SUPPLY CHAIN FINANCE FOR SMALL AND MEDIUM-SIZED ENTERPRISES

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ABSTRACT

The financing of small and medium-sized enterprises (SMEs) is a problem that has been discussed in practice and science for a long time. The information asymmetry between capital providers and capital borrowers was identified as one of the main difficulties. Supply chain finance provides solutions that can reduce this information asymmetry and offers instruments for the acquisition of working capital beyond traditional bank credit. The contribution shows the current state of supply chain finance in relation to SMEs and proposes an agent-based approach to minimize the capital costs of the supply chain. The aim of the agent-based model is to support the negotiations between the capital demanding company and the capital-providing companies, considering the information asymmetry between external and internal supply chain actors. To implement the model, a multi-agent system has been set up to support negotiations on financing options. An agent-based model consisting of three components is proposed, which automatically supports a capital demander in identifying the most favorable financing option for the supply chain. The potential of the use of multi-agent systems in supply chain finance is shown. Especially for SMEs there is a chance to overcome the difficulty of information asymmetry by working closely together through the instrument of the supply chain finance to finance projects that are favourable for the entire supply chain.

KEYWORDS: 1) SMALL AND MEDIUM-SIZED ENTERPRISES 2) INFORMATION ASYMMETRY 3) SUPPLY CHAIN FINANCE 4) MULTI-AGENT SYSTEMS

1. Introduction

Compared to the financing of large companies SME financing suffers from more serious information asymmetry due the fact that most SMEs are more opaque and can only provide less collateral. When it comes to SME lending there is a gap between borrower and the lender regarding both financial and non-financial information which is resultant in adverse selection and moral hazard. In this paper we address a Multi-agent system (MAS) approach in a Supply chain finance (SCF) setting to overcome the challenges of SME financing. Supply chain finance is a collaborative method that provides tools that enable small and medium-sized enterprises to meet their capital needs. The various instruments are based on the idea of converting non-liquid assets (e.g., raw materials, inventories, and receivables) into cash. Interest in SCF is growing (Hofmann and Kotzab 2010; Lekkakos and Serrano 2016), especially among SMEs, as they are often under pressure from more powerful, better capitalized members of the supply chain. Moreover, access to credit granted by banks is more difficult due to lack of collateral and information asymmetry (Fiordelisi et al. 2014; Gobbi and Sette 2014).

Among other things, digital structures are a prerequisite for SCF. Multi-agent systems have the potential to represent such structures, since the decentralized approach is able to represent the dynamic structures of a supply chain. The application areas of MAS in SCM have evolved from internal company processes such as order and production planning and control (Haasis et al. 2010) to complicated decision support processes involving the management of individual companies as well as interacting SCM partners (Lee and Kim 2008). As the name suggests, MAS consist of several agents. In this case, the agent is a closed computer system operating in a particular environment. It can act flexibly and autonomously to achieve its specified goals (Franklin and Graesser 1996). In multi-agent decision systems, the agents participating in the system must make joint decisions as a group. Mechanisms for joint decision making can be based on economic mechanisms such as an auction or on alternative mechanisms such as reasoning. The focus of supply chain management has been on optimizing and designing the flow of goods and information, whereas the financial flows in the supply chain are often neglected from a supply chain management perspective (More and Basu 2013). This is also true for the application of MAS technology.

2. Literature Review

As can be seen from the literature, there are numerous MAS application examples that support the management of goods and information flows in a supply chain (Moyaux et al. 2006; Rahman et al. 2019). In contrast, very few authors deal with MAS applications for supply chain finance (Abdollahzade et al. 2018; Fiedler et al. 2019). For this reason, an agentbased approach for SCF is proposed, which is particularly suitable for SMEs. Numerous studies on the development, instruments, and actors of SCF can be found in the literature (Caniato et al. 2019; Chakuu et al. 2019; Chen et al. 2020; Gelsomino et al. 2016; More and Basu 2013, Xu et al. 2018). However, only recently has the interest of SCF in relation to SMEs come into focus, as a literature review using the topic-guiding terms "supply chain finance" and "small and medium sized enterprises" in the EBSCO Information Services (EIS) and ScienceDirect databases revealed. From Figure 1, it is clear that interest in this topic has been increasing rapidly from 2018. Accordingly, more than 80% of the 40 articles classified as relevant in the literature search focus on the past three years.
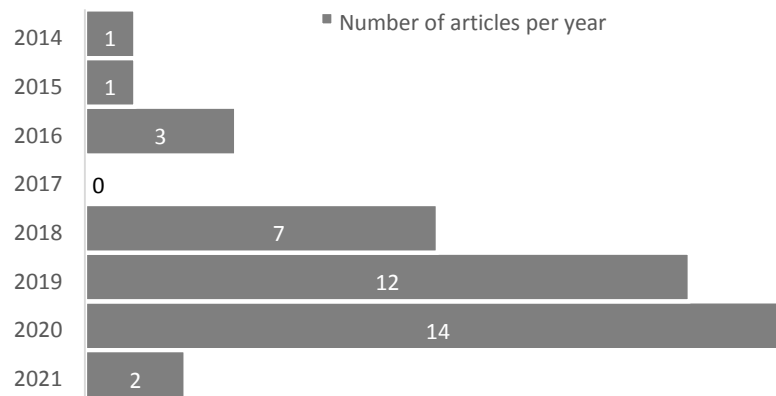
Figure 1: Distribution of the articles relevant to the topic over the years

Another interesting observation is the concentration of publications in China. Although there are papers on the subject spread around the globe, these are only isolated studies in each case, as figure two shows. In terms of international collaboration, China also has the largest number of papers. Liu, Zhou and Wu compared SCF in China to SCF in mature economies. They state that SCF in China is not exactly the same as "SCF" as it is perceived in the mature economy, which is articulated in mainstream SCM English literature. The Chinese business context in which SCF has been implemented has played a dominant role in initiating, affecting and even shaping SCF (Liu et al. 2015).

3. Research Methodology

Within our research we follow a design science research approach. The aim is to utilise gained knowledge to solve problems, create change or improve existing solutions and to generate new knowledge, insights and theoretical explanations. Therefore, we develop and implement a MAS to contribute to the SME financing in a Supply Chain setting. A critical feature of SCF is the provision of financial support based on a core company, which extends good credit to upstream and downstream companies and facilitates lending without assuming unacceptable risks. However, for a capital-demanding company that is in a complex supply chain, selecting appropriate financing options is not trivial. To this end, a MAS approach is proposed to automate and facilitate the process of selecting best possible financing options in the supply chain. The objective of the agent-based model is to support the negotiation between the capital-demanding company (N) and the capital-providing company (G), taking into account the information asymmetry between external and internal supply chain actors and the added trust in the adoption of SC financing. The best SC financing option for a project (P) is sought, and two decisions must be made. Firstly, it must be determined whether financing should be provided outside the SC via an external investor (K e.g. a bank) or internally via SC players with strong capital resources. Secondly, it is assumed that several potential (internal) capital providers are available within the SC. It must therefore be determined who provides the best financing option, taking into account information asymmetry and trust. The ideas presented here enhance the model of Gomm (2008).

The MAS must be able to determine the best internal financing option through automated negotiations. Thus, during the negotiation phase, the price or other terms of the

transaction are determined. Automated negotiation is an iterative communication and decision-making process between at least two agents who cannot fulfill their goals through unilateral actions and exchange offers and arguments to reach a consensus (Bichler et al. 2003). This negotiation process is implemented by an auction. Typically, when two or more agents enter into a conversation, they must first negotiate conversation rules. Such typical rules are called protocols. Juneja et al. (2015) have gathered various communication protocols developed and applied for MAS.

4. Results

To implement the model, a MAS is set up to support negotiations on financing options. The underlying scenario runs in three phases. In phase one, the cost of debt capital (both the company demanding capital and potential internal investors are dependent on debt capital) and, on this basis, the expected returns are determined (cf. Figure 2).
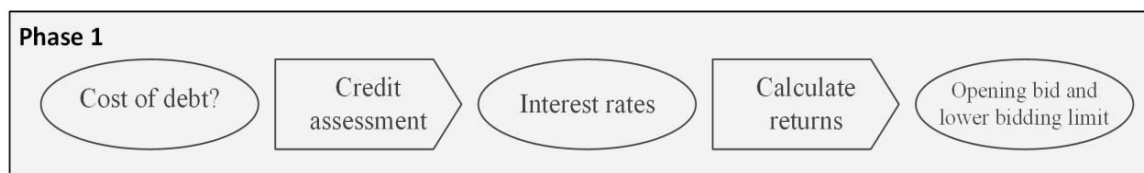

Figure 2: Process MAS for SCF in Phase 1

The second phase (cf. Figure 3) is characterized by negotiations. At this stage, potential internal investors know their respective costs of capital and the extent of the expected gain in confidence. The basis of the agent-based negotiations is an auction, implemented by means of a negotiation protocol developed for this purpose based on the Iterated-Contract-Net Protocol (FIPA 2000). Two types of agents participate in the auction, a capital demand agent as the initiator of the auction and several internal capital providers/investors as participants. The initiator invites the participants to bid and they submit their bids in the form of proposals. The initiator can accept one or more of the bids and reject the others. Or he restarts the process by issuing a revised request for bids (new starting bid) with the intention of getting better bids. The initiator is thus enabled to gradually refine his request for proposals until a suitable contract is concluded. The auction ends when no participant is willing to submit any more bids.
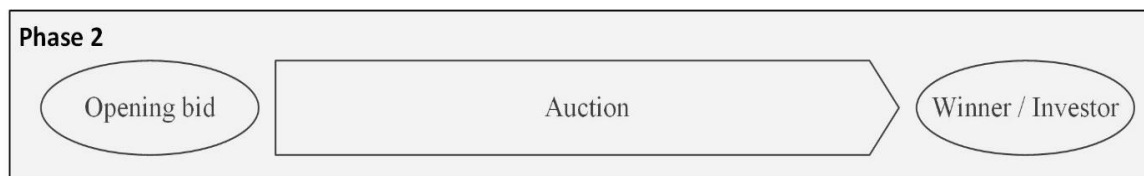

Figure 3: Process MAS for SCF in Phase 2

In the third and final phase (cf. Figure 4), a winner has emerged from the previous negotiation phase. Now it must be checked whether the winning offer of the internal investor is more advantageous than that of the external investor (e.g., a bank). In both cases, the actual lending, repayment, and profit determination take place and the process is complete.
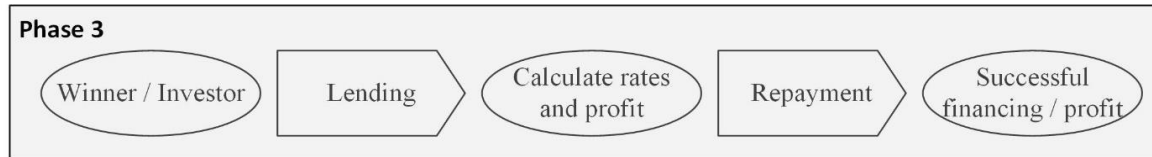
Figure 4: Process MAS for SCF in Phase 3

The parameters used in the model (Gomm 2008) are explained below:
- i_N is the interest rate of K for company N
- i_G is the interest rate of K for company G
- r_N is the net return of N from the project P
- r_G is the return demanded by G from N for the financing of P
- $r_{Project}$ is the gross return of the project P
- $0 < p \leq 1$ is the Likelihood of success of project P from G's point of view
- p_0 is the estimation of project success at the starting point (G has a certain amount of cost-free information, since SC actor)
- p_{infopt} is the optimal level of information for N with respect to G
- y is the non-financial external effect (benefit) of G in financing P
- C are the costs of information transmission per communicated share

Calculation of the expected return for the capital-demanding company N:

- In the case of external financing via the capital market K
$rN = \text{rProjekt} - iN$
- in the case of internal financing via investor G
$rN = \text{rProjekt} - rG - c$
$c = \Delta p * C$
$\Delta p = pinfopt - p0$

Calculation of the expected return for the capital-providing company G (internal Investor):

- $rG = piinfoptG\ y$
- $pinfopt\ iC\underline{G}$

A numerical example shows how information asymmetry is considered in the model and its effects. Since the focus here is on information asymmetry, the parameter y is not considered and is assumed to be zero. As summarized in Table 1, the example depicts a supply chain consisting of a capital seeker, four internal capital providers/investors, and a bank as an external capital provider. For a project to be financed, for which a return of 20% is expected upon successful implementation, there is a capital requirement of 2000 monetary units (MU) for a financing period of 2 years.

Table 1: Key data of the experiment

	N	G_1	G_2	G_3	G_4
i	6,0%	5,5%	4,5%	3,5%	2,5%
Credit volume		2000 MU			
Duration		2 years			
C		100 MU			
rProject		20,0%			
p0		45%			

It is assumed that the internal investors would also finance the project with external capital and borrow money on the capital market. The individual internal investors have different conditions, which can be explained, for example, by different positions within the SC or by different degrees of relationship with the lender. The higher the lender's assessment of the risk due to the availability or non-availability of information, the higher the cost of capital. But there is also information asymmetry within the SC. Whether an internal investor considers financing the project and on what terms also depends on the assessment of the risk. This happens in the model based on the level of information regarding the project risk (p_{infopt}). Initially, all investors have the same information level of 45%. The transmission of further information is possible but is associated with costs of 100 MU for each additional share of information. Thus, the more information available to an internal investor, the lower its return requirement from the company seeking capital. However, transferring further information to reduce the required return only makes sense up to the point where the costs exceed the benefits. The scenario just explained is implemented by the three types of agent capital demander (N), internal investor (G) and external investor (K) in the MAS, whereby the agent "internal investor" is needed four times and the other two once each. The negotiation starts with the opening bid of 6%, i.e., the interest rate that would be due in the case of financing via an external investor. The four potential internal investors enter the auction and aim to take over the financing with the highest possible prospect of profit.

Table 2: Lower bid boundaries and optimal information levels

	G_1	G_2	G_3	G_4
$pinf\ pt$	100%	94,87%	83,67%	70,71%
r_G	5,5%	4,74%	4,18%	3,54%

For this purpose, the lowest possible bid, i.e., the required returns ($r_{G1} - r_{G4}$), must be calculated before the auction starts (cf. Table 2). These depend on the likelihood of success of the project in the form of the parameter p_{infopt}, i.e., the level of information that the potential internal investor has regarding the project. For N, it is worthwhile to transfer information in order to reduce the required rate of return until the costs are higher than the resulting reduction in the cost of capital (Gomm 2008). The course of the auction is shown below.

Table 3: Auction results

Starting bid	6,00%			
round	G_1	G_2	G_3	G_4
1	5,66%	5,66%	5,93%	5,58%
2	5,58%	5,15%	5,16%	5,48%
3		4,83%	4,81%	4,98%
4		4,81%	4,66%	4,77%
5			4,21%	4,46%
6			4,21%	3,96%
7				3,72%

G_4 wins the auction (cf. Table 3) and is willing to provide the financing for a required return (r_G) of 3.72%. The return (r_N) of 14.99% for the company seeking capital is now the result of the project return of 20% minus G_4's return requirement and the information costs (c) of 1.29%. From N's point of view, it would therefore make sense to allocate the financing internally, since approximately one percent more return can be expected here than with financing via the capital market ($r_N = \max(14{,}99\%; 14{,}00\%)$). This result is also due to the fact that the level of information regarding the project, which the actors within the SC have at the beginning, was measured at 45%. The situation is different if the starting point of the information level is only 20%. Then the share of the information to be transferred increases and thus the costs incurred for it. The required return of G_4 determined in the new auction is now 4%. Because of the information costs of 2.54% now incurred in this scenario, the expected return of the company demanding capital is only 13.46%. Thus, internal financing by the auction winner is not the best option, as a higher return of 14% can be expected with financing via the external capital provider.

5. Conclusions

SCF turns the actors within the supply chain into intermediaries who can partly overcome the problem of asymmetric information between capital markets (e.g., banks) and the parties seeking capital. Due to the numerical example, it can be concluded that it is in the interest of all SC actors to exchange information regarding projects to be financed. Close cooperation and networking between the companies within the SC are advantageous in this respect, as this enables a level of information based on their position in the SC that is significantly higher than that of external players. Especially SMEs may benefit from our proposed SCF approach due to the higher information asymmetry compared to the financing of corporations. For future research, we consider it furthermore as worthwhile to investigate the different meanings of SCF in Asian and European literature and practice.

6. References

Abdollahzade, A.; Shahbazi, M.; Rajabzadeh Ghatari, A. (2018): Conceptual Agent based Modeling in Supply Chain: An Economic Perspective. In: Environmental Energy and Economic Research 2 (4), 250–263.

Bichler, M.; Kersten, G.; Strecker, S. (2003): Towards a structured design of electronic negotiations. In: Group Decision and Negotiation 12 (4), 311–335.

Caniato, F.; Henke, M.; Zsidisin, G. A. (2019): Supply Chain Finance: Historical Foundations, Current Research, Future Developments. In: Journal of Purchasing and Supply Management (25), 99–104.

Chakuu, S.; Masi, D.; Godsell, J. (2019): Exploring the relationship between mechanisms, actors and instruments in supply chain finance: A systematic literature review. In: International Journal of Production Economics 216, 35–53. DOI: 10.1016/j.ijpe.2019.04.013.

Chen, L.; Chan, H. K.; Zhao, X. (2020): Supply chain finance: Latest research topics and research opportunities. In: International Journal of Production Economics 229, 107766.

Fiedler, A.; Sackmann, D.; Haasis, H. D. (2019): A Literature Review on the State of the Art of Multi-agent Systems in Supply Chain Management. In: Logistics Management, 62– 74.

Fiordelisi, F.; Monferra, S.; Sampagnaro, G. (2014): Relationship lending and credit quality. In: Journal of Financial Services Research 46 (3), 295–315.

FIPA (2000): FIPA iterated contract net interaction protocol specification.

Franklin, S.; Graesser, A. (1996): Is It an agent, or just a program?: A taxonomy for autonomous agents. In: International Workshop on Agent Theories, Architectures, and Languages, 21–35.

Gelsomino, L. M.; Mangiaracina, R.; Perego, A.; Tumino, A. (2016): Supply chain finance: a literature review. In: Int Jnl Phys Dist & Log Manage 46 (4), 348–366. DOI: 10.1108/IJPDLM-08-2014-0173.

Gobbi, G.; Sette, E. (2014): Do firms benefit from concentrating their borrowing? Evidence from the great recession. In: Review of Finance 18 (2), 527–560.

Gomm, M. (2008): Supply Chain Finanzierung: Optimierung der Finanzflüsse in Wertschöpfungsketten: Erich Schmidt Verlag GmbH & Co KG.

Haasis, H. D.; Zimmermann, F.; Plöger, M. (2010): Unternehmensübergreifende Bestandsallokation mittels software-basierter Multiagenten-Systeme. In: Supply Management Research, 263–276.

Hofmann, E.; Kotzab, H. (2010): Supply chain-oriented approach of working capital management. In: Journal of Business Logistics 31 (2), 305–330.

Juneja, D.; Jagga, A.; Singh, A. (2015): A review of FIPA standardized agent communication language and interaction protocols. In: Journal of Network Communications and Emerging Technologies 5 (2), 179–191.

Lee, J.-H.; Kim, C.-O. (2008): Multi-agent systems applications in manufacturing systems and supply chain management: a review paper. In: International Journal of Production Research 46 (1), 233–265. DOI: 10.1080/00207540701441921.

Lekkakos, S. D.; Serrano, A. (2016): Supply chain finance for small and medium sized enterprises: the case of reverse factoring. In: Int Jnl Phys Dist & Log Manage 46 (4), 367– 392. DOI: 10.1108/IJPDLM-07-2014-0165.

Liu, X.; Zhou, L.; Wu, J-C J. (2015): Supply chain finance in China: Business innovation and theory development. In: Sustainability 7, 14689-14709

More, D.; Basu, P. (2013): Challenges of supply chain finance. In: Business Process Management Journal 19 (4), S. 624–647. DOI: 10.1108/BPMJ-09-2012-0093.

Moyaux, T.; Chaib-Draa, B.; D'Amours, S. (2006): Supply chain management and multiagent systems: an overview. In: Multiagent based supply chain management, S. 1–27.

Rahman, H. A.; Park, J.; Suh, J. (2019): Use of Software Agent Technology in Management Information System: A Literature Review and Classification. In: Asia Pacific Journal of Information Systems 29 (1), S. 65–82.

Xu, X.; Chen, X.; Jia, F.; Brown, S.; Gong, Y.; Xu, Y. (2018): Supply chain finance: A systematic literature review and bibliometric analysis. In: International Journal of Production Economics 204, S. 160–173. DOI: 10.1016/j.ijpe.2018.08.003.