Financing Suppliers under Performance Risk

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ABSTRACT

This chapter focuses on the relative efficiency of two innovation pre-shipment financing schemes that enable suppliers to obtain financing for production: *purchase order financing* (POF, under which financial institutions offer loans to suppliers by considering the value of purchase orders) and *buyer direct financing* (BDF, under which manufacturers lend directly to suppliers). Both schemes are closely related to suppliers' *performance risk* (whether the supplier can deliver the order successfully). When the manufacturer and the bank have symmetric information regarding the supplier's operational capabilitiy, we find that even though POF and BDF yield the same payoffs, BDF allows more flexibility in contract terms. However, when the manufacturer has superior information, BDF leads to higher payoffs when the supplier is severely financially constrained. The relative benefit of BDF is more pronounced when the supply market contains a larger fraction of inefficient suppliers, when efficiency gaps between suppliers are greater, or when the manufacturer's alternative sourcing option is more expensive.

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Introduction

As globalization broadens, many manufacturers (or intermediaries) source products from small suppliers (or contract manufacturers), who are often located in developing countries and lack of financing sources. To meet the financing needs of the aforementioned suppliers, two innovative *pre-shipment* financing schemes have recently emerged. The first is known as *purchase order financing* (POF), under which financial institutions lend to suppliers based on purchase orders issued by reputable manufacturers. POF lenders include traditional commercial banks and specialized POF lenders (Tice, 2010). Unlike asset-based loans or factoring, which are backed by tangible assets, the repayment of a POF loan depends on the supplier's successful delivery of the associated purchase order. Because a POF loan is only granted based on purchase orders issued by creditworthy buyers, the major risk associated with POF is not the buyer's credit risk but the supplier's *performance risk*, i.e. that the supplier may fail to deliver the order according to the buyer's specifications on quality, timeliness, or compliance (Gustin, 2014). Under the second scheme, which we call *buyer direct financing* (BDF), the manufacturer acts as both the buyer and the lender and directly finances suppliers for production. BDF has been adopted by manufacturers such as Rolls-Royce and GlaxoSmithKline, and supply chain intermediaries such as Li & Fung.

As both POF and BDF are still taking shape, industry experts are debating whether financial intermediaries (i.e. banks and specialized lenders) or supply chain partners (i.e. manufacturers or supply chain intermediaries) are in a better position to finance suppliers. On the one hand, many critics argue that manufacturers should leave financing to professionals with domain expertise. On the other, because the efficiency of both POF and BDF hinges on supplier performance and because manufacturers have better *control* over and *knowledge* of suppliers (Fung *et al.*, 2007), manufacturers can provide financing more efficiently. For instance, manufacturers can design supply contracts to incentivize suppliers to improve delivery performance. They often also have better information than banks in terms of suppliers' intrinsic operational efficiency due to previous interactions, extensive auditing, or domain knowledge of particular purchase orders. These observations motivated us to examine two research questions more formally in this chapter. First, by combining the roles of buyer and lender under BDF, which we refer to as the manufacturer's *control advantage*, can the manufacturer better incentivize suppliers to improve their delivery performance under BDF? Second, does the manufacturer's *information advantage* about suppliers' operational capabilities make BDF a superior financing scheme? And if so, under what circumstances?

Focusing on the impact of different supply chain financing schemes on supply risk, our paper is related to three research streams: supply risk management, supply chain finance, and signaling games. We refer the readers to Babich and Kouvelis (2018), Tang (2006), Yang and Birge (2018), and Tang *et al.* (2018) for a detailed discussion on the related literature.

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POF vs. BDF under symmetric information

To answer the first research question, we analyze a model consisting of three parties: a manufacturer, a financially constrained supplier who can exert costly and unobservable effort to improve delivery reliability, and a bank operating in a competitive lending market (note that the bank only plays a role in POF). Without access to other financing means, the supplier can only borrow through either POF or BDF to cover his production cost. To focus on the manufacturer's control advantage under BDF, we first assume that the manufacturer and the bank have symmetric information about the supplier's operational efficiency. This assumption is relaxed in the next section.

2.1 Sourcing with POF

Consider a make-to-order supply chain comprising one manufacturer and one supplier. To focus on supply risk, the demand faced by the manufacturer is normalized to 1. The manufacturer sources the product from the supplier, who incurs a production cost $c > 0$ (raw material, wages, etc.) to execute the order.

Our models capture two salient features that are common among suppliers seeking POF or BDF. First, the supplier is financially constrained.

Specifically, we assume that the supplier has no cash on hand and only has fixed assets (e.g. plants and equipment) that are indispensable to his operation. The collateral value of the assets is $a \geq 0$.

Second, the supplier is unreliable and can only deliver the order with a certain probability. The supplier can improve the delivery probability by exerting costly efforts that are not observable to any other parties. The base delivery probability is scaled to 0. To increase the delivery probability from 0 to $e \in (0, 1)$, the supplier needs to exert effort that is associated with a disutility (cost of effort) ke^2 with $k > 0$. This cost of effort is non-monetary and hence does not enter the supplier's cash flow. The supplier's (effort) cost factor k captures the supplier's operational efficiency: A supplier with a lower k can achieve the same delivery probability at a lower cost of effort than a supplier with higher k. In this section, we assume that k is known to all parties. We later extend this model to the case where the manufacturer and the supplier know the exact value of k while the bank knows only the distribution.

The sequence of the game is as follows. Acting as the Stackelberg leader, the manufacturer sets the contract terms and the supplier, as the follower, decides whether to accept the supply contract. Without loss of generality, we focus on the following contingent contract: The manufacturer pays the supplier the contract price p upon successful delivery and pays zero otherwise. After receiving a contract with price p that is acceptable to him, the supplier takes the purchase order to the bank and borrows c in the form of a POF loan to start production. By considering the purchase order with contingent payment p and the collateral value of the supplier's fixed asset a, the bank decides whether to lend c to the supplier and, if so, what interest rate i_B to charge.

Under this POF loan contract, if the supplier delivers successfully, he receives payment p from the manufacturer, pays the principal and interest $(1 + i_B)c$ to the bank, and keeps the rest. If delivery is not successful, the supplier receives no payment, the POF loan defaults, the bank liquidates the supplier's fixed assets and recovers a, and the supplier is left with nothing. Therefore, the supplier's objective is to maximize his expected payoff Π_S, where

$$\Pi_S = e[p - (1 + i_B)c] - (1 - e)a - ke^2. \tag{2.1}$$

As shown, Π_S consists of three parts: the expected gain upon successful delivery (after paying off the loan plus interest) $e[p - (1 + i_B)c]$, the expected loss of assets to the lender in the event of delivery failure $(1 - e)a$, and the cost of effort ke^2. As our model is mainly motivated by made-to-order products, we assume that once the goods are produced, the supplier has to sell them to the manufacturer. Therefore, without loss of generality, we normalize his outside option to 0, i.e. the supplier accepts a contract only when $\Pi_S \geq 0$.

Finally, to focus on the supplier's performance risk, we assume that the manufacturer has no credit risk and will pay the supplier as long as the order is delivered successfully. The bank is assumed to operate in a competitive lending market, and hence it sets the interest rate so that the lending amount c equals its expected payoff discounted at the bank's cost of capital, which is normalized to zero.

Before characterizing the equilibrium contract, we first identify the first-best solution: In a centralized chain, we find that the manufacturer will source from the supplier if and only if $\frac{v^2}{4k} \geq c$. The resulting delivery probability is $\frac{v}{2k}$, and the corresponding chain payoff is $\frac{v^2}{4k} - c$.[1] Finally, to avoid trivial cases, we assume that the supplier's cost c and his asset level a satisfy: $0 \leq a \leq c \leq \frac{v^2}{4k}$.

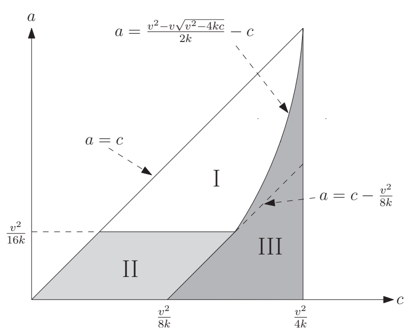

Figure 2.1: Illustration of different regions under the optimal POF contract.

[1] We refer the readers to Tang *et al.* (2018) for the detailed derivation of this result and the following ones in this chapter.

The optimal contract and corresponding equilibrium outcome as illustrated in Figure 2.1. As shown, when the supplier's asset value a is relatively large (Region I in Figure 2.1), the supplier has a stronger incentive to exert more effort to increase his delivery probability in order to protect his assets. Recognizing this, it is optimal for the manufacturer to set the contract price at the lowest level that is acceptable to the supplier. As a decreases, the supplier's delivery probability in equilibrium also declines. The decline in both a and the delivery probability leads to a higher interest rate. In Region II, as the supplier's asset value a is low, the supplier has little to lose and hence is less incentivized to exert effort to increase delivery probability. Anticipating this, the bank increases the interest rate charged under POF. To offset the increasing financial burden borne by the supplier, the manufacturer offers a price that decreases in a. As such, the manufacturer's payoff is lowered as the supplier becomes more financially constrained. Finally, when the supplier's net financing need $(c - a)$ is sufficiently large (Region III), it is too costly for the manufacturer to offer a price that is acceptable to herself and the bank. Hence, sourcing from the reliable supplier is simply unprofitable.

2.2 Joint sourcing and financing under BDF

As shown previously, both the total supply chain payoff and delivery probability are both lower under POF relative to the first-best benchmark. Can such inefficiency be mitigated under BDF, which allows the manufacturer to jointly determine the sourcing and loan terms?

Under BDF, the bank does not play a role and the manufacturer determines both the contingent price p and interest rate i_M (for lending c to the supplier). Upon successful delivery, the manufacturer deducts the principal and interest $(1 + i_M)c$ from p and pays the rest to the supplier. When the supplier fails to deliver, the manufacturer does not pay the supplier and seizes the supplier's assets a to partially recover the loan. To compare BDF and POF directly, we assume that the manufacturer's cost of capital is also zero, and the liquidation value of the asset is a, both the same as the bank's. The interaction between the supplier and manufacturer under BDF is analogous to that under POF.

First, under given (p, i_M), the supplier's best response and participation condition are similar to that under POF, with i_B being replaced by i_M. Anticipating this, the manufacturer chooses p and i_M jointly to maximize her payoff $\Pi_M = e(v-p) + [e(1+i_M)c + (1-e)a - c]$, the sum of the expected operational savings and her financing earnings from the BDF loan.

By analyzing the above game, we find that BDF does not improve supply chain efficiency relative to POF despite the manufacturer's ability to jointly optimize the contingent payment and interest rate. The reason is as follows. In both POF and BDF, the supplier's incentive to exert effort is determined solely by the difference between his payoff when the order is delivered and that when the order is not delivered. Under POF, the contingent nature of the supply contract already equips the manufacturer with a lever to maximize the above difference, which cannot be further improved under BDF.

That said, BDF offers the manufacturer more flexibility in setting the contract price and interest rates jointly. Specifically, the price p^B and interest rate i_M^B under BDF can induce optimal performance as long as $p^B - (1+i_M^B)c$ stays constant. Such flexibility can be of value. For instance, in certain markets, regulations may cap interest rates at certain levels, which renders POF infeasible when the supplier's asset level is very low. However, BDF allows the manufacturer to facilitate financing by lowering the contract price and interest rate simultaneously.

3

POF vs. BDF under the manufacturer's information advantage

To answer the second question, we extend the above model by considering the case in which the supplier can be either efficient or inefficient in terms of their operational capabilities. The cost factor k is k_H for the efficient ones ($\tau = H$) and k_L for the inefficient one ($\tau = L$), where $k_L > k_H > 0$. Thus, the efficient supplier incurs lower (effort) costs than the inefficient supplier in order to achieve the same delivery probability. The actual type is known to the manufacturer, but the bank only knows the distribution: The supplier is efficient with probability λ and inefficient with probability $(1 - \lambda)$. Intuitively, λ is probably higher in a developed country than an emerging market. Because the manufacturer knows the supplier's actual type and the bank is not involved under BDF, the performance of BDF remains the same as before. However, POF may become less efficient in this case due to the bank's information disadvantage. In the following, we first establish how POF is influenced by the manufacturer's private information, and then identify the benefit of BDF under such information asymmetry.

3.1 The impact of the manufacturer's private information on POF

To model the manufacturer's private information, we extend the basic POF model in the last section by incorporating a signaling component. First, as the *sender* of the signal, the manufacturer offers a supply contract with price p (the *signal*) to the supplier. The supplier then takes the contract to obtain POF financing from the bank (the *receiver* of the signal). Upon observing the signal p, the bank forms a posterior belief about the supplier's type using Bayes' rule and offers financing terms accordingly. As in the signaling games literature, we adopt the Perfect Bayesian Equilibrium (PBE) as the relevant equilibrium concept.

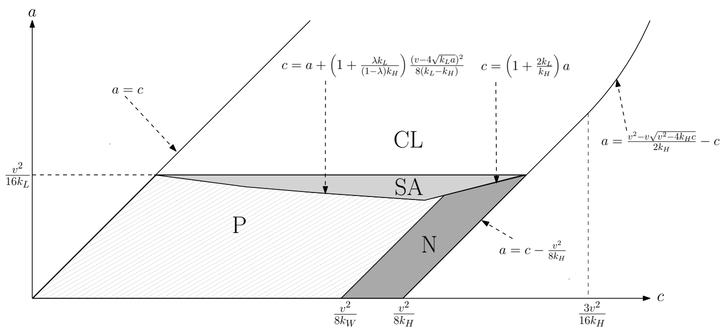

Figure 3.1: Regions of the stable dominant PBE.

Notes. CL represents *costless* separating; SA represents separating based on the *supplier's acceptance* constraint, P represents *pooling*, N represents that *no* equilibrium exists. The illustration is generated using $\frac{k_L}{k_H} = 1.5$ and $\lambda = 0.5$.

By characterizing both the separating and pooling equilibria, and using both Pareto dominance and the Intuitive Criterion, the different regions of the stable dominant PBE is illustrated in Figure 3.1. First, when the supplier's asset value a is relatively high (Region CL), the manufacturer simply offers the same contract as under symmetric information, which can already signal the supplier's type. This is because in this region, the price offered to the efficient supplier under symmetric information is already lower than the lowest price an inefficient supplier would accept even if the bank mistakenly believed that he was efficient. As such, the manufacturer's payoff under asymmetric information is identical to that under symmetric information. In other words, signaling is *costless* to the manufacturer.

Second, where the supplier's asset value a is slightly below $\frac{v^2}{16k_L}$ and the net financing need $(c - a)$ is medium (Region SA), unlike in Region CL, the bank will no longer treat the price under symmetric information as a credible signal that the supplier is efficient. However, it is still cost-efficient for the manufacturer to deviate the price offered to the efficient supplier from the optimal one under symmetric information in order as a credible signal. In particular, the manufacturer signals that the supplier is efficient by making the contract unacceptable to an inefficient one.

As the supplier's asset a drops further while the net financing need $c - a$ remains not too high (Region P in Figure 3.1), separating the two types of suppliers is either infeasible ($c \geq \left(1 + \frac{2k_L}{k_H}\right) a$) or less cost-efficient than pooling ($c < \left(1 + \frac{2k_L}{k_H}\right) a$). Thus, the stable dominant equilibrium is a pooling one. In equilibrium, the manufacturer offers a single price regardless of the supplier's type. In response, the bank treats all suppliers as having cost factor equal to the weighted average $k_W = \lambda k_H + (1 - \lambda) k_L$, and hence offers a single interest rate to all suppliers.

Finally, where a is small and $c - a$ is large (Region N), neither pooling nor separating equilibria exist and hence the manufacturer does not source from the supplier, regardless of his type. To elaborate, when $c - a > \frac{v^2}{8k_W}$, under the belief that the supplier's cost factor is the weighted average one, the bank is not willing to lend unless the manufacturer offers a price greater than v, which is clearly not economical. Therefore, no pooling equilibrium exists. On the other hand, separating equilibrium does not exist for the same reason as we explained in Region P when $c \geq \left(1 + \frac{2k_L}{k_H}\right) a$.

In summary, due to the three-party supply chain setting and the specific mechanism that the manufacturer relies on for separation, i.e., the supplier's acceptance constraint, the manufacturer's information advantage has bifurcating impacts on the performance of POF. On the one hand, when the supplier's asset level is not too low, signaling the supplier's cost factor through the sourcing contract is actually costless.

However, as the supplier's asset level drops, signaling the true type of the supplier quickly becomes too costly, leading to two scenarios: First, when $c - a$ is low, the manufacturer offers the pooling price and the bank treats both types of suppliers as the weighted average; and second, when $c - a$ is high, no equilibrium exists that allows the manufacturer to source from the efficient supplier, and hence the manufacturer has to give up a valuable sourcing opportunity.

3.2 The Benefit of BDF under Information Asymmetry

Armed with the stable dominant equilibrium associated with the signaling game under POF, we now examine the conditions under which BDF is more appealing than POF when the manufacturer has an information advantage over the bank. Because the bank is not involved under BDF, the information asymmetry between the manufacturer and the bank has no impact on the performance of BDF. In other words, even with information asymmetry, the manufacturer's and supplier's payoffs under BDF equals to POF under symmetric information. Thus, the benefit of BDF for the manufacturer (relative to POF) that can be attributed to information asymmetry is captured by the difference in the manufacturer's payoffs between the symmetric information case and the asymmetric one. Also, we note that the information asymmetry does not adversely influence the performance of POF when the manufacturer faces an inefficient supplier. Therefore, in the rest of this section, we focus on the scenario in which the manufacturer sources from efficient suppliers. Such a focus is also supported by anecdotal evidence that many manufacturers only offer BDF to suppliers with good track records.

Combining the above results, we can examine the conditions under which BDF is preferable as follows. First, we note that BDF is more valuable to the manufacturer when the supplier's asset value a is low. Therefore, it is more beneficial for the manufacturer when she focuses her financing capacity on helping her most financially constrained suppliers, as well as offering financing to a supplier when the value of the supplier's assets shrinks, such as during an economic downturn. This result provides a plausible explanation for the emergence of BDF during financial crises. For example, during the 1997 Asian Financial Crisis, Li & Fung offered direct financing to its cash-strapped suppliers in Indonesia (Tang, 2006).

Second, BDF is more appealing to the manufacturer when the efficient supplier's cost factor k_H is low, i.e. when the supplier is more cost efficient. Therefore, it could be more beneficial to directly lend to efficient suppliers who need help with acquiring new equipment to improve their operational efficiency.

Third, BDF is more valuable for the manufacturer when the market consists of mostly inefficient suppliers (i.e. when λ is low). Note that as λ decreases, the weighted average cost factor k_W becomes larger, leading to two implications: The manufacturer offers a higher contract price under pooling (Region P) or fails to source from the supplier (Region N). As such, BDF is an effective financing scheme for manufacturers who source from developing markets comprised predominantly of inefficient suppliers.

Fourth, the benefit of BDF also increases as her outside option v becomes more expensive. When v is larger, we can see from Figure 3.1 that Regions SA, P, and N expand. Furthermore, under POF, it is more likely that the manufacturer will incur signaling costs or not source from the supplier. As such, BDF becomes more appealing to the manufacturer when the supplier is more specialized and the alternative sourcing option is particularly expensive (i.e. when v is high). Consistent with the anecdotal evidence, manufacturers that work with specialized suppliers, such as Rolls-Royce and GSK, are among the pioneers of directly financing their suppliers.

Finally, while we mainly focus on the benefits of BDF for the manufacturer, owing to her leader position in the supply chain, BDF can also improve profitability for the efficient supplier. Specifically, the efficient supplier would directly benefit from BDF in Region N, as the presence of information asymmetry prohibits the efficient supplier from obtaining a supply contract under POF that he could secure under BDF otherwise. In addition, in Region SA, the contract price under POF is lower than that under BDF as the manufacturer must, in order to signal credibly to the bank that the supplier is indeed efficient, offer a lower contract price under POF. As such, the supplier's payoff is also adversely affected. In summary, the above result suggests that BDF can also benefit the efficient supplier under information asymmetry, achieving a win–win situation for both parties in the supply chain.

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Conclusion

By focusing on understanding the relative efficiency of two innovative financing schemes (POF and BDF) in managing suppliers' endogenous performance risk, this chapter reveal two important managerial implications. First, the relative benefit of BDF resides more on the manufacturer's information advantage than her control advantage. Second, by formally analyzing the financial implications of the manufacturer's information advantage, we identify operational and financial environments in which manufacturers may benefit more by financing their suppliers directly. Specifically, we find that manufacturers should direct their financing capacity to suppliers who are extremely constrained financially, and those who are more specialized and costly to replace, and/or those in need of upgrade their facilities for operational improvement. As such, BDF is likely to be a valuable financing option in high-tech and pharmaceutical industries where the above characteristics are commonly observed. In addition, our results also reveal that BDF is more valuable in emerging economies with weak financial sectors that have limited information acquisition capability, and huge supplier quality heterogeneity, and during financial crises when the supplier's financing need is high.

As the first attempt at comparing POF and BDF, this research can be extended in many aspects. For example, this chapter focuses on performance risk as captured in a binary distribution. Examining yield uncertainty following a continuous distribution could further generalize the result in this paper. In addition, our single-supplier model can be extended to a multi-supplier framework, including both multiple competing suppliers and/or suppliers producing complementary components. While we expect that the qualitative results in this chapter remain valid, the interaction between different suppliers under endogenous effort choice may further enrich our understanding. Information asymmetry is another dimension along which the model can be extended. Currently, we consider only information asymmetry regarding the supplier's operational efficiency. Further studies on the manufacturer's superior information regarding other parameters such as the supplier's asset level, the manufacturer's outside option, and others can also be promising. Furthermore, for tractability, we focus on a single-period model in this chapter. In the future, this modeling framework can be extended into a multi-period setting with learning, which may allow additional insights to be generated. Finally, due to data availability, our results are connected only with anecdotal evidence. However, should data become available, empirical research may be conducted to verify the various predictions that this chapter generates.

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