

Platform financing vs. bank financing: Strategic choice of financing mode under seller competition

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Abstract

Third-party sellers on online platforms primarily rely on banks to meet their financing requirements and are often constrained by the lack of sufficient working capital. Online platforms such as Amazon and Alibaba have ushered new dynamics in the e-commerce financing landscape by offering working capital loans to these sellers, thereby directly competing with banks and influencing market competition. This paper analytically studies how the competition between third-party sellers on platforms affects the strategic financing choices of sellers, namely, platform financing (P) vs. bank financing (B). We examine how the financing choice influences sellers' pricing decisions in the competitive product market. Based on the sellers' financing choices, four lending modes are possible: BB, PP, BP, and PB. Our analyses provide critical insights on the optimal financing choices and uncover the interplay of pricing, product substitution, referral fees, and production costs. We show that any seller deviating from PP to a hybrid mode (BP/PB) leads to a higher platform interest rate and a lower seller profit. We find that the competing sellers choose a hybrid lending mode when the unit production cost is low. However, the platform always prefers PP, leading to an all-win outcome in the supply chain when the production cost is high. Furthermore, for products with low referral fees and high substitution effect, BP/PB emerges as equilibrium, while for products with low referral fees and low substitution effect, PP is the equilibrium outcome. Interestingly, we find that both sellers may choose bank financing when their working capital levels are high.

Keywords: Supply chain management, Operations-finance interface, Platform financing, Bank financing, Seller competition

1. Introduction

Marketplace services offered by online platforms such as Amazon, Alibaba, and JD.com have been a major catalyst for the growth of online retail in the recent past. In the third quarter of 2021, the marketplace sales by third-party sellers on Amazon has accounted for 56% of the paid units and generated \$103.37 billion revenues from third-party seller services in 2021 (Coppola,

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2021). Globally, in 2021, third-party marketplaces have witnessed an 81% year-on-year growth in gross merchandise value (Ali, 2021).

The success of a marketplace model depends on the scale, size, and number of third-party sellers on the platform. Most of the sellers on these platforms are small and medium-sized businesses (SMBs) with limited financial resources. For example, 73% of third-party sellers on Amazon have only one to five employees, while 10% of them only have six to ten employees (Chevalier, 2021). One of the critical challenges that SMBs face is access to short-term working capital financing (Yan et al., 2020). Traditionally, SMBs have resorted to bank loans to meet their working capital requirements. However, due to their size, insufficient assets, and limited credit history, it is often difficult for SMBs to secure bank loans. Additionally, since the credit crisis of 2008, bank financing has become costly for these small businesses (Tang et al., 2018; Wang et al., 2019). The lack of low-cost financing threatens the day-to-day operations of small businesses and, in turn, creates roadblocks for the marketplace model to achieve its full potential.

To overcome this critical challenge, marketplace providers have recently come up with innovative financing schemes under the umbrella of “platform credit financing” (PCF) for SMBs selling on their respective platforms. Amazon has been at the forefront of PCF offering non-asset-based loans to SMBs selling on its platform through the Amazon Lending Program. Since its inception in 2011, Amazon Lending has provided short-term loans to SMBs amounting to \$1 billion every year. Caleb Light, the Vice President of Sales for Power Practical (i.e., the SMB), in Salt Lake City, Utah, emphasizes the importance of Amazon Lending (i.e., platform credit financing): *“Traditional funding vehicles wouldn’t support our model of direct to consumer and we needed help. Amazon stepped in and is a great partner for us. The loans from Amazon Lending enabled us to expand inventory and resulted in us having a very strong and successful 2016.”* (Business Wire, 2017).

Amazon Lending has now been extended to SMBs in the UK, Canada, France, China, Germany, and India. Other e-commerce giants, such as JD.com, Alibaba, etc., have also introduced financing options for SMBs selling on their platforms (popularly known as Jing Bao Bei, Pay later, respectively). To help capital-constrained sellers, Indian e-commerce giant Flipkart has come up with its own financial services division of Flipkart Growth Capital ¹ (Lendingcart, 2020). A list of various PCF programs and their operational details are provided in Table 1.

With PCF, new competitive dynamics pan out in the e-commerce landscape. Platforms compete directly with financial institutions like banks in offering working capital loans to third party sellers. **Even though access to bank financing can be limited for SMBs, it is still one of the most common forms of short-term financing option². According to a recent survey by the US Federal Deposit Insurance Corporation (FDIC), banks are still the most common source of external financing for small businesses³. PCF adds another viable financing option for SMBs and this leads to lending market competition and adds a further layer of intricacy in the product market competition between the sellers.** The sellers compete amongst each other

¹<https://seller.flipkart.com/slp/content/flipkart-growth-capital>

²<https://markaaz.com/the-most-common-types-of-small-business-financing/>.

³<https://www.census.gov/programs-surveys/sbls/about.html>

Platform credit financing	Lending platform	Operational details
Amazon Lending	Amazon	Amazon decides the interest rate and provides the loan amount. The SMB seller takes a loan as per requirement. In some countries, Amazon provides loans through its partners like banks and other financing institutes. ^a
Jingbaobei	JD.com	JD.com provides loans to sellers in three minutes after a seller applies for a loan through its automated financing platform by analyzing the seller’s sales value and financial data. ^b
Alibaba Pay Later	Alibaba.com	SMBs selling on Alibaba.com can get credit up to 150,000 USD within minutes. It is available in the US, Europe, Brazil, and other countries. ^c
eBay seller capital	eBay.com	eBay provides business loans up to 500,000 USD, working capital loans, and lines of credit up to 250,000 USD through its several lending partners such as Lending Point, FDIC, and others. The application process is online and takes 1 – 2 days maximum. ^d

^a <https://sell.amazon.com/programs/amazon-lending>

^b <https://blog.karatos.in/a?ID=00250-97d93ad3-f548-4f94-b818-3992cfcbeb5a>

^c <https://leelinesourcing.com/alibaba-pay-later/>

^d <https://pages.ebay.com/sellercapital/>

Table 1: Illustrations of current practices of PCF (platform credit financing)

and the product market intensity driven by factors such as product substitutability, platform referral fees and the production costs drive the interest rates of the lenders and the financing choices of the sellers. Important decisions pertaining to product market competition between the sellers such as pricing and selling quantities are influenced by the interest rate at which sellers obtain financing in a competitive lending market. Therefore, the financing choice of the competing third party sellers add an interesting aspect to the determinants of market intensity in the e-commerce domain.

Even though the business press has reported platform financing modalities in detail (Deliverr, 2020), the academic literature is limited in terms of analyzing this novel mechanism. Among the existing literature on platform financing, Wang et al. (2019); Yan et al. (2020), and Rath et al. (2021) have studied the dynamics of platform credit financing from the context of a single e-commerce seller. However, none of these papers have considered competition between the lenders in determining the optimal interest rates and the product market competition between the sellers as they sell their products on the marketplace and seek financing options. We endeavour to fill this important research gap. More specifically, we aim to analyze competitive dynamics at two levels, (i) between the lenders (bank and platform) and (ii) between the sellers, and explore how they shape the lenders’ financing decisions (i.e., interest rates) and sellers’ operational decisions (i.e., selling quantities and retail prices). The sellers are capital constrained and they choose between platform credit financing (PCF) or simply ‘platform financing’, and traditional bank credit financing (BCF) or ‘bank financing’. Based on the sellers’ financing choices, we consider four distinct lending modes: (i) both sellers choose BCF (BB mode), (ii) both sellers choose PCF (PP mode), and (iii) one of the competing sellers chooses BCF while the other

opts for PCF (BP or PB mode). Our objective is to analyze each lending mode and how it impacts the lenders' (the bank and the platform) financial and sellers' operational decisions. Extant literature in PCF has identified production cost as a critical parameter in determining the optimal lending choice for a seller in a monopolistic setting (Zhen et al., 2020; Rath et al., 2021). We extend this intriguing line of analysis by exploring the impact of sellers' production costs in the context of platform financing under product and lending market competition. In summary, we address the following research questions in this study:

- (i) What should be the equilibrium financing choices of competing sellers: bank financing or platform financing? Which lending mode would be preferred by the platform?
- (ii) How does product and lending market competition shape the sellers' pricing and the lenders' interest rate decisions?
- (iii) How do critical parameters such as production cost, referral fee, and degree of product substitution impact the equilibrium financing choices of competing sellers?

To answer these questions, we develop a stylized game-theoretic model in which two competing third-party sellers sell their products through an intermediary platform. Based on the sellers' financing choices, we study four distinct lending modes: BB, PP, BP, and PB. For each lending mode, we determine the optimal interest rates charged by lenders, i.e., the bank and/or the platform, and sellers' optimal selling quantity (and pricing) decisions. Finally, we derive the equilibrium lending mode choice for the competing sellers. Our paper contributes to the emerging field of supply chain finance (SCF) by establishing the equilibrium conditions for BCF and PCF, considering the dynamics between the important decision variables, such as sellers' retail price and the interest rate offered by the lenders.

The major insights and findings are as follows. We find that when one of the competing sellers moves to platform financing from bank financing, the bank interest rate reduces. This leads to reduced market prices and enhanced selling quantities for both sellers. The platform's interest rate decreases when one of the competing sellers moves to bank financing under low unit production cost and increases when the unit production cost is high. When both sellers choose the same financing mode, we find that the bank charges a higher interest rate than the platform. The dynamics between lending market competition, the degree of product substitution, and whether the lender is a part of the product supply chain all drive these important and critical outcomes.

Conventional wisdom suggests that both sellers may achieve maximum profits under platform financing. In contrast, we find that both sellers are not always better off with platform financing. Under a hybrid lending mode, i.e., when one of the sellers opts for bank and the other opts for platform financing, or vice versa, a seller may obtain a higher profit as compared to both of them opting for platform financing. However, the platform always prefers PP mode compared to other lending modes. Our findings suggest that, in a competitive market, production costs might be a significant determinant of the best financing option for sellers. Each seller may choose a different funding source, bank, or platform for products like apparel and eye-wear, when the production cost is low. In contrast, when it comes to goods related to high production costs, such as high-end electronics and furniture items, there exists a win-win-win outcome with both the sellers as well as the platform earning the highest profit under platform

financing.

Our analyses on the interplay of referral fee charged by the platform and the degree of product substitution uncovers some interesting results. Platform finance turns out to be the best financing approach for both the sellers and the customers for products with substantial referral fees, such as jewelry and furniture. For products with modest referral fees, however, the degree of substitution becomes a crucial decision factor. A hybrid loan lending mode emerges as the equilibrium for products with a high substitution effect, such as groceries, whereas platform financing stays the equilibrium outcome for products with a low substitution effect, such as books.

For robustness checking and deriving more insights, we analyze multiple model extensions. First, we examine the impact of sellers' initial working capital on their optimal financing choice. Our analyses show that as the difference in working capital levels of the two sellers increases, hybrid financing mode becomes the Nash equilibrium. However, as the working capital levels increase, both sellers tend to choose bank or platform financing rather than a hybrid lending mode. Interestingly, we find that platform financing becomes the Nash equilibrium choice at moderate levels of working capital even though both sellers can earn a higher profit with bank financing. The above results have important managerial implications as initial working capital levels can be an important driver for optimal financing choices for the competing sellers. Second, we analyze a scenario where the lenders set their interest rates before the sellers choose their lending modes. This extension provides a decision-making sequence where all the lending modes emerge as equilibria. Further, we explore price competition among the sellers and extend the base model to the case with n competing sellers. We find that the results of our base model are robust for practical parametric values under these two scenarios. Finally, we model the impact of the sellers' repayment failure risk. We find that in the presence of repayment failure risk, when the cost of goodwill is high and the referral fee is low, both sellers choose bank financing. For a high cost of goodwill and a low referral fee, the platform offers a higher interest rate to the sellers, making PCF unattractive. As a result, both sellers choose bank financing, thereby establishing the lending mode BB as the Nash equilibrium.

The rest of the paper is organized as follows. In Section 2, we present a review of the literature and identify research gaps. Section 3 discusses the model formulation and Section 4 presents the analytical results for the different lending modes. The equilibrium outcomes are provided in Section 5. We perform numerical analyses in Section 6 and present **five** model extensions in Section 7. Finally, we provide critical managerial insights and concluding remarks in Section 8.

2. Literature Review

This study contributes to the emerging literature on supply chain finance that aims to analyze the comparative dynamics of platform financing with bank financing in the presence of seller competition in the end market. Therefore, we first discuss the existing literature related to supply chain finance, firm competition, and platform retailing.

2.1. Supply Chain Finance

This stream of literature is at the interface of operations and finance that primarily deals with supply chain members' operational and financial decisions (Zhao and Huchzermeier, 2015). We refer the readers to Babich and Kouvelis (2018), Choi (2020), Huang et al. (2022), Du et al. (2023), and references therein for an exhaustive review. In this paper, we cover two categories of supply chain financing literature: bank financing and platform financing.

Bank financing is one of the traditional methods of obtaining working capital loans. Buzacott and Zhang (2004) analyze the joint operational and financing decisions of multiple firms under bank financing and show that bank financing can improve firms' profit. Jing et al. (2012) compare bank financing with trade credit financing in a two-tier supply chain setting in which both the manufacturer and the retailer are capital-constrained. The authors show that the bank should provide a loan to the manufacturer when the production cost is low; otherwise, it should lend to the retailer. Kouvelis and Zhao (2016) investigate different types of hybrid contracts under bank financing in the presence of bankruptcy risk and default cost. Later, Tunca and Zhu (2018) show that the retailer-intermediated bank financing reduces the interest rate and improves the supply chain players' profit. Wu et al. (2019) conduct an empirical analysis to study the effect of different financing strategies: bank financing and trade credit financing, on a capital-constrained firm's inventory decision. They show that the bank financing affects the firm's inventory decision more than the trade credit financing.

The growing popularity of platform financing among third-party sellers has drawn the research community's attention in the recent past. This stream of literature predominately studies how platform financing impacts the supply chain members' operational and financing decisions. Wang et al. (2019) is one of the early papers in this stream of research. They study platform financing in a newsvendor-based supply chain setting and compare it with bank financing. They find that platform financing can coordinate the supply chain. Gong et al. (2020) show that platform financing can benefit both the platform and capital-constrained sellers. Yan et al. (2020) show that even if the downstream supplier opens a competing offline channel, the platform can provide financing to the supplier on its platform. This is because the net profit gain from the lending business can offset the revenue loss due to channel competition. Similarly, in a dual channel setting, Zhen et al. (2020) compare two financing strategies for a capital-constrained manufacturer: platform financing and retailer financing. The manufacturer prefers retailer financing to platform financing when the channel competition is high. Rath et al. (2021) compare platform financing and bank financing in the presence of the seller's performance risk and show that the seller may benefit from platform financing. Qin et al. (2021) study platform financing in a green supply chain in which a manufacturer needs financing for procurement and carbon emission reduction. They find that platform financing can benefit both the platform and the capital-constrained manufacturer when the platform endogenously sets the usage fee rate. Yi et al. (2021) compare platform guarantee financing with platform direct financing and bank financing. They show that platform guarantee financing can improve the total supply chain profit. Chang et al. (2022) study how an online retailer's financing decision interacts with the downstream platform's selling mode decision. The authors show that platform financing is not advantageous over bank financing when the manufacturer's working capital is low. Ma et al.

(2022) show that when the platform’s opportunity cost exceeds the bank’s opportunity cost, the whole supply chain prefers providing the self-supported loan or assisted loan; otherwise, joint loan and assisted loan are preferred depending on the procurement cost.

Furthermore, our paper is tangentially related to the literature on buyer financing. This stream of literature considers downstream buyers/retailers as lenders to their capital-constrained sellers/manufacturers (Tang et al., 2018; Gupta and Chen, 2020; Jain et al., 2023). Li et al. (2023) study and characterize two types of buyer financing: partial credit guarantee and full credit guarantee. Another form of buyer financing is reverse factoring, in which the buyer becomes a guarantor to the bank so that the debt obligation can be met. This helps its sellers to mitigate the default risk associated with product quality (Tunca and Zhu, 2018), or order delivery capability (Kouvelis and Xu, 2021). In a two-echelon supply chain, Jena et al. (2023) show that reverse factoring may bring higher profits for a downstream retailer and its capital-constrained manufacturer. Compared to these studies, we focus on platform financing, where an e-commerce platform finances its upstream sellers.

Besides the above studies, our paper is also related to the literature that considers operational and financial decisions in the presence of upstream/downstream competition. Babich et al. (2007) study a supply chain with one retailer and multiple competing risky suppliers. They find that if the number of suppliers is low, a high default correlation is better for the downstream retailer; however, a low default correlation is beneficial for the suppliers and the supply chain. Yang et al. (2015) show that a firm does not always benefit from its competitor’s bankruptcy; however, upstream suppliers and downstream customers may benefit from this. Lee et al. (2018) empirically study trade credit financing under supplier competition and find that when the market power of a supplier is low, the suppliers utilize trade credit financing more to obtain competitive advantage. Deng et al. (2018) compare bank financing with buyer financing in the presence of multiple capital-constrained suppliers. They identify the market conditions in which bank financing is better than buyer financing for the buyer and suppliers. Gu et al. (2021) study how a capital-constrained supplier’s financing strategy interacts with a manufacturer’s sourcing strategy. Recently, Ning (2022) show that in the presence of buyer competition, trade credit financing reduces the effect of double marginalization and improves the total supply chain profit. Our paper complements this stream of research by studying lending market competition, i.e., competition between bank financing and platform financing, in the presence of seller competition.

A stream of research has compared platform financing with bank financing. In the setting of a single e-commerce seller, Wang et al. (2019), Yan et al. (2020), and Chang et al. (2022) have explored the dynamics of platform credit financing. However, none of these studies have taken into account both the seller-to-seller product market competition as they compete to sell their goods on a platform and look for financing choices, as well as the lender-to-lender competition between a platform and a bank in deciding on the best interest rates. We consider seller competition and the supply side risk (see Section 7) in the analysis, making the study more practical and generating additional insights for supply chain managers. In Table 5 of the online supplement, we compare our paper to the most relevant studies on supply chain financing and include the similarities and major differences of our paper to those studies. For more details,

readers are referred to the Appendix D of the online supplement.

2.2. Platform Retailing

Our study also contributes to the literature on platform retailing that investigates the operational and marketing decisions of online platforms and third-party sellers. The platform acts as a marketplace and charges a percentage of sellers' revenue (Wang et al., 2004). The majority of papers focus on studying two distinct modes of product sales on platforms: resell (wholesale) and agency model (Jing et al., 2012; Abhishek et al., 2016; Tan and Carrillo, 2017; Lu et al., 2018; Zhang and Zhang, 2020). Tian et al. (2018) and Lai et al. (2022) examine the problem of seller competition while choosing their optimal sales format. Shen et al. (2019) and Ha et al. (2021) study a seller's strategic choice of distribution channel in the presence of an online platform. In contrast to these papers, we consider the financial service provided by an online platform to its sellers and explore the implications of this service on their operational and financial decisions.

3. Model

We consider a two-echelon supply chain that consists of two competing sellers (represented by subscripts '1' and '2'), an intermediary e-commerce platform (represented by subscript 'e'), and a traditional financial institution such as a bank (represented by subscript 'b'). The sellers produce their products and sell them to customers in the end market via the platform. For the remainder of the paper, we use "she" to denote the sellers, and "he" and "it" to represent the platform and the bank, respectively.

3.1. Sellers' Lending Modes

Both sellers simultaneously decide whether to borrow from the bank or directly from the intermediary platform. Thus, each seller chooses between two lending alternatives: "bank financing" (B) and "platform financing" (P). We assume that the sellers' lending (or borrowing) choices are strategic decisions as such decisions enable them to fulfill customer demand on time. Based on the sellers' lending choices, four different lending market alternatives are possible: (i) **BB Mode**: Under BB Mode, both sellers choose to borrow their required amount from the bank. Since third-party sellers (or SMBs) have traditionally obtained working capital loans from the bank, we set BB Mode as the benchmark scenario. (ii) **PP Mode**: Unlike BB Mode, under this scenario, both sellers obtain loan amount from the hosting platform. (iii) **BP/PB Mode**: Both BP and PB modes are hybrid modes in which one seller secures a loan from the bank and the competing seller obtains a loan from the online platform.

For the remainder of this study, we denote the sellers' lending modes using superscripts BB, PP, BP, and PB to indicate interest rates, market prices, and firms' profit and to determine equilibrium outcomes. Figure 1 illustrates the strategic interplay between the sellers, the online platform, and the bank.

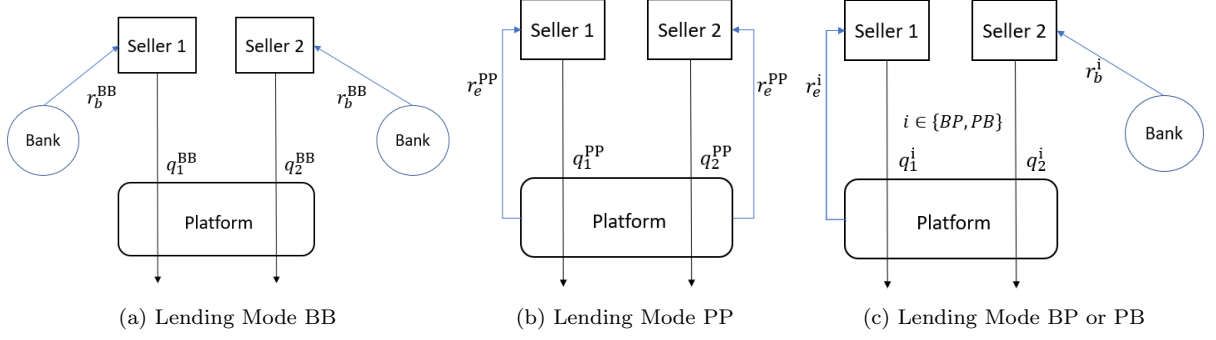


Figure 1: Lending Modes: BB, PP, and BP/PB

3.2. Sellers' Characteristics

The sellers are capital-constrained and obtain loans either from the bank or the online platform to operate their businesses at the desired level, i.e., fulfilling customer demand in the end market. The initial working capital of each seller is assumed to be zero (Tang et al., 2018). However, in Section 7.1, we extend our work by examining a scenario in which seller j has an initial working capital, $w_j(> 0)$, $j \in \{1, 2\}$, and examine the impact of w_j on sellers' strategic lending choices. Similar to Kouvelis and Zhao (2012) and Kouvelis and Zhao (2018), we also assume that the length of the credit period is equal to the selling horizon and the risk-free rate is zero. After securing the working capital loans, both sellers produce two substitutable products and sell them to end customers through the common online platform. The sellers engage in Cournot competition in the downstream customer market, and hence, set their selling quantities to maximize their profit.

Let indices i and j stand for lending mode structure $i \in \{BB, PP, BP, PB\}$ and seller j , respectively. If q_j^i be the sales quantities for seller $j \in \{1, 2\}$ under lending mode $i \in \{BB, PP, BP, PB\}$, then the inverse demand function (market price) for seller j is given by

$$p_j^i(q_j^i, q_k^i) = 1 - q_j^i - \gamma q_k^i, j \neq k, j, k \in \{1, 2\}, i \in \{BB, PP, BP, PB\}$$

where γ is the degree of product substitutability between the sellers. When γ approaches 0, the sellers' products become completely independent. If γ approaches 1, the products are perfect substitutes.

The sellers incur a unit production cost (raw materials, wages, etc.) $c > 0$ (Tang et al., 2018). Thus, under the lending mode i , the seller j borrows an amount cq_j^i from a lender (either the bank or the online platform). She repays the loan amount only after successfully fulfilling the customer demand via the online platform. We assume that each capital-constrained seller j is granted a sufficiently large borrowing amount by the lender so that she will be able to produce the required market output (Wang et al., 2019).

3.3. Bank

The bank is a financial institution that traditionally provides loans to third-party sellers. The loan interest rate charged by the bank from each seller is denoted by r_b^i under lending mode $i \in \{BB, BP, PB\}$. If a seller j borrows an amount cq_j^i from the bank, she repays an amount

$cq_j^i(1 + r_b^i)$ to the bank after fulfilling the customer demand. For the ease of our analyses, we assume that the bank is a risk-neutral profit maximizer and therefore, it decides the loan interest rate r_b^i that maximizes its profit (Zhen et al., 2020; Chang et al., 2022).

3.4. Platform

The platform (e.g., Amazon, JD.com, Tmall.com) hosts an online marketplace for third-party sellers and charges a referral fee for each unit of product sold by the sellers on the platform. Following e-commerce industry practices, we assume that the referral fee is exogenously given and is α fraction of a seller's revenue (Wang et al., 2019; Yan et al., 2020; Sun et al., 2022). Anecdotal data suggest that the referral fee α ranges from 8% – 45%. For example, in Table 2, we provide referral fees that Amazon charges from sellers for different product categories⁴. Following e-commerce industry practices, in this research, we assume that $\alpha < \frac{1}{2}$ so that sellers keep a major share of the revenues and have enough incentive to participate in the online marketplaces.

Product category	Referral fee
Clothing and Accessories	17%
Consumer Electronics	8%
Eyewear and Footwear	15%
Books, DVD, Music, Software, Video	15%

Table 2: Referral fees charged by Amazon for different product categories

Let r_e^i represent the loan interest rate charged by the platform to the sellers under lending mode $i \in \{PP, BP, PB\}$. Thus, if seller j borrows the total production cost cq_j^i from the platform, she repays $cq_j^i(1 + r_e^i)$ to him once she has fulfilled the customer demand. When the platform lends money to sellers, he obtains revenues from two distinct sources: referral fees and interest amount. The platform decides the loan interest rate r_e^i that maximizes his profit.

3.5. Sequence of Events

The sequence of events for the overall game is shown in Figure 2. In Section 7.2, we extend our work by analyzing a scenario where both lenders (i.e., the bank and the platform) simultaneously decide their loan interest rates before sellers choose their lending strategies.

3.6. The Optimization Problem

Under lending mode $i \in \{BB, PP, BP, PB\}$, given r_b^i and r_e^i , seller j decides the selling quantity that maximizes her profit. If seller j obtains working capital loan from player $l \in \{b, e\}$, the

⁴For more details on referral fees charged by Amazon, please visit: <https://sell.amazon.com/pricing#referral-fees>

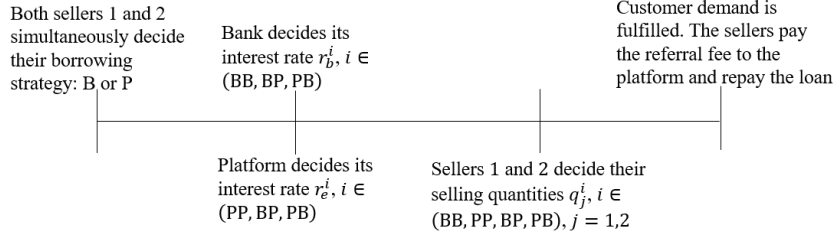


Figure 2: Timing of the Game

profit function of the seller under lending mode i is given by

$$\Pi_j^i(q_j^i, q_k^i, r_l^i) = \begin{cases} (1 - \alpha)p_j^i(q_j^i, q_k^i)q_j^i - cq_j^i(1 + r_l^i), j \neq k, j, k \in \{1, 2\}, l = b & \text{if } i = \text{BB} \\ (1 - \alpha)p_j^i(q_j^i, q_k^i)q_j^i - cq_j^i(1 + r_l^i), j \neq k, j, k \in \{1, 2\}, l = e & \text{if } i = \text{PP} \\ (1 - \alpha)p_j^i(q_j^i, q_k^i)q_j^i - cq_j^i(1 + r_l^i), j \neq k, j, k \in \{1, 2\}, l \in \{b, e\} & \text{if } i \in \{\text{BP}, \text{PB}\} \end{cases}.$$

Given the lending mode $i \in \{\text{BB}, \text{BP}, \text{PB}\}$, the bank maximizes its profit while deciding the interest rate r_b^i . The profit function of the bank under lending mode i is given by

$$\Pi_b^i(q_j^i, q_k^i, r_b^i) = \begin{cases} c \sum_{j=1}^2 q_j^i(1 + r_b^i) - c \sum_{j=1}^2 q_j^i = cr_b^i \sum_{j=1}^2 q_j^i & \text{if } i = \text{BB} \\ cq_1^i(1 + r_b^i) - cq_1^i = cq_1^i r_b^i & \text{if } i = \text{BP} \\ cq_2^i(1 + r_b^i) - cq_2^i = cq_2^i r_b^i & \text{if } i = \text{PB} \end{cases}.$$

Finally, given the lending mode $i \in \{\text{PP}, \text{BP}, \text{PB}\}$, the platform also maximizes his profit by determining the interest rate r_e^i . The platform's profit function under lending mode i is given by

$$\Pi_e^i(q_j^i, q_k^i, r_e^i) = \begin{cases} \alpha \sum_{j=1}^2 p_j^i(q_j^i, q_k^i)q_j^i & \text{if } i = \text{BB} \\ \alpha \sum_{j=1}^2 p_j^i(q_j^i, q_k^i)q_j^i + cr_e^i \sum_{j=1}^2 q_j^i & \text{if } i = \text{PP} \\ \alpha \sum_{j=1}^2 p_j^i(q_j^i, q_k^i)q_j^i + cq_2^i r_e^i & \text{if } i = \text{BP} \\ \alpha \sum_{j=1}^2 p_j^i(q_j^i, q_k^i)q_j^i + cq_1^i r_e^i & \text{if } i = \text{PB} \end{cases}.$$

We provide a summary of key model parameters and variables in Table 3.

4. Analysis

In this section, we analyze each lending mode and determine equilibrium outcomes. From the sequence of events (Figure 2), each seller chooses between two borrowing strategies: bank financing (B) or platform financing (P). The sellers' strategic form game is represented by Table 4. We refer to this strategic form game between the two sellers as the "lending subgame". In Section 5, we examine when each of the lending modes becomes a pure strategy Nash equilibrium for the lending subgame. Throughout this section, we assume that $c < \bar{c} \stackrel{\text{def}}{=} \min \left\{ \frac{(1-\alpha)(2(1-\alpha)+\gamma)}{2+\gamma(1+\alpha)}, \frac{(1-\alpha)((2-\gamma)(2+\gamma)(4+\gamma)-\alpha(16-4\gamma+\gamma^3))}{16+(1+\alpha)\gamma(4-\gamma(4+\gamma))} \right\}$; this assumption ensures the existence and uniqueness of each mode and its corresponding equilibrium outcomes. Next,

Description	
Parameters for Base Model	
$\alpha :$	Referral fee rate/consignment fee rate, $0 < \alpha < \frac{1}{2}$
$c :$	Unit production cost, $c > 0$
$\gamma :$	Degree of substitution between two sellers' products, $0 < \gamma < 1$
Parameters for Extensions	
$w_j :$	Initial working capital of seller j , $j \in \{1, 2\}$
$\theta :$	Intensity of price competition, $0 < \theta < 1$
$\lambda :$	Probability with which each seller is unable to repay the loan, $0 < \lambda < 1$
$G :$	Unit cost of goodwill loss for the platform in case a seller unable to repay the loan, $G > 0$
$\beta :$	Unit collateral value of sellers' asset expressed as a percentage of the total loan, $0 < \beta < 1$
Lending Mode	
BB :	Index for the scenario in which both sellers choose bank financing
PP :	Index for the scenario in which both sellers choose platform financing
BP, PB :	Index for the scenario in which both one seller chooses bank financing and the competing seller chooses platform financing
Subscripts	
$j :$	1 for the seller 1, 2 for the seller 2
$l :$	b for the bank, e for the online platform
Decision Variables	
$q_j^i :$	Market demand of seller j , $j \in \{1, 2\}$ for lending mode i , $i \in \{BB, PP, BP, PB\}$
$p_j^i :$	Product price of seller j , $j \in \{1, 2\}$ for lending mode i , $i \in \{BB, PP, BP, PB\}$
$r_b^i :$	Lending rate charged by the bank for lending mode i , $i \in \{BB, BP, PB\}$
$r_e^i :$	Lending rate charged by the platform for lending mode i , $i \in \{PP, BP, PB\}$
Profit Functions	
$\Pi_j^i :$	Profit of seller j , $j \in \{1, 2\}$ for lending mode i , $i \in \{BB, PP, BP, PB\}$
$\Pi_e^i :$	Profit of the platform for lending mode i , $i \in \{BB, PP, BP, PB\}$
$\Pi_b^i :$	Profit of the bank for lending mode i , $i \in \{BB, BP, PB\}$

Table 3: Key Model Parameters and Variables

we determine equilibrium outcomes under each lending mode. For detailed proofs of lemmas, readers are referred to Appendix B1 of the Online Supplement.

		<i>Seller 2</i>	
		Bank Financing	Platform Financing
<i>Seller 1</i>	Bank Financing	(Π_1^{BB}, Π_2^{BB})	(Π_1^{BP}, Π_2^{BP})
	Platform Financing	(Π_1^{PB}, Π_2^{PB})	(Π_1^{PP}, Π_2^{PP})

Table 4: Strategic Form Game Representation

4.1. Lending Mode BB

Under this setting, the bank first decides the interest rate, r_b^{BB} , for both sellers. Next, the sellers simultaneously determine their selling quantities $q_j^{BB}, j \in \{1, 2\}$. As the sellers are symmetric, at equilibrium, we later find that $q_1^{BB} = q_2^{BB}$. The profit functions for the sellers, platform, and bank are as follows:

$$\Pi_j^i(q_j^i, q_k^i, r_b^i) = (1 - \alpha)p_j^i(q_j^i, q_k^i)q_j^i - cq_j^i(1 + r_b^i), j \neq k, j, k \in \{1, 2\}, i = BB,$$

$$\Pi_e^i(q_1^i, q_2^i, r_b^i) = \alpha \sum_{j=1}^2 p_j^i(q_1^i, q_2^i)q_j^i, i = BB,$$

$$\Pi_b^i(q_1^i, q_2^i, r_b^i) = c \sum_{j=1}^2 q_j^i(1 + r_b^i) - c \sum_{j=1}^2 q_j^i = cr_b^i \sum_{j=1}^2 q_j^i, i = BB.$$

We solve this two-stage subgame by backward induction. In the second stage, for any given bank interest rate, r_b^{BB} , we first characterize the sellers' equilibrium selling quantities q_1^{BB} and q_2^{BB} that would maximize $\Pi_1^{BB}(q_1^{BB}, q_2^{BB}, r_b^{BB})$ and $\Pi_2^{BB}(q_1^{BB}, q_2^{BB}, r_b^{BB})$, respectively. In the first stage, we determine the interest rate, r_b^{BB} for the bank while maximizing its profit $\Pi_b^{BB}(q_1^{BB}, q_2^{BB}, r_b^{BB})$. In Lemma 1, we characterize the equilibrium outcomes under BB mode.

Lemma 1. *There exists a unique equilibrium for the lending mode BB. The equilibrium lending rate, sales quantities, and market prices are given by:*

$$\begin{aligned} r_b^{BB} &= \frac{1 - \alpha - c}{2c}, \\ q_j^{BB} &= \frac{1 - \alpha - c}{2(1 - \alpha)(2 + \gamma)}, j \in \{1, 2\}, \\ p_j^{BB} &= \frac{(1 - \alpha)(3 + \gamma) + c(1 + \gamma)}{2(1 - \alpha)(2 + \gamma)}, j \in \{1, 2\}. \end{aligned}$$

The corresponding equilibrium profits of sellers, platform, and bank are given by: $\Pi_j^{BB} = \frac{(1 - \alpha - c)^2}{4(1 - \alpha)(2 + \gamma)^2}, j \in \{1, 2\}$, $\Pi_e^{BB} = \frac{\alpha(1 - \alpha - c)((1 - \alpha)(3 + \gamma) + c(1 + \gamma))}{2(1 - \alpha)^2(2 + \gamma)^2}$, and $\Pi_b^{BB} = \frac{(1 - \alpha - c)^2}{2(1 - \alpha)(2 + \gamma)}$, respectively.

4.2. Lending Mode PP

In this setting, first, the platform decides the interest rate, r_e^{PP} , for sellers 1 and 2. Next, the competing sellers simultaneously determine their sales quantities $q_j^{PP}, j \in \{1, 2\}$. The profit

functions for the sellers and platform are given by:

$$\Pi_j^i(q_j^i, q_k^i, r_e^i) = (1 - \alpha)p_j^i(q_j^i, q_k^i)q_j^i - cq_j^i(1 + r_e^i), j \neq k, j, k \in \{1, 2\}, i = \text{PP},$$

$$\Pi_e^i(q_j^i, q_k^i, r_e^i) = \alpha \sum_{j=1}^2 p_j^i(q_j^i, q_k^i)q_j^i + c \sum_{j=1}^2 q_j^i(1 + r_e^i) - c \sum_{j=1}^2 q_j^i = \alpha \sum_{j=1}^2 p_j^i(q_j^i, q_k^i)q_j^i + c \sum_{j=1}^2 q_j^i r_e^i, i = \text{PP}.$$

We again solve this subgame by backward induction. In the second stage, for any given platform interest rate, r_e^{PP} , we first determine the sellers' equilibrium sales quantities q_1^{PP} and q_2^{PP} that maximize $\Pi_1^{\text{PP}}(q_1^{\text{PP}}, q_2^{\text{PP}}, r_e^{\text{PP}})$ and $\Pi_2^{\text{PP}}(q_1^{\text{PP}}, q_2^{\text{PP}}, r_e^{\text{PP}})$, respectively. In the first stage, we solve the platform's profit maximization problem to determine the interest rate, r_e^{PP} . The equilibrium results in PP mode are shown in the following lemma.

Lemma 2. *There exists a unique equilibrium for lending mode PP. The equilibrium lending rate, sales quantities, and market prices are given by:*

$$\begin{aligned} r_e^{\text{PP}} &= \frac{(1 - \alpha)(2(1 - \alpha) + \gamma) - c(2 + \gamma(1 + \alpha))}{2c(2 - \alpha + \gamma)}, \\ q_j^{\text{PP}} &= \frac{1 - c}{2(2 - \alpha + \gamma)}, j \in \{1, 2\}, \\ p_j^{\text{PP}} &= \frac{2(1 - \alpha) + (1 + c)(1 + \gamma)}{2(2 - \alpha + \gamma)}, j \in \{1, 2\}. \end{aligned}$$

The corresponding equilibrium profits of the sellers and the platform are given by: $\Pi_j^{\text{PP}} = \frac{(1 - \alpha)(1 - c)^2}{4(2 - \alpha + \gamma)^2}, j \in \{1, 2\}$, $\Pi_e^{\text{PP}} = \frac{(1 - c)^2}{2(2 - \alpha + \gamma)}$, respectively.

4.3. Lending Mode BP/PB

In this setting, let seller j ($j = 1$ for BP and $j = 2$ for PB) obtains the working capital loan from the bank, whereas the competing seller $k, k \neq j$ ($k = 2$ for BP and $k = 1$ for PB), opts for platform financing. Given a lending mode $i \in \{\text{BP}, \text{PB}\}$, the bank and the platform first simultaneously announce the interest rate under bank financing (r_b^i) and platform financing (r_e^i), respectively. Then, the sellers j and k decide the optimal sales quantities q_j^i and q_k^i , respectively. Under lending mode $i \in \{\text{BP}, \text{PB}\}$, the profit functions of both the sellers j and k ($j, k \in \{1, 2\}, j \neq k$), platform, and bank are as follows:

$$\Pi_j^i(q_j^i, q_k^i, r_b^i) = (1 - \alpha)p_j^i(q_j^i, q_k^i)q_j^i - cq_j^i(1 + r_b^i),$$

$$\Pi_k^i(q_j^i, q_k^i, r_e^i) = (1 - \alpha)p_k^i(q_j^i, q_k^i)q_k^i - cq_k^i(1 + r_e^i),$$

$$\Pi_e^i(q_j^i, q_k^i, r_e^i) = \alpha \sum_{l=1}^2 p_l^i(q_j^i, q_k^i)q_l^i + cq_k^i r_e^i,$$

$$\Pi_b^i(q_j^i, q_k^i, r_b^i) = cq_j^i(1 + r_b^i) - cq_j^i = cq_j^i r_b^i.$$

We again solve the subgame by backward induction. For any given bank interest rate r_b^i and platform interest rate r_e^i , we first solve sellers j and k equilibrium quantities q_j^i and q_k^i while maximizing $\Pi_j^i(q_j^i, q_k^i, r_b^i)$ and $\Pi_k^i(q_j^i, q_k^i, r_e^i)$, respectively. Finally, we determine the optimal

interest rates r_b^i and r_e^i while maximizing $\Pi_b^i(q_j^i, q_k^i, r_b^i)$ and $\Pi_e^i(q_j^i, q_k^i, r_e^i)$, respectively. Next, in Lemma 3, we characterize the equilibrium outcomes for lending mode BP/PB.

Lemma 3. *There exists a unique equilibrium for lending mode $i \in \{BP, PB\}$. The equilibrium lending rates, sales quantities, and market prices are given by:*

$$\begin{aligned} r_b^i &= \frac{(4 - \gamma^2)(4(2 - \alpha)(1 - c - \alpha) - 2(1 - c)(1 - \alpha)\gamma + (1 - c - \alpha(1 + c))\gamma^2)}{c(32(2 - \alpha) - 4(5 + \alpha)\gamma^2 + (1 + \alpha)\gamma^4)}, \\ r_e^i &= \frac{(2 - \gamma)((1 - \alpha)((2 - \gamma)(2 + \gamma)(4 + \gamma) - \alpha(16 - 4\gamma + \gamma^3)) - c(16 + (1 + \alpha)\gamma(4 - \gamma(4 + \gamma))))}{c(32(2 - \alpha) - 4(5 + \alpha)\gamma^2 + (1 + \alpha)\gamma^4)}, \\ q_j^i &= \frac{2(4(2 - \alpha)(1 - \alpha - c) - 2\gamma(1 - \alpha)(1 - c) - \gamma^2(1 - c - \alpha(1 + c)))}{(1 - \alpha)(32(2 - \alpha) - 4(5 + \alpha)\gamma^2 + (1 + \alpha)\gamma^4)}, \\ q_k^i &= \frac{(1 - \alpha)(16 - 2\gamma(2 + \gamma) - \alpha\gamma(8 - \gamma^2)) - 2c(8(1 - \alpha) - 2\gamma - (1 - \alpha)\gamma^2)}{(1 - \alpha)(32(2 - \alpha) - 4(5 + \alpha)\gamma^2 + (1 + \alpha)\gamma^4)}, \\ p_j^i &= \frac{2c(1 + \gamma)(8 - 4\alpha - 2(1 + \alpha)\gamma - (1 - \alpha)\gamma^2) - (1 - \alpha)(6 - \gamma^2)(4\alpha - (2 - \gamma)(4 + \gamma))}{(1 - \alpha)(32(2 - \alpha) - 4(5 + \alpha)\gamma^2 + (1 + \alpha)\gamma^4)}, \\ p_k^i &= \frac{2c(1 + \gamma)((2 + \gamma)(4 + \gamma) - \alpha(8 - (4 - \gamma)\gamma))}{(1 - \alpha)(32(2 - \alpha) - 4(5 + \alpha)\gamma^2 + (1 + \alpha)\gamma^4)} \\ &\quad + \frac{(1 - \alpha)((2 - \gamma)(4 + \gamma)(6 - \gamma^2) - \alpha(32 - \gamma(16 - \gamma(4 + (1 - \gamma)\gamma))))}{(1 - \alpha)(32(2 - \alpha) - 4(5 + \alpha)\gamma^2 + (1 + \alpha)\gamma^4)}. \end{aligned}$$

Under any lending mode $i \in \{BP, PB\}$, the equilibrium profits of sellers j and k ($j, k \in \{1, 2\}, j \neq k$), and bank are given by: $\Pi_j^i = \frac{4(4(2 - \alpha)(1 - \alpha - c) - 2\gamma(1 - \alpha)(1 - c) - \gamma^2(1 - c - \alpha(1 + c)))^2}{(1 - \alpha)(32(2 - \alpha) - 4(5 + \alpha)\gamma^2 + (1 + \alpha)\gamma^4)^2}$, $\Pi_k^i = \frac{((1 - \alpha)(16 - 2\gamma(2 + \gamma) - \alpha\gamma(8 - \gamma^2)) - 2c(8(1 - \alpha) - 2\gamma - (1 - \alpha)\gamma^2))^2}{(1 - \alpha)(32(2 - \alpha) - 4(5 + \alpha)\gamma^2 + (1 + \alpha)\gamma^4)^2}$, $\Pi_b^i = \frac{2(4 - \gamma^2)(4(2 - \alpha)(1 - \alpha - c) - 2\gamma(1 - \alpha)(1 - c) + (1 - \alpha - c(1 + \alpha))\gamma^2)^2}{(1 - \alpha)(32(2 - \alpha) - 4(5 + \alpha)\gamma^2 + (1 + \alpha)\gamma^4)^2}$, respectively. The equilibrium profit of platform can be obtained by plugging in the equilibrium values of r_e^i , q_l^i , and $p_l^i, l \in \{1, 2\}$ into $\Pi_e^i = \alpha \sum_{l=1}^2 p_l^i(q_j^i, q_k^i)q_l^i + cq_k^i r_e^i$, $i \in \{BP, PB\}$ ⁵.

5. Results

In this section, we analyze the equilibrium outcomes for the four lending modes and provide managerial insights. We present all the proofs of this section in Appendix A of the Online Supplement.

5.1. Interest Rate

Proposition 1 shows how the bank and platform interest rates change when one of the competing sellers deviates from BB (or PP).

Proposition 1. *The following relationships hold for the equilibrium bank and platform interest rates:*

- (a) $r_b^{BB} > r_b^i, i \in \{BP, PB\}$.
- (b) $r_e^{PP} > r_e^i, i \in \{BP, PB\}$, if $c < c_1 \stackrel{def}{=} \frac{(1 - \alpha)((2 - \gamma)(2 + \gamma)^2(4 + \gamma) + 4\alpha^2(12 - \gamma^2) - \alpha(2 + \gamma)(40 - \gamma(8 + (4 - \gamma)\gamma)))}{(2 - \gamma)(2 + \gamma)^2(4 + \gamma) - 4\alpha(4 + \gamma^2 + \gamma^3) - \alpha^2(16 - 24\gamma - 2\gamma^3 - \gamma^4)}$.

⁵The value of $\Pi_e^i, i \in \{BP, PB\}$ is complex and it is shown in the Appendix B1 of the Online Supplement).

Otherwise, $r_e^i > r_e^{PP}$, if $c \geq c_1$.

(c) $r_b^{BB} > r_e^{PP}$.

Proposition 1(a) and 1(b) exhibit the impact of lending market competition on bank (or platform) interest rate, i.e., how the bank (or platform) adjusts the interest rate when the lending market becomes competitive. Proposition 1(a) states that when only one of the competing sellers changes her financing mode from bank financing to platform financing, the bank interest rate reduces. The reason behind this is provided below. When both sellers obtain financing from the bank, the bank has a monopoly in the lending market, thereby setting an interest rate that maximizes its profit. However, a deviation by any seller from BB to BP/PB intensifies the lending market competition. As a result, the bank reduces its interest rate when one of the competing sellers shifts from bank financing to platform financing. It may also be noted that r_b^{BB} is independent of the degree of product substitution γ , i.e., the intensity of product market competition does not affect r_b^{BB} (for more details, see Lemma 1). This is because the bank is not part of the vertical product supply chain consisting of the sellers and the platform. In the absence of product market competition, the profit-maximizing bank sets a very high interest rate under BB mode as compared to BP or PB mode.

In contrast, in Proposition 1(b), we find a threshold policy on the platform interest rate when one of the competing sellers deviates from PP mode to a hybrid (BP or PB) mode. The platform interest rate under PP mode is higher than that of under BP/PB mode when the unit production cost is low. The reasons can be explained as follows. Under PP mode, the platform is the only lender to both the sellers. Under BP or PB mode, the lending market competition intensifies and the platform interest rate tends to go down. Due to a low production cost c , the bank reduces its interest rate $r_b^i, i \in \{BP, PB\}$. The platform also reduces its interest rate $r_e^i, i \in \{BP, PB\}$ due to the lending market competition effect. Hence, we can conclude that $r_e^{PP} > r_e^i, i \in \{BP, PB\}$, when c is low. On the other hand, when one of the competing sellers deviates from PP to a hybrid mode, the platform interest rate may go up if the unit production cost c is high. This is because, unlike PP mode, both the platform and the bank become lenders under BP/PB mode. Due to a high cost c , the sellers reduce their sales quantities. To compensate for that, the bank that is not part of the product supply chain increases its interest rate $r_b^i, i \in \{BP, PB\}$. Finding an opportunity, the platform (also a competitor to the bank in the lending market) also charges a high interest rate. Thus, the cost effect (due to a high production cost c) outweighs the lending market competition effect. However, under PP mode, the platform is the only lender and he sets a relatively low interest rate r_e^{PP} as compared to r_b^i to encourage sellers to sell more quantities, thereby obtaining a larger profit from referral fee and the interest payment from loans. Hence, when c is high, we find that $r_e^{PP} < r_e^i, i \in \{BP, PB\}$.

Proposition 1(c) characterizes the interest rate under platform financing and bank financing when both sellers choose the same financing mode. We find that the bank charges a higher interest rate than the platform, i.e., $r_b^{BB} > r_e^{PP}$. This is because the bank is not a part of the product supply chain, whereas the platform is a downstream supply chain partner. Moreover, the bank has only one source of income in bank financing: interest fee, and thus, it sets a high interest rate r_b^{BB} . In contrast, the platform has two sources of revenue under platform financing: interest fee and referral fee. The platform strategically lowers the interest rate under

platform financing to induce higher demand, increasing the total revenue. Hence, we find that $r_b^{BB} > r_e^{PP}$.

Existing literature suggests that the bank can charge a higher interest rate as compared to other lenders in the lending market. In a monopolistic model setup, Wang et al. (2019) report that the interest rate in bank financing is always higher than that in platform financing. Similarly, Zhen et al. (2020) show that in a dual channel setting, the bank interest rate can be more than the platform interest rate when the referral fee or channel competition is high. In a duopolistic market with two competing sellers, we find a similar insight (see Proposition 1(c)). Furthermore, our study complements the existing literature on supply chain finance by showing the impact of lending market competition on the bank and platform interest rates.

5.2. Market Prices and Selling Quantities

We now focus on comparing market prices and selling quantities under different lending modes. Proposition 2 shows how the sellers' market prices and selling quantities change when one of them deviates from BB (or PP).

Proposition 2. *When one of the competing sellers deviates from a symmetric mode (BB or PP) to a hybrid mode (BP or PB), we get:*

- (a) $p_1^{BB} > p_1^{PB}$ and $p_2^{BB} > p_2^{PB}$, $q_1^{BB} < q_1^{PB}$ and $q_2^{BB} < q_2^{PB}$.
- (b) $p_1^{PP} > p_1^{BP}$ and $p_2^{PP} > p_2^{PB}$, if $c < c_2 \stackrel{\text{def}}{=} \frac{(1-\alpha)((2-\gamma)\gamma(1+\gamma)(2+\gamma)(4+\gamma)-\alpha(2+\gamma)(4+\gamma)(4-(2-\gamma)(1-\gamma)\gamma)+2\alpha^2(8+8\gamma^2-\gamma^4))}{(1+\gamma)(4\alpha(4-\gamma)(1-\gamma)(2+\gamma)+(2-\gamma)\gamma(2+\gamma)(4+\gamma)-\alpha^2(16-\gamma(8-8\gamma+\gamma^3)))}$. Otherwise, $p_1^{BP} > p_1^{PP}$ and $p_2^{PB} > p_2^{PP}$, if $c \geq c_2$.
- (c) $q_1^{PP} < q_1^{BP}$ and $q_2^{PP} < q_2^{PB}$, if $c < c_3 \stackrel{\text{def}}{=} \frac{(1-\alpha)(16\alpha^2+(2-\gamma)\gamma(2+\gamma)(4+\gamma)-\alpha(32+\gamma(8-8\gamma+\gamma^3)))}{(2-\gamma)\gamma(2+\gamma)(4+\gamma)+4\alpha(2+\gamma)(4-\gamma-\gamma^2)-\alpha^2(16+8\gamma-\gamma^4)}$. Otherwise, $q_1^{BP} < q_1^{PP}$ and $q_2^{PB} < q_2^{PP}$, if $c \geq c_3$.
- (d) $p_j^{BB} > p_j^{PP}$ and $q_j^{BB} < q_j^{PP}$, $j \in \{1, 2\}$.

Proposition 2(a) states that when one of the competing sellers deviates from BB mode to a hybrid mode (i.e., seller 1 deviating to PB mode or seller 2 deviating to PB mode), she decreases the product price and increases the sales quantities at the end market. This is because a deviation by any seller will intensify lending market competition, leading to a reduction in the bank and platform interest rates (see Proposition 1(a)). As a result, we find reduced market prices and enhanced selling quantities for both sellers. Next, in Proposition 2(b) (and Proposition 2(c)), we show a threshold policy on sellers' market prices (and selling quantities) when one of the competing sellers deviates from PP mode to a hybrid mode. If the unit production cost is low, the deviating seller sets a lower market price and a higher sales quantity. The reason behind this is as follows. Under any hybrid mode (BP or PB), when the production cost is low, the platform reduces his interest rate (see Proposition 1(b)). Due to the lending market competition effect, the bank interest rate also goes down, leading to a reduced market price for the deviating seller under BP/PB mode. In contrast, if the unit production cost is high, the deviating seller sets a higher market price and a lower sales quantity. This is because, due to a high production cost, the platform interest rate goes up (see Proposition 1(b)). In response, the bank sets a higher interest rate as it is not part of the product supply chain. As a result, we find elevated market prices and reduced selling quantities for both sellers. Thus, when a seller switches from platform financing to bank financing and the competing seller

continues to opt for platform financing, the deviating seller's market price increases and selling quantity decreases. From Proposition 2(d), we find that the sellers set higher market prices and lower selling quantities under the BB mode compared to the PP mode. This is because the bank charges a higher interest rate than the platform.

Our findings contribute to the existing literature on online supply chain finance (Yan et al., 2020; Rath et al., 2021). According to Rath et al. (2021), a monopoly seller's market price in bank financing can be more than that in platform financing. In a duopoly market setup, Shen et al. (2020) prove that the market price under bank financing is more than that under hybrid financing mode and pure trade credit financing. In a dual channel setting, Yan et al. (2020) and Zhen et al. (2020) show that the retail price could be higher under bank financing than platform financing. In contrast, in a supply chain with two competing sellers, we show that, based on the market conditions, a seller may set a lower/higher market price (higher/lower selling quantities) under a hybrid financing mode compared to the PP mode.

5.3. Sellers' Profits

Next, we compare sellers' profits under different lending modes. Especially in Proposition 3, we show how the sellers' profits change if one of them deviates from a symmetric mode (BB or PP) to a hybrid mode.

Proposition 3. *When one of the competing sellers deviates from a symmetric mode (BB or PP) to a hybrid mode (BP or PB), we get:*

- (a) $\Pi_1^{BB} < \Pi_1^{PB}$ and $\Pi_2^{BB} < \Pi_2^{BP}$.
- (b) $\Pi_1^{PP} < \Pi_1^{BP}$ and $\Pi_2^{PP} < \Pi_2^{PB}$, if $c < c_3$. Otherwise, $\Pi_1^{BP} < \Pi_1^{PP}$ and $\Pi_2^{PB} < \Pi_2^{PP}$, if $c \geq c_3$.
- (c) $\Pi_j^{BB} < \Pi_j^{PP}$, $j \in \{1, 2\}$.

Proposition 3(a) shows that a seller always increases her profit when switching from BB mode to a hybrid mode (i.e., seller 1 deviating to PB mode or seller 2 deviating to BP mode). This is because the deviating seller charges less price and sells more quantities in the end market. However, the increase in selling quantities is sufficient to counterbalance the decrease in market price, thereby leading to a larger profit under a hybrid mode as compared to the BB mode. Proposition 3(b) indicates a threshold policy on a seller's profit while her deviating from the PP mode to a hybrid mode. The reason can be explained as follows. Under any hybrid mode, when the production cost is low, both the bank and the platform reduce their interest rates. As a result, the deviating seller's selling quantities go up and her profit also rises. On the other hand, when the production cost is high, the deviating seller reduces her selling quantities and thus decreases her profit. The seller earns more revenue and profit in PP than in PB when the production cost is high. In Proposition 3(c), we show that when sellers have the same financing mode (i.e., BB or PP mode), their profits are always higher under the PP mode than the BB mode. The reason is that the sellers always sell more quantities under the PP mode compared to the BB mode, leading to higher profits.

Previous literature has also analyzed a seller's profit under bank financing and platform financing (Wang et al., 2019; Gong et al., 2020; Zhen et al., 2020; Rath et al., 2021). Wang et al. (2019) find that an online seller can obtain higher profit under platform financing when the referral fee is high. Similarly, Gong et al. (2020) and Zhen et al. (2020) show that platform

financing can increase an upstream seller's profit. Recently, Rath et al. (2021) demonstrate that an online seller's profit can be better off in bank financing in the presence of the seller's default risk. In contrast, our study concludes that both sellers are always better off under platform financing (PP mode) than bank financing (BB mode). However, in the case of a hybrid lending mode (BP mode or PB mode), based on the market conditions, a seller may obtain a higher profit under a hybrid lending mode as compared to the PP mode.

The theoretical findings under Proposition 3 are also corroborated by various anecdotal evidence. Amazon Lending had around 20,000 sellers in 2017 under its funding umbrella. **Over the years**, Amazon Lending has expanded significantly, and in 2022 it served more than 1 million customers and sellers. Currently, Amazon has around 25,000 subcategories, which means that Amazon Lending is gaining importance. This data highlights the fact that competition has increased both in the lending market as well as in the product market. Many of the competing sellers are shifting to Amazon Lending under product market competition. This is in line with the result derived in Proposition 3(a).

Furthermore, Amazon Lending provides very high loan amounts, \$750,000 to sellers in quick time⁶. Therefore, this is an exciting proposition for sellers that require financing for high loan amounts. This corroborates the usefulness of platform financing for high loan amounts and is in line with the findings derived in Proposition 3(b) and (c).

5.4. Sellers' Lending Mode Selection Game

Having characterized the sellers' profits under each lending mode, we now investigate when each of the lending modes becomes Nash equilibrium (for more details, see Table 4). The next proposition introduces the result of the lending subgame represented in Table 4.

Proposition 4. *The lending mode BB is never a Nash equilibrium for the lending subgame.*

The lending mode BB does not sustain in equilibrium. This is because Proposition 3 shows that both sellers will always have incentives to deviate from bank financing to platform financing (from BB to one of the hybrid modes: BP or PB). Next, in Theorem 1, we characterize the Nash equilibrium of the lending subgame.

Theorem 1. *The lending subgame can be characterized as follows:*

- (a) *If $c < c_3$, then both BP and PB are equilibria⁷.*
- (b) *If $c \geq c_3$, then PP is the unique equilibrium.*

Theorem 1 indicates that apart from BB, all other lending modes may arise as Nash equilibria. First, both hybrid modes (BP and PB) will arise as Nash equilibria if $c < c_3$. In equilibrium, if one of the competing sellers chooses bank financing, the other seller should always choose platform financing. From the discussion of Proposition 3(a), we know that the seller who opted for platform financing will never deviate from the hybrid mode to BB mode.

⁶<https://www.techtarget.com/searchaws/feature/How-Amazon-became-a-force-in-SMB-lending>

⁷There also exists a unique, symmetric, mixed-strategy Nash equilibrium, where each seller chooses the BCF with a probability of $\frac{\pi_1^{BP} - \pi_1^{PP}}{\pi_1^{BP} - \pi_1^{PP} + \pi_1^{PB} - \pi_1^{BB}}$ and the PCF with a probability of $\frac{\pi_1^{PB} - \pi_1^{BB}}{\pi_1^{BP} - \pi_1^{PP} + \pi_1^{PB} - \pi_1^{BB}}$. For detailed analyses on the mixed-strategy Nash equilibrium, readers are referred to the proof of Theorem 1 in Appendix A of the Online Supplement.

Similarly, the seller who opted for bank financing will not deviate from the hybrid mode to PP mode as long as $c < c_3$ (see Proposition 3(b)). Thus, when $c < c_3$, both BP and PB may arise as Nash equilibrium. Thus, the *game of chicken*⁸ scenario arises when production cost is low. In contrast, PP is the unique Nash equilibrium when $c \geq c_3$. It can be shown that whenever one of the competing sellers chooses not to deviate from PP, the other prefers not to deviate either. From the discussion after Proposition 3(b), we know that when the production cost is high, none of the sellers has the incentive to deviate from PP mode to a hybrid mode. Hence, PP is the Nash equilibrium strategy when the production cost is high.

In the absence of seller competition and lending market competition, we find that a monopoly seller always prefers platform financing over bank financing. Thus, one can predict that, in a competitive market, both sellers should opt for platform financing. On the contrary, we prove that both sellers are not always better off with platform financing. One of them may choose bank financing, while the other seller can continue with platform financing if the unit production cost is low. This is because the interaction between lending market competition and seller competition encourages the bank and the platform to reduce their interest rate. As a result, the deviating seller may obtain a higher profit under any hybrid lending mode.

The above results contribute to the extant knowledge in SCF, where researchers have analyzed PCF in a non-competitive set-up and have established production cost as an important parameter that drives the optimal financing choice of the seller. Zhen et al. (2020) study a capital-constrained manufacturer selling through dual-channel and find that PCF becomes the optimal financing choice as the revenue sharing rate or unit production cost increases. Rath et al. (2021) find that when the production cost is low and the cost of goodwill loss for the platform is high, the seller opts for bank financing. Whereas, under high production costs and low values of the cost of goodwill loss, the financing choice of the seller shifts to PCF. Our results extend this line of research by providing equilibrium financing choices for competing sellers under lending market competition marked by PCF and BCF. With PCF gaining popularity, the production cost-based thresholds benefit capital-constrained sellers in their search for low-cost financing modes.

5.5. Platform Profitability

Next, we compare the platform's profit across different lending modes.

Proposition 5. *Comparing the equilibrium platform profits for different lending modes, we obtain: $\Pi_e^{PP} > \Pi_e^i > \Pi_e^{BB}$, $i \in \{BP, PB\}$.*

From Proposition 5, we find that the platform always prefers PP mode as compared to other lending modes. The reason for this is as follows. When the platform provides working capital loans, he has two sources of revenue: referral fees and interest payment; otherwise, he obtains revenues only from referral fees. Under PP mode, the platform obtains revenues associated with referral fees and interest payments from both sellers. However, under BB, he only gets referral fee revenues. Under any hybrid lending mode (BP or PB), he obtains revenues related

⁸For more details about the *game of chicken*, the readers are referred to Fudenberg and Tirole (1991).

to interest payments only from one seller along with the referral fees. Hence, $\Pi_e^{PP} > \Pi_e^i > \Pi_e^{BB}$, $i \in \{BP, PB\}$.

Previous literature has shown that a platform can be better off with platform financing (Wang et al., 2019; Yan et al., 2020; Rath et al., 2021). Wang et al. (2019) find that a platform can obtain higher profit under the platform financing strategy. Yan et al. (2020) suggest that a platform is always better off with platform financing in a dual-channel supply chain. Rath et al. (2021) show that the platform's profit is always higher under platform financing, even in the presence of the seller's default risk. From the above analysis, we find that our insights are robust, i.e., the platform always prefers platform financing even in the presence of downstream product market competition.

6. Numerical Analyses

In this section, we conduct numerical experiments and discuss the implications on two competing sellers' strategic financing choices. We first study the impact of referral fee rate and degree of product substitution on the optimal financing choices of the two capital-constrained sellers when both bank financing and platform financing modes are available⁹. Next, due to the complexities of the expressions on consumer surplus, we numerically examine the impact of the problem parameters on consumer surplus. We use the following parametric values for presenting important insights: $\alpha = 0.15$, $\gamma = 0.5$, and $c = 0.3$. This numerical setup follows all model assumptions. It also derives support from existing literature on supply chain finance (Wang et al., 2019; Yan et al., 2020). We have run the model for various other parametric values and obtained similar results.

6.1. The impact of referral fee and degree of substitution

From the theoretical analysis, we have derived the sellers' equilibrium financing strategy for different unit production costs (see Theorem 1). However, due to computational complexities, we cannot find how two crucial parameters related to our study (i.e., referral fee rate and the degree of substitution) affect the equilibrium strategy of the sellers. The referral fee rate is typically preset by the platform as per the product category and it impacts sellers' strategic financing choices. Owing to the product market competition effect, the degree of substitution can also affect the sellers' profits and the Nash equilibrium strategy. Thus, it is important to analyze the effect of referral fees and the degree of substitution on the sellers' financing choices.

From Figure 3, we find that PP is the equilibrium lending mode when the referral fee rate is high. Under a high referral fee rate, the platform charges less interest rate under PP mode to induce higher demand. As a result, his referral fee revenue and profit go up. We call this the referral fee effect. Similarly, when the referral fee is low, a hybrid lending mode: PB or BP mode (PP mode), may arise as the Nash equilibrium under a high (low) degree of substitution. When the degree of substitution is high, the competition between the sellers becomes high,

⁹Throughout the numerical analyses, we have only considered the feasible business scenarios where the demand, selling price, interest rate, and profit of the players are non-negative

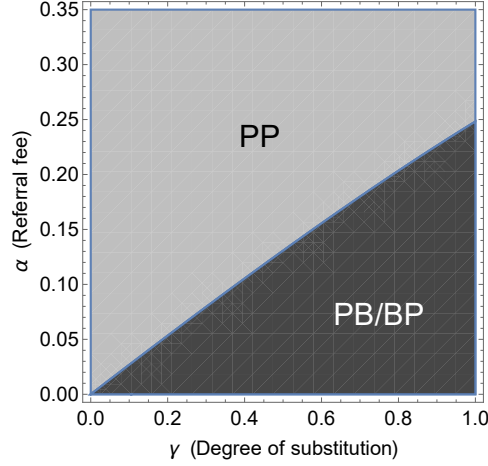


Figure 3: Sellers' financing choices based on α vs. γ . Parameter value: $c = 0.3$

reducing the market prices of both sellers. Due to this product market competition effect, the platform's referral fee revenue reduces, and the platform tries to compensate by charging a higher interest rate under the PP mode as compared to the hybrid mode. Hence, the hybrid modes become the Nash equilibria. However, when the degree of substitution is low, the product market competition effect is low, leading to a lower interest rate under PP mode. Therefore, PP emerges as the unique Nash equilibrium. We summarise the findings in Table 5.

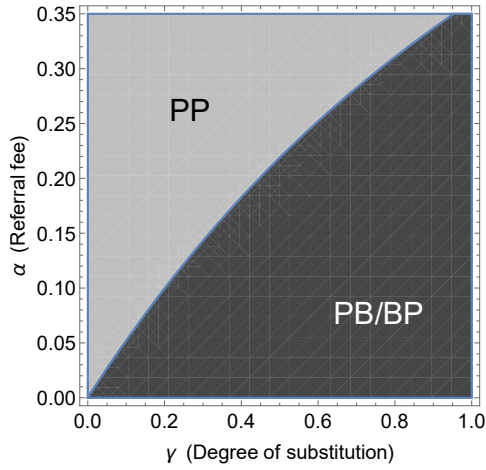
		<i>Degree of substitution (γ)</i>	
		Low	High
<i>Referral fee rate (α)</i>	Low	PP	BP/PB
	High	PP	PP

Table 5: Equilibrium financing choices for sellers based on product categories

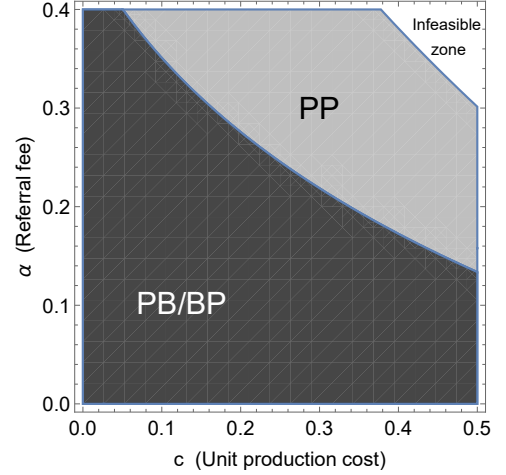
6.2. Consumer Surplus

In this section, we study the impact of referral fees, degree of product substitution, and unit cost of production on consumer surplus under different lending modes. We refer readers to Appendix B2 (see the Online Supplement) for detailed analyses on consumer surplus. From our analyses, we find that when the referral fee is high, PP mode generates a higher consumer surplus (see Figure 4(a) and Figure 4(b)).

When the referral fee is low, a hybrid mode: BP or PB mode (PP mode) provides a higher surplus to consumers if the degree of substitution is high (low) or the unit production cost is low (high). This suggests that, similar to the competing sellers, consumers may also benefit from the lending market competition. The lending market competition exerts additional pressure on the lender (the bank and the platform) to reduce their interest rates, which in turn reduces the selling price, and expands the market size. Thus, BP/PB mode can generate a higher consumer surplus than PP mode. Moreover, it is evident from our analyses that the PP mode can lead to a 'win-win-win' outcome in which both the sellers, the platform, and the customers mutually benefit.



(a) Comparison of consumer surplus based on α and γ , where $c = 0.3$



(b) Comparison of consumer surplus based on α and c , where $\gamma = 0.5$

Figure 4: Comparison of consumer surplus under different lending modes

7. Model Extensions

In this section, we study several model extensions. In the first extension (Section 7.1), we investigate the effect of competing sellers' initial working capital on their supply chain financing decisions. In Section 7.2, we study a scenario in which both lenders (the bank and the platform) set their interest rates before sellers choose the financing strategies. In Section 7.3, we consider price competition between the two sellers. In Section 7.4, we generalize the base model by considering n (where $n \geq 2$) competing sellers in the end market. Finally, in Section 7.5, we extend our base model by considering the sellers' risk of repayment failure.

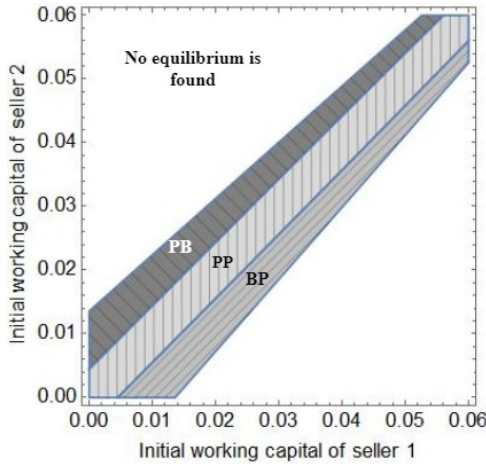
7.1. The impact of initial working capital for sellers

In the base case scenario, we assume that both the sellers have no initial working capital. In reality, sellers may have some initial working capital and may need to take loans to cover the remaining production cost expenses. As the loan amount changes with initial working capital, it can affect the optimal financing strategies of the two sellers. In this section, we consider the case where the seller j has initial working capital w_j ($w_j > 0$). The profit functions of the sellers, the platform and the bank under lending mode $i \in \{BB, PP, BP, PB\}$ are provided in Appendix C1 (see Online Supplement). Following the same methodology as adopted in the base model, we derive the equilibrium expressions under all four financing modes. The equilibrium expressions are provided in Appendix C1. Due to the complexity of the equilibrium outcomes, we numerically analyze the impact of various problem parameters on the sellers' strategic choice of lending modes.

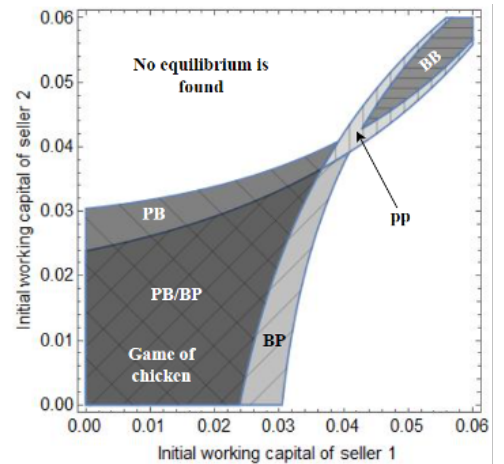
Thus, we examine the sellers' optimal financing strategies in the presence of initial working capital. Throughout our analyses in this extension, we keep the values of unit production cost and referral fee fixed: $c = 0.3$, $\alpha = 0.05$, and vary the degree of product substitution γ (or the intensity of product market competition)¹⁰. First, we consider the intensity of product market

¹⁰Throughout our analysis for this scenario, we extensively explored a wide range of parameter values (varying

competition is low (in Figure 5a, the value of $\gamma = 0.1$). We find that when the difference in working capital between the sellers (or working capital asymmetry) is low, they prefer PP mode similar to the base case (see Figure 3). As the intensity of product market competition is low, both sellers act like monopolist firms capturing their own market share. When the working capital asymmetry is low, the net effect of working capital on the sellers' profits remains the same. In this case, the bank charges a higher interest rate than the platform, leading to both sellers opting for platform financing. Contrary to the base case, when the working capital asymmetry increases (i.e., one of the sellers' working capital increases), a hybrid mode (PB or BP) emerges as the Nash equilibrium. The seller with significantly higher working capital deviates from opting for platform financing to bank financing. For instance, if the working capital of seller 1 is significantly higher than that of seller 2 (i.e., the value of $w_1 - w_2$ is large enough), seller 1 chooses bank financing and seller 2 chooses platform financing. As $w_1 - w_2$ is large enough, seller 2 seeks more loan amount compared to seller 1. The platform interest rate further increases as the referral fee is low ($\alpha = 0.05$). As a result, the platform charges a higher interest rate than that of the bank. Anticipating a higher platform interest rate, seller 1 switches to the bank who offers her a relatively lower interest rate. Thus, when product market competition is low and the working capital asymmetry is high, either BP or PB becomes the Nash equilibrium.



(a) Degree of substitution, $\gamma = 0.1$



(b) Degree of substitution, $\gamma = 0.9$

Figure 5: Sellers financing choices based working capital w_j , $j = 1, 2$. Parameter values: $c = 0.3$, $\alpha = 0.05$

Additionally, we observe a few interesting phenomena when product market competition is high (in Figure 5b, the value of $\gamma = 0.9$). We find that when one of the sellers' working capital is low and the working capital asymmetry is low, both hybrid modes (PB and BP) become Nash equilibria. Similar to the base case, the game of chicken scenario arises (see Theorem 1). As explained earlier, if the working capital asymmetry increases, either PB or BP becomes Nash equilibrium. When the value of γ is high enough, the market competition between the sellers goes up, reducing their downstream market prices. Due to this product market competition effect, the platform's revenue from referral fees reduces, and he tries to compensate for it by

c , α , and γ). As depicted in Figure 5, we present the details of only two sets of specific parameters (in Figure the values of γ are 0.1 and 0.9, respectively) where we kept the following values fixed: $c = 0.3$, $\alpha = 0.05$.

charging a higher interest rate under the PP mode as compared to the hybrid mode. Hence, when product market competition is high, but both sellers' individual working capital as well as the working capital asymmetry are low, the hybrid modes (BP and PB) become the Nash equilibria. We find a similar phenomenon when the sellers' working capital is zero, i.e., $w_j = 0$, $j = 1, 2$ (in Figure 3, we observe that for $\alpha = 0.05$, as γ increases from 0.1 to 0.9, the equilibrium lending mode switches from PP to PB/BP).

However, as the sellers' working capital increases, both tend to choose a symmetric lending mode (BB or PP) rather than a hybrid one. The most exciting finding emerges when the sellers' working capital is moderate and the working capital asymmetry is low. We find that for moderate values of working capital, PP is the Nash equilibrium although both sellers obtain a higher profit with bank financing¹¹. This is because each seller gains if she deviates from bank financing to platform financing when her working capital is high enough. None of the sellers has the incentive to choose bank financing as each one anticipates that her competitor will deviate to platform financing if she chooses bank financing. As a result, both sellers end up choosing platform financing and exhibit the prisoner's dilemma (Fudenberg and Tirole, 1991)¹². Thus, instead of BB, PP mode emerges as Nash equilibrium even though BB generates higher profits for the sellers. We also observe that the sellers' profits from bank financing increase as their working capital increases. Thus, both sellers find incentives to switch from platform financing to bank financing. We find that when the sellers' working capital is high and the working capital asymmetry is low, both of them choose bank financing. This is evident as the bank financing mode becomes more lucrative to sellers compared to platform financing at a lower value of referral fee (remember that the value of $\alpha = 0.05$)¹³. Under this scenario, although both BB and PP modes emerge as Nash equilibrium, sellers choose Pareto-optimal BB mode instead of PP mode. This is because the sellers obtain higher profits under BB compared to the PP mode.

7.2. When lenders set their interest rates before sellers choose the lending strategies

In the base case scenario, we assume that the sellers' financing choices are strategic decisions; thus, they simultaneously choose their lending strategies before the lenders (the bank and the platform) set their respective interest rates. In this extension, we allow for the possibility that the bank and the platform can set their loan interest rates before sellers choose their lending strategies. At first, the bank and the platform set their interest rates $\hat{r}_b$ and $\hat{r}_e$. After that, both sellers simultaneously decide their lending strategies. Finally, the sellers simultaneously set their selling quantities $\hat{q}_j^i$, $j \in \{1, 2\}$ for each lending mode $i \in \{BB, PP, BP, PB\}$.

We solve the overall game by backward induction. Under a specific lending mode $i \in \{BB, PP, BP, PB\}$, we first solve the sellers' quantity competition subgame and obtain optimal selling quantities $\hat{q}_j^i$ (same as the base case). Next, given the bank and platform interest rates

¹¹For example, in Figure 5b, for $w_1 = w_2 = 0.04$, we calculate that $\Pi_j^{BB} = 0.051229$, and $\Pi_j^{PP} = 0.051193$, $j = 1, 2$, $\Pi_1^{BP} = \Pi_2^{PB} = 0.050897$ and $\Pi_1^{PB} = \Pi_2^{BP} = 0.051514$. Clearly, $\Pi_1^{PP} > \Pi_1^{BP}$ and $\Pi_2^{PP} > \Pi_2^{PB}$ but $\Pi_1^{BB} < \Pi_1^{PB}$ and $\Pi_2^{BB} < \Pi_2^{BP}$. Hence, PP is a Nash equilibrium but BB is not a Nash equilibrium. Surprisingly, $\Pi_1^{BB} > \Pi_j^{PP}$.

¹²This is the prisoner's dilemma because PP is a Nash equilibrium even though both sellers would have benefited from platform financing (in Figure 5b, for $w_1 = w_2 = 0.04$, we find that $\Pi_1^{BB} > \Pi_j^{PP}$).

¹³It can be easily shown that as higher values of α (for example, at $\alpha = 0.3$), PP is the Nash equilibrium, i.e., the sellers never choose bank financing over platform financing.

$\hat{r}_b$ and $\hat{r}_e$, we solve the sellers' "lending subgame" in which both sellers simultaneously choose their equilibrium financing strategies: bank financing or platform financing (see Appendix C2 of the Online Supplement for further details).

We show that if $\hat{r}_b < \hat{r}_e$ (similarly, if $\hat{r}_b > \hat{r}_e$), both sellers choose bank financing (platform financing). Further, the lending mode BP or PB is never an equilibrium unless $\hat{r}_b = \hat{r}_e$. Finally, we determine the optimal $\hat{r}_b$ and $\hat{r}_e$ while maximizing the lenders' profits. Next, in the following proposition, we characterize the equilibrium interest rates.

Proposition 6. *When the bank and the platform set their interest rates before sellers choose their lending modes, the equilibrium interest rates are $\hat{r}_b^* = \hat{r}_e^* = \frac{(1-\alpha)(2(1-\alpha)+\gamma)-c(2+\gamma(1+\alpha))}{2c(2-\alpha+\gamma)}$.*

Under such a unique scenario, each seller chooses either bank financing or platform financing and an equal profit under each lending subgame, i.e., $\Pi_1^i = \Pi_2^i = \frac{(1-\alpha)(1-c)^2}{4(2-\alpha+\gamma)^2}$, $i \in \{\text{BB}, \text{PP}, \text{BP}, \text{PB}\}$. Thus, if $\hat{r}_b^* = \hat{r}_e^* = \frac{(1-\alpha)(2(1-\alpha)+\gamma)-c(2+\gamma(1+\alpha))}{2c(2-\alpha+\gamma)}$, we obtain a hybrid equilibrium where all lending modes, BB, PP, BP, and PB are equilibria.

7.3. Price competition between sellers

In the base case scenario (Section 4), we assumed that both upstream sellers compete over quantities. In this extension, we consider that the sellers engage in price competition. Similar to the base case, both sellers first decide their strategic lending choices: bank financing (B) or platform financing (P). After that, the lender decides its interest rate (under BP/PB mode, both lenders decide their interest rates). Finally, both sellers engage in price competition. For our analyses, we use a commonly used linear demand function with the following form (Cai, 2010; Wu et al., 2015; Shen et al., 2019):

$$q_j^i(p_j^i, p_k^i) = 1 - p_j^i + \theta p_k^i, j \neq k, j, k \in \{1, 2\},$$

where θ measures the intensity of price competition. A higher value of θ indicates a greater intensity of price competition (i.e., a more competitive market). Like the base model, we use backward induction to derive the equilibrium expressions under all four financing modes. For brevity, we do not repeat a similar analysis. In Appendix C3 (see Online Supplement), we provide the equilibrium outcomes for all four lending modes (BB, PP, BP, and PB). Due to the complexity of the equilibrium outcomes, we numerically analyze the impact of various problem parameters on the sellers' strategic choice of lending modes. In Figure 6, we investigate how referral fee rate and the intensity of price competition impact the sellers' equilibrium lending strategies¹⁴. Given the practical values of referral fees ($\alpha < \frac{1}{2}$), Figure 6 demonstrates that our insights from this extension are robust. Similar to the base model, when sellers compete over prices, the lending mode BB never becomes an equilibrium strategy (see Lemma 10 in the Online Supplement for more details). Further, when the referral fee rate is high, in equilibrium, both sellers choose the platform financing strategy. When the intensity of price competition

¹⁴Throughout our analysis for this scenario, we extensively explored a wide range of parameter values (varying the value of c). It is important to emphasize that our insights remain consistent and robust across all parameter sets. As depicted in Figure 6, we present the details of a specific parameter set where we kept the value of c fixed at 0.3.

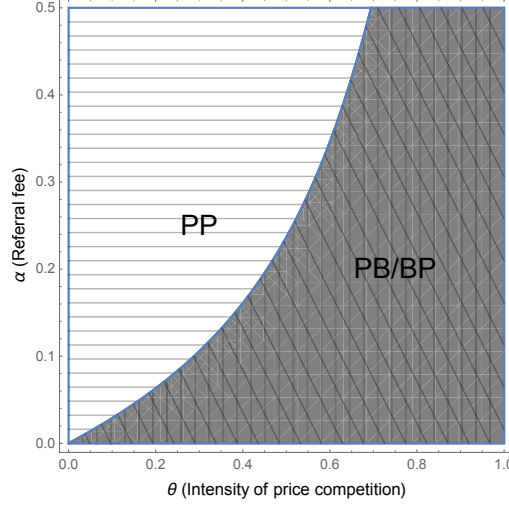


Figure 6: Sellers' financing choices based on α vs. θ . Parameter value: $c = 0.3$

(θ) is high, both seller chooses an asymmetric borrowing strategy. If one of them chooses bank financing, the other opts for platform financing.

7.4. The impact of n competing sellers

In this section, we generalize the base case scenario by considering multiple competing sellers. Thus, we consider a supply chain consisting of n (where $n \geq 2$) identical sellers, an intermediary e-commerce platform, and a bank. Each seller distributes its product to the end market via the intermediary platform. At first, these n sellers simultaneously decide their borrowing strategies: bank financing (B) and platform financing (P). After that, lenders (either the bank, or the platform, or both) decide their interest rates. Finally, n competing sellers engage in quantity competition.

To begin our analysis, we assume each of the sellers experiencing the following demand function:

$$p_j^i = 1 - q_j^i - \gamma \sum_{k=1: k \neq j}^n q_k^i, j \in \{1, \dots, n\}.$$

Without loss of generality, we assume that the first m , ($0 < m < n$), number of sellers out of n sellers obtain the working capital loan from the bank, whereas the remaining $(n - m)$ sellers choose platform financing. We obtain a composite lending mode: BBB... m times ...PPP...($n - m$) times, or in abbreviation, $B^m P^{n-m}$ ¹⁵. It may be noted that (i) if $m = n$, we obtain a lending mode B^n , in which all sellers choose bank financing, (ii) if $m = 0$, we obtain a lending mode P^n , in which all sellers choose platform financing. Next, given a composite lending mode $i = B^m P^{n-m}$, the profit functions of sellers, platform, and bank are as follows:

$$\Pi_j^i(q_j^i, r_b^i) = (1 - \alpha)p_j^i q_j^i - c q_j^i (1 + r_b^i), j = 1, \dots, m,$$

¹⁵There will be a total of 2^n distinct lending modes in the overall game. This implies that for a composite lending mode $B^m P^{n-m}$, we get $\binom{n}{n-m}$ different lending strategies. For example, when $n = 3$, there are $\binom{3}{0}$ number of B^3 (lending mode BBB), $\binom{3}{1}$ number of $B^2 P$ (lending modes BBP, BPB, and PBB), $\binom{3}{2}$ number of BP^2 (lending modes BPP, PBP, and PPB), and $\binom{3}{3}$ number of P^3 (lending mode PPP).

$$\begin{aligned}\Pi_k^i(q_k^i, r_e^i) &= (1 - \alpha)p_k^i q_k^i - cq_k^i(1 + r_e^i), k = (m + 1), \dots, n, \\ \Pi_e^i(r_e^i) &= \alpha \sum_{l=1}^n p_l^i q_l^i + \sum_{k=m+1}^n cq_k^i r_e^i, i = B^m P^{n-m}, \\ \Pi_b^i(r_b^i) &= \sum_{j=1}^m cq_j^i(1 + r_b^i) - \sum_{j=1}^m cq_j^i = \sum_{j=1}^m cq_j^i r_b^i.\end{aligned}$$

We again solve the subgame by backward induction. For any given bank interest rate r_b^i and platform interest rate r_e^i , we first solve sellers' equilibrium quantities q_j^i and q_k^i while maximizing $\Pi_j^i(q_j^i, r_b^i)$ and $\Pi_k^i(q_k^i, r_e^i)$, respectively. In Appendix C4 (see Online Supplement), we provide detailed analyses and derive the equilibrium outcomes for the generic case in which m sellers choose bank financing and $n - m$ sellers choose platform financing (i.e., the composite lending mode $i = B^m P^{n-m}$).

Given the practical values of referral fees ($\alpha < \frac{1}{2}$), we find that all n sellers never choose bank financing¹⁶. Due to analytical intractability in comparing equilibrium expressions, in this scenario, we conduct numerical experiments and present how sellers' strategic choices of lending mode vary over the degree of substitution (γ) and referral fee (α). In Figure 7, we demonstrate two distinct cases: (a) $n = 3$ and (b) $n = 4$. In particular, in Figure 7a, we observe that when the referral fee rate is high, PPP is the equilibrium lending mode. When the degree of product substitution is high and the referral fee rate is low, BP² is the composite lending mode (i.e., all PPB, PBP, and BPP are Nash equilibria). On the other hand, in Figure 7b, we observe that for moderate values of α , BP³ is the equilibrium composite lending mode (i.e., all lending modes: BPPP, PBPP, PPBP, and PPPB, a total of $\binom{4}{1}$ different lending modes are Nash equilibria). Whereas for lower values of α , B²P² (i.e., all lending modes: BBPP, BPBP,..., and PPBB, a total of $\binom{4}{2}$ different lending modes are Nash equilibria) is the equilibrium composite lending mode.

7.5. The impact of sellers' risk of repayment failure

In this extension, we consider that there is a risk associated with the sellers' repayment of the loan's principal and interest. Let λ ($0 < \lambda < 1$) be the probability with which a seller obtains no revenue and is unable to repay the loan. This implies that out of 100 times, a seller would fail to fulfill customer orders 100λ times, whereas she would successfully fulfill customer orders $100(1 - \lambda)$ times. One possible source of repayment failure is a seller failing to fulfill customer orders. For example, she may fail to deliver products according to buyers' specifications in terms of product quality, conformity, and delivery timeliness (Tang et al., 2018; Yan et al., 2020; Rath et al., 2021). Thus, with probability $(1 - \lambda)$, a seller would pay repayment amount $cq_j(1 + r_l)$ back to the lender $l = b, e$. In the case of repayment failure, traditional financial lenders like banks liquidate the seller's fixed assets (like plants and equipment) that have been kept as mortgage against the loan amount (Tang et al., 2018; Rath et al., 2021). Let βc , with

¹⁶There exists a threshold on c such that B^n can be a Nash equilibrium. This is possible for very large values of α and when the number of sellers exceeds a threshold. However, for $\alpha \leq 0.5$, B^n (B^3) is not a Nash equilibrium. For example, in the Online Supplement, we prove that BBB is not a Nash equilibrium when $n = 3$. For further details, readers are referred to Lemma 10 in the Online Supplement.

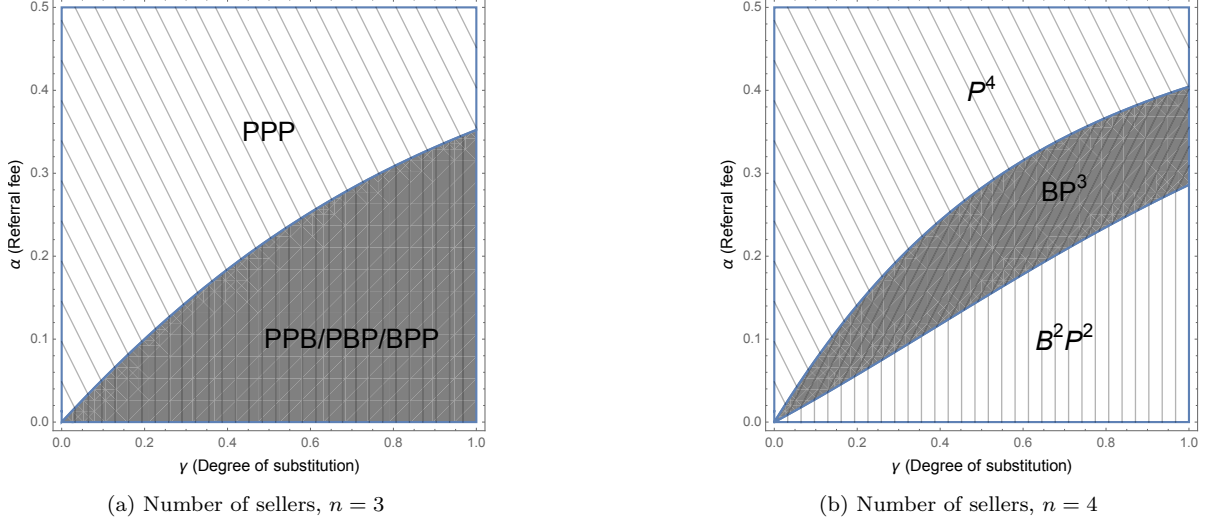


Figure 7: Sellers' financing choices based on α vs. γ . Parameter value: $c = 0.3$

$0 < \beta < 1$, be the unit collateral value of the seller's assets. Conversely, platforms like Amazon and Taobao provide loans to sellers without collateral¹⁷. If the seller fails to repay the loan, the platform not only loses the loan amount but also it does not get any amount as referral fees. Further, the platform also incurs a unit cost of goodwill $G > 0$ (i.e., seller j incurs the total cost of goodwill Gq_j) due to customer dissatisfaction associated with the non-fulfillment of orders. Without loss of generality, we assume such a linear goodwill cost structure (Cho et al., 2019; Rath et al., 2021). The remaining parameters and variables are the same as the main model. Again, we use backward induction to derive the equilibrium expressions under all four financing modes. For brevity, we do not repeat a similar analysis. In Appendix C5 (see Online Supplement), we provide the equilibrium outcomes for all four lending modes (BB, PP, BP, and PB). Due to the high level of complexity in equilibrium outcomes, we numerically analyze the strategic lending subgame between sellers. Similar to Figure 3, in this section, we explore how referral fee rate and the degree of substitution impact the sellers' equilibrium lending strategies¹⁸.

Figure 8 shows how the cost of goodwill moderates the sellers' lending strategies¹⁹. In Figure 8a, we observe that when the cost of goodwill is low, our results are similar to the base model. We find that both sellers never choose the bank financing strategy. There exists a threshold in the cost of goodwill, G , below which the equilibrium BB does not exist (see Lemma 15 in the Online Supplement for more details). This is because, at lower values of the cost of goodwill, the platform financing becomes more attractive to sellers. Surprisingly, in Figure 8b, we observe that when the cost of goodwill is high, for smaller values of referral fees, both sellers can choose bank financing. In the presence of the risk of repayment failure, the platform offers sellers a

¹⁷see <https://economictimes.indiatimes.com/industry/services/retail/amazon-plans-to-offer-loans-to-indian-sellers/articleshow/50923644.cms>

¹⁸Throughout our analysis for this scenario, we extensively explored a wide range of parameter values (varying the values of λ , G , c , and β). As depicted in Figure 8, we present the details of only two specific parameter sets (in Figure 8a and 8b, the values of G are kept at 0.75 and 2.75, respectively) where we kept the following values fixed: $\lambda = 0.1$, $c = 0.3$, and $\beta = 0.2$.

¹⁹In Figure 8, the infeasible region defines the conditions where sellers' demand becomes non-positive.

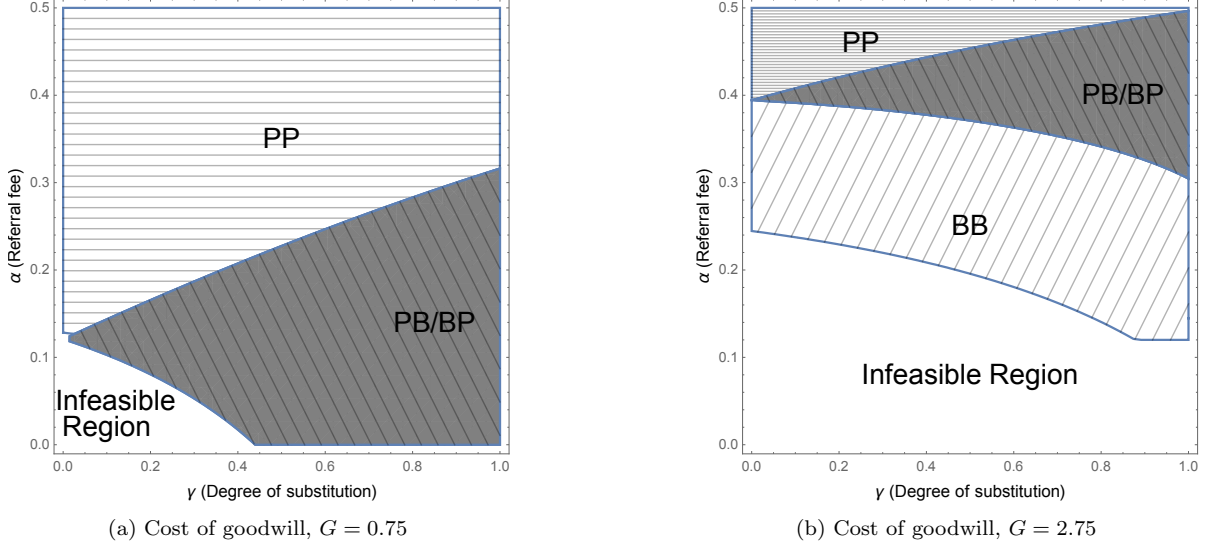


Figure 8: Sellers financing choices with the risk of repayment failure, based on α vs. γ . Parameter values: $\lambda = 0.1$, $c = 0.3$, $\beta = 0.2$

higher interest rate for a high cost of goodwill and a low referral fee, making PCF unattractive. As a result, both sellers choose bank financing, thereby establishing the lending mode BB as the Nash equilibrium.

8. Managerial Insights and Concluding Remarks

This paper analyzes the dynamics of lending market competition between a bank and a platform in the presence of seller competition and, thus, contributes to the existing literature on supply chain finance. We determine the lender's (the bank or the platform) optimal interest rate and the sellers' optimal sales quantities and market prices. Our findings contribute both theoretically to the extant academic literature and provide critical managerial insights to practitioners. We first highlight important theoretical contributions. Rath et al. (2021) and Zhen et al. (2020) find that in a monopolistic setup, the bank interest rate can be lower than the platform interest rate under certain market conditions; however, we show that the interest rate under pure bank financing is always higher than that under pure platform financing when multiple online sellers are capital constrained. Similarly, Rath et al. (2021), Yan et al. (2020), and Zhen et al. (2020) prove that an online seller's market price under bank financing can be less than that under platform financing. In contrast, our findings exhibit that in a competitive marketplace setup, the market prices are always higher under pure bank financing. On the other hand, the market prices under hybrid mode can be lower than those under platform financing. Shen et al. (2020) find analogous results in their comparative analysis of bank financing and trade credit. Existing studies such as Chang et al. (2022) and Wang et al. (2019) exhibit that a monopoly seller can earn a higher profit under bank or platform financing, depending on market conditions. We find that in a competitive market, online sellers never achieve a higher profit under pure bank financing compared to pure platform financing. However, under a hybrid financing mode (PB/BP), the seller's profit can be higher under bank financing. Previous studies such as Chang et al. (2022), Wang et al. (2019), and Yan et al. (2020) determine market conditions under which bank or

platform financing can be an equilibrium financing strategy. Our study enriches this line of research and suggests hybrid financing modes (PB/BP) can be equilibrium financing choices for n (where $n \geq 2$) competing sellers. In line with the prior works of (Rath et al. (2021) and Yi et al. (2021), we show that the platform is always better off under pure platform financing. Apart from these new findings, we extend our model to highlight the impact of the seller's risk of repayment failure and the sequence of financing decisions on the equilibrium financing choices of competing sellers.

Next, we present some important practical insights of our work. We find that when only one of the competing sellers changes her financing choice from bank financing to platform financing, banks such as HSBC or JP Morgan that actively fund sellers may reduce their interest rates. This would reduce market prices and enhance selling quantities for both sellers. On the other hand, for the lending rates offered by Amazon or JD there exists a threshold policy when one of the competing sellers deviates from platform financing to bank financing. Amazon or JD should lower its interest rate when one of the competing sellers changes her financing choice to bank financing under low unit production cost and increase it when the unit production cost is high. We find that the deviating seller sets a lower market price and higher sales quantities when the unit production cost is low. Otherwise, she sets a higher market price and lower sales quantities under a high unit production cost. Further, when both sellers choose the same financing mode, we find that the bank charges a higher interest rate than the platform leading to higher market prices and lower selling quantities. The interplay of lending market competition, the degree of product substitution, and whether the lender is part of the product supply chain lead to these interesting results. The above results provide critical insights on the lending rates of the bank as well as the platform and their impact on selling prices in a competitive setting.

Without seller and lending market competition, we find that a monopoly seller always prefers platform financing over bank financing. Thus, one may expect, in a competitive market, both sellers would opt for platform financing. In contrast, we show that both sellers are not always better off with platform financing. Under a hybrid lending mode, i.e., when one of the sellers opts for bank, and the other opts for platform financing and vice versa, a seller may obtain a higher profit based on the production cost than both opting for platform financing. One of the sellers may choose financing offered by banks such as HSBC while the other seller can continue with platform financing offered by Amazon Lending or JD if the unit production cost is low. Hence, production cost can be considered to be an important factor in deriving the optimal financing choice for sellers in a competitive market.

In line with the extant knowledge, our findings also show that the platform earns the highest profit when both sellers opt for platform financing. As an interesting and useful result, we derive a win-win-win outcome for both the sellers and the platform under platform financing when the production cost is high. To summarize, for products such as clothing, sunglasses, etc., where the production cost is low, each seller may choose a different lending source. They may opt for financing offered by banks such as HSBC or choose Amazon Lending or financing offered by Alibaba. Whereas, for products associated with high production costs, such as high-end electronics and furniture items, a win-win-win outcome exists with both the sellers and the platform earning the highest profit under platform financing. The above result corroborates

why Amazon Lending is turning out to be a fruitful option for sellers for loans as high as \$750,000.²⁰

Further, we analyze the interplay of referral fees charged by the platform and the degree of substitution associated with the product and how these important factors impact the equilibrium financing strategies of the sellers. We find that for products linked to high referral fees, such as jewelry and furniture, Amazon or JD may provide competitive interest rates and emerge as the optimal financing strategy for both sellers. On the other hand, for products associated with low referral fees, the degree of substitution becomes a critical deciding factor. For products with a high substitution effect, such as grocery items, a hybrid lending mode emerges as the equilibrium, whereas for products that have a low substitution effect, such as books, platform financing remains the equilibrium outcome. Therefore, HSBC and JP Morgan should focus on sellers in product categories with low referral fees and high substitution effect. Amazon or JD's lending products are more apt for products with low substitution effects.

As model extensions, we first study the impact of sellers' initial working capital and then evaluate a case in which the lenders determine their interest rates before the sellers decide on their loan options. Our analyses show that as the difference in working capital levels of the two sellers increases hybrid financing mode (either PB or BP) becomes Nash equilibrium. However, as the working capital levels increase, both sellers tend to choose a symmetric lending mode (BB or PP) rather than a hybrid lending mode. Interestingly, we find that platform financing becomes the Nash equilibrium, although both of them can obtain a higher profit with bank financing. None of the sellers choose bank financing as each one anticipates that her competitor will choose platform financing if she chooses bank financing; as a result, both sellers end up choosing platform financing. The second extension provides a decision-making process under which all of the financing modes emerge as equilibria. Further, our analyses show that the base model results are robust under price competition and n competing sellers for practical parametric values. Finally, our analysis of the impact of the sellers' risk of repayment failure reveals that when there is a chance that the repayment will fail and the cost of goodwill is high, and the referral fee is low, both sellers choose bank financing. The platform provides the sellers with a higher interest rate for a low referral fee and a high cost of goodwill, making PCF unattractive. Because both sellers choose bank financing, BB's lending mode is established as the Nash equilibrium.

Our paper is one of the first studies that explore the impact of both the lending market and seller competition in an e-commerce setup. We can further extend this work in multiple ways. Nowadays, data related to inventory and business transactions of e-retailers is being shared between platforms and financial institutions to offer quick trade financing loans. One such example is the alliance between the Alibaba Group and HSBC (Pymnts, 2020). A future research project could explore how transactional data sharing between a platform and a financial institution may open new models for supply chain finance. We can also consider seller competition under the performance risk and investigate its impact in deriving equilibrium lending modes. We may explore the impact of production cost asymmetry between sellers on their strategic

²⁰<https://www.techtarget.com/searchaws/feature/How-Amazon-became-a-force-in-SMB-lending>

financing choices.

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Appendix

Bounds of unit production cost c

For all $\alpha \in \{0, 1\}$, $\gamma \in \{0, 1\}$,

1. $r_b^{BB} = \frac{1-\alpha-c}{2c} > 0$ implies that $c < 1 - \alpha$,
2. $r_e^{PP} = \frac{(1-\alpha)(2(1-\alpha)+\gamma)-c(2+\gamma(1+\alpha))}{2c(2-\alpha+\gamma)} > 0$, implies that $c < \frac{(1-\alpha)(2(1-\alpha)+\gamma)}{2+\gamma(1+\alpha)}$,
3. $r_b^i = \frac{(4-\gamma^2)(4(2-\alpha)(1-c-\alpha)-2(1-c)(1-\alpha)\gamma+(1-c-\alpha-c\alpha)\gamma^2)}{c(32(2-\alpha)-4(5+\alpha)\gamma^2+(1+\alpha)\gamma^4)} > 0$ implies that $c < \frac{(1-\alpha)((2-\gamma)(4+\gamma)-4\alpha)}{(2-\gamma)(4+\gamma)-\alpha(4-\gamma(2-\gamma))}$, $i \in \{BP, PB\}$,
4. $r_e^i = \frac{(2-\gamma)((1-\alpha)((2-\gamma)(2+\gamma)(4+\gamma)-\alpha(16-4\gamma+\gamma^3))-c(16+(1+\alpha)\gamma(4-\gamma(4+\gamma))))}{c(32(2-\alpha)-4(5+\alpha)\gamma^2+(1+\alpha)\gamma^4)} > 0$ implies that $c < \frac{(2-\gamma)(2+\gamma)(4+\gamma)-\alpha(16-4\gamma+\gamma^3)}{16+(1+\alpha)\gamma(4-\gamma(4+\gamma))}$, $i \in \{BP, PB\}$.

It is easy to prove that $\frac{(1-\alpha)(2(1-\alpha)+\gamma)}{2+\gamma(1+\alpha)} < 1 - \alpha$ and $\frac{(2-\gamma)(2+\gamma)(4+\gamma)-\alpha(16-4\gamma+\gamma^3)}{16+(1+\alpha)\gamma(4-\gamma(4+\gamma))} < \frac{(1-\alpha)((2-\gamma)(4+\gamma)-4\alpha)}{(2-\gamma)(4+\gamma)-\alpha(4-\gamma(2-\gamma))}$, for all $\alpha \in \{0, 1\}$, $\gamma \in \{0, 1\}$. Combining all the bounds together we conclude that $c < \bar{c} \stackrel{def}{=} \min \left\{ \frac{(1-\alpha)(2(1-\alpha)+\gamma)}{2+\gamma(1+\alpha)}, \frac{(2-\gamma)(2+\gamma)(4+\gamma)-\alpha(16-4\gamma+\gamma^3)}{16+(1+\alpha)\gamma(4-\gamma(4+\gamma))} \right\}$.