minimisation involves interest payments and other possible costs. The results of this model provide a solution to minimise all these costs. The design of multiple business objectives optimisation via a GP model has improved the single business objective limitation in Chapter 5; however, it is still limited by the assumption in market demand. In chapter 6, the MOO model which is based on the PQM model assumes that market demand is known and fixed. This assumption is unrealistic as in the majority of situations the market demand is unknown or floated.

When solving NLP models, this thesis adopts LINDO as the solution. It can linearize the NLP models in Section 6.4.2 and Section 6.4.3. However, some studies have debated the stability of LINDO in linearization (Olsen and Vanderplaats, 1989; Cunningham and Schrage, 2004; Leyffer and Mahajan, 2010). This requires an appropriate discussion in future research.

Despite these limitations, the empirical analysis by AHP and mathematical modelling provide an understanding on the topic of how working capital constrained companies create credit portfolios. In this thesis, this topic has been discussed by designing different types of mathematical models. Although there are some limitations of these models, further studies can make them more rational and realistic in order to implement them into business practice.

7.5 Implications for Future Research

In relation to these findings and limitations in this thesis, there are still some academic issues that remain to be studied in future. These issues can be addressed for new development in some relevant areas.

Future innovation can be developed by modifying the limitations in this thesis. Based on the summary in Chapter 7.4, an investigation should be developed to confirm all the possible concerns influencing credit selection. The consideration of concerns in this thesis was realised only via a systemic literature review, there is a possibility that other potential concerns of working capital constrained companies which influence decisions about credit borrowing in business practise could have been ommitted.

Due to limited access to all relevant papers, some concerns may be have been ignored in the process of developing the systemic literature review. An investigation is necessary in future research in order to update the list of concerns. In addition, the adoption of the MOO model is an effective method to optimise multi-objective problems. Future research should focus on more practical business objectives through the investigation of working capital constrained companies.

Moreover, according to the summary of the limitations in this thesis, modelling assumptions limited the solution of scheduling a credit portfolio to be applied in business practice. Chapter 6 develops MOO model by adopting the PQM model. In this scenario, the working capital constrained company has to borrow external capital to manage procurement and inventory in order to meet the fixed demands of the market. It is clear that the specifying fixed demands varies from reality, it is therefore suggested that this assumption be improved in future research. A possible way to modify this limitation is to design a market with random demands instead of the fixed demands in this thesis. Furthermore, the SC credit portfolio problems in this thesis are treated as linear and nonlinear problems, respectively and they are optimised by adopting the LP model and MOO model. Future research may consider the integration of credit borrowing activity and SCM within an unpredictable or random- demand market, which can in turn develop a LP model or a NLP model to optimise credit portfolio selection.

Appendices

Appendix I

Question List 1- Measuring Weights of Criteria

	Part 1 - Basic Question										
1	Could you select from the following options to describe the population of employees in your company?	A. Less than 10 B. 10-99 C. 100-499 D. 500-1000 E. More than 1000 F. One branch as an international company									
2	Which development phase does / did the firm stay in?	A. Start-up B. Rapid growth C. Maturity D. Decline E. Rebirth F. Death									
3	Has the firm sustained the rejection of a credit application before? If yes please go to Question 4	Yes No									
4	Which of the following institutions rejected the application?	Bank Trader/ Partner Others									
	Part 2 - AHP Questions	**Select from criterion in the question**	**Intensity of Importance**								
	AHP Matrix Criteria										
Varieties of commercial credits are offered to borrowers. Borrowers normally consider different aspects to satisfy their borrowing goals or business strategies. Their consideration focuses on costs (A); their own business conditions (B), borrowing constraints (C) which might influence their borrowing choices and requirements to			**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**

credits (lender) (D). These aspects are the main criteria directly impacting on borrowers' considerations of credit selection and will further determine the relative weight of importance in the sub criteria.											
1	Which does the firm consider more in borrowing commercial credit, in the aspect of costs? Alternatively, the aspect of own business conditions? And how important is this factor in the consideration? (A: B)										
2	Which does the firm consider more in borrowing commercial credit, in the aspect of costs? Or the aspect of borrowing constraints which might limit borrowing choices? And how important of this factor in the consideration? (A: C)										
3	Which does the firm consider more in borrowing commercial credit, in the aspect of costs? Or the aspect of requirements to credits as a borrower? And how important of this factor in the consideration? (A: D)										
4	Which does the firm consider more in borrowing commercial credit, in the aspect of the own business conditions? Or the aspect of borrowing constraints which might limit borrowing choices? And how important of this factor in the consideration? (B: C)										
5	Which does the firm consider more in borrowing commercial credit, in the aspect of own business conditions? Or the aspect of requirements to credits as a borrower? (B: D)										
6	Which does the firm consider more in borrowing commercial credit, in the aspect of borrowing constraints which might limit borrowing choices? Or the aspect of requirements to credits as a borrower? (C: D)										

Cost is an intuitive element in borrowers' consideration for selecting commercial credit. Briefly borrowing costs involve interest rates (A1), administration fees (A2) and transaction costs (A3) which have a significant influence on credit selecting decisions. Different types of credit have different requirements in these factors. This section set these factors to measure their weight of importance in influencing credit selection.		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	As a short-term credit borrower, in the process of applying for commercial credit, paying different interest rates to lenders (A1), or spending different administration fees in credit management (A2), which influences the selecting decision significantly? What is the level of its impact? (A1:A2)									
2	Facing different commercial loans, paying different interest rates to lenders (A1) or being charged different transaction costs (A3), which has more influence in your consideration? What is the level of its impact? (A1:A3)									
3	For spending different administration fees in credit management, or being charged different transaction cost, which is more impact on consideration of loan selection? And please specific the influence level (A2:A3)									
In debt-credit relationships, borrowers are always required to publicise variety of information to lenders. Therefore, to a certain degree, borrowers' willingness (level) to publicise financial information (B1) actually reflects their loan selection. Sometimes, organizational structure (B2) also directly decides the suitable category of commercial loans. Moreover, accountants in organizations as the human capital (B3) also attend the decision making for credit selection; their analysis based on the realization of financial situation could offer a		1	2	3	4	5	6	7	8	9

better suggestion for credit selection. Business duration (B4) is an element to present firms' competitiveness to lenders. It could also be utilized to match credit requirements which has specific standard on business duration.											
1	Therefore, in the process of building debt-credit relationships, disclosing financial information to the public in order to access more commercial loans, or relying on organizational structure to select one suitable commercial loan, which has more impact on the consideration, and how far for its impacts? (B1:B2)										
2	Disclosing the financial information to the public to widen credit selection, or relying on accountants' analysis to select credit, which has more impact on credit selection? And how far for its impacts? (B1:B3)										
3	Disclosing financial information to public to widen credit selection, or selecting credit to satisfy credit standards in business duration, which one has more influence on credit selection? And how far for its impacts? (B1:B4)										
4	Relying on organizational structure to select one suitable commercial loan, or relying on accountants' analysis to select credit, which has more impacts on credit selection? And how far for its impacts? (B2:B3)										
5	Relying on organizational structure to select one suitable commercial loan, or selecting credit to satisfy credit standards in business duration, which one has more influence on credit selection? And how far for its impacts? (B2:B4)										
6	Relying on accountants' analysis to select credit, which has more impact on credit selection, or selecting credit to satisfy credit standards in										

	business duration, which one has more influence on credit selection? And how far for its impacts? (B3:B4)										
Borrowers-lenders' distance (C1) is a barrier for communication and information exchange. Although technology has already promoted debt-credit relationship extending to a far distance, the uncertainty of approval and credit issue are sometimes influenced by distance. As a result, borrowers are unwilling to apply to far-distance lenders due to their diffident strategies for answering these uncertainties. In addition, borrowers often consider their lengths of building debt-credit relationship (C2) with lenders, which has a direct influence on credit interest rate, repayment periods and so on.			1	2	3	4	5	6	7	8	9
1	Therefore, comparing the importance of distance and debt-credit relationship, aims to debate which has more influence on credit selection when borrowers are willing to build a debt-credit relationship, and how far for its importance? (C1:C2)										
Borrowers have their own criteria for measuring a suitable credit from a variety of choices. Facing different categories of commercial credit, borrowers require lenders to offer the information involving approval time (D1), repayment period (D2), lending volume (D3) and accuracy of credit (Whether applied credit is issued on time) (D4), in order to filter out one suitable credit to satisfy their criteria. Therefore, this section compares and evaluates these elements to rank borrowers' considerations in order of importance.			1	2	3	4	5	6	7	8	9
1	As the borrower, for different approval time, or repayment periods, which is more important in selecting credit, and how far for its impact? (D1:D2)										

2	For different approval time, or different lending volumes, which is more important in selecting credit, and how far for its impact? (D1:D3)										
3	For different approval time, or different accuracy of credit, which is more important in selecting credit, and how far for its impact? (D1:D4)										
4	For different repayment periods, or different lending volumes, which has more impact on credit selecting considerations? And how far for its impact? (D2:D3)										
5	For different repayment periods, or different accuracy of credit, which has more impact on credit selecting consideration? And how far for its impact? (D2:D4)										
6	For different lending volumes, or different accuracy of credit, which is considered more in selecting credit, and how far for this influence on the consideration? (D3:D4)										

Question List 2- Measuring Rating of Credits

Part 1 – Introduction
Based on the result in Question List 1, in all selected criteria which aim to measure their weights in influencing borrowers' borrowing consideration, the first stage AHP analysis confirms these criteria weight ratings and will select important criteria for measuring the alternative credit ratings (Bank loan (BL), trade credit (TC) and 3PL credit (3PLC)). Therefore, in the second stage data collection, it will calculate weights of these credits with conditions of the weight rating with the condition of the selected criteria in first stage. This investigation aims to realize that in these three kinds of commercial credits, which one has shorter approval time, lower administration fees, more accurate of credit, larger lending volume, and more flexible repayment period and lower interest rate. Respondents should select one for the options and mark their ratings in the following form.
Part 2 - AHP Questions

AHP Matrix Criteria		Select from criterion in the question	Intensity of Importance								
Borrowers are all willing to go through a shorter approval time in their application in order to achieve their credits. For bank credit, trade credit and 3PL credit. Borrowers have already built a realization about their approval time through experience and practice. Therefore, the following questions will mark the rating of these three credits in order to confirm a credit which has a shortest approval time.			1	2	3	4	5	6	7	8	9
1	For bank loan and trade credit, which one has a shorter approval time in the process of application? (BL:TC)										
2	For bank loan and 3PL credit, which one has a shorter approval time in the process of application? (BL:3PLC)										
3	For trade credit and 3PL credit, which one has a shorter approval time in the process of application? (TC:3PLC)										
Borrower has their investment to manage the credit they applied. The aim of setting administration fees is making a reduction for costs. Therefore, borrowers are willing to achieve a credit which requires a lower administration fees. The following questions will determine a credit which has a lowest administration fees.			1	2	3	4	5	6	7	8	9
1	For bank overdraft and trade credit, which one requires a lower administration fees in credit management ?(BO:TC)										

2	For bank loan and 3PL credit, which one requires a lower administration fees in credit management (BO:3PLC)										
3	For trade credit and 3PL credit, which one requires a lower administration fees in credit management ?(TC:3PLC)										
Borrowers hope to achieve a larger lending volume from their lenders. Therefore the following questions are aim to confirm one credit which has a largest lending volume.			1	2	3	4	5	6	7	8	9
1	For bank loan and trade credit, which one has a larger lending volume ?(BO:TC)										
2	For bank loan and 3PL credit, which one has a larger lending volume? (BO:3PLC)										
3	For trade credit and 3PL credit, which one has a larger lending volume ?(TC:3PLC)										
Borrowers are willing to design their repayment period more flexiBOe, which could contribute to their inventory management and financial flow. For these three kinds of credit, the following questions will require borrowers to determine one credit which has most flexible repayment period through their experience.			1	2	3	4	5	6	7	8	9
1	For bank loan and trade credit, which one has more flexible repayment period ?(BO:TC)										
2	For bank loan and 3PL credit, which one has more flexible repayment period ?(BL:3PLC)										
3	For trade credit and 3PL credit, which one has more flexible repayment period ?(TC:3PLC)										
Interest Rate as a main part of consideration when borrowers select their commercial credit. For these three credits, the following questions will ask borrowers to find a credit which has a lowest interest rate during their repayment process, or			1	2	3	4	5	6	7	8	9

which one is easy to access a lowest interest rate in the process of negotiating with lenders.											
1	For bank loan and trade credit, which one has lower interest rate for the repayment, or which one is easy to access a lower interest rate ?(BO:TC)										
2	For bank loan and 3PL credit, which one has lower interest rate for the repayment, or which one is easy to access a lower interest rate ?(BO:3PLC)										
3	For trade credit and 3PL credit, which one has lower interest rate for the repayment, or which one is easy to access a lower interest rate ?(TC:3PLC)										

Appendix II

The Sample of Calculating the Importance of Borrowers' concerns and Preferences

First Criteria

	A	B	C	D
A	1.000	3.000	7.000	2.000
B	0.333	1.000	3.000	0.500
C	0.143	0.333	1.000	0.200
D	0.500	2.000	5.000	1.000
SUM	1.976	6.333	16.000	3.700

	A	B	C	D	**WEIGHT**	***Priority***
A	0.506	0.474	0.438	0.541	0.48944	4
B	0.169	0.158	0.188	0.135	0.16230	5
C	0.072	0.053	0.063	0.054	0.06037	1
D	0.253	0.316	0.313	0.270	0.28789	2

Check CR and if CR <= 0.10, it will be acceptable

	1.000			3.000			7.000			2.000
	0.333			1.000			3.000			0.500
0.48944	0.143	+	0.16230	0.333	+	0.06037	1.000	+	0.28789	0.200
	0.500			2.000			5.000			1.000
										Weighted Sum Vector (WSV)
	0.489437		0.486903		0.422581		0.575786		**1.974707**	
	0.163146		0.162301		0.181106		0.143946		**0.650499**	
=	0.06992	+	0.0541	+	0.060369	+	0.057579	=	**0.241967**	
	0.244719		0.324602		0.301843		0.287893		**1.159057**	

Divide the elements of WSV by Weight
4.034649
4.007978
4.008158
4.026001

λ	CR
4.019197	**0.00711**
CI	**ACCEPTABLE**
0.006399	
RI	
0.9	

The

Evaluation for the Importance of Main Criteria

	Factor A n=3						
	A1	A2	A3				
A1	**1.000**	0.500	3.000				
A2	2.000	**1.000**	4.000				
A3	0.333	0.250	**1.000**				
Sum	3.333	1.750	8.000				
	Standardized Matrix						
	A1	A2	A3	**WEIGHT**	***Priority***		
A1	0.300	0.286	0.375	0.32025	2		
A2	0.600	0.571	0.500	0.55716	1		
A3	0.100	0.143	0.125	0.12259	3		
		Check CR and if CR <= 0.10, it will be acceptable					
	1.000			0.500			3.000
0.32025	2.000	+	0.55716	1.000	+	0.12259	4.000

	0.333			0.250			1.000	
							Weighted Sum Vector (WSV)	
	0.320248		0.278581		0.367767		0.966597	
=	0.640496	+	0.557163	+	0.490356	=	1.688015	
	0.106643		0.139291		0.122589		0.368522	**Check CR and if CR <= 0.10, it will be acceptable**
		Divide the elements of WSV by Weight				**λ**		**CR**
3.018274						3.018032		**0.015545**
3.029662						**CI**		**ACCEPTABLE**
3.006161						0.009016		
						RI		
						0.58		

The Evaluation for the Importance of Sub-criteria A

	Factor B n=4			
	B1	B2	B3	B4
B1	**1.000**	5.000	4.000	3.000
B2	0.200	**1.000**	0.333	0.500
B3	0.250	3.000	**1.000**	2.000
B4	0.333	2.000	0.500	**1.000**
Sum	1.783	11.000	5.833	**6.500**

	Standardized Matrix					
	B1	B2	B3	B4	**WEIGHT**	***Priority***
B1	0.561	0.455	0.686	0.462	0.54065	1
B2	0.112	0.091	0.057	0.077	0.08427	4
B3	0.140	0.273	0.171	0.308	0.22301	2
B4	0.187	0.182	0.086	0.154	0.15207	3

		Check CR and if CR <= 0.10, it will be acceptable								
	1.000			5.000			4.000			3.000
0.54065	0.200	+	0.08427	1.000	+	0.22301	0.333	+	0.15207	0.500
	0.250			3.000			1.000			2.000
	0.333			2.000			0.500			1.000
									Weighted Sum Vector (WSV)	
	0.540646		0.421338		0.892045		0.4562		2.3103	
	0.108129		0.084268		0.074263		0.0760		0.3427	
=	0.135162	+	0.252803	+	0.223011	+	0.3041	=	0.9151	
	0.180215		0.168535		0.111506		0.1521		0.6123	

					λ			
		Divide the elements of WSV by Weight			4.117477		**Check CR and if CR <= 0.10, it will be acceptable**	
4.273134					**CI**		**CR**	
4.066768					0.039159		**0.04351**	
4.103495					**RI**		**ACCEPTABLE**	
4.026512					0.90			

The Evaluation for the Importance of Sub-criteria B

	Factor C n=2			
	C1	C2		
C1	1	4		
C2	0.25	1		
SUM	1.25	5		
	Standardized Matrix			
	C1	C2	**WEIGHT**	***Priority***
C1	0.8	0.8	0.8	1
C2	0.2	0.2	0.2	2
Second-moment judgement matrix does not require consistency test (Saaty, 2013)				

The Evaluation for the Importance of Sub-criteria C

	Factor D n=4			
	D1	D2	D3	D4
D1	**1.000**	4.000	3.000	2.000
D2	0.250	**1.000**	3.000	2.000
D3	0.333	0.333	**1.000**	0.500
D4	0.500	0.500	2.000	**1.000**
Sum	2.083	5.833	9.000	**5.500**

	Standardized Matrix					
	D1	D2	D3	D4	**WEIGHT**	***Priority***
D1	0.480	0.686	0.333	0.364	0.46570	1
D2	0.120	0.171	0.333	0.364	0.24711	2
D3	0.160	0.057	0.111	0.091	0.10474	4
D4	0.240	0.086	0.222	0.182	0.18245	3

		Check CR and if CR <= 0.10, it will be acceptable								
	1.000			4.000			3.000			2.000
0.46570	0.250	+	0.24711	1.000	+	0.10474	3.000	+	0.18245	2.000
	0.333			0.333			1.000			0.500

	0.500			0.500			2.000			1.000
									Weighted Sum Vector (WSV)	
	0.4657		0.988427		0.314231		0.3649		2.1333	
	0.116425		0.247107		0.314231		0.3649		1.0427	
=	0.155078	+	0.082287	+	0.104744	+	0.0912	=	0.4333	
	0.23285		0.123553		0.209487		0.1824		0.7483	
						λ				**Check CR and if CR <= 0.10, it will be acceptable**
		Divide the elements of WSV by Weight				4.259736		**CR**		
4.580754						**CI**		**0.096198**		
4.219478						0.086579		**ACCEPTABLE**		
4.137081						**RI**				
4.101630						0.90				

The Evaluation for the Importance of Sub-criteria D

Appendix III

The summary of studies employing AHP in the methodology

Author (S)	Subject	Objective (s)	Criteria	Method(s)
Mohamed *et al.* (1996)	Supplier selection	Total cost minimization	• Cost • Quality • Delivery	AHP
Ghodsypour and O'Brien (1998)	Supplier selection	Total value of purchasing maximization	• Cost • Quality (Defects, Process capability) • Service (On-time delivery, Base of Communication, Response to changes, Process flexibility)	AHP and Linear Programming (LP)
Badri (1999)	The problem of global facility location allocation	AHP: Select the best location Goal Programming (GP): 1) Minimizing Total cost	• Political situation of foreign country • Global competition and survival • Government regulations • Economic related factors	AHP and GP

		2) Satisfying product demand by distribution center 3) Maintaining county restriction for air standards Maintaining a policy of desired expansion		
Yahya and Kingsman (1999)	Vender rating for an entrepreneur	Rating one highest mark for different vendors	• Quality • Responsiveness • Discipline • Delivery • Technological capability management • Financial position • Past performance attitude • Communication system • Desire for business	AHP
Eon-Kyung *et al.* (2001)	Supplier selection	Determining a best supplier	• Quality (Rejection rate in the incoming quality control, Rejection rate from customers, Time loss in the production line, Remedy for quality problems)	AHP

			• Cost (Cost reduction, Pricing structure) • Delivery (Compliance with due date, Compliance with quantity) • Service (Financial status, Level of cooperation and information exchange, Technological and R&D capability, Production facility and capacity)		
Ramanathan (2001)	Environment impact assessment in house purchasing	Best property to buy	• Location • Price • Age		AHP
Hafeez *et al.* (2002)	Determining the key capabilities of a firm	The evaluation of financial performance contribution and non-financial performance contribution	Financial aspects: • Sales growth • Operating profit • Return on capital employed	Non-financial aspects: • Market share • New product introduction • Customer satisfaction	AHP
Yang and Kuo (2003)	Facilities layout design problem	Evaluation and select a good layout design generator.	• Flexibility • Accessibility • Maintenance		AHP and data envelopment analysis (DEA)
Albayrak and Erensal (2004)	Human performance improvement	How human performance can be improved effectively	• Conditional Factor (Physical workplace, Organization of work)		AHP

			• Managerial factors (Leadership, Participation involvement, Company culture) • Individual factors (Human performance capability, Attitude in human performance)	
Bayazit (2005)	Flexible manufacturing systems (FMS) selection	FMS evaluation	• Advantages • Risks • Disadvantages • Opportunities	AHP
Liu and Hai (2005)	Supplier selection	Best supplier selection (Total ranking comparison)	• Quality • Responsiveness • Discipline • Delivery • Financial • Management • Technological capability • Facility	AHP
Lee and Kozar (2006)	The effect of website quality on e-business success	Choice of the most preferred website	• Information quality • Service quality • Systems quality • Vendor- specific quality	AHP

Gencer and Gürpinar (2007)	Supplier selection	Determine a best supplier	• General information of the supplier • Organization profile of the supplier • Financial status of the supplier • Equipment status of the supplier • Manufacturing capability of the supplier • Material delivering capability of the supplier • Quality system certificate of the supplier • Quality system documentation of the supplier • Quality system application of the supplier		AHP and ANP
Tugrul *et al.* (2012)	3PL providers selection	Deciding on which 3PL's to consider	• Cost of service • Service level performance and quality • Comprehensive global capabilities • Information technology capabilities and integration • Expertise and experience specific to the respondent's industry • Strong local presence and capability		AHP
Ordoobadi (2013)	Advanced manufacturing evaluation	Measure performance of all advanced technologies with	Benefits: • Increased flexibility • Increased quality	Risks: • Incompatibility with current operation	AHP and Taguchi loss functions

		respect to risks and benefits	• Increased productivity • Expanded use of the technology • Promotion of strategic objectives • Competitive strengths • Increased customer satisfaction • Increased market opportunities • Increased case of operation • Improved employee relations	• Obsolescence due to poor timing of adoption • Reduction in versatility of personnel skills • Lower employee performance due to resistance • to change • Not completing the implementation • Increase in labor contract costs	
Sonal K. Thengane *et al.* (2014)	hydrogen	Cost minimization	• Greenhouse gas emissions • Raw material & utilities consumption • Scalability		AHP and Fuzzy AHP

	production technologies comparison		• Energy efficiency • Waste& non-GHG emissions	
Zietsman and Vanderschuren (2014)	Multiple airport system assessment	Matching different passengers' levels	• Socio-economic development: • Spatial and urban planning • Transportation improvement, efficiency and provision • Environmental preservation • Financial viability	AHP
Govindan *et al.* (2014)	The implementation of green supply chain management	Barriers analysis of green SCM implementation	• Involvement and support • Financial • Technology • Knowledge • Outsourcing	AHP
Quezada and López-Ospina (2014)	Strategy map design	AHP: Identify a strategy map LP: 1) To reduce the number of relationships selected	• Finances • Clients • Internal processes • Growth and learning	AHP and LP

		2) To increase the accumulated importance of those relationships selected		
Shad *et al.* (2014)	Supplier development under uncertainty	Develop a realization about customers' requirements on suppliers' characteristics	• Cost • Conformity • Punctuality • Efficacy • Lead time	AHP, LP and Quality function deployment (QFD)
Galvez *et al.* (2015)	Reserve logistics network design	AHP: Evaluate the preferences of stakeholders involved in the network LP: minimize all the costs associated with waste treatment	• Cost • Crossed distance • Durability • Feasibility	AHP and LP

Appendix IV

Model dimensions in SCM

Model purpose	No.	Model type	No.	Model technique	No.	Solution Approach	No.
Descriptive – deterministic	56	Analytical	77	Artificial intelligence	5	AHP/ANP	20
Descriptive – stochastic	3	Heuristics	7	Discrete-event simulation	1	Data envelopment analysis	3
Normative – deterministic	63	Hybrid	1	Game theory	1	Goal programming	2
Normative – stochastic	12	Mathematical programming	36	Meta-heuristics	1	Input–output-analysis	4
		Simulation	9	Multi-criteria decision making	25	Life cycle analysis	24
		Various/other	4	Multi-objective	34	LP/MILP	18
				Simple heuristics	1	Metrics	8
				Single-objective	2	Nonlinear programming	5
				System dynamics	3	Rough set	3
				Systemic models	39	Variation inequality	6
				Various/other	22	Various/other	31
						n.a.	7
						Singular (Dynamic programming, genetic algorithms, and neural networks)	3

Model dimensions in SCM (Brandenburg *et al.*, 2014)

References

Abad, P.L. (2003) 'Optimal pricing and lot-sizing under conditions of perishability, finite production and partial backordering and lost sale', *European Journal of Operational Research*, 144(3), pp. 677-685.

Abdel-Malek, L., Montanari, R. and Morales, L.C. (2004) 'Exact, approximate, and generic iterative models for the multi-product Newsboy problem with budget constraint', *International Journal of Production Economics*, 91(2), pp. 189-198.

Abdesamed, K.H. and Wahab, K.A. (2014) 'Financing of small and medium enterprises (SMEs): Determinants of bank loan application', *African Journal of Business Management*, 8(17), p. 1.

Acharya, V. and Naqvi, H. (2012) 'The seeds of a crisis: A theory of bank liquidity and risk taking over the business cycle', *Journal of Financial Economics*, 106(2), pp. 349-366.

Acimovic, J. and Graves, S.C. (2014) 'Making better fulfillment decisions on the fly in an online retail environment', *Manufacturing & Service Operations Management*, 17(1), pp. 34-51.

Adams, D.W. and Nehman, G.I. (1979) '"Borrowing costs and the demand for rural credit"', *The Journal of Development Studies*, 15(2), pp. 165-176.

Agarwal, S., Chomsisengphet, S., Liu, C. and Souleles, N.S. (2015) 'Do consumers choose the right credit contracts?', *Review of Corporate Finance Studies*, p. cfv003.

Agarwal, S. and Hauswald, R. (2010) 'Distance and Private Information in Lending', *Review of Financial Studies*.

Agier, I. and Szafarz, A. (2013) '"Microfinance and Gender: Is There a Glass Ceiling on Loan Size?"', *World Development*, 42, pp. 165-181.

Aissaoui, N., Haouari, M. and Hassini, E. (2007) 'Supplier selection and order lot sizing modeling: A review', *Computers & Operations Research*, 34(12), pp. 3516-3540.

Albayrak, E. and Erensal, Y. (2004) 'Using analytic hierarchy process (AHP) to improve human performance: An application of multiple criteria decision making problem', *Journal of Intelligent Manufacturing*, 15(4), pp. 491-503.

Alesina, A.F., Lotti, F. and Mistrulli, P.E. (2013) 'Do women pay more for credit? Evidence from Italy', *Journal of the European Economic Association*, 11(s1), pp. 45-66.

Alexander Tedeschi, G. (2006) 'Here today, gone tomorrow: Can dynamic incentives make microfinance more flexible?', *Journal of Development Economics*, 80(1), pp. 84-105.

Allen, F., Qian, Y., Tu, G. and Yu, F. (2015) 'Entrusted Loans: A Close Look at China's Shadow Banking System', *Available at SSRN 2621330*.

Allesina, S., Azzi, A., Battini, D. and Regattieri, A. (2010) 'Performance measurement in supply chains: new network analysis and entropic indexes', *International Journal of Production Research*, 48(8), pp. 2297-2321.

Amid, A., Ghodsypour, S.H. and O'Brien, C. (2006) 'Fuzzy multiobjective linear model for supplier selection in a supply chain', *International Journal of Production Economics*, 104(2), pp. 394-407.

Amid, A., Ghodsypour, S.H. and O'Brien, C. (2009) 'A weighted additive fuzzy multiobjective model for the supplier selection problem under price breaks in a supply Chain', *International Journal of Production Economics*, 121(2), pp. 323-332.

Anagnostopoulos, K.P. and Mamanis, G. (2010) 'A portfolio optimization model with three objectives and discrete variables', *Computers & Operations Research*, 37(7), pp. 1285-1297.

Anderson, B.M. (1917) *The Value of Money*. New York: The Macmillan Company.

Andersson, F., Mausser, H., Rosen, D. and Uryasev, S. (2001) 'Credit risk optimization with Conditional Value-at-Risk criterion', *Mathematical Programming*, 89(2), pp. 273-291.

Angelini, P., Di Salvo, R. and Ferri, G. (1998) 'Availability and cost of credit for small businesses: Customer relationships and credit cooperatives', *Journal of Banking & Finance*, 22(6–8), pp. 925-954.

Aouni, B., Colapinto, C. and La Torre, D. (2014) 'Financial portfolio management through the goal programming model: Current state-of-the-art', *European Journal of Operational Research*, 234(2), pp. 536-545.

Arena, M.P. and Dewally, M. (2012) 'Firm location and corporate debt', *Journal of Banking & Finance*, 36(4), pp. 1079-1092.

Armendáriz de Aghion, B. (1999) 'On the design of a credit agreement with peer monitoring', *Journal of Development Economics*, 60(1), pp. 79-104.

Åstbro, T. and Bernhardt, I. (2005) 'The Winner's Curse of Human Capital', *Small Business Economics*, 24(1), pp. 63-78.

Atieno, R. (2001) *Formal and informal institutions' lending policies and access to credit by small-scale enterprises in Kenya: An empirical assessment*. African Economic Research Consortium Nairobi.

Atiya, A.F. (2001) 'Bankruptcy prediction for credit risk using neural networks: A survey and new results', *IEEE Transactions on Neural Networks*, 12(4), pp. 929-935.

Azadian, F., Murat, A.E. and Chinnam, R.B. (2012) 'Dynamic routing of time-sensitive air cargo using real-time information', *Transportation Research Part E: Logistics and Transportation Review*, 48(1), pp. 355-372.

Badri, M.A. (1999) 'Combining the analytic hierarchy process and goal programming for global facility location-allocation problem', *International Journal of Production Economics*, 62(3), pp. 237-248.

Badu, E., Edwards, D.J. and Owusu-Manu, D. (2012) 'Trade credit and supply chain delivery in the Ghanaian construction industry: Analysis of vendor interactions with small to medium enterprises', *Journal of Engineering, Design and Technology*, 10(3), pp. 360-379.

Bădulescu, D. (2010) 'SMEs financing: the extent of need and the responses of different credit structures', *Theoretical and Applied Economics*, 7(7), p. 25.

Baghalian, A., Rezapour, S. and Farahani, R.Z. (2013) 'Robust supply chain network design with service level against disruptions and demand uncertainties: A real-life case', *European Journal of Operational Research*, 227(1), pp. 199-215.

Banerjee and Duflo (2014) 'Do Firms Want to Borrow More? Testing Credit Constraints Using a Directed Lending Program', *Review of Economic Studies*, 81(2), pp. 572-607.

Bannier, C.E., Hirsch, C.W. and Wiemann, M. (2012) 'Do credit ratings affect firm investments? The monitoring role of rating agencies', *The Monitoring Role of Rating Agencies (July 17, 2012)*.

Baños-Caballero, S., García-Teruel, P.J. and Martínez-Solano, P. (2010) 'Working capital management in SMEs', *Accounting & Finance*, 50(3), pp. 511-527.

Bar-Isaac, H. and Shapiro, J. (2011) 'Credit Ratings Accuracy and Analyst Incentives', *The American Economic Review*, 101(3), pp. 120-124.

Barkaoui, M., Berger, J. and Boukhtouta, A. (2015) 'Customer satisfaction in dynamic vehicle routing problem with time windows', *Applied Soft Computing*, 35, pp. 423-432.

Barrot, J.-N. (2015) 'Trade Credit and Industry Dynamics: Evidence from Trucking Firms', *The Journal of Finance*, pp. n/a-n/a.

Bates, T. (1997a) 'Financing small business creation: The case of Chinese and Korean immigrant entrepreneurs', *Journal of Business Venturing*, 12(2), pp. 109-124.

Bates, T. (1997b) 'UNEQUAL QCCESS: Financial Institution Lending to Black-and White-Owned Small Business Start-ups', *Journal of Urban Affairs*, 19(4), pp. 487-495.

Bayazit, O. (2005) 'Use of AHP in decision-making for flexible manufacturing systems', *Journal of Manufacturing Technology Management*, 16(7), pp. 808-819.

Becchetti, L. and Trovato, G. (2002) 'The determinants of growth for small and medium sized firms. The role of the availability of external finance', *Small Business Economics*, 19(4), pp. 291-306.

Beck, T. and Demirguc-Kunt, A. (2006) 'Small and medium-size enterprises: Access to finance as a growth constraint', *Journal of Banking & Finance*, 30(11), pp. 2931-2943.

Beck, T., Demirgüç-Kunt, A. and Martinez Peria, M.S. (2008) 'Banking Services for Everyone? Barriers to Bank Access and Use around the World', *The World Bank Economic Review*, 22(3), pp. 397-430.

Beck, T., Demirgüç-Kunt, A. and Pería, M.S.M. (2011) 'Bank Financing for SMEs: Evidence Across Countries and Bank Ownership Types', *Journal of Financial Services Research*, 39(1), pp. 35-54.

Behr, P., Entzian, A. and Güttler, A. (2011) 'How do lending relationships affect access to credit and loan conditions in microlending?', *Journal of Banking & Finance*, 35(8), pp. 2169-2178.

Behr, P. and Sonnekalb, S. (2012) 'The effect of information sharing between lenders on access to credit, cost of credit, and loan performance – Evidence from a credit registry introduction', *Journal of Banking & Finance*, 36(11), pp. 3017-3032.

Bell, J. (2014) *Doing Your Research Project: A guide for first-time researchers*. McGraw-Hill Education (UK).

Bellucci, A., Borisov, A. and Zazzaro, A. (2010) 'Does gender matter in bank–firm relationships? Evidence from small business lending', *Journal of Banking & Finance*, 34(12), pp. 2968-2984.

Bennardo, A., Pagano, M., Piccolo, S. (2010) 'Multiple-Bank Lending, Creditor Rights and Information Sharing', *CSEF Working Paper No. 211*.

Berg, T., Saunders, A. and Steffen, S. (2015) 'The Total Cost of Corporate Borrowing in the Loan Market: Don't Ignore the Fees', *The Journal of Finance*, pp. n/a-n/a.

Berger, A. and Udell, G. (1998) 'The economics of small business finance: The roles of private equity and debt markets in the financial growth cycle', *Journal of Banking & Finance*, 22(6–8), pp. 613-673.

Berger, A.N. (2003) 'The economic effects of technological progress: Evidence from the banking industry', *Journal of Money, credit, and Banking*, 35(2), pp. 141-176.

Berger, A.N. and Black, L.K. (2011) 'Bank size, lending technologies, and small business finance', *Journal of Banking & Finance*, 35(3), pp. 724-735.

Berger, A.N. and DeYoung, R. (1997) 'Problem loans and cost efficiency in commercial banks', *Journal of Banking & Finance*, 21(6), pp. 849-870.

Berger, A.N., Miller, N.H., Petersen, M.A., Rajan, R.G. and Stein, J.C. (2005) 'Does function follow organizational form? Evidence from the lending practices of large and small banks', *Journal of Financial Economics*, 76(2), pp. 237-269.

Berger, A.N. and Udell, G.F. (1995) 'Relationship Lending and Lines of Credit in Small Firm Finance', *The Journal of Business*, 68(3), pp. 351-381.

Berger, A.N. and Udell, G.F. (2002) 'Small business credit availability and relationship lending: The importance of bank organisational structure', *The economic journal*, 112(477), pp. F32-F53.

Berger, E. and Nakata, C. (2013) 'Implementing Technologies for Financial Service Innovations in Base of the Pyramid Markets', *Journal of Product Innovation Management*, 30(6), pp. 1199-1211.

Berkowitz, J. and White, M.J. (2004) 'Bankruptcy and small firms' access to credit ', *The RAND Journal of Economics*, 35(1), pp. 69-84.

Berlin , M. and Mester , L.J. (1998) '"On the profitability and cost of relationship lending"', *Journal of Banking and Finance* 22(6-8), pp. 873-97.

Bhagwat, R. and Sharma, M.K. (2007) 'Performance measurement of supply chain management: A balanced scorecard approach', *Computers & Industrial Engineering*, 53(1), pp. 43-62.

Bharath, S., Dahiya, S., Saunders, A. and Srinivasan, A. (2007) 'So what do I get? The bank's view of lending relationships', *Journal of Financial Economics*, 85(2), pp. 368-419.

Bharath, S.T., Dahiya, S., Saunders, A. and Srinivasan, A. (2011) 'Lending Relationships and Loan Contract Terms', *Review of Financial Studies*, 24(4), pp. 1141-1203.

Bhatt, N. and Tang, S.-Y. (1998) 'The problem of transaction costs in group-based microlending: An institutional perspective', *World Development*, 26(4), pp. 623-637.

Biais, B. and Gollier, C. (1997) '"Trade credit and credit rationing"', *Review of Financial Studies* 10, pp. 903-937.

Bichou, K. and Gray, R. (2004) 'A logistics and supply chain management approach to port performance measurement', *Maritime Policy & Management*, 31(1), pp. 47-67.

Bielen, F. and Demoulin, N. (2007) 'Waiting time influence on the satisfaction-loyalty relationship in services', *Managing Service Quality: An International Journal*, 17(2), pp. 174-193.

Biesebroeck, J.V. (2005) '"Firm Size Matters: Growth and Productivity Growth in African Manufacturing"', *Economic Development and Cultural Change*, 53(3), pp. 545-583.

Binks, M.R. and Ennew, C.T. (1996) 'Growing firms and the credit constraint', *Small Business Economics*, 8(1), pp. 17-25.

Binks, M.R. and Ennew, C.T. (1997) 'The relationship between U.K. Banks and their small business customers', *Small Business Economics* 9(2), pp. 167-178.

BIS (2012) *SME Access to External Finance* (BIS Economics Paper No.16). Department for Business Innovation & Skills. [Online]. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/32263/12-539-sme-access-external-finance.pdf (Accessed: 20/08/2016).

Biswas, S. and Narahari, Y. (2004) 'Object oriented modeling and decision support for supply chains', *European Journal of Operational Research*, 153(3), pp. 704-726.

Black, S.E. and Strahan, P.E. (2002) 'Entrepreneurship and Bank Credit Availability', *The Journal of Finance*, 57(6), pp. 2807-2833.

Blackwell, D.W. and Winters, D.B. (1997) 'Banking relationships and the effect of monitoring on loan pricing', *Journal of Financial Research*, 20(2), pp. 275-289.

Blanchflower, D.G., Levine, P.B. and Zimmerman, D.J. (2003) 'Discrimination in the Small-Business Credit Market', *Review of Economics and Statistics*, 85(4), pp. 930-943.

Blasio, G.d. (2005) 'Does Trade Credit Substitute Bank Credit? Evidence from Firm-level Data', *Economic Notes*, 34(1), pp. 85-112.

Bo Becker and Ivashina, V. (2014) '"Cyclicality of credit supply: Firm level evidence "', *Journal of Monetary Economics* 62, pp. 76-93.

Bonaccorsi di Patti, E. and Gobbi, G. (2001) 'The changing structure of local credit markets: Are small businesses special?', *Journal of Banking & Finance*, 25(12), pp. 2209-2237.

Bowersox, D.J., Closs, D.J. and Cooper, M.B. (2002) *Supply chain logistics management*. McGraw-Hill New York, NY.

Boyaci, T. and Gallego, G. (2004) 'Supply chain coordination in a market with customer service competition', *Production and Operations Management*, 13(1), pp. 3-22.

Brace, I. (2008) *Questionnaire design: How to plan, structure and write survey material for effective market research*. Kogan Page Publishers.

Branch, C.S.B.P. (2002) *Financing SMEs in Canada, Barriers Faced by Women, Youth, Aboriginal and Minority Entrepreneurs in Accessing Capital. Phase 1, Literature Review [electronic Resource]*. Small Business Policy Branch, Industry Canada.

Brau, J.C. (2002) 'Do Banks Price Owner–Manager Agency Costs? An Examination of Small Business Borrowing', *Journal of Small Business Management*, 40(4), pp. 273-286.

Brealey, R.A., Myers, S.C., Allen, F. and Mohanty, P. (2012) *Principles of corporate finance*. Tata McGraw-Hill Education.

Brereton, P., Kitchenham, B.A., Budgen, D., Turner, M. and Khalil, M. (2007) 'Lessons from applying the systematic literature review process within the software engineering domain', *Journal of Systems and Software*, 80(4), pp. 571-583.

Bricongne, J.-C., Fontagné, L., Gaulier, G., Taglioni, D. and Vicard, V. (2012) 'Firms and the global crisis: French exports in the turmoil', *Journal of International Economics*, 87(1), pp. 134-146.

Broverman, S.A. (2010) *"Mathematics of Investment and Credit"*. Winsted: ACTEX Publications.

Brown, J.D. and Earle, J.S. (2015) 'Finance and Growth at the Firm Level: Evidence from SBA Loans', *Available at SSRN*.

Brown, M. and Zehnder, C. (2007) 'Credit reporting, relationship banking, and loan repayment', *Journal of Money, Credit and Banking*, 39(8), pp. 1883-1918.

Burnetas, A. and Ritchken, P. (2005) 'Option pricing with downward-sloping demand curves: The case of supply chain options', *Management Science*, 51(4), pp. 566-580.

Caputo, A.C., Pelagagge, P.M. and Salini, P. (2013) 'AHP-based methodology for selecting safety devices of industrial machinery', *Safety Science*, 53, pp. 202-218.

Carling, K. and Lundberg, S. (2005) 'Asymmetric information and distance: an empirical assessment of geographical credit rationing', *Journal of Economics and Business*, 57(1), pp. 39-59.

Carpenter, R.E. and Petersen, B.C. (2002) 'Is the growth of small firms constrained by internal finance?', *Review of Economics and statistics*, 84(2), pp. 298-309.

Casey, E. and O'Toole, C.M. (2014) 'Bank lending constraints, trade credit and alternative financing during the financial crisis: Evidence from European SMEs', *Journal of Corporate Finance*, 27, pp. 173-193.

Cassar, G. (2004) 'The financing of business start-ups', *Journal of Business Venturing*, 19(2), pp. 261-283.

Cavalluzzo, K., xa, S, Cavalluzzo, L., xa, C, Wolken, J., xa and D (2002) 'Competition, Small Business Financing, and Discrimination: Evidence from a New Survey', *The Journal of Business*, 75(4), pp. 641-679.

Cavana, R.Y., Delahaye, B.L. and Sekaran, U. (2001) *Applied Business Research: qualitative and quantitive methods*. Australia, Milton, Queensland: John Wiley & Sons Australia.

Chakraborty, A. and Hu, C.X. (2006) 'Lending relationships in line-of-credit and nonline-of-credit loans: Evidence from collateral use in small business', *Journal of Financial Intermediation*, 15(1), pp. 86-107.

Chan, R.C. (2014) 'Financial constraints, working capital and the dynamic behavior of the firm', *World Bank Policy Research Working Paper*, (6797).

Chan, T.S.F. and Chan, H.K. (2004) 'The future trend on system-wide modelling in supply chain studies', *The International Journal of Advanced Manufacturing Technology*, 25(7), pp. 820-832.

Chang, C.-T. (2007) 'Multi-choice goal programming', *Omega*, 35(4), pp. 389-396.

Chang, H.L. and Byong-Duk, R. (2011) '"Trade credit for supply chain coordination"', *European Journal of Operational Research*, 214(1), pp. 134-146.

Chapman, R.L., Soosay, C. and Kandampully, J. (2003) 'Innovation in logistic services and the new business model: a conceptual framework', *International Journal of Physical Distribution & Logistics Management*, 33(7), pp. 630-650.

Che, Y.-K. and Sethi, R. (2014) 'Credit market speculation and the cost of capital', *American Economic Journal: Microeconomics*, 6(4), pp. 1-34.

Chemmanur, T.J. and Fulghieri, P. (1994) 'Investment bank reputation, information production, and financial intermediation', *The Journal of Finance*, 49(1), pp. 57-79.

Chen, L.-H. and Kang, F.-S. (2010) 'Coordination between vendor and buyer considering trade credit and items of imperfect quality', *International Journal of Production Economics*, 123(1), pp. 52-61.

Chen, X. (2008) *Service Operations and Logistics, and Informatics, 2008. IEEE/SOLI 2008. IEEE International Conference on*. 12-15 Oct. 2008.

Chen, X. and Cai, G. (2011) 'Joint Logistics and financial services by a 3PL firm', *European Journal of Operational Research*, 214(3), pp. 579-587.

Chen, X. and Wan, G. (2011) 'The effect of financing on a budget-constrained supply chain under wholesale price contract', *Asia-Pacific Journal of Operational Research*, 28(04), pp. 457-485.

Chen, X. and Wang, A. (2012) 'Trade credit contract with limited liability in the supply chain with budget constraints ', *Annals of Operations Research*, 196(1), pp. 153-165.

Chen, X. and Xie, X. (2009) 'The value of integrated logistics and finance services of third party logistics firms', *International Journal of Services Operations and Informatics*, 4(4), pp. 333-351.

Chen, X. and Zhu, D. (2005) 'Innovation of Logistics' Finance Service-Finance Logistics', *Logistics Technology*, 3, pp. 4-15.

Chen, Y., Shi, Y., Wei, X. and Zhang, L. (2014) 'How does credit portfolio diversification affect banks' return and risk? Evidence from Chinese listed commercial banks', *Technological and Economic Development of Economy*, 20(2), pp. 332-352.

Cheng, N.S. and Pike, R. (2003) 'The trade credit decision: evidence of UK firms', *Managerial and Decision Economics*, 24(6-7), pp. 419-438.

Chevallier, J. (2012) 'Banking and borrowing in the EU ETS: A review of economic modelling, current provisions and prospects for future design', *Journal of Economic Surveys*, 26(1), pp. 157-176.

Ching-Chung Lin, Shou-Lin Yang and Lee, H.-I. (2015) 'Bank Concentration and enterprise borrowing cost risk: Evidence from Asian markets', *Asian Ecoomic and Financial Review*, 5(2), pp. 194-201.

Cho, D.W., Lee, Y.H., Ahn, S.H. and Hwang, M.K. (2012) 'A framework for measuring the performance of service supply chain management', *Computers & Industrial Engineering*, 62(3), pp. 801-818.

Chodorow-Reich, G. (2014) 'The Employment Effects of Credit Market Disruptions: Firm-level Evidence from the 2008–9 Financial Crisis', *The Quarterly Journal of Economics*, 129(1), pp. 1-59.

Choi, K.J., Koo, H.K., Lim, B.H. and Yoo, J. (2015) 'The Determinants of Unsecured Credit Constraint', *Available at SSRN 2657352*.

Christian, K. (2007) 'Do good or bad borrowers pledge more collateral?', *International Journal of Managerial Finance*, 3(2), pp. 132-163.

Chung, K.-J. and Cárdenas-Barrón, L.E. (2012) 'The complete solution procedure for the EOQ and EPQ inventory models with linear and fixed backorder costs', *Mathematical and Computer Modelling*, 55(11), pp. 2151-2156.

Cobb, B.R. and Johnson, A.W. (2014) 'A note on supply chain coordination for joint determination of order quantity and reorder point using a credit option', *European Journal of Operational Research*, 233(3), pp. 790-794.

Coe, N.M. (2014) 'Missing links: Logistics, governance and upgrading in a shifting global economy', *Review of International Political Economy*, 21(1), pp. 224-256.

Cole, R., Goldberg, L.G. and White, L.J. (2004) 'Cookie cutter vs. character: The micro structure of small business lending by large and small banks', *Journal of Financial and Quantitative Analysis* 39(2), pp. 227-251.

Cole, R.A. (1998) 'The importance of relationships to the availability of credit', *Journal of Banking & Finance*, 22(6–8), pp. 959-977.

Cole, R.A. (2013) 'What do we know about the capital structure of privately held US firms? Evidence from the surveys of small business finance', *Financial Management*, 42(4), pp. 777-813.

Coleman, S. (2007) 'The Role of Human and Financial Capital in the Profitability and Growth of Women-Owned Small Firms', *Journal of Small Business Management*, 45(3), pp. 303-319.

Coleman, S. and Carsky, M. (1999) 'Sources of Capital for Small Family-Owned Businesses: Evidence from the National Survey of Small Business Finances', *Family Business Review*, 12(1), pp. 73-84.

Coleman, S. and Robb, A. (2009) 'A comparison of new firm financing by gender: evidence from the Kauffman Firm Survey data', *Small Business Economics*, 33(4), pp. 397-411.

Comeig, I., Fernández-Blanco, M.O. and Ramírez, F. (2015) 'Information acquisition in SME's relationship lending and the cost of loans', *Journal of Business Research*, 68(7), pp. 1650-1652.

Comelli, M., Féniès, P. and Tchernev, N. (2008) 'A combined financial and physical flows evaluation for logistic process and tactical production planning: Application in a company supply chain', *International Journal of Production Economics*, 112(1), pp. 77-95.

Constantinidis, C., Cornet, A. and Asandei, S. (2006) 'Financing of women-owned ventures: The impact of gender and other owner -and firm-related variables', *Venture Capital*, 8(2), pp. 133-157.

Cook, L.D. (1999) 'Trade credit and bank finance: Financing small firms in Russia', *Journal of Business Venturing*, 14(5–6), pp. 493-518.

Cook, P. and Nixson, F. (2000) *Finance and small and medium-sized enterprise development*. Citeseer.

Corbetta, D.R. (2003) *"Social Research: Theory, Methods and Techniques"*. London: Sage.

Cornett, M.M., McNutt, J.J., Strahan, P.E. and Tehranian, H. (2011) 'Liquidity risk management and credit supply in the financial crisis', *Journal of Financial Economics*, 101(2), pp. 297-312.

Cotugno, M., Monferrà, S. and Sampagnaro, G. (2013) 'Relationship lending, hierarchical distance and credit tightening: Evidence from the financial crisis', *Journal of Banking & Finance*, 37(5), pp. 1372-1385.

Coulson, A.B. and Monks, V. (1999) 'Corporate environmental performance considerations within bank lending decisions', *Eco - Management and Auditing*, 6(1-10).

Cowling, M. (2010) 'The role of loan guarantee schemes in alleviating credit rationing in the UK', *Journal of Financial Stability*, 6(1), pp. 36-44.

Cowling, M., Liu, W. and Ledger, A. (2012) 'Small business financing in the UK before and during the current financial crisis', *International Small Business Journal*, 30(7), pp. 778-800.

Cowling, M., Liu, W., Zhang, N., Jones, P. and Battisti, M. (2016) 'Access to bank finance for UK SMEs in the wake of the recent financial crisis', *International Journal of Entrepreneurial Behavior & Research*, 22(6).

Craig, B.R., Jackson, W.E. and Thomson, J.B. (2007) 'Small Firm Finance, Credit Rationing, and the Impact of SBA-Guaranteed Lending on Local Economic Growth', *Journal of Small Business Management*, 45(1), pp. 116-132.

Crespo Marquez, A., Bianchi, C. and Gupta, J.N.D. (2004) 'Operational and financial effectiveness of e-collaboration tools in supply chain integration', *European Journal of Operational Research*, 159(2), pp. 348-363.

Cressy, R. and Olofsson, C. (1997) 'The financial conditions for Swedish SMEs: Survey and research agenda', *Small business economics*, 9(2), pp. 179-192.

Cristina Martínez-Sola, Pedro J. García-Teruel and Martínez-Solano, P. (2012) '"Trade credit policy and firm value"', *Accounting and Finance* 53(3), pp. 791-808.

Croson, R., Donohue, K., Katok, E. and Sterman, J. (2014) 'Order stability in supply chains: coordination risk and the role of coordination stock', *Production and Operations Management*, 23(2), pp. 176-196.

Croxton, K.L. (2003) 'The Order Fulfillment Process', *Inernational Journal of Logistics Management* 14(1), pp. 19-32.

Cull, R., Davis, L.E., Lamoreaux, N.R. and Rosenthal, J.-L. (2006) 'Historical financing of small- and medium-size enterprises', *Journal of Banking & Finance*, 30(11), pp. 3017-3042.

Cull, R., Xu, L.C. and Zhu, T. (2009) 'Formal finance and trade credit during China's transition', *Journal of Financial Intermediation*, 18(2), pp. 173-192.

Cunningham, K. and Schrage, L. (2004) 'The LINGO algebraic modeling language', in *Modeling languages in mathematical optimization*. Springer, pp. 159-171.

Dahiya, S., Saunders, A. and Srinivasan, A. (2003) 'Financial Distress and Bank Lending Relationships', *The Journal of Finance*, 58(1), pp. 375-399.

Dan, S., Yongjian, L. and Xiaoqiang, C. (2012) *Service Systems and Service Management (ICSSSM), 2012 9th International Conference on*. 2-4 July 2012.

Das, S.K. and Abdel-Malek, L. (2003) 'Modeling the flexibility of order quantities and lead-times in supply chains', *International Journal of Production Economics*, 85(2), pp. 171-181.

Dass, N. and Massa, M. (2011) 'The impact of a strong bank-firm relationship on the borrowing firm', *Review of Financial Studies*, 24(4), pp. 1204-1260.

de Janvry, A., McIntosh, C. and Sadoulet, E. (2010) 'The supply- and demand-side impacts of credit market information', *Journal of Development Economics*, 93(2), pp. 173-188.

De Meyer, A., Nakane, J., Miller, J.G. and Ferdows, K. (1989) 'Flexibility: the next competitive battle the manufacturing futures survey', *Strategic Management Journal*, 10(2), pp. 135-144.

Degryse, H., de Goeij, P. and Kappert, P. (2012) 'The impact of firm and industry characteristics on small firms' capital structure', *Small Business Economics*, 38(4), pp. 431-447.

Degryse, H. and Ongena, S. (2005) 'Distance, Lending Relationships, and Competition', *The Journal of Finance*, 60(1), pp. 231-266.

Dehejiaa, R., Montgomerye, H. and Morducha, J. (2012) '"Do interest rates matter? Credit demand in the Dhaka slums"', *Journal of Development Economics*, 97(2), pp. 437-449.

Dehning, B., Richardson, V.J. and Zmud, R.W. (2007) 'The financial performance effects of IT-based supply chain management systems in manufacturing firms', *Journal of Operations Management*, 25(4), pp. 806-824.

Denis, D.J. and Mihov, V.T. (2003) 'The choice among bank debt, non-bank private debt, and public debt: evidence from new corporate borrowings', *Journal of Financial Economics*, 70(1), pp. 3-28.

Department for Business Innovation & Skills (2013) *SME Access to Finance Schemes*. [Online]. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/192618/bis-13-p176b-sme-access-to-finance-measures.pdf (Accessed: 10/09/2016).

Derban, W.K., Binner, J.M. and Mullineux, A. (2005) 'Loan repayment performance in community development finance institutions in the UK', *Small Business Economics*, 25(4), pp. 319-332.

DeYoung, R., Glennon, D. and Nigro, P. (2008) 'Borrower–lender distance, credit scoring, and loan performance: Evidence from informational-opaque small business borrowers', *Journal of Financial Intermediation*, 17(1), pp. 113-143.

Dhawan, R. (2001) 'Firm size and productivity differential: theory and evidence from a panel of US firms', *Journal of Economic Behavior & Organization*, 44(3), pp. 269-293.

Dierkes, M., Erner, C., Langer, T. and Norden, L. (2013) 'Business credit information sharing and default risk of private firms', *Journal of Banking & Finance*, 37(8), pp. 2867-2878.

Dietrich, A. (2010) 'Explaining loan rate differentials between small and large companies: evidence from Switzerland', *Small Business Economics*, 38(4), pp. 481-494.

Dietsch, M. and Petey, J. (2002) 'The credit risk in SME loans portfolios: Modeling issues, pricing, and capital requirements', *Journal of Banking & Finance*, 26(2–3), pp. 303-322.

Dillman, D.A. (2007) *"Mail and Internet Survey: The Tailored Desin Method"*. Second edn. Hoboken: NJ: Wiley.

Dimelis, S., Giotopoulos, I. and Louri, H. (2015) *Can firms grow withour credit?: evidence from the Euro Area, 2005-2011: a quantile panel analysis*. London: Hellenic Observatory, European Institute.

Ding, S., Guariglia, A. and Knight, J. (2013) 'Investment and financing constraints in China: Does working capital management make a difference?', *Journal of Banking & Finance*, 37(5), pp. 1490-1507.

Doblas-Madrid, A. and Minetti, R. (2013) 'Sharing information in the credit market: Contract-level evidence from U.S. firms', *Journal of Financial Economics*, 109(1), pp. 198-223.

Doh-Shin Jeon and Lovo, S. (2013) '"Credit rating industry: A helicopter tour of stylized facts and recent theories"', *International Journal of Industrial Organizations*, 31(5), pp. 643-651.

Dong, J.-X., Lee, C.-Y. and Song, D.-P. (2015) 'Joint service capacity planning and dynamic container routing in shipping network with uncertain demands', *Transportation Research Part B: Methodological*, 78, pp. 404-421.

Drechsler, W. and Natter, M. (2012) 'Understanding a firm's openness decisions in innovation', *Journal of Business Research*, 65(3), pp. 438-445.

Drobetz, W., Gounopoulos, D., Merikas, A. and Schröder, H. (2013) 'Capital structure decisions of globally-listed shipping companies', *Transportation Research Part E: Logistics and Transportation Review*, 52, pp. 49-76.

Drucker, S. and Puri, M. (2005) 'On the Benefits of Concurrent Lending and Underwriting', *The Journal of Finance*, 60(6), pp. 2763-2799.

Duffee, G.R. and Zhou, C. (2001) 'Credit derivatives in banking: Useful tools for managing risk?', *Journal of Monetary Economics*, 48(1), pp. 25-54.

Ebenezer, A.B. and Asiedu, M.K. (2013) 'The Relationship Between Working Capital Management and Profitablity of Listed Manufacturing Companies in Ghana', *International Journal of Business and Social Research*, 3(2), pp. 25-34.

El-Kholy, A.M. (2014) 'A Multi-objective Fuzzy Linear Programming Model for Cash Flow Managment ', *International Journal of Engineering Research and Applications* 4(8), pp. 152-163.

Elsas, R. (2005) 'Empirical determinants of relationship lending', *Journal of Financial Intermediation*, 14(1), pp. 32-57.

Elsas, R. and Krahnen, J.P. (1998) 'Is relationship lending special? Evidence from credit-file data in Germany', *Journal of Banking & Finance*, 22(10), pp. 1283-1316.

Engemann, M., Eck, K. and Schnitzer, M. (2014) 'Trade Credits and Bank Credits in International Trade: Substitutes or Complements?', *The World Economy*, 37(11), pp. 1507-1540.

Eon-Kyung, L., Sungdo, H. and Sheung-Kown, K. (2001) 'Supplier selection and management system considering relationships in supply chain management', *IEEE Transactions on Engineering Management*, 48(3), pp. 307-318.

Erica Field, Rohini Pande, John Papp and Park, Y.J. 7 (2012) '"Repayment Flexibility Can Reduce Financial Stress: A Randomized Control Trial with Microfinance Clients in India"' September 26, 2012 *PLoS ONE*. 9.

Erik, H. (2009) 'Inventory financing in supply chains: A logistics service provider-approach', *International Journal of Physical Distribution & Logistics Management*, 39(9), pp. 716-740.

Estampe, D., Lamouri, S., Paris, J.-L. and Brahim-Djelloul, S. (2013) 'A framework for analysing supply chain performance evaluation models', *International Journal of Production Economics*, 142(2), pp. 247-258.

Esty, B.C. (2004) 'Why Study Large Projects? An Introduction to Research on Project Finance', *European Financial Management*, 10(2), pp. 213-224.

European Central Bank, E. (2014) *"Survey on the access to finance of small and medium-sized enterprises in the Euro area"*. Frankfurt am Main: European Central Bank.

Eurosystem (2014) *"Survey on the access to finance of small and medium-sized enterprises in the Euro area"*. Frankfurt am Main: European Central Bank

Evans, D. and Evans, W. (2007) *"The complete real estate encyclopedia"*. The McGraw-Hill Companies, Inc

F. Espino-Rodríguez, T. and Rodríguez-Díaz, M. (2014) 'Determining the core activities in the order fulfillment process: an empirical application', *Business Process Management Journal*, 20(1), pp. 2-24.

Fabbri, D. and Menichini, A.M.C. (2016) 'The commitment problem of secured lending', *Journal of Financial Economics*, 120(3), pp. 561-584.

Faia, E. and Monacelli, T. (2007) 'Optimal interest rate rules, asset prices, and credit frictions', *Journal of Economic Dynamics and Control*, 31(10), pp. 3228-3254.

Fairchild, A. (2005) 'Intelligent matching: integrating efficiencies in the financial supply chain', *Supply Chain Management: An International Journal*, 10(4), pp. 244-248.

Fan, J.P.H., Wong, T.J. and Zhang, T. (2013) '"Institutions and organizational structure: The case of state-owned corporate pyramids"', *The Journal of Law, Economics, & Organization*, 29(6), pp. 1217-1252.

Farag, M., Harland, D. and Nixon, D. (2013) 'Bank capital and liquidity', *Bank of England Quarterly Bulletin*, p. Q3.

Farahani, R., Rezapour, S. and Kardar, L. (2011) *Logistics operations and management: concepts and models*. Elsevier.

Farahani, R.Z. and Elahipanah, M. (2008) 'A genetic algorithm to optimize the total cost and service level for just-in-time distribution in a supply chain', *International Journal of Production Economics*, 111(2), pp. 229-243.

Farinha, L.s.A. and Santos, J.A.C. (2002) 'Switching from Single to Multiple Bank Lending Relationships: Determinants and Implications', *Journal of Financial Intermediation*, 11(2), pp. 124-151.

Fatoki, O.O. and Smit, A.V.A. (2011) 'Constraints to credit access by new SMEs in South Africa: A supply-side analysis', *African Journal of Business Management*, 5(4), p. 1413.

Ferreira, M.A. and Laux, P.A. (2007) 'Corporate Governance, Idiosyncratic Risk, and Information Flow', *The Journal of Finance*, 62(2), pp. 951-989.

Ferris, J.S. (1981) 'A transactions theory of trade credit use', *The Quarterly Journal of Economics*, 96(2), pp. 243-270.

Filippo, M.d., Ranaldo, A. and Wrampelmeyer, J. (2016) *Unsecured and Secured Funding* (2016/16). Switzerland Swiss Institute of Banking and Finance Gallen, U.o.S.

Fiordelisi, F. and Mare, D.S. (2014) 'Competition and financial stability in European cooperative banks', *Journal of International Money and Finance*, 45, pp. 1-16.

Firth, M., Lin, C., Liu, P. and Wong, S.M.L. (2009) 'Inside the black box: Bank credit allocation in China's private sector', *Journal of Banking & Finance*, 33(6), pp. 1144-1155.

Fishman, A. (2009) 'Financial intermediaries as facilitators of information exchange between lenders and reputation formation by borrowers', *International Review of Economics & Finance*, 18(2), pp. 301-305.

Fisman, R. and Love, I. (2003) 'Trade Credit, Financial Intermediary Development, and Industry Growth', *The Journal of Finance*, 58(1), pp. 353-374.

Foglia, A., Laviola, S. and Marullo Reedtz, P. (1998) 'Multiple banking relationships and the fragility of corporate borrowers', *Journal of Banking & Finance*, 22(10–11), pp. 1441-1456.

Frame, W.S., Srinivasan, A. and Woosley, L. (2001) 'The effect of credit scoring on small-business lending', *Journal of Money, Credit and Banking*, pp. 813-825.

Franca, R.B., Jones, E.C., Richards, C.N. and Carlson, J.P. (2010) 'Multi-objective stochastic supply chain modeling to evaluate tradeoffs between profit and quality', *International Journal of Production Economics*, 127(2), pp. 292-299.

Francis, J.J., Johnston, M., Robertson, C., Glidewell, L., Entwistle, V., Eccles, M.P. and Grimshaw, J.M. (2010) 'What is an adequate sample size? Operationalising data saturation for theory-based interview studies', *Psychology and Health*, 25(10), pp. 1229-1245.

Freund, C.L. and Spatafora, N. (2005) 'Remittances: transaction costs, determinants, and informal flows', *World Bank Policy Research Working Paper*, (3704).

Gallagher, R.B. (2015) *Analysis of the Small Business Administration 8 (a) business development program*. Monterey, California: Naval Postgraduate School.

Galvez, D., Rakotondranaivo, A., Morel, L., Camargo, M. and Fick, M. (2015) 'Reverse logistics network design for a biogas plant: An approach based on MILP optimization and Analytical Hierarchical Process (AHP)', *Journal of Manufacturing Systems*, 37, Part 3, pp. 616-623.

Gao, C., Shen, H. and Cheng, T.C.E. (2010) 'Order-fulfillment performance analysis of an assemble-to-order system with unreliable machines', *International Journal of Production Economics*, 126(2), pp. 341-349.

Gao, Z. and Tang, L. (2003) 'A multi-objective model for purchasing of bulk raw materials of a large-scale integrated steel plant', *International Journal of Production Economics*, 83(3), pp. 325-334.

García Menéndez, L. and Feo Valero, M. (2009) 'European Common Transport Policy and Short-Sea Shipping: Empirical Evidence Based on Modal Choice Models', *Transport reviews*, 29(2), pp. 239-259.

Ge, Y. and Qiu, J. (2007) 'Financial development, bank discrimination and trade credit', *Journal of Banking & Finance*, 31(2), pp. 513-530.

Gehrig, T. (1998) 'Screening, cross-border banking, and the allocation of credit', *Research in Economics*, 52(4), pp. 387-407.

Gelos, R.G. and Werner, A.M. (2002) 'Financial liberalization, credit constraints, and collateral: investment in the Mexican manufacturing sector', *Journal of Development Economics*, 67(1), pp. 1-27.

Gelsomino, L.M., Riccardo, M., Perego, A. and Angela, T. (2016) 'Supply chain finance: modelling a dynamic discounting programme', *Journal of Advanced Management Science*, 4(4), pp. 283-291.

Gencer, C. and Gürpinar, D. (2007) 'Analytic network process in supplier selection: A case study in an electronic firm', *Applied Mathematical Modelling*, 31(11), pp. 2475-2486.

Ghatak, M. and Guinnane, T.W. (1999) 'The economics of lending with joint liability: theory and practice1', *Journal of Development Economics*, 60(1), pp. 195-228.

Ghauri, P. and Gronhaug, k. (2005) *"Research Methods in Business Studies: A practical Guide"*. Third edn. Harlow: Financial Times Prentice Hall.

Ghodsypour, S.H. and O'Brien, C. (1998) 'A decision support system for supplier selection using an integrated analytic hierarchy process and linear programming', *International Journal of Production Economics*, 56–57, pp. 199-212.

Giannetti, C. (2012) '"Relationship lending and firm innovativeness"', *Journal of Empirical Finance*, 19(5), pp. 762-781.

Giannetti, M., Burkart, M. and Ellingsen, T. (2011) '"What you sell is what you lend? Explaining trade credit contracts"', *Review of Financial Studies*, 24(4), pp. 1261-1298.

Giannetti, M. and Ongena, S. (2009) 'Financial integration and firm performance: Evidence from foreign bank entry in emerging markets', *Review of Finance*, 13(2), pp. 181-223.

Gill, A., Biger, N. and Mathur, N. (2010) 'The relationship between working capital management and profitability: Evidence from the United States', *Business and Economics Journal*, 10(1), pp. 1-9.

Gill, J. and Johnson, P. (2002) *"Research Methods for Managers"*. Third edn. London Paul Chapman.

Gjerdrum, J., Shah, N. and Papageorgiou, L.G. (2002) 'Fair transfer price and inventory holding policies in two-enterprise supply chains', *European Journal of Operational Research*, 143(3), pp. 582-599.

Glass, J.C., McKillop, D.G. and Rasaratnam, S. (2010) 'Irish credit unions: investigating performance determinants and the opportunity cost of regulatory compliance', *Journal of Banking & Finance*, 34(1), pp. 67-76.

Glennon, D. and Nigro, P. (2005) 'Measuring the Default Risk of Small Business Loans: A Survival Analysis Approach', *Journal of Money, Credit and Banking*, 37(5), pp. 923-947.

Gligor, D.M., Esmark, C.L. and Holcomb, M.C. (2015) 'Performance outcomes of supply chain agility: When should you be agile?', *Journal of Operations Management*, 33–34, pp. 71-82.

Godquin, M. (2004) 'Microfinance Repayment Performance in Bangladesh: How to Improve the Allocation of Loans by MFIs', *World Development*, 32(11), pp. 1909-1926.

Goetschalckx, M., Vidal, C.J. and Dogan, K. (2002) 'Modeling and design of global logistics systems: A review of integrated strategic and tactical models and design algorithms', *European Journal of Operational Research*, 143(1), pp. 1-18.

Gomm, M.L. (2010) 'Supply chain finance: applying finance theory to supply chain management to enhance finance in supply chains', *International Journal of Logistics: Research and Applications*, 13(2), pp. 133-142.

Goss, A. and Roberts, G.S. (2011) '"The impact of corporate social responsibility on the cost of bank loans"', *Journal of Banking & Finance*, 35(7), pp. 1794-1810.

GOV.UK (2016) *Business finance explained* [Online]. Available at: https://www.gov.uk/business-finance-explained/overdrafts.

Govindan, K., Kaliyan, M., Kannan, D. and Haq, A.N. (2014) 'Barriers analysis for green supply chain management implementation in Indian industries using analytic hierarchy process', *International Journal of Production Economics*, 147, Part B, pp. 555-568.

Gozzi, J.C. and Schmukler, S. (2016) *Public credit guarantees and access to finance* (1122). University of Warwick.

Graham, J.R., Harvey, C.R. and Puri, M. (2015) 'Capital allocation and delegation of decision-making authority within firms', *Journal of Financial Economics*, 115(3), pp. 449-470.

Graham, S.J.H., Merges, R.P., Samuelson, P. and Sichelman, T. (2009) 'High Technology Entrepreneurs and the Patent System: Results of the 2008 Berkeley Patent Survey', *Berkeley Technology Law Journal*, 24(4), pp. 1255-1327.

Greenbank, P. (2001) 'Objective setting in the micro-business', *International Journal of Entrepreneurial Behavior & Research*, 7(3), pp. 108-127.

Guillén, G., Mele, F.D., Bagajewicz, M.J., Espuña, A. and Puigjaner, L. (2005) 'Multiobjective supply chain design under uncertainty', *Chemical Engineering Science*, 60(6), pp. 1535-1553.

Guiso, L. (1998) 'High-tech firms and credit rationing', *Journal of Economic Behavior & Organization*, 35(1), pp. 39-59.

Gunasekaran, A., Patel, C. and McGaughey, R.E. (2004) 'A framework for supply chain performance measurement', *International Journal of Production Economics*, 87(3), pp. 333-347.

Gunasekaran, A., Patel, C. and Tirtiroglu, E. (2001) 'Performance measures and metrics in a supply chain environment', *International journal of operations & production Management*, 21(1/2), pp. 71-87.

Güner, A.B. (2006) 'Loan Sales and the Cost of Corporate Borrowing', *Review of Financial Studies*, 19(2), pp. 687-716.

Gupta, S. and Dutta, K. (2011) 'Modeling of financial supply chain', *European Journal of Operational Research*, 211(1), pp. 47-56.

Hadjimanolis, A. (1999) 'Barriers to innovation for SMEs in a small less developed country (Cyprus)', *Technovation*, 19(9), pp. 561-570.

Hafeez, K., Zhang, Y. and Malak, N. (2002) 'Determining key capabilities of a firm using analytic hierarchy process', *International Journal of Production Economics*, 76(1), pp. 39-51.

Hall, S. (2001) 'Credit channel effects in the monetary transmission mechanism', *Bank of England Quarterly Bulletin, Winter*.

Han, L., Fraser, S. and Storey, D.J. (2009) 'Are good or bad borrowers discouraged from applying for loans? Evidence from US small business credit markets', *Journal of Banking & Finance*, 33(2), pp. 415-424.

Hand, D.J. and Henley, W.E. (1997) 'Statistical Classification Methods in Consumer Credit Scoring: a Review', *Journal of the Royal Statistical Society: Series A (Statistics in Society)*, 160(3), pp. 523-541.

Hansmann, H., Kraakman, R. and Squire, R. (2006) 'Law and the Rise of the Firm', *Harvard Law Review*, pp. 1333-1403.

Hao, J. and Li, Z. (2014) 'Research on Problems of Small and Micro Enterprise's (SME) Insurance Appointment Keeping', *Management & Engineering*, (14), p. 49.

Harhoff, D. and Körting, T. (1998) 'Lending relationships in Germany – Empirical evidence from survey data', *Journal of Banking & Finance*, 22(10–11), pp. 1317-1353.

Haron, H., Said, S.B., Jayaraman, K. and Ismail, I. (2013) 'Factors Influencing Small Medium Enterprises (SMES) in Obtaining Loan', *International Journal of Business and Social Science*, 4(15).

Harrison, D. (2014) 'A new European capital market', *Law and Financial Markets Review*, 8(4), pp. 318-321.

Hau, L., Kut, S. and Christopher, T. (2000) 'The Value of Information Sharing in a Two-Level Supply Chain', *Management Science*, 46(5), pp. 626-643.

Haynes, G.W., Walker, R., Rowe, B.R. and Hong, G.-S. (1999) 'The Intermingling of Business and Family Finances in Family-Owned Businesses', *Family Business Review*, 12(3), pp. 225-239.

Heger, T. and Rohrbeck, R. (2012) 'Strategic foresight for collaborative exploration of new business fields', *Technological Forecasting and Social Change*, 79(5), pp. 819-831.

Heider, F. and Inderst, R. (2012) 'Loan Prospecting', *Review of Financial Studies*.

Hendricks, K.B. and Singhal, V.R. (2005) 'An Empirical Analysis of the Effect of Supply Chain Disruptions on Long-Run Stock Price Performance and Equity Risk of the Firm', *Production and Operations Management*, 14(1), pp. 35-52.

Hewson, C., Yule, P., Laurent, D. and Vogel, C. (2003) *"Internet Research Methods: A Practical Guide for the Social and Behavioural Sciences"*. London: Sage.

Hibbeln, M. (2010) *Risk Management in Credit Portfolios: Concentration Risk and Base II*. Heidelberg: Springer Science & Business Media.

HM Revenue & Customs (2012) *Letters of credit for importers and exporters*. [Online]. Available at: https://www.gov.uk/guidance/letters-of-credit-for-importers-and-exporters.

Hong, K.-s. and Lee, C. (2013) 'Optimal time-based consolidation policy with price sensitive demand', *International Journal of Production Economics*, 143(2), pp. 275-284.

Hosseini, S.S., Khaledi, M., Ghorbani, M. and Brewin, D.G. (2012) 'An analysis of transaction costs of obtaining credit in rural Iran', *Journal of Agriculture Science and Technology*, 14(1), pp. 243-256.

Houston, J.F., Lin, C., Lin, P. and Ma, Y. (2010) 'Creditor rights, information sharing, and bank risk taking', *Journal of Financial Economics*, 96(3), pp. 485-512.

Howorth, C. and Westhead, P. (2003) 'The focus of working capital management in UK small firms', *Management Accounting Research*, 14(2), pp. 94-111.

Hubbard, R.G., Kuttner, K.N. and Palia, D.N. (2002) 'Are There Bank Effects in Borrowers' Costs of Funds? Evidence from a Matched Sample of Borrowers and Banks*', *The Journal of Business*, 75(4), pp. 559-581.

Huemer, L. (2012) 'Unchained from the chain: Supply management from a logistics service provider perspective', *Journal of Business Research*, 65(2), pp. 258-264.

Hur, J., Raj, M. and Riyanto, Y.E. (2006) 'Finance and trade: A cross-country empirical analysis on the impact of financial development and asset tangibility on international trade', *World Development*, 34(10), pp. 1728-1741.

Huston, S.J. (2012) 'Financial literacy and the cost of borrowing', *International Journal of Consumer Studies*, 36(5), pp. 566-572.

Huyghebaert, N. (2006) 'On the Determinants and Dynamics of Trade Credit Use: Empirical Evidence from Business Start-ups', *Journal of Business Finance & Accounting*, 33(1-2), pp. 305-328.

Huyghebaert, N., Van de Gucht, L. and Van Hulle, C. (2007) 'The Choice between Bank Debt and Trace Credit in Business Start-ups', *Small Business Economics*, 29(4), pp. 435-452.

Hyra, D., Doughty, M. and Center, M.P. (2014) 'SBA Lending Equity and Efficiency Challenges'.

Ilat, V. and Pontoh, W. (2014) '"The consideration and purpose of borrowing: An empirical evidence from Indonesia Listed companies"', *American Journal of Applied Sciences* 11(7), pp. 1172-1180.

İlhan Eroğlu and Eroğlu, N. (2012) '"Monetary transmission channels and an assessment within the framework of the 2008 global financial crisis"', *African Journal of Business Management*, 6(29), pp. 8554-8563.

Ioannidou, V. and Ongena, S. (2010) '"Time for a Change": Loan Conditions and Bank Behavior when Firms Switch Banks', *The Journal of Finance*, 65(5), pp. 1847-1877.

Iyer, R., Peydró, J.-L., da-Rocha-Lopes, S. and Schoar, A. (2014) 'Interbank liquidity crunch and the firm credit crunch: Evidence from the 2007–2009 crisis', *Review of Financial studies*, 27(1), pp. 347-372.

J.Bell (2005) *"Doing Your Research Project"*. Forth edn. Buckingham Open University Press

Jansen, J. (2016) 'Supply Chain Finance', *Vestnik (Chelyabisnsk State University)*.

Jappelli, T. and Pagano, M. (2002) 'Information sharing, lending and defaults: Cross-country evidence', *Journal of Banking & Finance*, 26(10), pp. 2017-2045.

Javed, H., Cindy, M. and Harry, M. (2006) 'SME financing in the UK and in China: a comparative perspective', *Journal of Small Business and Enterprise Development*, 13(4), pp. 584-599.

Jayaratne, J. and Wolken, J. (1999) 'How important are small banks to small business lending?: New evidence from a survey of small firms', *Journal of Banking & Finance*, 23(2–4), pp. 427-458.

Jensen, M.C. (2001) 'Corporate budgeting is broken, let's fix it', *Harvard Business Review*, pp. 94-101.

Jiménez, G., Lopez, J.A. and Saurina, J. (2013) 'How does competition affect bank risk-taking?', *Journal of Financial Stability*, 9(2), pp. 185-195.

Jimenez, G., Ongena, S., Peydro, J.-L. and Saurina, J. (2012) 'Credit Supply and Monetary Policy: Identifying the Bank Balance-Sheet Channel with Loan Applications', *The American Economic Review*, 102(5), pp. 2301-2326.

Jimenez, G., Salas, V. and Saurina, J. (2006) 'Determinants of collateral', *Journal of financial economics*, 81(2), pp. 255-281.

Jiménez, G., Salas, V. and Saurina, J. (2009) 'Organizational distance and use of collateral for business loans', *Journal of Banking & Finance*, 33(2), pp. 234-243.

Jin, J., Wei, Z. and Liu, G. (2014) 'Comparative research of financial model in supply chain', *Advances in Global Optimization*, 95, pp. 497-505.

Jin, Y. and Ryan, J.K. (2012) 'Price and service competition in an outsourced supply chain', *Production and Operations Management*, 21(2), pp. 331-344.

Jing, B. and Seidmann, A. (2014) 'Finance sourcing in a supply chain', *Decision Support Systems*, 58, pp. 15-20.

Johan, S.A. and Wu, Z. (2014) '"Does the quality of lender-borrower relationships affect small business access to debt? Evidence from Canada and implications in China"', *International Review of Financial Analysis* 36, pp. 206-211.

John, A.B. and Rachel, Q.Z. (2004) 'Inventory Management with Asset-Based Financing', *Manage. Sci.*, 50(9), pp. 1274-1292.

John, K., Lynch, A.W. and Puri, M. (2003) 'Credit Ratings, Collateral, and Loan Characteristics: Implications for Yield*', *The Journal of Business*, 76(3), pp. 371-409.

Johnson, C.L. and Kriz, K.A. (2005) 'Fiscal Institutions, Credit Ratings, and Borrowing Costs', *Public Budgeting & Finance*, 25(1), pp. 84-103.

Jonathan, T. and Jonathan, L. (2003) 'Small firm finance and public policy', *Journal of Small Business and Enterprise Development*, 10(1), pp. 50-61.

Josephson, A. and Marshall, M.I. (2014) 'The Effectiveness of Post-Katrina Disaster Aid: The Influence of SBA Loans on Small Businesses in Mississippi'.

Juho, S., Kari, T. and Max, F. (2012) 'How logistics-service providers can develop value-added services for SMEs: a dyadic perspective', *The International Journal of Logistics Management*, 23(1), pp. 31-49.

Juttner, U., Peck, H. and Christopher, M. (2003) 'Supply chain risk management: outlining an agenda for future research ', *International Journal of Logistics Research and Applications: A Leading Journal of Supply Chain Management* 6(4), pp. 197-210.

Kainuma, Y. and Tawara, N. (2006) 'A multiple attribute utility theory approach to lean and green supply chain management', *International Journal of Production Economics*, 101(1), pp. 99-108.

Kallberg, J.G. and Udell, G.F. (2003) 'The value of private sector business credit information sharing: The US case', *Journal of Banking & Finance*, 27(3), pp. 449-469.

Kang, J., x, Koo and Stulz, R.M. (2000) 'Do Banking Shocks Affect Borrowing Firm Performance? An Analysis of the Japanese Experience', *The Journal of Business*, 73(1), pp. 1-23.

Kannan, D., Khodaverdi, R., Olfat, L., Jafarian, A. and Diabat, A. (2013) 'Integrated fuzzy multi criteria decision making method and multi-objective programming approach for supplier selection and order allocation in a green supply chain', *Journal of Cleaner Production*, 47, pp. 355-367.

Karjalainen, J. (2011) 'Audit quality and cost of debt capital for private firms: Evidence from Finland', *International journal of auditing*, 15(1), pp. 88-108.

Karlan, D. and Zinman, J. (2009) 'Expanding Credit Access: Using Randomized Supply Decisions to Estimate the Impacts', *Review of Financial Studies*.

Kaya, O., Schildbach, J., Ag, D.B. and Hoffmann, R. (2014) 'SME financing in the euro area', *New solutions to an old problem. EU Monitor–Global Financial Markets. Deutsche Bank Research*, 14, p. 2014.

Kazim, S. (2015) 'Investigating the value of reducing errors in inventory information from a supply chain perspective', *Kybernetes*, 44(2), pp. 176-185.

Khang, K. and King, T.-H.D. (2015) 'Capital market access and corporate loan structure', *Applied Economics*, 47(4), pp. 374-397.

Khorramshahgol, R. (2012) 'An integrated strategic approach to supplier evaluation and selection', *International Journal of Information Technology & Decision Making*, 11(01), pp. 55-76.

Kirschenmann, K. (2015) 'Credit rationing in small firm-bank relationships', *Journal of Financial Intermediation*.

Kjenstad, E.C., Su, X. and Zhang, L. (2015) 'Credit rationing by loan size: A synthesized model', *The Quarterly Review of Economics and Finance*, 55, pp. 20-27.

Klapper, L. (2006) 'The role of factoring for financing small and medium enterprises', *Journal of Banking & Finance*, 30(11), pp. 3111-3130.

Klapper, L., Laeven, L. and Rajan, R. (2012) 'Trade Credit Contracts', *Review of Financial Studies*, 25(3), pp. 838-867.

Kouvelis, P., Chambers, C. and Wang, H. (2006) 'Supply Chain Management Research and Production and Operations Management: Review, Trends, and Opportunities', *Production and Operations Management*, 15(3), pp. 449-469.

Kouvelis, P. and Zhao, W. (2012) 'Financing the Newsvendor: Supplier vs. Bank, and the Structure of Optimal Trade Credit Contracts', *Operations Research*, 60(3), pp. 566-580.

Kristianto, Y., Gunasekaran, A., Helo, P. and Sandhu, M. (2012) 'A decision support system for integrating manufacturing and product design into the reconfiguration of the supply chain networks', *Decision Support Systems*, 52(4), pp. 790-801.

Kumar, M., Vrat, P. and Shankar, R. (2004) 'A fuzzy goal programming approach for vendor selection problem in a supply chain', *Computers & Industrial Engineering*, 46(1), pp. 69-85.

Laeven, L. and Valencia, F. (2013) 'The real effects of financial sector interventions during crises', *Journal of money, credit and Banking*, 45(1), pp. 147-177.

Lai, G., Debo, L.G. and Sycara, K. (2009) 'Sharing inventory risk in supply chain: The implication of financial constraint', *Omega*, 37(4), pp. 811-825.

Lam, H., Choy, K., Ho, G., Cheng, S.W. and Lee, C. (2015) 'A knowledge-based logistics operations planning system for mitigating risk in warehouse order fulfillment', *International Journal of Production Economics*, 170, pp. 763-779.

Lambert, D.M. and Cooper, M.C. (2000) 'Issues in Supply Chain Management', *Industrial Marketing Management*, 29(1), pp. 65-83.

Large, R.O., Kramer, N. and Hartmann, R.K. (2013) 'Procurement of logistics services and sustainable development in Europe: Fields of activity and empirical results', *Journal of Purchasing and Supply Management*, 19(3), pp. 122-133.

Lee, C.H. and Rhee, B.-D. (2011) 'Trade credit for supply chain coordination', *European Journal of Operational Research*, 214(1), pp. 136-146.

Lee, H.-M. and Yao, J.-S. (1998) 'Economic production quantity for fuzzy demand quantity, and fuzzy production quantity', *European Journal of Operational Research*, 109(1), pp. 203-211.

Lee, H. and Whang, S. (2000) 'Information sharing in a supply chain', *International Journal of Manufacturing Technology and Management*, 1(1), pp. 79-93.

Lee, J., Kang, S.-H., Rosenberger, J. and Kim, S.B. (2010) 'A hybrid approach of goal programming for weapon systems selection', *Computers & Industrial Engineering*, 58(3), pp. 521-527.

Lee, N., Sameen, H. and Cowling, M. (2015) 'Access to finance for innovative SMEs since the financial crisis', *Research policy*, 44(2), pp. 370-380.

Lee, W.-C. (2005) 'Inventory model involving controllable backorder rate and variable lead time demand with the mixtures of distribution', *Applied mathematics and computation*, 160(3), pp. 701-717.

Lee, Y. and Kozar, K.A. (2006) 'Investigating the effect of website quality on e-business success: An analytic hierarchy process (AHP) approach', *Decision Support Systems*, 42(3), pp. 1383-1401.

Levenson, A.R. and Willard, K.L. (2000a) 'Do Firms Get the Financing They Want? Measuring Credit Rationing Experienced by Small Businesses in the U.S', *Small Business Economics*, 14(2), pp. 83-94.

Levenson, A.R. and Willard, K.L. (2000b) 'Do firms get the financing they want? Measuring credit rationing experienced by small businesses in the US', *Small Business Economics*, 14(2), pp. 83-94.

Levit, J.K. (2005) 'Bottom-up Approach to International Lawmaking: The Tale of Three Trade Finance Instruments, A', *Yale J. Int'l L.*, 30, p. 125.

Levitsky, J. and Prasad, R.N. (1987) *Credit guarantee schemes for small and medium enterprises*. World Bank Washington, DC.

Leyffer, S. and Mahajan, A. (2010) 'Software for nonlinearly constrained optimization', *Wiley Encyclopedia of Operations Research and Management Science*.

Li, H., Meng, L., Wang, Q. and Zhou, L.-A. (2008) 'Political connections, financing and firm performance: Evidence from Chinese private firms', *Journal of Development Economics*, 87(2), pp. 283-299.

Li, J. and Muckstadt, J. (2013) 'Fulfilling orders in a multi-echelon capacitated on-line retail system: PART TWO, real-time purchasing and fulfillment decision making, School of Operations Research and Information Engineering', *School of Operations Research and Information Engineering, Cornell University 14850*, (1482).

Li, T. and Ma, J. (2015) 'Complexity analysis of dual-channel game model with different managers' business objectives', *Communications in Nonlinear Science and Numerical Simulation*, 20(1), pp. 199-208.

Li, X. and Lin, J.-H. (2016) 'Shadow-banking entrusted loan management, deposit insurance premium, and capital regulation', *International Review of Economics & Finance*, 41, pp. 98-109.

Lin, C., Ma, Y., Malatesta, P. and Xuan, Y. (2011) '"Ownership structure and the cost of corporate borrowing"', *Journal of Financial Economics* 100(1), pp. 1-23.

Lin, C., Ma, Y., Malatesta, P. and Xuan, Y. (2013) 'Corporate ownership structure and the choice between bank debt and public debt', *Journal of Financial Economics*, 109(2), pp. 517-534.

Lin, M., Prabhala, N.R. and Viswanathan, S. (2012) 'Judging Borrowers by the Company They Keep: Friendship Networks and Information Asymmetry in Online Peer-to-Peer Lending', *Management Science*, 59(1), pp. 17-35.

Lin, T.-T. and Chou, J.-H. (2015) 'Trade credit and bank loan: Evidence from Chinese firms', *International Review of Economics & Finance*, 36, pp. 17-29.

Liu, C.-L. and Lyons, A.C. (2011) 'An analysis of third-party logistics performance and service provision', *Transportation Research Part E: Logistics and Transportation Review*, 47(4), pp. 547-570.

Liu, F.-H.F. and Hai, H.L. (2005) 'The voting analytic hierarchy process method for selecting supplier', *International Journal of Production Economics*, 97(3), pp. 308-317.

Liu, S. and Papageorgiou, L.G. (2013) 'Multiobjective optimisation of production, distribution and capacity planning of global supply chains in the process industry', *Omega*, 41(2), pp. 369-382.

Lorentz, H., Solakivi, T., Toyli, J. and Ojala, L. (2016) 'Trade credit dynamics during the phases of the business cycle- a value chain prespective', *Supply Chain Management: An International Journal*, 21(3), pp. 1-8.

Lu, F.-Q., Huang, M., Ching, W.-K. and Siu, T.K. (2013) 'Credit portfolio management using two-level particle swarm optimization', *Information Sciences*, 237, pp. 162-175.

Lu, Y., Guo, H., Kao, E.H. and Fung, H.-G. (2015) 'Shadow banking and firm financing in China', *International Review of Economics & Finance*, 36, pp. 40-53.

Luca Mattia, G., Riccardo, M., Alessandro, P. and Angela, T. (2016) 'Supply chain finance: a literature review', *International Journal of Physical Distribution & Logistics Management*, 46(4), pp. 348-366.

Luo, Y. and Tung, R.L. (2007) 'International expansion of emerging market enterprises: A springboard perspective', *J Int Bus Stud*, 38(4), pp. 481-498.

Luoto, J., McIntosh, C. and Wydick, B. (2007) 'Credit Information Systems in Less Developed Countries: A Test with Microfinance in Guatemala', *Economic Development and Cultural Change*, 55(2), pp. 313-334.

Manova, K. (2008) 'Credit constraints, equity market liberalizations and international trade', *Journal of International Economics*, 76(1), pp. 33-47.

Manova, K., Wei, S.-J. and Zhang, Z. (2014) 'Firm Exports and Multinational Activity Under Credit Constraints', *Review of Economics and Statistics*, 97(3), pp. 574-588.

Marc Cowling and Siepel, J. (2013) '"Public intervention in UK small firm credit markets: Value-for-money or waste of scarce resources?"', *Technovation* 33(8-9), pp. 265–275.

Marlow, S. and Patton, D. (2005) 'All Credit to Men? Entrepreneurship, Finance, and Gender', *Entrepreneurship Theory and Practice*, 29(6), pp. 717-735.

Marotta, G. (2005) 'When do trade credit discounts matter? Evidence from Italian firm-level data', *Applied Economics*, 37(4), pp. 403-416.

Martinelli, C. (1997) 'Small firms, borrowing constraints, and reputation', *Journal of Economic Behavior & Organization*, 33(1), pp. 91-105.

Martínez, C. and León, C. (2015) 'The cost of collateralized borrowing in the Colombian money market: Does connectedness matter?', *Journal of Financial Stability*.

Mason-Jones, R. and Towill, D.R. (1999) 'Total cycle time compression and the agile supply chain', *International Journal of Production Economics*, 62(1–2), pp. 61-73.

McNamara, G. and Bromiley, P. (1999) 'Risk and return in organizational decision making', *Academy of Management Journal*, 42(3), pp. 330-339.

Meisel, F. and Bierwirth, C. (2014) 'The design of Make-to-Order supply networks under uncertainties using simulation and optimisation', *International Journal of Production Research*, 52(22), pp. 6590-6607.

Melo, M.T., Nickel, S. and Saldanha-da-Gama, F. (2009) 'Facility location and supply chain management – A review', *European Journal of Operational Research*, 196(2), pp. 401-412.

Memmel, C., Schmieder, C. and Stein, I. (2007) *Relationship lending-Empirical evidence for Germany*. Deutsche Bundesbank.

Mentzer, J.T., DeWitt, W., Keebler, J.S., Min, S., Nix, N.W., Smith, C.D. and Zacharia, Z.G. (2001) 'Defining Supply Chain Management ', *Journal of Business Logistics*, 22(2), pp. 1-25.

Michael Firth, Stephen X. Gongb and Shan, L. (2013) '"Cost of goverment and firm value"', *Journal of Corporate Finance* 21, pp. 136-152.

Michalski, G. (2007) 'Portfolio management approach in trade credit decision making', *Romanian Journal of Economic Forecasting*, 3, pp. 42-53.

Mihir, S., Rangu, R. and Shankar, P.S.V. (2007) 'Rural Credit in 20th Century India: Overview of History and Perspectives', *Economic and Political Weekly*, 42(15), pp. 1351-1364.

Mills, K. and McCarthy, B. (2014) 'The state of small business lending: Credit access during the recovery and how technology may change the game', *Harvard Business School General Management Unit Working Paper*, (15-004).

Min, H. and Zhou, G. (2002) 'Supply chain modeling: past, present and future', *Computers & Industrial Engineering*, 43(1–2), pp. 231-249.

Minetti, R. and Zhu, S.C. (2011) 'Credit constraints and firm export: Microeconomic evidence from Italy', *Journal of International Economics*, 83(2), pp. 109-125.

Mishra, S.S. and Singh, P.K. (2013) 'Partial backlogging EOQ model for queued customers with power demand and quadratic deterioration: computational approach', *American Journal of Operational Research*, 3(2), pp. 13-27.

Mitra, S. and Bagchi, P.K. (2008) 'Key Success Factors, Performance Metrics, and Globalization Issues in the Third-Party Logistics (3PL) Industry: A Survey of North American Service Providers', *Supply Chain Forum: An International Journal*, 9(1), pp. 42-54.

Mohamed, A.Y., Mohammed, Z. and Bidhu, M. (1996) 'Supplier selection in an advanced manufacturing technology environment: an optimization model', *Benchmarking for Quality Management & Technology*, 3(4), pp. 60-72.

Mohammed, S.C. (2007) 'Overcoming entrepreneurship development constraints: the case of Bangladesh', *Journal of Enterprising Communities: People and Places in the Global Economy*, 1(3), pp. 240-251.

Moro, A. and Fink, M. (2013) 'Loan managers' trust and credit access for SMEs', *Journal of Banking & Finance*, 37(3), pp. 927-936.

Moussawi-Haidar, L., Dbouk, W., Jaber, M.Y. and Osman, I.H. (2014) 'Coordinating a three-level supply chain with delay in payments and a discounted interest rate', *Computers & Industrial Engineering*, 69, pp. 29-42.

Mula, J., Peidro, D., Díaz-Madroñero, M. and Vicens, E. (2010) 'Mathematical programming models for supply chain production and transport planning', *European Journal of Operational Research*, 204(3), pp. 377-390.

Murfin and Njoroge, K. (2015) '"The Implicit Costs of Trade Credit Borrowing by Large Firms"', *Review of Financial Studies*, 28(1), pp. 112-14.

Murfin, J. and Njoroge, K. (2014) 'The Implicit Costs of Trade Credit Borrowing by Large Firms', *Review of Financial Studies*.

Nagurney, A. (2010) 'Optimal supply chain network design and redesign at minimal total cost and with demand satisfaction', *International Journal of Production Economics*, 128(1), pp. 200-208.

Ngatchou, P., Zarei, A. and El-Sharkawi, A. (2005) *Proceedings of the 13th International Conference on, Intelligent Systems Application to Power Systems*. 6-10 Nov. 2005.

Nichols, J., Pennington-Cross, A. and Yezer, A. (2005) 'Borrower Self-Selection, Underwriting Costs, and Subprime Mortgage Credit Supply', *The Journal of Real Estate Finance and Economics*, 30(2), pp. 197-219.

Niskanen, J. and Niskanen, M. (2006) 'The Determinants of Corporate Trade Credit Policies in a Bank-dominated Financial Environment: the Case of Finnish Small Firms', *European Financial Management*, 12(1), pp. 81-102.

Nwankwo, O. and Osho, G.S. (2010) 'An empirical analysis of corporate survival and growth: Evidence from efficient working capital management', *International Journal of Scholarly Academic Intellectual Diversity*, 12(1), pp. 1-13.

Ogura, Y. and Uchida, H. (2014) 'Bank consolidation and soft information acquisition in small business lending', *Journal of Financial Services Research*, 45(2), pp. 173-200.

Oh, J.-H. and Johnston, W.J. (2014) 'Credit lender–borrower relationship in the credit card market – Implications for credit risk management strategy and relationship marketing', *International Business Review*, 23(6), pp. 1086-1095.

Oikonomou, I., Brooks, C. and Pavelin, S. (2014) 'The Effects of Corporate Social Performance on the Cost of Corporate Debt and Credit Ratings', *Financial Review*, 49(1), pp. 49-75.

Olsen, G. and Vanderplaats, G. (1989) 'Method for nonlinear optimization with discrete design variables', *AIAA journal*, 27(11), pp. 1584-1589.

Ono, A. and Uesugi, I. (2009) 'Role of collateral and personal guarantees in relationship lending: Evidence from Japan's SME loan market', *Journal of Money, Credit and Banking*, 41(5), pp. 935-960.

Oppenheim, A.N. (2000) *Questionnaire design, interviewing and attitude measurement*. Bloomsbury Publishing.

Ordoobadi, S.M. (2013) 'Application of AHP and Taguchi loss functions in evaluation of advanced manufacturing technologies', *The International Journal of Advanced Manufacturing Technology*, 67(9-12), pp. 2593-2605.

Ortiz-Molina, H. and Penas, M.F. (2007) 'Lending to small businesses: the role of loan maturity in addressing information problems', *Small Business Economics*, 30(4), pp. 361-383.

Ouyang, L.-Y. and Chuang, B.-R. (2001) 'Mixture inventory model involving variable lead time and controllable backorder rate', *Computers & industrial engineering*, 40(4), pp. 339-348.

Özçelik, E. and Taymaz, E. (2008) 'R&D support programs in developing countries: The Turkish experience', *Research Policy*, 37(2), pp. 258-275.

P.H.Jarvinen (2000) *European Conference on Information Systems (ECIS)* AIS Electronic Library (AISeL)

Padachi, K. (2006) 'Trends in working capital management and its impact on firms' performance: an analysis of Mauritian small manufacturing firms', *International Review of business research papers*, 2(2), pp. 45-58.

Padilla, A.J. and Pagano, M. (2000) 'Sharing default information as a borrower discipline device', *European Economic Review*, 44(10), pp. 1951-1980.

Pal, B., Sana, S.S. and Chaudhuri, K. (2014) 'Three stage trade credit policy in a three-layer supply chain–a production-inventory model', *International Journal of Systems Science*, 45(9), pp. 1844-1868.

Palma-Mendoza, J.A. (2014) 'Analytical hierarchy process and SCOR model to support supply chain re-design', *International Journal of Information Management*, 34(5), pp. 634-638.

Paolo, M. and Leandro, P. (2016) 'What is the appropriate sample size to run analytic hierarchy process in a survey-based research? ', *International Symposium on the Analytic Hierarchy Process*. London, August 5

Pattnaik, M. (2013) 'A single item non linear programming (NLP) economic order quantity model with space constraint', *The International Journal's Research Journal of Social Science & Management*, 03(2), pp. 25-30.

Paul Robsona, Charles Akuetteh, Ian Stone, Paul Westhead and Wright, M. (2013) '"Credit-rationing and entrepreneurial experience: Evidence from a resource deficit context"', *Entrepreneurship & Regional Development: An international journal*, 25(5-6), pp. 349-370.

Pedrycz, W. and Mingli, S. (2011) 'Analytic Hierarchy Process (AHP) in Group Decision Making and its Optimization With an Allocation of Information Granularity', *Fuzzy Systems, IEEE Transactions on*, 19(3), pp. 527-539.

Peidro, D., Mula, J., Jiménez, M. and del Mar Botella, M. (2010) 'A fuzzy linear programming based approach for tactical supply chain planning in an uncertainty environment', *European Journal of Operational Research*, 205(1), pp. 65-80.

Peltoniemi, J. and Vieru, M. (2013) '"Personal guarantees, loan pricing, and lending structure in Finnish small business loans"', *Journal of Small Business Management* 51(2), pp. 235-255.

Peters, B. and Westerheide, P. (2009) 'Short-term borrowing for long-term projects: Are family businesses more susceptible to'irrational'financing choices?'.

Petersen, M.A. and Rajan, R.G. (1997) 'Trade Credit: Theories and Evidence', *Review of Financial Studies*, 10(3), pp. 661-691.

Petersen, M.A. and Rajan, R.G. (2002) '"Does distance still matter? The information revolution in small business lending"', *The Journal of Finance* 57(6), pp. 2533-2570.

Pfohl, H.-C. and Gomm, M. (2009) 'Supply chain finance: optimizing financial flows in supply chains', *Logistics Research*, 1(3-4), pp. 149-161.

Phillips, C.A. (1931) *Bank Credit: A study of the principles and factors underlying advances made by banks to borrowers* New York: The MacMillan Company.

Pietro, E., Alan, M. and Edward, S. (2013) 'Technology adoption in small and medium-sized logistics providers', *Industrial Management & Data Systems*, 113(7), pp. 967-989.

Pike, R., Cheng, N.S., Cravens, K. and Lamminmaki, D. (2005) 'Trade Credit Terms: Asymmetric Information and Price Discrimination Evidence From Three Continents', *Journal of Business Finance & Accounting*, 32(5-6), pp. 1197-1236.

Ponsich, A., Jaimes, A.L. and Coello, C.A.C. (2013) 'A Survey on Multiobjective Evolutionary Algorithms for the Solution of the Portfolio Optimization Problem and Other Finance and Economics Applications', *Evolutionary Computation, IEEE Transactions on*, 17(3), pp. 321-344.

Pritchard, J. (2016) *Personal Guarantee Basics*. Available at: https://www.thebalance.com/personal-guarantee-basics-315207 (Accessed: 10 September).

Psillaki, M. and Eleftheriou, K. (2015) 'Trade Credit, Bank Credit, and Flight to Quality: Evidence from French SMEs', *Journal of Small Business Management*, 53(4), pp. 1219-1240.

Puro, L., Teich, J.E., Wallenius, H. and Wallenius, J. (2010) 'Borrower Decision Aid for people-to-people lending', *Decision Support Systems*, 49(1), pp. 52-60.

Qian, M. and Yeung, B.Y. (2015) 'Bank financing and corporate governance', *Journal of Corporate Finance*, 32, pp. 258-270.

Quezada, L.E. and López-Ospina, H.A. (2014) 'A method for designing a strategy map using AHP and linear programming', *International Journal of Production Economics*, 158, pp. 244-255.

Raghavan and Mishra (2011) 'Short-term financing in a cash-constrained supply chain', *International Journal of Production Economics*, 134(2), pp. 407-412.

Rahman, S. (2011) 'An exploratory study of outsourcing 3PL services: an Australian perspective', *Benchmarking: An international journal*, 18(3), pp. 342-358.

Rahman, S. and Wu, Y.C.J. (2011) 'Logistics outsourcing in China: the manufacturer-cum-supplier perspective', *Supply Chain Management: An International Journal*, 16(6), pp. 462-473.

Rai, A., Patnayakuni, R. and Seth, N. (2006) 'Firm Performance Impacts of Digitally Enabled Supply Chain Integration Capabilities', *MIS Quarterly*, 30(2), pp. 225-246.

Ramanathan, R. (2001) 'A note on the use of the analytic hierarchy process for environmental impact assessment', *Journal of Environmental Management*, 63(1), pp. 27-35.

Ramanathan, R. (2011) 'An empirical analysis on the influence of risk on relationships between handling of product returns and customer loyalty in E-commerce', *International Journal of Production Economics*, 130(2), pp. 255-261.

Ramanathan, U. (2014) 'Performance of supply chain collaboration – A simulation study', *Expert Systems with Applications*, 41(1), pp. 210-220.

Ramiah, V., Zhao, Y., Moosa, I. and Graham, M. (2014) 'A behavioural finance approach to working capital management', *The European Journal of Finance*, pp. 1-26.

Ranaldo, A. and Wrampelmeyer, J. (2016) *Unsecured and Secured Funding*. University of St. Gallen, School of Finance.

Rauterkus, A. and Munchus, G. (2014) 'Geographical location: does distance matter or what is the value status of soft information?', *Journal of Small Business and Enterprise Development*, 21(1), pp. 87-99.

Reinke, J. (1998) 'How to lend like mad and make a profit: A micro-credit paradigm versus the start-up fund in South Africa', *The Journal of Development Studies*, 34(3), pp. 44-61.

Rice, T. and Strahan, P.E. (2010) 'Does Credit Competition Affect Small-Firm Finance?', *The Journal of Finance*, 65(3), pp. 861-889.

Richard, A.R. (2007) 'Applying the TOC five-step focusing process in the service sector: A banking subsystem', *Managing Service Quality: An International Journal*, 17(2), pp. 209-234.

Robert, T.H. and Mark, A.F. (1998) 'The financing preferences of small firm owners', *International Journal of Entrepreneurial Behavior & Research*, 4(3), pp. 239-248.

Roberts, G. and Yuan, L.E. (2010) 'Does institutional ownership affect the cost of bank borrowing?', *Journal of Economics and Business*, 62(6), pp. 604-626.

Robson, C. (2002) *"Real World Research"*. Second edn. Oxford: Blackwell.

Romano, C.A., Tanewski, G.A. and Smyrnios, K.X. (2001) 'Capital structure decision making: A model for family business', *Journal of Business Venturing*, 16(3), pp. 285-310.

Romero, C. (2004) 'A general structure of achievement function for a goal programming model', *European Journal of Operational Research*, 153(3), pp. 675-686.

Rosenberg, J.M. (1993) *"Dictionary of Business and Management"*. 3rd Revised edn. New York John Wiley & Sons, Inc.

Rowley, J. (2014) 'Designing and using research questionnaires', *Management Research Review*, 37(3), pp. 308-330.

S. Raghavan and Mishra, V.K. (2011) 'Short-term financing in a cash-constrained supply chain', *International Journal of Production Economics*, 134(2), pp. 407-412.

Saaty, T.L. (1990) '"How to make a decision: The Analytic Hierarchy Process"', *European Journal of Operational Research*, 48(1), pp. 9-26.

Saaty, T.L. (1994) 'Highlights and critical points in the theory and application of the analytic hierarchy process', *European journal of operational research*, 74(3), pp. 426-447.

Saaty, T.L. (2013) 'The Modern Science of Multicriteria Decision Making and Its Practical Applications: The AHP/ANP Approach', *Operations Research*, 61(5), pp. 1101-1118.

Saaty, T.L. and Vargas, L.G. (2012) *"Models, Methods, Concepts & Applications of the Analytic Hierarchy Process"*. New York Springer

Sabri, E.H. and Beamon, B.M. (2000) 'A multi-objective approach to simultaneous strategic and operational planning in supply chain design', *Omega*, 28(5), pp. 581-598.

Saidenberg, M.R. and Strahan, P.E. (1999) 'Are banks still important for financing large businesses?', *Current Issues in Economics and Finance*, 5(12), pp. 1-6.

Sana, S.S. (2011) 'A production-inventory model of imperfect quality products in a three-layer supply chain', *Decision Support Systems*, 50(2), pp. 539-547.

Sanchez-Ballesta, J.P. and Garcia-Meca, E. (2011) 'Ownership structure and the cost of debt', *European Accounting Review*, 20(2), pp. 389-416.

Santiago Carbó-Valverde, Francisco Rodríguez-Fernández and Udell, G.F. (2012) *"Trade credit, The financial crisis, and firm access to finance"* (683/2012). Ahorros, F.d.l.C.d.

Sapienza, P. (2002) 'The Effects of Banking Mergers on Loan Contracts', *The Journal of Finance*, 57(1), pp. 329-367.

Sapienza, P. (2004) 'The effects of government ownership on bank lending', *Journal of Financial Economics*, 72(2), pp. 357-384.

Sarkar, B., Cárdenas-Barrón, L.E., Sarkar, M. and Singgih, M.L. (2014) 'An economic production quantity model with random defective rate, rework process and backorders for a single stage production system', *Journal of Manufacturing Systems*, 33(3), pp. 423-435.

Sato, Y. (2012) 'Optimal budget planning for investment in safety measures of a chemical company', *International Journal of Production Economics*, 140(2), pp. 579-585.

Sauermann, H. and Roach, M. (2013) 'Increasing web survey response rates in innovation research: An experimental study of static and dynamic contact design features', *Research Policy*, 42(1), pp. 273-286.

Saunders, A. and Steffen, S. (2011) 'The costs of being private: Evidence from the loan market', *Review of Financial Studies*, 24(12), pp. 4091-4122.

Saunders, M., Lewis, P. and Thornhill, A. (2009) *"Research Methods for Business Students"*. Fifth edn. Essex: Pearson Education Limited

Sawik, T. (2014) 'Optimization of cost and service level in the presence of supply chain disruption risks: Single vs. multiple sourcing', *Computers & Operations Research*, 51, pp. 11-20.

Sawik, T. (2015) 'On the fair optimization of cost and customer service level in a supply chain under disruption risks', *Omega*, 53, pp. 58-66.

Schmitt, A.J. (2011) 'Strategies for customer service level protection under multi-echelon supply chain disruption risk', *Transportation Research Part B: Methodological*, 45(8), pp. 1266-1283.

Seifert, D., Seifert, R.W. and Protopappa-Sieke, M. (2013) 'A review of trade credit literature: Opportunities for research in operations', *European Journal of Operational Research*, 231(2), pp. 245-256.

Selim, H., Araz, C. and Ozkarahan, I. (2008) 'Collaborative production–distribution planning in supply chain: A fuzzy goal programming approach', *Transportation Research Part E: Logistics and Transportation Review*, 44(3), pp. 396-419.

Serrano, S.D.L.A. (2016) 'Supply chain finance for small and medium sized enterprises: the case of reverse factoring ', *internation Jouranl of Physical Distribution and Logistics Management* 46(4), pp. 1-33.

Shad, Z., Roghanian, E. and Mojibian, F. (2014) 'Integration of QFD, AHP, and LPP methods in supplier development problems under uncertainty', *Journal of Industrial Engineering International*, 10(1), pp. 1-9.

Sharifi, S. and Flores, G.M. (2013) 'Options for short-term credit in the United Kingdom', *Available at SSRN 2259542*.

Shi, X., Li, L.X., Yang, L., Li, Z. and Choi, J.Y. (2012) 'Information flow in reverse logistics: an industrial information integration study', *Information Technology and Management*, 13(4), pp. 217-232.

Shi, X. and Zhang, S. (2010) 'An incentive-compatible solution for trade credit term incorporating default risk', *European Journal of Operational Research*, 206(1), pp. 178-196.

Shi, Y., Zhang, A., Arthanari, T., Liu, Y. and Cheng, T.C.E. (2016) 'Third-party purchase: An empirical study of third-party logistics providers in China', *International Journal of Production Economics*, 171, Part 2, pp. 189-200.

Shockley, J. and Fetter, G. (2015) 'Distribution co-opetition and multi-level inventory management performance: An industry analysis and simulation', *Journal of Purchasing and Supply Management*, 21(1), pp. 51-63.

Shore, B. (2001) 'Information Sharing in Global Supply Chain Systems', *Journal of Global Information Technology Management*, 4(3), pp. 27-50.

Siddiqi, N. (2006) *Credit Risk Scorecards: Developing and Implementing Intelligent Credit Scoring*. Hoboken, New Jersey: John Wiley& Sons, Inc.

Siddiqui (2014) *Comprehensive Financial Accounting XI*. Laxmi Publications.

Sieke, M.A., Seifert, R.W. and Thonemann, U.W. (2012) 'Designing service level contracts for supply chain coordination', *Production and Operations Management*, 21(4), pp. 698-714.

Sierksma, G. (2001) *Linear and Integer Programming: Theory and Practice*. Second Edition edn. CRC Press.

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*, 34(3), pp. 298-324.

Singh, G., Tripathi, A., Srivastava, A. and Iyer, M. (2015) 'Integrated Supply Chain Outsourcing - Expanding the Role of Third Party Logistics in the Upstream Industry', 2015/11/24/. SPE: Society of Petroleum Engineers.

Sloman, J., Wride, A. and Garratt, D. (2012) *"Economics"*. Pearson.

Sonal K. Thengane , Andrew Hoadley, Sankar Bhattacharya, Sagar Mitra and Santanu Bandyopadhyay (2014) '"Cost-benefit analysis of different hydrogen production technologies using AHP and Fuzzy AHP"', *International Journal of Hydrogen Energy*, 39(28), pp. 15293–15306.

Song, D.-P., Dong, J.-X. and Xu, J. (2014) 'Integrated inventory management and supplier base reduction in a supply chain with multiple uncertainties', *European Journal of Operational Research*, 232(3), pp. 522-536.

Song, J. and Yao, D.D. (2013) *Supply chain structures: Coordination, information and optimization*. New York Springer Science + Business Media, LLC

Spitter, J.M., Hurkens, C.A.J., de Kok, A.G., Lenstra, J.K. and Negenman, E.G. (2005) 'Linear programming models with planned lead times for supply chain operations planning', *European Journal of Operational Research*, 163(3), pp. 706-720.

Srisai Chilukuri and Rao, K.S. (2014) '"Effective Credit Approval and Appraisal System: Loan Review Mechanism of Commercial Banks"', *International Journal of Innovation Research and Development* 3(12), pp. 267-274.

Stango, V. and Zinman, J. (2013) *Borrowing high vs. borrowing higher: Sources and consequences of dispersion in individual borrowing costs*. National Bureau of Economic Research.

Stevenson, A. and Waite, M. (2010) *Oxford dictionary of English*. Oxford University Press, USA.

Storey, D.J. (2004) 'Racial and Gender Discrimination in the Micro Firms Credit Market?: Evidence from Trinidad and Tobago', *Small Business Economics*, 23(5), pp. 401-422.

Tamborini, R. (2014) 'Interest-Rate Spread and Public-Debt Dynamics in a Two-Country Monetary-Union Portfolio Model', *Open Economies Review*, 25(2), pp. 243-261.

Tamiz, M., Azmi, R.A. and Jones, D.F. (2013) 'On selecting portfolio of international mutual funds using goal programming with extended factors', *European Journal of Operational Research*, 226(3), pp. 560-576.

Teng, J.-T. and Lou, K.-R. (2012) 'Seller's optimal credit period and replenishment time in a supply chain with up-stream and down-stream trade credits', *Journal of Global Optimization*, 53(3), pp. 417-430.

Teng, J.-T., Min, J. and Pan, Q. (2012) 'Economic order quantity model with trade credit financing for non-decreasing demand', *Omega*, 40(3), pp. 328-335.

Tennent, J. (2012) *"Guide to Cash Management"*. Hoboken, New Jersey: John Wiley & Sons, Inc.

Terry, J.V. (1995) *Dictionary for Business and Finance* Third edn. Fayetteville: The University of Arkansas Press.

Thomas, D.J. and Griffin, P.M. (1996) 'Coordinated supply chain management', *European Journal of Operational Research*, 94(1), pp. 1-15.

Thomas, L.C. (2000) 'A survey of credit and behavioural scoring: forecasting financial risk of lending to consumers', *International journal of forecasting*, 16(2), pp. 149-172.

Tiemessen, H.G.H., Fleischmann, M., van Houtum, G.-J., van Nunen, J.A.E.E. and Pratsini, E. (2013) 'Dynamic demand fulfillment in spare parts networks with multiple customer classes', *European Journal of Operational Research*, 228(2), pp. 367-380.

Torre, A.d.L., Peria, M.S.M. and Schmukler, S.L. (2010) 'Bank involvement with SMEs: Beyond relationship lending', *Journal of Banking and Finance* 34(9), pp. 2280-2293.

Trappey, A.J.C., Trappey, C.V., Chang, S.W.C., Lee, W.T. and Hsu, T.N. (2016) 'A one-stop logistic services framework supporting global supply chain collaboration', *Journal of Systems Science and Systems Engineering*, 25(2), pp. 229-253.

Trappey, A.J.C., Trappey, C.V., Dai, D.W.T., Chang, S.W.C. and Lee, W.T. (2014) *Computer Supported Cooperative Work in Design (CSCWD), Proceedings of the 2014 IEEE 18th International Conference on*. 21-23 May 2014.

Trappey, C.V., Lin, G.Y.P., Trappey, A.J.C., Liu, C.S. and Lee, W.T. (2011) 'Deriving industrial logistics hub reference models for manufacturing based economies', *Expert Systems with Applications*, 38(2), pp. 1223-1232.

Treichel, M.Z. and Scott, J.A. (2006) 'Women-Owned businesses and access to bank credit: Evidence from three surveys since 1987', *Venture Capital*, 8(1), pp. 51-67.

Triantaphyllou, E. and Mann, S.H. (1995) 'USING THE ANALYTIC HIERARCHY PROCESS FOR DECISION MAKING

IN ENGINEERING APPLICATIONS: SOME CHALLENGES', *International Journal of Industrial Engineering: Applications and Practice*, 2(1), pp. 35-44.

Tugrul, U.D., Andreas, U. and Aparna, B. (2012) 'Use of analytic hierarchy process (AHP) for selection of 3PL providers', *Journal of Manufacturing Technology Management*, 24(1), pp. 28-51.

Udell, G.F. (2008) 'What's in a relationship? The case of commercial lending', *Business Horizons*, 51(2), pp. 93-103.

UK Export Finance (2013a) *"Guidance of Supplier Credit Financing Facility"*. Available at: https://www.gov.uk/supplier-credit-financing-facility (Accessed: 09/24).

UK Export Finance (2013b) *Guide of Buyer Credit Facility*. Available at: https://www.gov.uk/guidance/buyer-credit-facility (Accessed: 10 September).

Usunier, J.C. (1998) *"International and Cross-cultural Management Research"*. London: Sage.

Uta, J. (2005) 'Supply chain risk management: Understanding the business requirements from a practitioner perspective', *The International Journal of Logistics Management*, 16(1), pp. 120-141.

Uzzi, B. (1999) 'Embeddedness in the Making of Financial Capital: How Social Relations and Networks Benefit Firms Seeking Financing', *American Sociological Review*, 64(4), pp. 481-505.

Vaaler, P.M. and McNamara, G. (2004) 'Crisis and competition in expert organizational decision making: Credit-rating agencies and their response to turbulence in emerging economies', *Organization Science*, 15(6), pp. 687-703.

Vachon, S. and Klassen, R.D. (2008) 'Environmental management and manufacturing performance: The role of collaboration in the supply chain', *International Journal of Production Economics*, 111(2), pp. 299-315.

Van Rixtel, A.A. and Gasperini, G. (2013) *Financial crises and bank funding: recent experience in the euro area*.BIS Working Paper

Vasiliauskas, A.V. and Jakubauskas, G. (2007) 'Principle and benefits of third party logistics approach when managing logistics supply chain', *Transport*, 22(2), pp. 68-72.

Vera, D. and Onji, K. (2010) 'Changes in the banking system and small business lending', *Small Business Economics*, 34(3), pp. 293-308.

Vidal, C.J. and Goetschalckx, M. (2001) 'A global supply chain model with transfer pricing and transportation cost allocation', *European Journal of Operational Research*, 129(1), pp. 134-158.

Voordeckers, W. and Steijvers, T. (2006) 'Business collateral and personal commitments in SME lending', *Journal of Banking & Finance*, 30(11), pp. 3067-3086.

Vos, E., Yeh, A.J.-Y., Carter, S. and Tagg, S. (2007) 'The happy story of small business financing', *Journal of Banking & Finance*, 31(9), pp. 2648-2672.

Vuyisani Moss, Hasan Dincer and Hacioglu, U. (2013) '"The nature of the creditor-debtor relationship in South Africa"', *International Journal of Reseach in Business and Social Science*, 2(2), pp. 2147-4478.

Wang, F., Lai, X. and Shi, N. (2011) 'A multi-objective optimization for green supply chain network design', *Decision Support Systems*, 51(2), pp. 262-269.

Wang, J.G. and Yang, J. (2016) 'Funding for "The Leftover Eighty Percent"—Micro and Small Loans for SMEs', in *Financing without Bank Loans*. Springer, pp. 1-13.

Wang, Q., Batta, R., Bhadury, J. and Rump, C.M. (2003) 'Budget constrained location problem with opening and closing of facilities', *Computers & Operations Research*, 30(13), pp. 2047-2069.

Wang, R.-C. and Liang, T.-F. (2004) 'Application of fuzzy multi-objective linear programming to aggregate production planning', *Computers & Industrial Engineering*, 46(1), pp. 17-41.

Wang, R.-C. and Liang, T.-F. (2005) 'Applying possibilistic linear programming to aggregate production planning', *International Journal of Production Economics*, 98(3), pp. 328-341.

Wang, W.-C., Teng, J.-T. and Lou, K.-R. (2014a) 'Seller's optimal credit period and cycle time in a supply chain for deteriorating items with maximum lifetime', *European Journal of Operational Research*, 232(2), pp. 315-321.

Wang, Y., Shao, Y. and Ou, J. (2014b) Changsha. International Conference on Management Science and Management Innovation

Waters, D. and Rinsler, S. (2014) *Global logistics: New directions in supply chain management*. Kogan Page Publishers.

Wheelock, D.C. and Wilson, P.W. (2000) 'Why do banks disappear? The determinants of US bank failures and acquisitions', *Review of Economics and Statistics*, 82(1), pp. 127-138.

Widyadana, G.A., Cárdenas-Barrón, L.E. and Wee, H.M. (2011) 'Economic order quantity model for deteriorating items with planned backorder level', *Mathematical and Computer Modelling*, 54(5), pp. 1569-1575.

Wilcox, J.A. and Berkely, U. (2011) 'The increasing importance of credit unions in small business lending', *Smail Business Administration*.

Wilner, B.S. (2000) 'The Exploitation of Relationships in Financial Distress: The Case of Trade Credit', *The Journal of Finance*, 55(1), pp. 153-178.

Wilson, N. and Summers, B. (2002) 'Trade Credit Terms Offered by Small Firms: Survey Evidence and Empirical Analysis', *Journal of Business Finance & Accounting*, 29(3-4), pp. 317-351.

Witmer, D.F., Colman, R.W. and Katzman, S.L. (1999) *"From Paper and Pen to Screen and Keyboard: Towards a methodology for survey research on the Internet"*. Thousand Oaks: CA:Sage.

Wittenberg-Moerman, R. (2008) 'The role of information asymmetry and financial reporting quality in debt trading: Evidence from the secondary loan market', *Journal of Accounting and Economics*, 46(2), pp. 240-260.

Wonglimpiyarat, J. (2011) 'Government programmes in financing innovations: Comparative innovation system cases of Malaysia and Thailand', *Technology in Society*, 33(1), pp. 156-164.

Wu, J., Ouyang, L.-Y., Cárdenas-Barrón, L.E. and Goyal, S.K. (2014) 'Optimal credit period and lot size for deteriorating items with expiration dates under two-level trade credit financing', *European Journal of Operational Research*, 237(3), pp. 898-908.

Wu, X.-l. and Zhou, J.-c. (2015) 'Retailer's Optimal Ordering Decision with Trade Credit Financing', in Qi, E., Su, Q., Shen, J., Wu, F. and Dou, R. (eds.) *Proceedings of the 5th International Asia Conference on Industrial Engineering and Management Innovation (IEMI2014)*. Atlantis Press, pp. 115-118.

Wu, Y. (2015) *Service Systems and Service Management (ICSSSM), 2015 12th International Conference on*. 22-24 June 2015.

Wu, Z. and Chua, J.H. (2012) 'Second-Order Gender Effects: The Case of US Small Business Borrowing Cost*', *Entrepreneurship Theory and Practice*, 36(3), pp. 443-463.

Wu, Z., Hedges, P.L. and Zhang, S. (2007) 'Effects of Concentrated Ownership and Owner Management on Small Business Debt Financing*', *Journal of Small Business Management*, 45(4), pp. 422-437.

Wuttke, D.A., Blome, C., Foerstl, K. and Henke, M. (2013a) 'Managing the Innovation Adoption of Supply Chain Finance—Empirical Evidence From Six European Case Studies', *Journal of Business Logistics*, 34(2), pp. 148-166.

Wuttke, D.A., Blome, C. and Henke, M. (2013b) 'Focusing the financial flow of supply chains: An empirical investigation of financial supply chain management', *International Journal of Production Economics*, 145(2), pp. 773-789.

Xia, X., Zhou, Y. and Lin, N. (2014) *ICLEM 2014@ sSystem Planning, Supply Chain Management, and Safety*. ASCE.

Xie, X.M., Zeng, S.X. and Tam, C.M. (2010) 'Overcoming barriers to innovation in SMEs in China: A perspective based cooperation network', *Innovation*, 12(3), pp. 298-310.

Xu, X., Cheng, X. and Sun, Y. (2015) 'Coordination contracts for outsourcing supply chain with financial constraint', *International Journal of Production Economics*, 162, pp. 134-142.

Yahya, S. and Kingsman, B. (1999) 'Vendor Rating for an Entrepreneur Development Programme: A Case Study Using the Analytic Hierarchy Process Method', *The Journal of the Operational Research Society*, 50(9), pp. 916-930.

Yang, S., Fu, Y., Yao, D. and Ren, C. (2014) 'The Role Analysis of Government in Intellectual Property Rights Pledge and Financing of Technological Small and Medium sized Enterprises', *International Journal of Business and Social Science*, 5(12).

Yang, S.A. and Birge, J.R. (2013) 'How inventory is (should be) financed:Trade credit in supply chains with demand uncertainty and costs of financial distress'. Social Science Research Network (SSRN).

Yang, T. and Kuo, C. (2003) 'A hierarchical AHP/DEA methodology for the facilities layout design problem', *European Journal of Operational Research*, 147(1), pp. 128-136.

Yang, X. (2011) 'Trade credit versus bank credit: Evidence from corporate inventory financing', *The Quarterly Review of Economics and Finance*, 51(4), pp. 419-434.

Yescombe, E.R. (2002) *Principles of project finance*. Academic Press.

Yu, M.-C., Goh, M. and Lin, H.-C. (2012) 'Fuzzy multi-objective vendor selection under lean procurement', *European Journal of Operational Research*, 219(2), pp. 305-311.

Zacharia, Z.G., Sanders, N.R. and Nix, N.W. (2011) '"The emerging role of the third-party logistics provider(3PL) as an orchestrator"', *Journal of Business Logistics* 32(1), pp. 40-54.

Zhao, S. and Xiong, Y. (2014) Washington DC. International Conference on Business Computing and Global Informatization.

Zhong, Y.-G. and Zhou, Y.-W. (2013) 'Improving the supply chain's performance through trade credit under inventory-dependent demand and limited storage capacity', *International Journal of Production Economics*, 143(2), pp. 364-370.

Zietsman, D. and Vanderschuren, M. (2014) 'Analytic Hierarchy Process assessment for potential multi-airport systems – The case of Cape Town', *Journal of Air Transport Management*, 36, pp. 41-49.

Zikmund, W.G., Babin, B.J., Carr, J.C. and Griffin, M. (2013) *Business research methods*. Cengage Learning.