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Financing Models in E-Commerce to Mitigate Disruptions: A Supply Chain Finance Perspective.

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Abstract:

With exponential growth of e-commerce giants like Amazon and Alibaba and their marketplace platforms, third party sellers also expect a tremendous rise in demand and revenue. In order to meet the requirements of increased demand, sellers need high working capital. So, most of these small and medium sized businesses need financing to support their operations. In the absence of sufficient traditional financing mechanisms, such as bank credit financing (BCF), we suggest a very recent financing strategy called platform credit financing (PCF) where the marketplace platform provides the required financing to the cash constrained third party sellers. We compare PCF with BCF in the presence of performance risk and design optimal strategies for each supply chain player.

Keywords: E-Commerce, Platform-based Financing, Supply Chain Finance, Game Theory

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Introduction:

In the recent past, online marketplaces such as Amazon and Alibaba have seen manifold growth (Tian, Vakharia, Tan, & Xu, 2018). The total units sold worldwide by the third-party sellers on the Amazon platform grew from 26% in 2007 to 53% in 2019 Q3. Even brick and mortar retail giant, Walmart, has started allowing third-party sellers to sell on its online marketplace. The success of these marketplaces depends heavily on small and medium sized (SMB) sellers who use these platforms to reach out to a huge population of potential buyers. These sellers have to surmount competition by engaging in reducing lead times, efficient inventory management, pricing decisions, and catering to customer expectations. However, the harsh reality is, many of these small and medium sized online Business-to-Customer (B2C sellers) often face a shortage of working capital for carrying out their business operations (Wang, Fan, & Yin, 2019). They must primarily depend on secured bank loans (Bank Credit Financing [BCF]) to address this liquidity issue. However, approximately 80% of commercial loan applications by these sellers (mainly SMBs) are rejected by banks (Vandenberg, 2003; Wang et al., 2019). This lack of financing hampers the operations of the online merchants thus jeopardising the viability and success of online B2C marketplace platforms.

To counter this threat, platforms have come up with a unique lending system for SMBs, better known as Platform Based Financing (PCF). Unlike BCF, PCF (e.g. Amazon lending) is a non-asset-based invitation-only financing scheme. It essentially means that there is no requirement of mortgage for availing the loan facility. But only those sellers, who receive an invitation from the platform, can apply for the loan. Amazon, through its *Amazon Lending* program, had lent more than 1 billion USD to SMBs in 2018.

For the platform, PCF can be a rewarding mechanism due to its unique ability to bring win-win for both the SMB as well as the platform. However, PCF can be risky also for the platform as it involves no mortgage. So, in case of bankruptcy, the borrower has nothing to lose, whereas the lender will lose the entire loan amount. Hence, platforms do not send loan invitation to all sellers. At the same time, they need to identify the capital-constrained SMBs, who are not eligible for BCF but carry a lower degree of supply risk. In this paper, we have considered the supply risk to be an operational risk which is one of the important characteristics of the working capital-constrained seller (Tang, Yang, & Wu, 2017). Another important aspect of this financing strategy is that the sellers should not be worse off in PCF compared to BCF; otherwise, they will not choose

PCF. Therefore, platforms need to figure out an optimal financing strategy that would be acceptable to the seller. Simultaneously, such strategy should minimise the loss of revenue due to unavailability of short-term financing and loss of capital due to bankruptcy of the borrower. The borrower (in this case, the seller) faces bankruptcy when it lacks sufficient resources to pay back the loan amount. There have been some recent studies which focus on online Supply Chain Finance (SCF) in the presence of demand uncertainty (Gong, Liu, Liu, & Ren, 2019; Gupta & Chen, 2019; Wang et al., 2019; Zhen, Shi, Li, & Zhang, 2020). Gong et al. (2019) analysed the value of PCF and established several factors related to price and profit of the stakeholders. Wang et al. (2019) compared BCF with PCF in the newsvendor setting. In a similar newsvendor setting, Gupta and Chen(2019) studied loan term and loan seniority. On the other hand, Zhen et al. (2020) investigated a manufacturer's optimal choice between BCF, PCF and RCF (Retailer based financing) in the dual-channel supply chain. All the above studies focus on platform credit financing under demand uncertainty. To the best of our knowledge, there is no study on online SCF in the context of supply risk, especially the risk for the platform related to sellers not being able to fulfil customer orders because of capital constraints. We try to fill this research gap and address the following research questions:

1) *What should be the optimal PCF strategy in the presence of supply-side risk?*

2) Under what conditions a seller will accept a PCF invitation?

3) Can PCF coordinate the supply chain? If not, what additional contracts can be introduced to coordinate the financial supply chain?

We develop a stylised game-theoretic model of a monopolistic online marketplace. We analyse a Stackelberg game between the cash-constrained online seller and the lender (bank under BCF, the platform under PCF) with the lender being the first mover. Since the seller is a small capital-constrained business, there is a risk that the seller is unable to fulfil customer orders because of operational inefficiencies. This leads to a double whammy for the platform- on one hand the platform loses financially because the seller defaults on the credit and on the other hand, the platform incurs goodwill loss because of unfulfilled customer orders.

The following sessions are organized as follows. Section 2 presents a literature review and discusses our contribution. Section 3 provides details regarding model formulation in various financing strategies. We explain the analytical results and numerical results in Section 4 and Section 5, respectively. Finally, we summarise our main findings and provide managerial insights as well as the future scope of research in section 6.

Literature review:

Our work is broadly at the interface of operations management and finance. It is mainly related to three research areas: supply chain finance (SCF), e-commerce supply chain and SCF contract design. We primarily study different financing strategies for a liquidity constrained online seller under endogenous performance risk.

The interface of supply chain risk and finance has been an active research area for a long time(de Véricourt & Gromb, 2018; Deng, Gu, Cai, & Li, 2018; Kolay, Lemmon, & Tashjian, 2012; Modigliani & Miller, 1958; Schwieterman, Goldsby, & Croxton, 2018). In the presence of market imperfection, many researchers have modelled the complex interaction between operations and financial decisions (Tunca & Zhu, 2017 Babich & Kouvelis, 2018; Buzacott & Zhang, 2004; Ding, Dong, & Kouvelis, 2007; Gaur & Seshadri, 2005; H. L. Lee & Tang, 1997;). A large chunk of SCF literature studies the trade credit financing (Gupta & Wang, 2009; Kouvelis & Zhao, 2012a; H. H. Lee, Zhou, & Wang, 2018; Luo & Shang, 2019). Kouvelis & Zhao, (2012b) formulated the structure of an optimal trade credit contract in the newsvendor setting when bank financing option is available to the buyer. Kouvelis, Wu, & Xiao, (2017) studied cost reduction and flexibility improvement effects of cash hedging in the supply chain. H.-H. Lee, Zhou, & Wang (2017) analyzed trade credit financing and its impact on supply chain performance empirically. They found smaller sized suppliers, and larger sized buyers use trade credit more. Competition among buyers and competition among supply chain partners have varying impact on trade credit. Haley & Higgins (1973) determined optimal order quantity and optimal order timing when inventory is financed by trade credit. Choda (2017) analysed optimal inventory decisions when multiple products are ordered under trade credit financing. A new form of trade credit financing, namely, Platform Credit Financing(PCF) was studied for online sellers by Wang, Fan, & Yin, (2019). This is a very recent form of financing introduced by the online marketplace platforms to fund liquidity constrained sellers on their platform. This has gained substantial attention from the practitioner community, but existing academic literature has a significant gap in terms of how PCF works in presence of performance risk of the seller who takes benefit of credit. We fill this gap by studying PCF and comparing it with conventional mode of SCF in e-commerce.

The fundamental domain of PCF makes our paper closely related to e-commerce and its changing dynamics under supply chain finance. Though this area is relatively new, there has been some recent research (Gong et al., 2019; Gupta & Chen, 2019; Wang et al., 2019; Zhen et al., 2020). Gong et al. (2019) investigated the value of PCF and established several findings related to price and profit of stakeholders. Wang et al. (2019) compared bank credit financing

(BCF) with PCF in the newsvendor set-up. Gupta & Chen (2019) focused on loan term and loan seniority in a newsvendor setting. Zhen et al., (2020) studied the manufacturer's optimal choice between BCF, PCF and RCF (Retailer based financing) in a dual-channel supply chain. However, we did not find any research in e-commerce SCF in the presence of performance risk of an online seller. We contribute to the existing literature by focusing on different financing schemes for a liquidity-constrained online retailer. The paper closest to our work is Wang et al., (2019). They considered a newsvendor set up and determined optimal financing strategy for e-commerce players exposed to demand risk. We incorporate the performance risk of the seller in our analysis. We analyze the effect of performance risk of the seller on PCF using a game-theoretic model.

Next we study the literature on supply chain contracts at the interface of operations and finance. Tunca & Zhu (2017) used a game theoretical framework to compare buyer intermediate financing with bank financing. They also supported their findings empirically. Kouvelis & Zhao, (2017) investigated the effect of credit rating on the operational and financing decisions of supply chain member with the help of modified newsvendor Stackelberg game. Caldentey & Haugh, (2009) designed supply chain contracts for financial hedging using a Stackelberg game. They found flexible contracts are preferred by financially constrained retailers. We refer the reader to the following papers for in-depth analysis of supply chain contracts under trade credit financing (C. H. Lee & Rhee, 2011; Y.-C. Tsao, 2017; Yan, Wang, Cheng, & Huang, 2016; Zhang, Dong, Luo, & Segerstedt, 2014) Y. C. Tsao (2019) designed two composite contracts (buyback and quantity flexibility) under TCF. Cao & Yu, (2018) compared quantity discount contract, revenue-sharing contract and buyback contract in the context of an emission-dependent supply chain. Zou & Tian (2020) designed a two-part trade credit contract. From the review of the existing literature, it is clear that TCF can increase supply chain efficiency through carefully designed supply chain contracts. Our final contribution to the supply chain finance literature is in terms of contract design for PCF. We suggest two new contracts in PCF and test whether they are able to increase the efficiency of the supply chain.

Model formulation:

We consider a supply chain comprising three players: an online seller who is cash-constrained (she), a pure marketplace platform (he), a bank (it) which works in a competitive market. All the three entities are risk-neutral. We assume there is no information asymmetry among the players.

The seller sells her product only on the platform at price p_j and pays platform $\alpha\%$ of the selling price as referral fee for each unit of the products sold. The referral fee is set as per the product category with no relationship with the mode of financing. It is in line with prevailing practices across e-commerce platforms. The demand faced by the seller is known to her. We assume the demand function to be linearly related to the price of the product. The maximum demand is taken to be 1 without any loss of generality. For producing the product, the seller incurs a cost $c > 0$. The seller is inherently unreliable. The performance risk of the seller is λ. It means out of 100 times, the seller fails to deliver the product λ times. But the seller incurs the production cost each time. Each time the seller fails to deliver the product, the platform incurs a goodwill loss cost k.

The seller has some fixed assets, which can be used as mortgage for getting a loan. For ease of calculation, we express it as a percentage of the total loan amount. Mortgage value has no effect on PCF, whereas it affects interest rate in BCF. In both PCF and BCF, the seller is the Stackelberg follower and lender is the Stackelberg leader.

In our analysis, we assume that the initial working capital of the seller is zero. The length of the credit period is equal to that of the selling period. The risk-free rate is zero.

The sequence of events is as follows. Each financing institute audits the performance risk of the seller and market conditions. Then they set the optimal interest rate first. The seller chooses the best financing source and starts producing the final product. If the orders are delivered successfully, then the seller gets sufficient revenue to pay the referral fee and repay the loan. If the orders are not fulfilled, then the seller goes bankrupt. In case of bankruptcy, the bank seizes the mortgaged assets, unlike platform which gets nothing. The timeline is provided in the figure below.

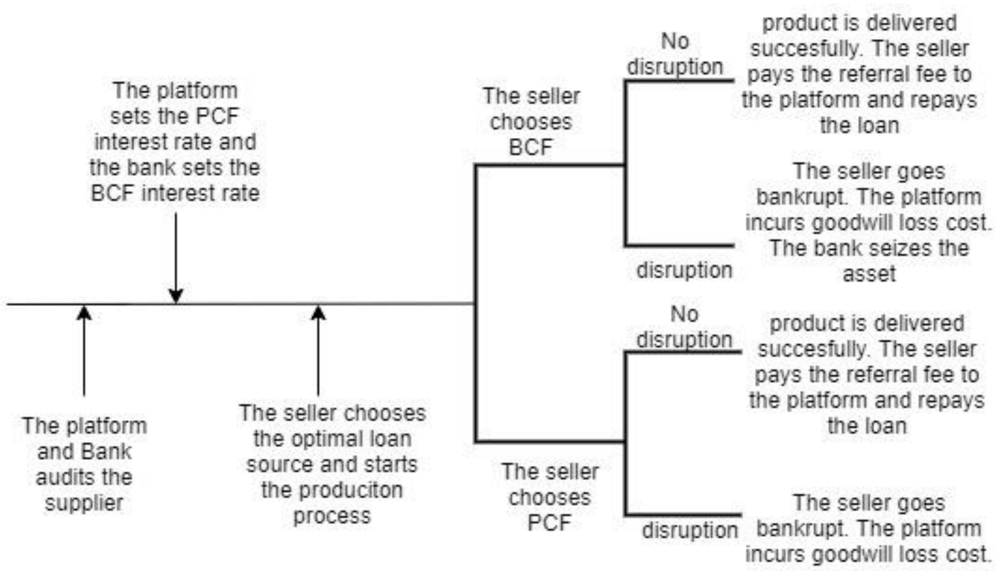

Figure 1 Sequence of Events under BCF and PCF

Notations:

d_j = demand of player i in situation j =1- p_j

π_i^j = Profit of player i in situation j, i=S for the seller, P for the platform, B for the bank, j is BCF for bank financing and PCF for platform financing

p_j = Price of a product sold by a seller in situation j

λ = risk of disruption of seller

α = referral fee of amazon (per product)

c = unit production cost per product

k = goodwill loss per unit loss of sale

m = mortgage amount in case of bank lending

r_i = loan interest rate (in %) by player i

Case 1: Bank credit Financing

In bank credit financing, the interest rate is decided in a competitive lending market by the bank. It is a function of the risk of disruption and mortgage value. Here for calculation simplicity, we have expressed mortgage value m as a percentage of the total principal amount available. For the bank, the decision variable is the interest rate and for the seller, the decision variable is price

$m = acd$ where a= mortgage value in term of % of the loan

$$\pi_s^B = (1-\lambda)(1-\alpha)dp-\lambda m-(1-\lambda)cd(1+r_b)$$

$$\pi_p^B = (1-\lambda)\alpha dp- \lambda kd$$

$$\pi_B^B = (1-\lambda)cd(1+r_b)+\lambda m-cd$$

First, we find the first-order condition of the profit function of the seller. Then we get an optimal price as a function of the interest rate. We replace the price in bank's profit function with the expression for the optimal price and find the optimal interest rate of the BCF. Then we back substitute and find the final optimal price and optimal profit of all the players. As the interest rate is competitively priced, the profit of the bank will be zero. The optimal values from the analysis are given below.

Case 2: Platform credit Financing

In PCF, platform decides the interest rate first, and then the seller determines the price that optimises its profit. Here platform is the Stackelberg leader and the seller is the Stackelberg follower. We solve this system of equations in the same manner as in case 1. The equations are given below

$$\pi_s^P = (1-\lambda)(1-\alpha)dp - (1-\lambda)cd(1+r_p)$$

$$\pi_p^P = (1-\lambda)\alpha dp - \lambda kd + (1-\lambda)cd(1+r_p) - cd$$

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References:

Babich, V., & Kouvelis, P. (2018). Introduction to the Special Issue on Research at the Interface of Finance, Operations, and Risk Management (iFORM): Recent Contributions and Future Directions. *Manufacturing & Service Operations Management*, *20*(1), 1–18. https://doi.org/10.1287/msom.2018.0706

Caldentey, R., & Haugh, M. B. (2009). Supply contracts with financial hedging. *Operations Research*, *57*(1), 47–65. https://doi.org/10.1287/opre.1080.0521

Cao, E., & Yu, M. (2018). Trade credit financing and coordination for an emission-dependent supply chain. *Computers and Industrial Engineering*, *119*(March), 50–62. https://doi.org/10.1016/j.cie.2018.03.024

Choda, J. (2017). Inventory, risk shifting, and trade credit. *Management Science*, *63*(10), 3207–3225. https://doi.org/10.1287/mnsc.2016.2515

de Véricourt, F., & Gromb, D. (2018). Financing Capacity Investment Under Demand Uncertainty: An Optimal Contracting Approach. *Manufacturing & Service Operations Management*, *20*(1), 85–96. https://doi.org/10.1287/msom.2017.0671

Deng, S., Gu, C., Cai, G. (George), & Li, Y. (2018). Financing Multiple Heterogeneous Suppliers in Assembly Systems: Buyer Finance vs. Bank Finance. *Manufacturing & Service Operations Management*, *20*(1), 53–69. https://doi.org/10.1287/msom.2017.0677

Gong, D., Liu, S., Liu, J., & Ren, L. (2019). Who benefits from online financing? A sharing economy E-tailing platform perspective. *International Journal of Production Economics*, (January). https://doi.org/10.1016/j.ijpe.2019.09.011

Gupta, D., & Chen, Y. (2019). Retailer-Direct Financing Contracts Under Consignment. *Manufacturing & Service Operations Management*, (May), msom.2018.0754. https://doi.org/10.1287/msom.2018.0754

Gupta, D., & Wang, L. (2009). A Stochastic Inventory Model with Trade Credit. *Manufacturing & Service Operations Management*, *11*(1), 4–18. https://doi.org/10.1287/msom.1070.0191

Haley, C. W., & Higgins, R. C. (1973). Inventory Policy and Trade Credit Financing. *Management Science*, *20*(4 pt 1), 464–471. https://doi.org/10.1287/mnsc.20.4.464

Kolay, M., Lemmon, M. L., & Tashjian, E. (2012). Spreading the Misery? Sources of Bankruptcy Spillover in the Supply Chain. *Ssrn*, *51*(6), 1955–1990. https://doi.org/10.2139/ssrn.2019733

Kouvelis, P., Wu, X., & Xiao, Y. (2017). Cash Hedging in a Supply Chain. *Ssrn*, (April 2019), 0–20. https://doi.org/10.2139/ssrn.3054701

Kouvelis, P., & Zhao, W. (2012a). Financing the newsvendor: Supplier vs. bank, and the structure of optimal trade credit contracts. *Operations Research*, *60*(3), 566–580. https://doi.org/10.1287/opre.1120.1040

Kouvelis, P., & Zhao, W. (2012b). Financing the Newsvendor: Supplier vs. Bank, and the Structure of Optimal Trade Credit Contracts. *Operations Research*, *60*(3), 566–580. https://doi.org/10.1287/opre.1120.1040

Kouvelis, P., & Zhao, W. (2017). Who Should Finance the Supply Chain? Impact of Credit Ratings on Supply Chain Decisions. *Manufacturing & Service Operations Management*, *20*(1), 19–35. https://doi.org/10.1287/msom.2017.0669

Lee, C. H., & Rhee, B. D. (2011). Trade credit for supply chain coordination. *European Journal of Operational Research*, *214*(1), 136–146. https://doi.org/10.1016/j.ejor.2011.04.004

Lee, H.-H., Zhou, J., & Wang, J. (2017). Trade Credit Financing Under Competition and Its Impact on Firm Performance in Supply Chains. *Manufacturing & Service Operations Management*, *20*(1), 36–52. https://doi.org/10.1287/msom.2017.0640

Lee, H. H., Zhou, J., & Wang, J. (2018). Trade credit financing under competition and its impact on firm performance in supply chains. *Manufacturing and Service Operations Management*, *20*(1), 36–52. https://doi.org/10.1287/msom.2017.0640

Luo, W., & Shang, K. H. (2019). Technical note—managing inventory for firms with trade credit and deficit penalty. *Operations Research*, *67*(2), 468–478. https://doi.org/10.1287/opre.2018.1787

Modigliani, F., & Miller, M. H. (1958). THE COST OF CAPITAL, CORPORATION FINANCE AND THE THEORY OF INVESTMENT. *American Economic Association*, *48*(3), 261–297. Retrieved from www.jstor.org/stable/1809766

Schwieterman, M. A., Goldsby, T. J., & Croxton, K. L. (2018). Customer and Supplier Portfolios: Can Credit Risks be Managed Through Supply Chain Relationships? *Journal of Business Logistics*, *39*(2), 123–137. https://doi.org/10.1111/jbl.12179

Tang, C. S., Yang, A., & Wu, J. (2017). Sourcing from Suppliers with Financial Constraints and Performance Risk Sourcing from Suppliers with Financial Constraints and Performance Risk. *Manufacturing & Service Operations Management*, (October).

Tian, L., Vakharia, A. J., Tan, Y. R., & Xu, Y. (2018). Marketplace, Reseller, or Hybrid: Strategic Analysis of an Emerging E-Commerce Model. *Production and Operations Management*, *27*(8), 1595–1610. https://doi.org/10.1111/poms.12885

Tsao, Y.-C. (2017). Channel coordination under two-level trade credits and demand uncertainty. *Applied Mathematical Modelling*, *52*, 160–173. https://doi.org/https://doi.org/10.1016/j.apm.2017.07.046

Tsao, Y. C. (2019). Coordinating contracts under default risk control-based trade credit. *International Journal of Production Economics*, *212*(March), 168–175. https://doi.org/10.1016/j.ijpe.2019.02.018

Tunca, T. I., & Zhu, W. (2017). Buyer Intermediation in Supplier Finance.

Management Science, *64*(12), 5631–5650. https://doi.org/10.1287/mnsc.2017.2863

Vandenberg, P. (2003). Adapting to the Financial Landscape: Evidence from Small Firms in Nairobi. *World Development*, *31*(11), 1829–1843. https://doi.org/10.1016/j.worlddev.2003.04.003

Wang, C., Fan, X., & Yin, Z. (2019). Financing online retailers: Bank vs. electronic business platform, equilibrium, and coordinating strategy. *European Journal of Operational Research*, *276*(1), 343–356. https://doi.org/10.1016/j.ejor.2019.01.009

Yan, J., Wang, X., Cheng, H., & Huang, L. (2016). Study on the coordination contract in supply chain under trade credit based on risk compensation. *Chaos, Solitons & Fractals*, *89*, 533–538. https://doi.org/https://doi.org/10.1016/j.chaos.2016.02.040

Zhang, Q., Dong, M., Luo, J., & Segerstedt, A. (2014). Supply chain coordination with trade credit and quantity discount incorporating default risk. *International Journal of Production Economics*, *153*, 352–360. https://doi.org/10.1016/j.ijpe.2014.03.019

Zhen, X., Shi, D., Li, Y., & Zhang, C. (2020). Manufacturer's financing strategy in a dual-channel supply chain: Third-party platform, bank, and retailer credit financing. *Transportation Research Part E: Logistics and Transportation Review*, *133*(May 2019), 101820. https://doi.org/10.1016/j.tre.2019.101820

Zou, X., & Tian, B. (2020). Retailer's optimal ordering and payment strategy under two-level and flexible two-part trade credit policy. *Computers and Industrial Engineering*, *142*(January), 106317. https://doi.org/10.1016/j.cie.2020.106317