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Optimal payment scheme when the supplier's quality level and cost are unknown

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ABSTRACT

When procuring a product from a supplier, a buyer faces the problem of designing a payment scheme to screen the supplier's quality level and cost. We explore an instalment payment (contract) consisting of an initial payment to the supplier as soon as the product is put in use, followed by a deferred payment that is contingent upon the product in normal operation within a certain period. We find that when the high quality supplier has a higher cost than the low quality supplier, and the suppliers' financing costs are lower than a certain threshold, the optimal instalment payment has two options: an initial-payment-only option preferred by the low quality supplier and a deferred-payment-only option preferred by the high quality supplier; otherwise, the optimal contract degenerates into an initial-payment-only option. Thus, our research complements past work on moral hazard where no initial payment is proposed. Moreover, we show that the buyer has an incentive to assist with the supplier's financing. Finally, we compare the instalment payment with the rental contract and show that when the supplier's financing cost is low or the quality difference among different supplier types is small, the rental contract is more likely to be preferred by the buyer than the instalment payment.

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1. Introduction

When sourcing from a supplier, the downstream buyer's key concern is how to encounter information asymmetry on the supplier's quality level and cost. In this paper we first investigate the role of the instalment payment contract in screening this two dimensional information asymmetry, and then compare it with the rental contract. Here, the instalment payment consists of an initial payment remitted when the product[1] is put into use and a deferred payment made after the product has been in normal operation or has demonstrated desired performances for a specified period of time. This deferred payment can be viewed as a reward: if the product remains in good condition for a certain period, then the buyer will reward the supplier. On the other hand, the rental contract refers to the "pay-as-you-go" contract that the buyer just rents the product from the supplier and returns it to the supplier as soon as the product is not used.

Our research questions are as follows: when to use the instalment payment scheme or the rental contract? If the buyer chooses the rental contract, then what is the optimal rental contract? Furthermore, if the buyer decides to adopt the instalment payment scheme, then what is the buyer's optimal instalment payment scheme? As a low quality product is more likely to fail before paying the deferred payment, thus this payment arrangement makes it too costly for the low quality supplier to imitate the high quality supplier. So, this underlying logic implies that the buyer should always adopt the deferred payment method to screen the supplier's quality level. But that being the case, why do we observe the pay-on-delivery arrangement in practice (Beil, 2010)? Here, the pay-on-delivery arrangement refers to a practice in which the chosen supplier receives only a fixed initial payment, independent of the supplier's type or whether the provided product fails during its service. That is, in this arrangement no deferred payment takes place at all.

In this paper, we investigate the questions above by considering a two echelon supply chain, in which the buyer procures a product from the supplier. There are two dimensions of asymmetric information: the supplier's quality level and cost (of getting the product), both of which can be either high or low. So, there are at most four *types* of the supplier: high quality and low cost, high quality and high cost, low quality and low cost, and low quality and high cost. As a screening game, the supplier exactly knows its type but the buyer does not. However, the buyer can design and offer a menu of contracts with different options to let the supplier tell the truth.

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[1] Usually, the product can be a machinery, tool, truck or equipment. We call it a *product* throughout the paper.

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For the relationship between the supplier's quality level and cost, we mainly consider three cases: *the substitutable case* (in which there exist a high quality and high cost type and a low quality and low cost type), *the complementary case* (in which there exist a high quality and low cost type and a low quality and high cost type), and *the independent case* (for each quality level, high or low, the buyer might be dealing with both a high and low cost type). It is worth noting that the supplier with high quality incurs a low cost is supported in practice (Lapré, Mukherjee, & Van Wassenhove, 2000; Srinidhi & Balachandran, 1996): first, the high quality supplier enjoys a sound basic infrastructure or better economies of scope, e.g., better trained and more experienced workers or a more scientific organisation of manufacturing; second, being at a more advanced stage along the learning curve, the high quality supplier reduces waste, thereby producing products in a more economical way and incurring a lower cost.

We analytically find that the optimal instalment payment scheme critically depends upon the relationship between the supplier's quality level and cost. Specifically, in the substitutable case, unless the supplier's financing cost is too high, the buyer offers an initial-payment-only option and a deferred-payment-only option. The low quality supplier prefers the first option, while the high quality supplier prefers the second option. So, the instalment payment leads to a separating equilibrium, which can screen the supplier's private information. Also, it is in the buyer's interest to assist with the supplier's financing to reduce the supplier's discount rate, since by doing so, the supplier increases his discounted value of the deferred payment.

However, in the complementary or independent case, an initial-payment-only option is offered by the buyer, because the deferred payment is not effective in screening the supplier's type as the high quality supplier can always imitate the low quality supplier. Therefore, we help to provide theoretical supports for the well-established pay-on-delivery arrangement in practice. Also, we provide theoretical supports to the common practice of ruling out the supplier type with low quality but high cost, since doing so greatly reduces the information rent (which is referred to as the profit the agent derives from having information not provided to the buyer) the buyer pays to other supplier types. Here, for exposition, we call this type *the least competent type*.

Additionally, we complement Babich and Tang (2012), who found that the buyer should adopt the deferred payment without any initial payment to motivate the supplier's high level of effort under moral hazard. Here, moral hazard refers to situations in which the product's quality depends upon the supplier's actions (e.g., putting forth high or low level of effort) that are unobservable to the buyer. Besides moral hazard, the second category of asymmetric information is adverse selection (Fudenberg & Tirole, 1991), in which the buyer cannot observe the product's quality. So, our work uncovers the fact that under adverse selection, the buyer should adopt the deferred payment for the high quality supplier only in the absence of the least competent supplier. Otherwise, the buyer should only use the initial payment. So, managers who want to take advantage of a deferred payment before deciding the exact payment scheme must know which kind of information asymmetry they are dealing with (moral hazard or adverse selection). If it is adverse selection, then as explored in our paper, the manager needs to understand the relationship between the supplier's quality level and its cost, i.e., whether the buyer is facing the substitutable, complementary or independent case.

As a primary theoretical contribution to the contract design literature under asymmetric information, we identify the buyer's key tradeoff in encountering the adverse selection issue: a payment later is discounted more by the supplier than an earlier payment (defined as *the valuation difference effect*). However, paying later rather than earlier makes the buyer more likely to screen the supplier's quality level simply because as time goes on, the lower quality product is more likely to fail (defined as *the screening effect*).

Furthermore, based on this tradeoff, we explore the effect of the rental contract on screening the supplier's private information. In terms of the buyer's profit, the instalment payment dominates the rental contract with a fixed rental rate mainly because of the valuation difference effect. Allowing the rental rate to be time dependent, the instalment payment is preferred by the buyer in the complete information and the independent cases, while for other cases, only when the supplier's financing cost is low enough (such as the supplier is not very small or does not have a restricted access to the financial market when compared with the buyer) or the quality difference among different supplier types is small, the rental contract dominates the instalment payment.[2]

The comparison of the instalment payment scheme and the rental contract under adverse selection fits with the case of procuring some medical equipment from an intermediary in China, especially when the inspection is destructive or time-consuming. More justification on this application is listed in Appendix. We find that when the supplier is large enough to have a deep pocket (or gets convenient and efficient access to the credit market), the rental contract is preferred by the buyer over the instalment payment. Hospitals in China usually deal with large suppliers, so our model predicts the popularity of the rental contract. Our prediction agrees with the practice, as the majority of MRI equipment is rented by the Chinese hospital.

Last but not least, to solve our multidimensional adverse selection is far more complicated than the conventional one-dimensional adverse selection problem, because the single crossing property (which is crucial for the existence of the separating equilibrium under one-dimensional adverse selection) does not hold in general. So, the techniques employed to draw up the buyer's optimal contract vary greatly among these three cases and can be applied to solve similar problems with instalment payment. That is our technical contribution.

The rest of the paper is organized as follows: Section 2 provides a brief literature review. Section 3 studies the basic model under complete information. Section 4 analyzes the buyer's contract design problem, while Section 5 presents a general payment as a continuous function of time including the rental contract. Section 6 gives a few concluding remarks. All proofs are given in the supplement. Throughout this paper, we use the terms *increasing* and *decreasing* in a weak sense unless otherwise noted.

2. Literature review

There are three streams of related research. The first is quality management research. The relationship between the quality level and the production cost comes from the state-of-the-art research on the learning curve. This includes the work of Fine (1986), Srinidhi and Balachandran (1996) and Lapré et al. (2000). They found that one firm can provide a high quality product at a low cost at the advanced stage of the learning curve. Under complete information, Lee, Rhee, and Cheng (2013) looked the coordination of a decentralized supply chain under revenue-sharing, buybacks contracts and quality compensation contracts given the supplier's quality uncertainty. Different from theirs, we are in a decentralized supply chain under asymmetric information.

[2] It is worth noting that our comparison between the instalment payment and the rental contract is from the operational perspective. In reality, several non-operational reasons limit the application of the rental contract. First, the purchased machine can be chosen as the mortgaged asset for applying loans; however, no rented machine can play such a role since it is not recognized as the buyer's asset. Second, sometimes buying a machinery can enjoy the tax deduction, e.g., the cut of purchase tax. Also, in the ever-increasing adoption of the value-added tax system, buying a machinery rather than renting one provides a reduced tax base. So, these non-operational factors favour buying the product instead of renting it. None of these factors is considered in our comparison because of our focused attention in the operations management field.

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