Second Sourcing vs. Sole Sourcing with Capacity Investment and Asymmetric Information

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We study the decision of a manufacturer (buyer), expecting new sourcing opportunities in the future, to select between a sole and a second sourcing mechanism for a non-commodity component. In a sole sourcing mechanism, the buyer commits to source from the current supplier. In a second sourcing mechanism, the buyer keeps the option open to source from a new supplier in the future. For a buyer that sources complex non-commodity inputs, this decision has to take into consideration supplier capacity investment, uncertain demand, supplier learning, and information asymmetry on the supply cost. Considering these factors, we compare sole and second sourcing mechanisms, and identify when a mechanism is preferred over the other. We find that (1) both a high and low capacity cost may benefit second sourcing (under the condition that the entrant’s cost is relatively low), (2) second sourcing is favored more when the buyer faces a higher level or more uncertainty of the future demand, and (3) second sourcing may result in over investment of the initial capacity.

1 Introduction

Focusing on core competences, companies are relying on external suppliers for activities with increasing complexity and strategic importance (Gottfredson et al., 2005; Maurer et al., 2004; Liker and Choi, 2004). In the automotive industry, suppliers provide not only small parts but increasingly complex subsystems such as exhaust systems, cockpits, front ends, and integrated seats. As the modularization of vehicles continues, OEMs will expect suppliers to deliver entire roof systems, integrated interiors, complete doors, and trunk lids (Maurer et al., 2004). A similar trend occurs in the electronics industry, where OEMs usually outsource most production or even entire system builds in order to focus on the functions of design and marketing (Barnes et al., 2000; Carbone, 2000).

Accompanying this trend of more complex sourcing activities are the dynamics of the supply market. On one hand, the development of supply bases in low cost countries brings new sourcing opportunities for OEMs, thanks to growing engineering and production capabilities and growth of the emerging economies in these areas (Balasubramanian and Padhi, 2005). On the other hand, faster development of new technology shortens the product life cycle and causes the emergence of new suppliers that embrace new technologies. As an example of supply base development, low quality

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of raw material and low productivity in developing countries had prevented more production in the automotive industry from going overseas. But as suppliers in China get more competitive in quality and cost, Ford was planning to double its purchasing of China-made parts, and DaimlerChrysler would increase the purchase of parts in China to more than $840 million in 2008 compared with $100 million in 2006 (Bloomberg News, 2006). As an example of technology development, Fujitsu Ltd. became a competitive newcomer to the electronics manufacturing industry by adopting advanced technologies that allow them to process silicon wafers that are 300mm in diameter with circuit lines as narrow as 90 nanometers. This motivated Lattice to migrate business from a Taiwanese supplier to Fujitsu (Einhorn, 2004).

Facing potential new supply opportunities in the future, a key question for a manufacturer is what relationship to build with a supplier, and we observe different choices made by companies in industry. Japanese companies are reputed for “keiretsu”, which features interlocking long-term relationships between companies. However, they also lamented the difficulties they had in breaking up existing relationships with suppliers (and switching to new suppliers) (Sako, 1992). On the contrary, GM actively moved away from partnership relationships with its suppliers. The average length of contracts GM offered fallen about 40 percent, from 1.8 years in 1989 to just over one year in 1993. GM also set up a system of worldwide competitive bidding, saving an estimated $4 billion per year in the prices it paid for parts between 1992 and 1994 (Fine et al., 1996).

Yet, recent years have witnessed a growing trend of companies consolidating their supply base and forming long-term relationships with their key suppliers (Maurer et al., 2004; Pyke and Johnson, 2003). For example, Chrysler’s average contract length nearly doubled over a ten-year period (Helper, 1991; Dyer, 1997). Ford planned to cut by more than half the number of suppliers from whom it buys 20 key parts by offering larger, long-term contracts on models built in 2008-2009 and beyond to a smaller group of suppliers (Mccracken, 2005). For Land Rover, more than 90 percent of components are bought from single suppliers (Lester, 2002).

In the electronics industry, most handset vendors rely on one main source for certain key components (while cueing up a second source for reliability and a quick ramp). But Apple has sourced its iPhone touchscreen display from four suppliers, who bid each time when Apple releases a factory order. By pitting suppliers against each other, Apple maintains the upper hand and keeps its costs low (Carson, 2007). As another example, Microsoft initially obtains some key components for its Xbox 360 game console systems from a single source, but they indicated that “we are under no obligation to exclusively source components from these vendors in the future.” (Microsoft Annual Report, 2005).
The diverse strategies followed by companies indicate that the supplier relationship choice for sourcing arrangements warrants further study. Based on the above observations, we identify several important characteristics that we believe should be captured in supplier relationship decisions:

**Capacity investment:** In order to provide complex customized products, a supplier is usually required to invest in specific capacity, such as workers with special skills, specific machines or tools, or facilities set up alongside the OEM’s site (Dyer, 2000). Capacity investment influences future supplier competition. While a new supplier may be more efficient than the incumbent supplier, the specific capacity investment, which is a sunk cost for the incumbent supplier, imposes extra cost for the new supplier. On the other hand, since the volume received by a supplier depends on the supplier relationship, the supplier relationship choice also leads to different capacity investment decision.

**Demand uncertainty:** Demand of a supplier that provides critical and customized components closely depends on, and hence is susceptible to, the variation of the final product demand. In the automotive industry, unstable and uncertain domestic volume is cited as one of the biggest challenges faced by manufacturers due to increased consumer choices (Andersson, 2006). The consumer electronics industry is notorious for risk stemming from short product life cycles and high demand uncertainty (Carbone, 2005). Demand uncertainty imposes additional difficulty on the capacity investment decision, which has to take into consideration the impact on utilization of capacity from not only supplier switching (in a second sourcing mechanism) but also variation of demand.

**Supplier learning:** Many production processes for complex components require steps that are not well defined at the beginning of the life cycle of the product. This leaves open room for a supplier to improve efficiency over time by further optimizing the production processes. In general, as OEMs shift more development and engineering work that requires complex tasks and customized products to their suppliers, it implies a significant potential for a supplier to accumulate knowledge and experience from learning, thus reducing costs over time (Monczka et al., 2005; Gray et al., 2005; Lewis and Yildirim, 2002).

**Information asymmetry:** Because the supplier tends to understand the technical processes better than the purchasing company, they are better positioned to identify areas of savings, for example, reducing the number of components by combining separate parts, applying near net shape fabrication techniques to reduce subsequent steps, changing part geometries and
increasing machining tolerances, alternating materials that can reduce cost of non-critical components, etc. (Ulrich and Eppinger, 2004). For technologically complex products, there is generally substantial private information about productivity or technologies due to uncertainty introduced by the innovative process (Lyon, 2006). With private information, the supplier could extract significantly more profits than otherwise possible. In fact, losing information on know-how and the supplier’s cost structure results in weaker bargaining power of the buyer and is one of the concerns of the risks of outsourcing. Due to this concern, Ford reclaimed more engineering responsibility for parts in order to regain core competencies and recapture the ability to judge the costs (AutoBeat Daily, 2002).

Before making the decision of selecting between long-term and short-term relationships, a buyer (manufacturer) needs to carefully design a sourcing mechanism and evaluate the profits of each relationship by considering the above factors. We study two sourcing mechanisms, sole sourcing and second sourcing, representing long-term and short-term relationships. In the sole sourcing mechanism, the buyer (manufacturer) commits the current and future demand volume to a single current supplier. In the second sourcing mechanism, the buyer commits only the current volume to the current supplier, but keeps the option open to source from another supplier in the future. Our goal in this paper is to understand when a mechanism is better for the buyer than the other.

In order to understand fundamental economic determinants of the sourcing mechanism selection, we analyze a model with a horizon of two periods. During the first period, only one supplier (the “incumbent”) is available. That supplier is then joined by a second potential supplier (the “entrant”) in the second period. The second period market demand is uncertain. Production capacity needs to be invested or expanded by suppliers. Through learning the incumbent enjoys cost reduction with its quantity unknown to the buyer, which allows her to earn rents in the second period. Under such circumstances we compare sole sourcing and second sourcing mechanisms and identify when one mechanism is preferred over the other. We will focus on the difference between the two mechanisms resulting from the internal decisions made by the buyer and suppliers in response to the relationship choice. The external factors, such as the extra cost of dealing with multiple suppliers in a second sourcing mechanism, are neglected, but could be added on top of our model without changing the internal mechanics.

We show that both the incumbent’s private information about his cost reduction through learning and demand uncertainty play an important role in the result of relationship selection. If the buyer has complete information of the incumbent’s cost, second sourcing is always better than sole
sourcing. But when the incumbent holds private information on her cost, sole sourcing may be better than second sourcing because it induces the supplier to accept a lower price at the beginning (Riordan and Sappington, 1989). Demand uncertainty influences how the buyer sources from the two suppliers in a second sourcing mechanism. If the demand is certain (and identical) in both periods, the buyer will source exclusively from the incumbent or the entrant. But if the future demand is uncertain, depending on the comparison of the suppliers’ capacity cost and production cost, the buyer may source from both suppliers, in which case the demand beyond the incumbent’s installed capacity will be allocated to the entrant. The two situations where the entrant serves as an exclusive or complementary supplier provide different value to the buyer.

If the entrant’s cost is relatively low, then second sourcing may be better than sole sourcing, depending on the capacity cost. We reveal an unintuitive result with respect to the impact of capacity cost on relationship selection: In the absence of demand uncertainty, second sourcing is preferred only when the capacity cost is low; but in the presence of demand uncertainty, second sourcing also becomes optimal when the capacity cost is high – in that case, the entrant should not replace the incumbent but be used as a supplemental supplier that provides the overflow demand beyond the incumbent’s capacity.

We show that more uncertainty of the future demand increases the favorability of second sourcing. This result is established by considering strategic suppliers with private information. In the operations literature, sourcing from multiple suppliers has shown to be an effective solution to mitigate supply and demand risk when it is difficult to respond to the change of supply or demand by quickly modifying capacity or delivery. In this paper, we provide another explanation for the value of second sourcing in a volatile environment.

If sole sourcing is credible, as we assume in our model, over-investment of the initial capacity will not occur in the optimal sourcing mechanism choice. But if a sole sourcing commitment is not credible and only second sourcing is feasible, our analysis shows that the supplier may be induced to invest in excess capacity at the beginning of the horizon. This is because capacity investment of the incumbent can be used as a leverage to influence supplier competition and the buyer’s ability to extract rent from the incumbent supplier.

2 Literature review

That is a body of literature in economics and operations management that provide us with theory and insights in procurement. We refer readers to Elmaghraby (2000) for a general overview of the
literature and to Laffont and Tirole (1993) for theories of procurement. In the rest of this section, our review focuses on the papers that consider multi-period supplier selection.

Papers in the economics literature focus on information structure. They consider private information of suppliers and assume single unit demand. The private cost of a supplier can be influenced by active investment or exogenous learning. These papers examine how the buyer should design the sourcing mechanism by leveraging supplier competition to reveal private information and reduce information rent.

In a multi-period setting, second sourcing or multiple suppliers may be adopted earlier or later in the time horizon. Deng and Elmaghraby (2005), Dasgupta (1990), Riordan (1996), Lewis and Yildirim (2002) and Klotz and Chatterjee (1995) focus on why multiple suppliers, who compete for an exclusive contract later, should be adopted at the beginning. The benefit in the future from investing in or sourcing from multiple suppliers at the beginning can be better information on suppliers’ quality (Deng and Elmaghraby (2005)) or bidding parity between suppliers. The bidding parity can be caused by suppliers investing to reduce the costs (Dasgupta, 1990; Riordan, 1996) or endogenous learning (Klotz and Chatterjee, 1995; Lewis and Yildirim, 2002). In our paper, we focus on whether new competing suppliers should be introduced later following a single sourcing stage. In this situation, the supplier competition influences the proceeding decision of the buyer and supplier on contract negotiation or investment.

A stream of papers in economics study the situation in which an incumbent supplier faces the competition from an entrant in the second stage, i.e., supplier competition is introduced later in the horizon. These papers are motivated by the defense industry and usually consider the incumbent learning or investing in R&D (cost-reduction) effort in the first stage. Anton and Yao (1987) and Rob (1986) analyze how to allocate demand between the two stages when the volume allocation influences the supplier’s learning-by-doing (Anton and Yao, 1987) or incentive of investment (Rob, 1986). Considering supplier investment, Stole (1994) and Laffont and Tirole (1988) study the supplier switching decision and its impact on the investment incentive of the incumbent, assuming the buyer pre-commit to the second period mechanism. All these papers assume that second sourcing is always an option, while in this paper we analyze whether a buyer should make himself open to the second sourcing option.

Elmaghraby and Oh (2004) and Riordan and Sappington (1989) are two papers closely related to ours, with specific comparison between sole sourcing and second sourcing mechanisms. Considering suppliers’ learning-by-doing, Elmaghraby and Oh (2004) compare the buyer’s profits from auctioning off a long-term contract with an eroding price and from conducting sequential indepen-
dent auctions. The former mechanism exhibits the feature of a long-term relationship and the latter is essentially a short-term relationship. They find that the latter mechanism often leads to more profits for the buyer. Alternatively, we show that sole sourcing is better than second sourcing under certain conditions (even in the reduced unit demand situation as in their model). The difference of the results may be related to the different auction mechanisms used (besides the slight difference on the sourcing mechanisms and information structure): Elmaghraby and Oh (2004) are based on the second price auction mechanism, while we take an optimal mechanism approach. With an optimal mechanism design approach, our analytical results are the optimal that can be achieved by the buyer, independent of the specific auction format used in the implementation (Myerson, 1981). Besides the difference of the mechanisms used, we also differ in that we consider uncertain demand with capacity investment decision, while they assume single unit demand. Thus, we are able to reveal the impact of demand uncertainty and capacity cost on relationship selection, which is not considered in their paper.

Riordan and Sappington (1989) argues that compared to sole sourcing, second sourcing is of limited value. Compared to Riordan and Sappington (1989), although our model is driven by the same basic reason for sole sourcing, i.e., more power to extract future information rent, we consider a different situation which is motivated by manufacturing applications concerning uncertain demand and capacity investment. This leads to new results driven by product demand uncertainty and capacity investment.

All the papers mentioned above assume that the buyer has single unit demand, and supplier investment, if considered, influences the supplier’s unit cost. We consider uncertain demand, which makes investment of capacity relevant. Taylor and Plambeck (2007) analyze repeated interaction between a single buyer and supplier, but do not consider asymmetric information and the availability of a second supplier. Considering a second supplier, a stream of literature in operations study dual sourcing without concerning private information or dynamic interaction with suppliers. In these papers, sourcing from a second supplier allows the buyer to mitigate supply or demand risk because the primary (cheap) supplier has finite capacity (e.g., Tomlin, 2006) or requires long lead time for inventory replenishment (e.g., Veeraraghavan and Scheller-Wolf, 2006). In this paper we show that second sourcing is more valuable when the buyer faces more demand uncertainty, a result that is consistent to the insights from that literature but based on a different reason.

Cachon and Zhang (2007) examine demand allocation in a multi-sourcing mechanism, assuming complete information of suppliers’ costs. Cachon and Zhang (2006) study single sourcing mechanisms of a buyer with incomplete information about a supplier’s cost. In both papers, the buyer
and suppliers interact only once to award the contract. The supply capacity and contract are
driven by the competition between simultaneously existing suppliers. Here we consider a dynamic
environment in which a supplier may face competition from suppliers that appear in the future.
We therefore focus on inter-temporal links between different sourcing periods. We investigate how
the buyer and supplier behave strategically based on forward and backward considerations.

Swinney and Netessine (2007) study a buyer's choice between long-term and short-term con-
tracts offered to a supplier, considering the supplier default risk. Assuming public information they
show that the possibility of supplier default offers a reason for a buyer to prefer long-term contracts
to short-term contracts. Our model considers private information of a supplier and is driven by a
different reason for sole sourcing (long-term contracts).

Finally, Gray et al. (2005) study the effect of negotiation power and learning on the dynamic
make-or-buy decision of a buyer. The cost reduction achieved by the supplier through learning
is public information. We consider cost reduction of the supplier as private information. In our
model, the buyer dominates in the relationship by leading the negotiation. Instead of focusing on
the make-or-buy decision, we assume producing-in-house is not an option and study how the buyer
should “buy” over multiple (two) periods from multiple suppliers. Besides the production cost,
which composes the variable cost and reduces overtime due to learning, we also consider capacity
cost as an important factor in the sourcing decision.

3 The Model

In the first subsection, we describe the key elements of the model. In the second subsection, we
formulate the optimal design of sole and second sourcing mechanisms. In the next section, we
analyze and compare these two mechanisms.

3.1 Model Description

The final product: A downstream firm (the “buyer”) has exclusive access to a final product
market that lasts for two periods; \( t \in \{1, 2\} \). In each period, the firm sells the product at a unit
price \( r \) and knows the demand in that period. However, due to the long duration of a period (for
example, a contract in the automotive industry typically lasts for a few years), the buyer in the first
period does not know the demand in the second period, i.e., the second period demand remains
uncertain until the beginning of the second period. To this end, let the first period demand be \( x_1 \),
and the second period demand \( X_2 \) drawn from a probability distribution \( G(\cdot) \) (density \( g(\cdot) \)) with
mean \( x_2 \). Define \( S(Q) = \mathbb{E}[\min(X_2, Q)] \) as the expected demand covered by capacity \( Q \) in the
second period. Production of the final product requires an essential input that the buyer sources from an external supplier. The in-house cost of the other inputs of the firm is normalized to zero.

**The capacity investment:** A supplier has to invest in capacity in order to produce inputs for the buyer. The capacity limits the quantity that the supplier can produce in a period. The capacity is acquired from a competitive market at a constant cost of $k$ per unit. This cost does not only include the purchasing cost but also may factor in the installation cost and salvage value. Therefore, the capacity cost may be considered higher for inputs with a lower level of standardization or higher degree of supplier-buying interdependence. We assume existing capacity can be expanded at the same unit cost, and the value of unused capacity in the outside market is normalized to zero. We assume the leadtime of capacity investment is negligible compared to the length of a horizon, and hence in each period capacity is invested after demand is realized. Nevertheless, capacity investment is still not a trivial decision: The supplier’s capacity invested in the first period influences her cost of satisfying demand and the result of supplier competition in the second period. Therefore, the first period investment has to take into consideration the uncertainty of supplier competition and demand in the second period. In addition, we assume capacity is contractible, i.e., buyer and supplier can write down a court-enforceable agreement on the amount of capacity to install. In Section 7 we relax this assumption by considering the situation when the capacity cannot be specified by the buyer. This is reasonable when capacity can be observed and verified. In fact, in the automotive industry the OEM often has control over specific capital investment (Dyer, 1997), or is given the opportunity to audit the amount spent by the supplier on capital investment used exclusively for the OEM and reimburses that cost (Visteon, 2003). Since the buyer and suppliers are risk-neutral, without loss of generality we assume the buyer pays the supplier the capacity cost separately from the unit price for the input.

**The upstream market:** Only a limited set of suppliers have the capability to use the capacity to produce the essential input for the buyer. To capture that over time new suppliers become available, we consider in period 1 one supplier (to whom we refer to as the “incumbent”) and in period 2 two suppliers (the incumbent from period one and a new “entrant”).

**The supplier capability:** The suppliers differ on their unit costs to produce the input for the buyer. In addition, the supplier cost may decrease over time due to learning. We assume this cost reduction is exogenously given and achieved as a result of experience. While it is possible that the buyer or supplier may make learning endogenous through the design of purchasing volume or investing in cost reduction efforts, exogenous learning is also commonly observed in practice and widely considered in the literature (see Yelle (1979) for a review and Section 2 for procurement
papers considering exogenous learning). In Section 7 we extend the analysis to endogenous learning when the supplier invests in cost reduction efforts or the buyer influences supplier learning through the purchasing volume. Let the unit cost of the incumbent be $c$ in period one, and $c_I = c - a$ in period two, where $a \in (0, c)$ captures the learning effect. The unit cost of the entrant in period two is $c_E$. As the incumbent’s cost reduction achieved through learning is uncertain, $c_I$ follows a distribution $F_I(\cdot)$ (density $f_I(\cdot)$). The entrant’s cost realization in the second period is unknown in the first period. It follows a distribution $F_E(\cdot)$ (density $f_E(\cdot)$) with an upper bound $\tau_E$.

**Information structure:** The initial cost of a supplier, $c$ for the incumbent and $c_E$ for the entrant, is common knowledge. This can be interpreted as that before establishing a relationship with a supplier, the buyer can evaluate the supplier’s cost by investigating the supplier’s material and labor costs, financial status, etc., which is publicly available. However, the buyer does not have complete information about how much cost reduction a supplier has achieved after the supplier has proceeded on the learning curve; the supplier’s improvement measures such as improved worker efficiency, reengineered production processes, reduced defective rates, etc., are unobservable for the buyer. Therefore, the incumbent’s second period cost $c_I$ is private information of the incumbent. Although in reality $c$ and $c_E$ can be private information as well, we can interpret this information structure as that learning adds further uncertainty on the supplier cost, and this information asymmetry plays an important role in the supplier relationship decision. In Section 7 we relax this assumption by incorporating private information on $c$ and $c_E$. Players know the probability distributions $F_I(\cdot)$ and $F_E(\cdot)$ from which $c_I$ and $c_E$ are drawn. In line with the mechanism design literature, we assume that $F_I(\cdot)$ is log-concave; i.e., $F_I(\cdot)/f_I(\cdot)$ is an increasing function. This condition is satisfied by a wide variety of commonly used distributions, including uniform and normal, and with some restrictions including beta, gamma and Weibull (Rosling, 2002; Bagnoli and Bergstrom, 2005).

**Sourcing mechanisms:** The buyer can commit sourcing from the incumbent supplier only over two periods. We refer to this mechanism as “sole sourcing”. The commitment of sole sourcing can be implemented by a high penalty fee charged to the buyer if the commitment is breached. Without such commitment, the buyer may source a fraction, or all of its needs from the entrant in the second period, depending on the realization of suppliers’ second period costs. We refer to this mechanism as “second sourcing”. We assume the entrant is guaranteed to appear in the second period of a second sourcing mechanism. The case that the entrant does not appear can be captured by having the entrant’s cost very high, which reduces second sourcing to sole sourcing.
3.2 Model Formulation

The sequences of events in sole sourcing and second sourcing are demonstrated in Figure 1.

![Figure 1: Sequences of events in sole sourcing and second sourcing.](image)

In notations, we use subscript $t = 1, 2$ indicating notations for period $t$, and “I” for Incumbent, “E” for Entrant. In each period, a supplier’s contract specifies the supplier’s capacity and the price the buyer has to pay for each unit that is ordered and produced. The buyer is the Stackelberg leader in the contracting mechanism by offering the supplier(s) a take-it-or-leave-it contract or a menu of contracts to select from. A supplier will select the best contract that generates him a non-negative profit.

**Sole sourcing mechanism:** The sequence of events in sole sourcing is described in Figure 1, upper part. In the first period of sole sourcing, the buyer offers a take-it-or-leave-it contract to the supplier. In the second period, the contract is renegotiated and the capacity may be expanded. We start with formulating the contracting problem in the second period.

In the second period, the contracting mechanism is implemented by a menu of contracts, each of which corresponds to a value of the supplier cost, given the first period capacity investment $Q_1$ and the second period demand $X_2$. For simplicity of exposition, in notations we suppress the dependency of the menu of contracts and the supplier’s second period profit on $Q_1$ and $X_2$. Denote by $T_2 = (Q_2, p_2)$ a second period contract of the supplier, where $Q_2$ is the supplier’s capacity and $p_2$ is the unit price paid by the buyer. As the capacity is specific, and hence once invested cannot be sold to other buyers, the second period capacity can only be higher than in the first period, $Q_2 \geq Q_1$. The menu of contracts provided by the buyer can be specified by $\{T_2 (c_I) : c_I \in [c - a, c]\}$. If the supplier’s production cost is $c_I$, then reporting a cost $\hat{c}_I$ results in profits for the supplier in
the second period:

$$\hat{\Pi}_2^I (\hat{c}_I, c_I) = (p_2 (\hat{c}_I) - c_I) \min (X_2, Q_2 (\hat{c}_I)) - k (Q_2 (\hat{c}_I) - Q_1).$$  \hspace{1cm} (1)$$

The first term is the payment received by the supplier from the buyer with the buyer ordering $X_2$ and the supplier producing up to $Q_2 (\hat{c}_I)$. The second term is the investment cost for the expanded capacity.

Based on the revelation principle (Myerson, 1981), it is optimal for the buyer to focus on contracts that are (1) incentive compatible (ICI); i.e., the supplier reports his true cost, $c_I$, in order to maximize his own profit, and (2) individual rational (IRI); i.e., the expected profit of the supplier from participation, irrespective of his cost, is non-negative. Given $Q_1$ and $X_2$, let $\Pi_2^I (c_I) = \hat{\Pi}_2^I (c_I, c_I)$ be the supplier’s expected profits when he reports truthfully. The optimal mechanism design in the second period can be formulated as:

$$\Pi_2 (Q_1, X_2) = \max_{T_2 (\cdot)} \mathbb{E}_{c_I} [(r - p_2 (c_I)) \min (X_2, Q_2 (c_I))]$$

s.t. $\forall c_I \in [c - a, c]: \begin{cases} \Pi_2^I (c_I) = \max_{\hat{c}_I} \hat{\Pi}_2^I (\hat{c}_I, c_I) \text{ (ICI)} \\ \Pi_2^I (c_I) \geq 0 \text{ (IRI)} \end{cases}$

In the first period, given a contract with capacity $Q_1$ and unit price $p_1$, the supplier’s profit is:

$$\Pi_1^I (Q_1, p_1) = (p_1 - c) \min (x_1, Q_1) - kQ_1,$$  \hspace{1cm} (2)$$

where the first term is the payment received minus the production cost in the first period, and the second term is the capacity investment cost. Taking the second period mechanism as an embedded decision, the first period decision problem for the buyer is then:

**SOLE SOURCING**: $\max_{Q_1, p_1} (r - p_1) \min (x_1, Q_1) + \mathbb{E}_{X_2} [\Pi_2 (Q_1, X_2)]$

s.t. $\Pi_1^I (Q_1, p_1) + \mathbb{E}_{c_I, X_2} [\Pi_2^I (c_I | Q_1, X_2)] \geq 0$ (IR)

The buyer is constrained by guaranteeing the supplier non-negative expected profits over the two periods (IR). From now on, we use the subscript “L” to represent variables for sole sourcing mechanisms.

**Second sourcing mechanism**: The sequence of events in second sourcing is described in Figure 1, bottom part. Contracting in the first period of second sourcing is the same as in the sole sourcing mechanism: The buyer offers a take-it-or-leave-it contract $(Q_1, p_1)$ to the supplier.

In the second period, the decisions are contingent on the second period demand, $X_2 \geq 0$, the incumbent’s installed capacity, $Q_1 \geq 0$, and the cost of the entrant $c_E$. For simplicity of
exposition, in notations we also suppress the dependency of the mechanism and suppliers’ profits in the second period on \(X_2, Q_1\) and \(c_E\). In addition to contracting the capacity and price with a supplier, the buyer also has to specify the demand allocation rule between the incumbent and entrant. This rule determines, given the realization of the second period demand, the demand volumes that will be allocated to the incumbent and entrant. The contract of the incumbent is thus a combination of the capacity \(Q_I^2 \geq Q_1\), unit price \(p_I^2\), and the demand volume \(y_I^2 \leq Q_I^2\); denote by \(T_I^2 = (Q_I^2, p_I^2, y_I^2)\) the incumbent’s contract. Similarly, the contract of the entrant is a combination of the capacity \(Q_E^2 \geq 0\), unit price \(p_E^2\), and the demand volume \(y_E \leq Q_E^2\); denote by \(T_E^2 = (Q_E^2, p_E^2, y_E)\) the entrant’s contract. The contracts awarded depend on the cost reported by the incumbent. Thus, the buyer offers a menu of contracts \(\{T_I^2(c_I) : c_I \in [c - a, c]\}\) to the incumbent, and \(\{T_E^2(c_I) : c_I \in [c - a, c]\}\) to the entrant. If the incumbent reports a cost \(\hat{c}_I\), then contracts \(T_I^2(\hat{c}_I)\) and \(T_E^2(\hat{c}_I)\) are offered to the incumbent and entrant, respectively. When the incumbent’s cost is \(c_I\), then, by reporting a cost \(\hat{c}_I\), the incumbent receives profits:

\[
\hat{\Pi}_I^2(\hat{c}_I, c_I) = (p_I^2(\hat{c}_I) - c_I) y_I^2(\hat{c}_I) - k(Q_I^2(\hat{c}_I) - Q_1),
\]

and it results in the entrant’s expected profits:

\[
\hat{\Pi}_E^2(\hat{c}_I, c_I) = (p_E^2(\hat{c}_I) - c_E) y_E(\hat{c}_I) - kQ_E^2(\hat{c}_I).
\]

Let \(\Pi_I^2(c_I) = \hat{\Pi}_I^2(c_I, c_I)\) and \(\Pi_E^2(c_I) = \hat{\Pi}_E^2(c_I, c_I)\) be the incumbent’s and entrant’s expected profits when the incumbent reports truthfully.

Similarly as in the sole sourcing mechanism, the menu of contracts is incentive compatible (ICI) and individual rational (IRI) for the incumbent. As the entrant’s cost is known to the buyer, it only needs to satisfy the individual rationality constraint (IRE) for the entrant. Therefore, the optimal mechanism design in the second period can be formulated as:

\[
\Pi_2(Q_1, X_2, c_E) = \max_{T_I^2(), T_E^2()} \mathbb{E}_{c_I} \left[ r \min (X_2, y_I^2(c_I) + y_E^2(c_I)) - p_I^2(c_I) y_I^2(c_I) - p_E^2(c_I) y_E^2(c_I) \right] \\
\text{s.t. } \forall c_I \in [c - a, c]: \begin{cases} 
\Pi_I^2(c_I) = \max_{c_I} \hat{\Pi}_I^2(\hat{c}_I, c_I) & \text{(ICI)} \\
\Pi_I^2(c_I) \geq 0 & \text{(IRI)} \\
\Pi_E^2(c_I) \geq 0 & \text{(IRE)} 
\end{cases}
\]

Taking the second period mechanism as an embedded decision, the first period decision problem for the buyer is:

SECONd SOURCING : \[
\max_{Q_1, p_1} (r - p_1) \min (x_1, Q_1) + \mathbb{E}_{X_2, c_E} [\Pi_2(Q_1, X_2, c_E)] \\
\text{s.t. } \Pi_I^1(Q_1, p_1) + \mathbb{E}_{c_I, X_2, c_E} [\Pi_I^2(c_I) | Q_1, X_2, c_E] \geq 0 \text{ (IR)} ,
\]

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Table 1: Summary of notations

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r$</td>
<td>the buyer’s revenue per unit</td>
</tr>
<tr>
<td>$c$</td>
<td>the incumbent’s first period cost</td>
</tr>
<tr>
<td>$a$</td>
<td>cost reduction of the incumbent</td>
</tr>
<tr>
<td>$k$</td>
<td>capacity investment cost per unit</td>
</tr>
<tr>
<td>$c_I$</td>
<td>the incumbent’s second period cost</td>
</tr>
<tr>
<td>$c_E$</td>
<td>the entrant’s second period cost</td>
</tr>
<tr>
<td>$\overline{c_E}$</td>
<td>upper bound of $c_E$</td>
</tr>
<tr>
<td>$f_I$</td>
<td>probability density of $c_I$</td>
</tr>
<tr>
<td>$F_I$</td>
<td>cumulative probability of $c_I$</td>
</tr>
<tr>
<td>$J(c_I)$</td>
<td>$= c_I + F_I(c_I)/f_I(c_I)$, the incumbent’s virtual cost</td>
</tr>
<tr>
<td>$f_E$</td>
<td>probability density of $c_E$</td>
</tr>
<tr>
<td>$F_E$</td>
<td>cumulative probability of $c_E$</td>
</tr>
<tr>
<td>$x_1$</td>
<td>the first period demand</td>
</tr>
<tr>
<td>$x_2$</td>
<td>the mean of the second period demand</td>
</tr>
<tr>
<td>$X_2$</td>
<td>the second period demand</td>
</tr>
<tr>
<td>$G$</td>
<td>cumulative probability of $X_2$</td>
</tr>
<tr>
<td>$g$</td>
<td>probability density of $X_2$</td>
</tr>
<tr>
<td>$S(Q)$</td>
<td>$= \mathbb{E}[\min{X_2, Q}]$, expected demand covered by capacity $Q$ in the second period</td>
</tr>
<tr>
<td>$\Pi_{L,t}^I(\Pi_{L,t})$</td>
<td>the buyer’s optimal profit in period $t$ of sole sourcing with (in)complete information on $c_I$; $\Pi_{L}^I = \Pi_{L,1}^I + \Pi_{L,2}^I$</td>
</tr>
<tr>
<td>$\Pi_{S,t}^* (\Pi_{S,t})$</td>
<td>the buyer’s optimal profit in period $t$ of second sourcing with (in)complete information on $c_I$; $\Pi_{S}^* = \Pi_{S,1}^* + \Pi_{S,2}^*$</td>
</tr>
<tr>
<td>$Q_{L}^* (Q_{L})$</td>
<td>the optimal capacity in the first period of sole sourcing with (in)complete information on $c_I$</td>
</tr>
<tr>
<td>$Q_{S}^* (Q_{S})$</td>
<td>the optimal capacity in the first period of second sourcing with (in)complete information on $c_I$</td>
</tr>
<tr>
<td>$O$</td>
<td>option value of second sourcing</td>
</tr>
<tr>
<td>$A$</td>
<td>allocation inefficiency cost of second sourcing</td>
</tr>
<tr>
<td>$M$</td>
<td>marginal benefit of second sourcing</td>
</tr>
</tbody>
</table>

where $\Pi_{I}^I (Q_1, p_1)$ is formulated in (2). The buyer is constrained by guaranteeing the supplier non-negative expected profits over the two periods (IR). From now on, we use subscript “S” to represent variables for second sourcing mechanisms.

We have provided the formulation of the optimal mechanism design problem for sole and second sourcing, when the incumbent holds private information of his cost in the second period. The similar formulation can be applied to the situation when the buyer has complete information; i.e., the incumbent’s second period cost is also known to the buyer. The only difference is that with complete information, the incentive compatibility constraint is not relevant anymore.

Table 1 summarizes the main notations used in the paper.
4 Benchmark: Complete Information

In this section, we analyze a benchmark situation where the buyer has complete information of the incumbent’s cost in the second period. The optimal result of sole sourcing is summarized in Lemma 1.

**Lemma 1** If \( r > c + k \), the buyer’s expected profits from an optimal sole sourcing mechanism is

\[
\Pi^*_L (Q^*_L) = \Pi^*_L,2 (Q^*_L) + \Pi^*_L,1 (Q^*_L), \quad \text{where} \quad Q^*_L = x_1, \quad \text{and}
\]

\[
\Pi^*_L,2 (Q) = (r - \mathbb{E}[c_I]) x_2 - k (x_2 - S(Q)), \quad (5)
\]

\[
\Pi^*_L,1 (Q) = (r - c) \min (x_1, Q) - kQ, \quad (6)
\]

are the buyer’s profits in the second and first periods with the first period capacity investment equal to \( Q \).

The assumption \( r > c + k \) ensures that it is always profitable to source from the incumbent in each period. If capacity \( Q \) is installed in the first period, then the expected capacity expansion in the second period is \( x_2 - S(Q) \) (see Equation (5)). In the optimal solution the first period capacity investment \( Q^*_L \) exactly covers the first period demand \( x_1 \); it is not profitable to over invest because the capacity can always be expanded if the second period demand turns out higher than \( x_1 \).

The next lemma summarizes the optimal result in second sourcing.

**Lemma 2** If \( r > \max (c, \bar{c}_E) + k \), the buyer’s expected profit from an optimal second sourcing mechanism is

\[
\Pi^*_S (Q^*_S) = \Pi^*_S,2 (Q^*_S) + \Pi^*_S,1 (Q^*_S), \quad \text{where} \quad Q^*_S = x_1, \quad \text{and}
\]

\[
\Pi^*_S,2 (Q) = r x_2 - S(Q) (\mathbb{E}[c_E + k|c_E + k < c_I] \Pr (c_E + k < c_I) + \mathbb{E}[c_I|c_E + k \geq c_I] \Pr (c_E + k \geq c_I))
\]

\[
- (x_2 - S(Q)) (\mathbb{E}[c_E + k|c_E < c_I] \Pr (c_E < c_I) + \mathbb{E}[c_I + k|c_E \geq c_I] \Pr (c_E \geq c_I)), \quad (7)
\]

\[
\Pi^*_S,1 (Q) = (r - c) \min (x_1, Q) - kQ, \quad (8)
\]

are the buyer’s profits in the second and first periods with the first period capacity investment equal to \( Q \).

Besides \( r > c + k \) (see Lemma 1), we also assume \( r > \bar{c}_E + k \) so that it is always profitable for the buyer to source from the entrant as well. (If such condition is not satisfied, then all entrant costs higher than \( r - k \) will be cut off, resulting in an effective upper bound of the entrant’s cost equal to \( r - k \).)
In the second period of a second sourcing mechanism, the incumbent and entrant compete for the volume. A key question is: Based on what criteria should the demand allocation between the two suppliers be decided? For the demand volumes covered by the incumbent’s installed capacity (covered demand, volume \( \min (X_2, Q) \), expectation \( S(Q) \)), the incumbent incurs the production cost \( c_I \), while the entrant incurs the production cost plus the cost for new capacity, \( c_E + k \). Therefore, the covered demand is allocated to the entrant if and only if \( c_E + k \leq c_I \). As the capacity cost is incurred only to the entrant but not to the incumbent, in this competition for covered demand the incumbent has a first mover capacity cost advantage equal to \( k \) due to the existing capacity.

For the demand excessive of the incumbent’s installed capacity (excessive demand, volume \( (X_2 - Q)^+ \), expectation \( x_2 - S(Q) \)), both the incumbent and entrant incur production cost and the cost for new capacity. As the cost of capacity \( k \) is the same for both suppliers, the incumbent does not have the first mover capacity cost advantage over the entrant in the competition for the excessive demand (as for the covered demand), and the allocation of the excessive demand only depends on comparing the unit production costs. As a result, the excessive demand is allocated to the entrant if and only if \( c_E \leq c_I \).

Since the excessive and covered demand are allocated based on different cost criteria, the buyer may simultaneously source from both the incumbent and entrant suppliers in the second period. This is the case when the buyer sources the excessive demand from the entrant and the covered demand from the incumbent. The demand allocation in the second period with complete information is summarized in Table 2.

\[
\begin{array}{|c|c|c|c|}
\hline
\text{Demand volume} & c_E < c_I - k & c_I - k \leq c_E < c_I & c_I \leq c_E \\
\hline
\text{Incumbent} & 0 & \min (X_2, Q) & X_2 \\
\hline
\text{Entrant} & X_2 & (X_2 - Q)^+ & 0 \\
\hline
\end{array}
\]

Similar to sole sourcing, the optimal capacity in the first period of second sourcing \( Q^*_S \) exactly matches the first period demand \( x_1 \). Over investment is costly not only because the second period demand is uncertain but also because the incumbent may receive zero demand from the buyer in the second period.

Based on Lemmas 1 and 2, it is easy to conclude that with complete information, second sourcing can only generate more profits for the buyer than sole sourcing.

\textbf{Proposition 1} \( \Pi^*_S \geq \Pi^*_L \).
The intuition for Proposition 1 is that with complete information, sole sourcing can be regarded as a special case of second sourcing in which the buyer never sources from the entrant. In the next section, we analyze and compare the two mechanisms with incomplete information, which may lead to sole sourcing strictly preferred to second sourcing.

5 Optimal Sourcing Mechanisms with Incomplete Information

5.1 Optimal sole sourcing mechanism

Define \( J(c_I) = c_I + F_I(c_I)/f_I(c_I) \). Lemma 3 characterizes the buyer’s optimal profit from sole sourcing with incomplete information.

**Lemma 3** If \( r > k + J(c) \), then the buyer’s profit in the sole sourcing mechanism is \( \Pi_L(Q_L) = \Pi_{L,2}(Q_L) + \Pi_{L,1}(Q_L) \), where \( Q_L = x_1 \) and

\[
\Pi_{L,2}(Q) = (r - \mathbb{E}[J(c_I)])x_2 - k(x_2 - S(Q)), \tag{9}
\]

\[
\Pi_{L,1}(Q) = (r - c) \min(x_1, Q) - kQ + x_2 \mathbb{E}[J(c_I) - c_I]. \tag{10}
\]

are the buyer’s profits in the second and first periods given the first period capacity \( Q \).

As the buyer does not have complete information about the supplier’s second period cost, the supplier receives positive rents (profits) in the second period; for the buyer the *ex ante* cost of the supplier is \( \mathbb{E}[J(c_I)] \) (Equation (9)). \( J(c_I) \), referred to as *virtual cost*, is greater than the actual cost \( c_I \). With the assumption of \( F_I(\cdot) \) log-concave, \( J(c_I) \) increases with \( c_I \). In Lemma 3 and hereafter, the condition \( r > k + J(c) \) assures that it is always profitable for the buyer to source from the incumbent rather than leaving demand unsatisfied in each period, even without knowing the incumbent’s actual cost.

The buyer will offer a price in the first period that makes the incumbent indifferent to accepting or rejecting the contract. In the first period, the supplier can accept a contract with the price even lower than the cost, with the knowledge that positive rents will be earned in the second period. This is called *buy-in*, or *low-balling* (Whang, 1995; DeAngelo, 1981; Anton and Yao, 1987; Klotz and Chatterjee, 1995) by the supplier. Expecting low-balling by the supplier, the buyer can design a contract in the first period that captures the supplier’s rent in the second period (see Equation (10)). The buyer thus acquires all *ex ante* profits of the supply chain, even with private information of the supplier in the second period.
Gray et al. (2005) show that when the supplier dominates, the supplier may offer a price lower than the cost in the first period. This is because a low price induces outsourcing in the first period, which gains the supplier an advantage in the second period due to learning-by-doing. Although based on a different negotiation power structure, we show a similar result: The supplier may produce for the buyer at a loss in the first period. The basic reason for this result is also similar: The supplier gains positive profit in the second period and hence can accept a loss in the first period. But the source of the supplier’s second period profit is different in these two models: In their model, the supplier obtains profit because she dominates in the relationship. In our model, it is because the supplier has private information on her cost reduction, which can be regarded as a source of negotiation power even when the buyer leads in the negotiation.

5.2 Optimal second sourcing mechanism

In a second sourcing mechanism, the incumbent has to compete with the entrant in the second period. Besides \( r > k + J(c) \), we also assume \( r > k + \bar{\tau}_E \) so that it is always profitable for the buyer to source from the entrant as well. The buyer’s optimal profit from a second sourcing mechanism is summarized in Lemma 4.

Lemma 4 If \( r > k + \max(J(c), \bar{\tau}_E) \), then the buyer’s profit in the second sourcing mechanism is

\[
\Pi_S(Q_S) = \Pi_{S,2}(Q_S) + \Pi_{S,1}(Q_S), \quad \text{where } Q_S = \arg \max_Q (\Pi_{S,2}(Q) + \Pi_{S,1}(Q)),
\]

\[
\Pi_{S,2}(Q) = rx_2 - S(Q) \left( \frac{\mathbb{E}[c_E + k | c_E + k < J(c_I)] \Pr(c_E + k < J(c_I))}{\mathbb{E}[J(c_I) | c_E + k \geq J(c_I)] \Pr(c_E + k \geq J(c_I))} \right) - (x_2 - S(Q)) \left( \frac{\mathbb{E}[c_E + k | c_E < J(c_I)] \Pr(c_E < J(c_I))}{\mathbb{E}[J(c_I) + k | c_E \geq J(c_I)] \Pr(c_E \geq J(c_I))} \right),
\]

\[
\Pi_{S,1}(Q) = (r - c) \min(x_1, Q) - kQ + \left( S(Q) \mathbb{E}[J(c_I) - c_I | c_E + k \geq J(c_I)] \Pr(c_E + k \geq J(c_I)) + (x_2 - S(Q)) \mathbb{E}[J(c_I) - c_I | c_E \geq J(c_I)] \Pr(c_E \geq J(c_I)) \right).
\]

Incumbent’s 2nd period rent

are the buyer’s profits in the second and first periods given the first period capacity \( Q \).

With incomplete information, the demand allocation in the second period between the incumbent and entrant is based on a similar criterion as with complete information, except that it is the virtual production cost instead of the true cost of the incumbent that enters the cost comparison between the incumbent and entrant suppliers. In other words, the buyer will source all demand from the entrant if and only if \( c_E + k \leq J(c_I) \), and otherwise source the excessive demand from
Table 3: Demand allocation with incomplete information

<table>
<thead>
<tr>
<th>Demand volume</th>
<th>$c_E &lt; J(c_I) - k$</th>
<th>$J(c_I) - k \leq c_E &lt; J(c_I)$</th>
<th>$J(c_I) \leq c_E$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incumbent</td>
<td>0</td>
<td>$\min(X_2, Q)$</td>
<td>$X_2$</td>
</tr>
<tr>
<td>Entrant</td>
<td>$X_2$</td>
<td>$(X_2 - Q)^+$</td>
<td>0</td>
</tr>
</tbody>
</table>

the entrant if and only if $c_E \leq J(c_I)$. The demand allocation in the second period with incomplete information is summarized in Table 3. Comparing Table 3 with 2, as $J(c_I) > c_I$, we can see that with incomplete information the buyer is more inclined to source from the entrant. This over-allocation to the entrant causes *allocation inefficiency* in the second period.

In the second period, as demand may be allocated to the entrant, the incumbent assumes less volume and hence gains lower rent on expectation in second sourcing than sole sourcing. Despite a lower second period rent, low-balling of the incumbent still exists in second sourcing as in a sole sourcing mechanism. That is, the buyer can offer a contract in the first period that captures *ex ante* the incumbent’s rent in the second period (see Equation (12)). Therefore, with second sourcing the buyer also captures all *ex ante* supply chain profit.

Note that the optimal capacity in the first period $Q_S$ is not necessarily equal to the demand $x_1$. This will be further discussed in Section 6.3.

To summarize, the buyer’s optimal profits from sole and second sourcing mechanisms with $c_I$ as private information take the same form as with complete information, except that the actual cost $c_I$ is replaced by the virtual cost $J(c_I)$. Myerson (1981) shows that in the optimal auction for a single object the bidders should be only compared by their virtual values (counterpart of virtual cost in a selling auction) and the seller only loses the information rent. We deploy this result to a two period setting in which the first period contract negotiation and capacity investment depend on the optimal outcome in the second period. This allows us to compare sole and second sourcing mechanisms and study the supplier relationship decision. Therefore, our focus is not on optimal mechanism design (as in Myerson (1981)), but on supplier relationship selection which uses optimal mechanism design as an embedded solution.

Although in our model the incumbent receives negative profit in the first period due to low-balling and positive rent in the second period due to private information, this is not necessarily the only possible profit flow in an optimal result. Instead of pressing for a low price at the beginning, the buyer could demand price reduction in the future, which may leave positive profits in both periods for the supplier. For risk neutral players, the different flows can result in the same net profit for
the buyer and the supplier. In fact, price reduction is often required in the practice of long term sourcing (Monczka et al., 2005). No matter which flow is realized, the essential point is that by choosing whether to commit to a single supplier, the buyer has different powers in demanding a low price, whether now or in the future.

6 Comparison of sole and second sourcing mechanisms

Based on the optimal sole and second sourcing mechanisms characterized in Lemmas 3 and 4, we now compare the two mechanisms and analyze the impact of various factors on the selection of the mechanisms.

6.1 Tradeoff between sole sourcing and second sourcing

Define

\[ O(\kappa) = \mathbb{E}[c_I - c_E - \kappa | c_I \geq c_E + \kappa] \Pr (c_I \geq c_E + \kappa), \]

\[ A(\kappa) = \mathbb{E}[c_E + \kappa - c_I | c_I > c_E + \kappa \leq J(c_I)] \Pr (c_I < c_E + \kappa \leq J(c_I)), \]

and

\[ M(\kappa) = O(\kappa) - A(\kappa) = \mathbb{E}[c_I - c_E - \kappa | c_E + \kappa \leq J(c_I)] \Pr (c_E + \kappa \leq J(c_I)), \]

where \( \kappa = 0, k \). Based on Lemmas 3 and 4, Lemma 5 characterizes the buyer’s profit difference between sole and second sourcing mechanisms for the given first period capacity.

Lemma 5 If \( r > k + \max (J(c), \bar{c}_E) \), then \( \Pi_S(Q) - \Pi_L(Q) = S(Q) M(k) + (x_2 - S(Q)) M(0) \).

\( O(\kappa) \) is the option value, and \( A(\kappa) \) is the allocation inefficiency cost of second sourcing; \( \kappa > 0 \) implies that the incumbent has a first mover capacity cost advantage, reflecting to a capacity cost lower by \( \kappa \) per unit than that of the entrant. Recall from the discussion of Lemma 2 that the incumbent has a first mover capacity cost advantage equal to \( k \) for covered demand, but zero for excessive demand. The interpretation of \( O(\kappa) \) and \( A(\kappa) \) based on the covered demand \( (\kappa = k) \) is as follows: On one hand, when \( c_E + k \leq c_I \), the second sourcing option reduces the unit cost of sourcing from \( c_I \) to \( c_E + k \); a second sourcing strategy captures the option value \( O(k) \) of the alternative sourcing opportunity. On the other hand, when \( c_E + k > c_I \), sourcing the covered demand from the entrant (which happens when \( c_E + k \leq J(c_I) \)) is inefficient and increases the unit cost from \( c_I \) to \( c_E + k \); a second sourcing strategy incurs the allocation inefficiency cost \( A(k) \). Therefore, compared to second sourcing, a sole sourcing mechanism lets go the option value of an alternative source, along with the cost of allocation inefficiency. \( M(k) \), the difference between the option
value and the cost of allocation inefficiency, is the marginal benefit of second sourcing associated with the covered demand for which the incumbent has the first mover capacity cost advantage. As the expectation of covered demand is \( S(Q) \), the profit difference between the two mechanisms on the covered demand is \( S(Q)M(k) \). Similarly, \( M(0) \) is the marginal benefit of second sourcing associated with the excessive demand, which has mean \( x_2 - S(Q) \); the profit difference on the excessive demand is therefore \( (x_2 - S(Q))M(0) \). Lemma 5 suggests that the advantage of second sourcing not only depends on the tradeoff between the option value and allocation inefficiency cost, but also on the relative volume of covered and excessive demand due to different marginal benefits of second sourcing on the two parts of demand.

In order to further understand the profit difference between the two mechanisms, we draw \( O(\kappa), A(\kappa) \) and \( M(\kappa), \kappa = 0, k \), as functions of \( \mu_E \) in Figure 2, assuming uniform distributions of \( c_E \) and \( c_I \). (In the extension in Section 7, we examine \( M(\kappa) \) under general cost distributions.)

Figure 2: \( O(\kappa), A(\kappa) \) and \( M(\kappa), \kappa = 0, 1 \), with changing \( \mu_E \). \( k = 0.3, c_I \sim U(0.3, 0.6), c_E \sim U(\mu_E - 0.1, \mu_E + 0.1) \).

We shall first examine \( O(0), A(0) \) and \( M(0) \), the factors associated with excessive demand. It can be easily derived that when the entrant’s expected cost \( \mu_E \) increases, the option value of the entrant \( O(0) \) always decreases. However, a higher \( \mu_E \) influences the allocation inefficiency cost \( A(0) \) in two ways: On one hand, it increases the cost when an inefficient allocation occurs; on the other hand, it reduces the probability of an inefficient allocation. Therefore \( A(0) \) increases with \( \mu_E \) when the value of \( \mu_E \) is low, but decreases when the value is high. Depending on the comparison between \( O(0) \) and \( A(0) \), the marginal benefit of second sourcing \( M(0) \) may be positive or negative. As shown in Figure 2, \( O(0) \) dominates \( A(0) \) when \( \mu_E \) is low, and the opposite when \( \mu_E \) is neither too high nor too low. When \( \mu_E \) is high, no excessive demand will be allocated to the entrant, and hence the option value \( O(0) \), allocation inefficiency cost \( A(0) \) and marginal benefit \( M(0) \) all equal
zero. The factors $O(k)$, $A(k)$ and $M(k)$ associated with covered demand demonstrate the same pattern with the change of $\mu E + k$.

The option value of second sourcing for the excessive demand, $O(0)$, is always higher than for the covered demand, $O(k)$, as the entrant wins the excessive demand easier than the covered demand (see Figure 2, left panel). But the allocation inefficiency cost on the excessive demand, $A(0)$, can be higher or lower than on the covered demand, $A(k)$ (see Figure 2, middle panel). When the entrant’s expected cost $\mu_E$ is low, $A(k)$ is higher than $A(0)$. This is because the cost due to over-allocating demand to the entrant, when the incumbent has the first mover capacity cost advantage, is more than when the incumbent does not have such advantage. However, this is not the case when $\mu_E$ is high. In this situation, the probability of the entrant winning the covered demand is much lower than winning the excessive demand, and thus $A(k)$ is lower than $A(0)$.

As a result, the marginal benefits of second sourcing on the covered and excessive demand, $M(k)$ and $M(0)$, can be both positive, both negative, or have opposite signs (see Figure 2, right panel). In the first two cases, the optimal sourcing mechanism is easily determined. In the last case, the sourcing mechanism selection depends on the expected volumes of covered and excessive demand, which are in turn impacted by the first period capacity investment.

6.2 Comparing the profits in sole and second sourcing mechanisms

Lemma 5 allows us to provide sufficient conditions of comparing the buyer’s profits from the two sourcing mechanisms based on $M(k)$ and $M(0)$.

**Proposition 2** If $r > k + \max(J(c), \bar{c}_E)$, and $c_I \sim U(c - a, c)$, $c_E \sim U(\mu_E - \Delta E/2, \mu_E + \Delta E/2)$, then,

(i) when $\mu_E > J(c) + \Delta E/2$, $\Pi_L(Q_L) = \Pi_S(Q_S)$,

(ii) when $\bar{\theta} < \mu_E < J(c) + \Delta E/2$, $\Pi_L(Q_L) > \Pi_S(Q_S)$, and,

(iii) when $\mu_E < \bar{\theta}$, $\Pi_S(Q_S) > \Pi_L(Q_L)$ in the condition $k < \bar{\theta} - \mu_E$ or $k > J(c) + \Delta E/2 - \mu_E$, where $\bar{\theta}$ is uniquely defined such that $M(0) = 0$ at $\mu_E = \bar{\theta}$ and $\bar{\theta} < J(c) + \Delta E/2$.

Recall from Proposition 1 that when the buyer has complete information, sole sourcing can only be worse than second sourcing. Now with information asymmetry, sole sourcing may generate more profit than second sourcing. Figure 3 demonstrates the regions of the entrant’s expected cost $\mu_E$ and capacity cost $k$ that lead to different comparison results between sole sourcing and second sourcing profits.
When $\mu_E$ is high ($\mu_E > J(c) + \Delta_E/2$), second sourcing reduces to sole sourcing, as the entrant will never be able to win the competition with the incumbent.

When $\mu_E$ is low ($\mu_E < \hat{\theta}$), second sourcing is better than sole sourcing when $k$ is both low ($k < \hat{\theta} - \mu_E$) and high ($k > J(c) + \Delta_E/2 - \mu_E$). This insight is new and is due to variation of the second period demand that generates excessive demand. With $\mu_E$ low, the option value of second sourcing is higher than the cost of allocation inefficiency for the excessive demand. If in addition the capacity cost $k$ is also low, the option value is higher than the cost of allocation inefficiency for the covered demand as well. Therefore, second sourcing is preferred to sole sourcing when both $\mu_E$ and $k$ are low. If $k$ is high, then the entrant is deterred from winning the covered demand, but the buyer still benefits from the entrant winning the excessive demand with $\mu_E$ low. Therefore, with $\mu_E$ low, high values of $k$ also benefits second sourcing. Thus the benefits from both competitions for covered and excessive demand can be drivers for second sourcing.

When $\mu_E$ is neither too high nor too low ($\hat{\theta} < \mu_E < J(c) + \Delta_E/2$), the option value of second sourcing is strictly dominated by the allocation inefficiency cost for the excessive demand and weakly dominated (they may both be zero) for the covered demand. Hence, in this situation second sourcing is inferior to sole sourcing.

Figure 3: Breakeven curves of $\mu_E$ and $k$ values with respect to sole sourcing and second sourcing profits. $r = 3$, $c = 0.9$, $a = 0.3$, $\Delta_E = 0.2$, $x_1 = 0.5$. $c_I \sim U(c - a, c)$, $c_E \sim U(\mu_E - \Delta_E/2, \mu_E + \Delta_E/2)$. Demand in the second period is uniformly distributed on $[0.35, 0.65]$. Lines (1) and (2) are the breakeven curves with $X_2 = x_1$. Line (1) is $k + \mu_E = \hat{\theta}$. Line (2) is $k + \mu_E = J(c) + \Delta_E/2$. 
Proposition 2 suggests that the buyer should leave the option of alternative sourcing open only if highly competitive new sources are expected to emerge (\( \mu_E \) low), e.g., due to emerging suppliers in low-cost countries or entry of new suppliers with better technologies. This is intuitive. However, the buyer has to be careful when in addition using the capacity cost as a decision basis. Second sourcing is favored when supply capacity investment is inexpensive, which can be the case when the buyer sources inputs with a high level of standardization or a low degree of supplier-buyer interdependence. But sourcing from the entrant can also be beneficial when inputs require costly specific capacity investment. The difference between the two cases is that in the former case, the buyer exclusively sources from the incumbent or entrant, while in the latter case, the entrant will only be used as a supplemental supplier that provides quantity for the overflow demand beyond the incumbent’s installed capacity.

If the capacity cost is neither too high nor too low (\( k \in (\hat{\theta} - \mu_E, c + a + \Delta_E/2) \)), sole sourcing may or may not be better than second sourcing. In this situation, allocation inefficiency cost is more than the option value for sourcing covered demand from the entrant, but is the opposite for the excessive demand. Thus the selection of the sourcing mechanism depends on the expected volumes of the excessive and covered demand, which are determined by the initial capacity investment.

Note if the demand is certain and identical in the two periods, \( x_1 = x_2 = x \), then there will be no excessive demand in the second period, and the profit difference characterized in Lemma 5 reduces to \( \Pi_S(Q) - \Pi_L(Q) = xM(k) \) for any \( Q \geq x \). In this case, the comparison of profits depends only on the sign of \( M(k) \) but not on the demand features, and second sourcing is preferred only when \( k \) is low. This result can be easily derived by adapting the model of Riordan and Sappington (1989), which considers unit demand. We extend Riordan and Sappington (1989) by considering demand uncertainty and capacity investment. In our result, the capacity cost impacts the sourcing strategy in a more sophisticated way. In addition, the initial capacity investment and future demand distribution play important roles in the sourcing mechanism design, as shown in Sections 6.3 and 6.4.

6.3 Impact of the initial capacity investment

We now turn to the first period decision and examine the difference of the first period capacity investment between sole and second sourcing. The second period competition in a second sourcing mechanism is shaped by the incumbent’s first period capacity investment. In expectation, a greater first period capacity results in more covered demand and less excessive demand in the second period. Therefore, the comparison of the initial capacity investments in the two mechanisms depends on
the comparison between the marginal benefits of second sourcing for covered and excessive demand. This is shown in Lemma 6.

**Lemma 6** If $r > k + \max(J(c), \bar{c}_E)$, then $\frac{d}{dq} \Pi_S(Q) - \frac{d}{dq} \Pi_L(Q) = \bar{G}(Q)(M(k) - M(0))$.

Recall from the discussion following Lemma 5 that $M(\kappa) = O(\kappa) - A(\kappa)$, with $O(\kappa) > O(k)$ and $A(0) \leq A(k)$. Based on Lemma 6, although more capacity invested in the first period of a second sourcing mechanism reduces the total option value, it may also lower the total allocation inefficiency cost (when $A(0) > A(k)$; i.e., the allocation inefficiency cost associated with excessive demand is more than with covered demand). As a result, second sourcing may induce a higher first period capacity investment than sole sourcing, although the second period return of capacity investment is lower in second sourcing (as the buyer may fully switch to the entrant) than in sole sourcing. The condition for this result is characterized in Proposition 3.

**Proposition 3** If $r > k + \max(J(c), \bar{c}_E)$, $c_I \sim U(c-a,c)$, $c_E \sim U(\mu_E - \Delta_E/2, \mu_E + \Delta_E/2)$ and $x_1$ is sufficiently low, then, $Q_L < Q_S$ when $\mu_E < J(c) + \Delta_E/2$ and $\mu_E + k$ high enough, and $Q_L < Q_S$ is accompanied by $\Pi_L(Q_L) > \Pi_S(Q_S)$.

Recall $Q_L = x_1$ from Lemma 3. We know that an incumbent supplier equipped with a large capital investment from the past deters the buyer from adopting an alternative source, and thus reduces the option value as well as the allocation inefficiency cost of second sourcing. Proposition 3 shows that when the alternative sourcing opportunity has limited advantage against the incumbent supplier ($\mu_E + k$ is high), it is in the interest of the buyer to invest more capacity upfront for the incumbent than he would with a sole sourcing commitment, thereby resulting in excess capacity in the first period. Even though each unit of excess capacity in the first period generates a loss, it brings more benefit due to lower allocation inefficiency cost than the loss of option value. The condition of $x_1$ being sufficiently low ensures that the capacity needed to cover the first period demand is not too high to allow the investment of redundant capacity, while $\mu_E < J(c) + \Delta_E/2$ ensures a positive probability of supplier switching in a second sourcing mechanism.

In the model, we have assumed that a sole sourcing commitment is credible. If such commitment is desirable ($\Pi_L(Q_L) > \Pi_S(Q_S)$) but not credible, Proposition 3 suggests that over-investment of the upfront capacity can be regarded as a soft substitute of commitment in a second sourcing contract. This is because a large investment results in a low switching probability, and hence credibly deters the buyer to source from the entrant.
Our result is similar to that in Spence (1977): Redundant capacity may be invested by the incumbent before entering the competition with an entrant. In their model, the incumbent is the quantity leader and the entrant is the follower in the post-entry game. Dixit (1980) shows that such over-investment will not occur if the incumbent and entrant act simultaneously on the quantity (Cournot game) or price (Bertrand game) in the post-entry game. In Spence (1977), over-investment allows the incumbent to expand production and reduce the price, which drives a negative profit of the entrant if she enters. Therefore, such over-investment serves as a credible threat made by the incumbent to the entrant, which deters the latter’s entry and in turn benefits the incumbent. Our result of over-investment in capacity is induced by the buyer instead of the equilibrium outcome of a duopoly model; it is used, in absence of commitment to a single supplier, to induce the incumbent to give up more profit in the first period and in turn benefits the buyer. Proposition 3 shows that the commitment power to sole sourcing will be preferred to over-investment in second sourcing.

By studying the decision of pre-qualifying multiple suppliers who compete for a procurement contract, Riordan (1996) also shows a result of over-investment – the buyer may invest in full capacity for two suppliers but award production to only one supplier. The reason for this investment of redundant capacity is that it increases supplier competition (creating bidding parity between suppliers) and hence reduces information rent paid by the buyer. In our model, the rationale for over-investment is different: It has the purpose of increasing the incumbent’s competitiveness and hence reducing supplier competition. This lowers the allocation inefficiency cost and allows the supplier to gain more rent in the future, that can be extracted by the buyer at the beginning of the horizon (low-balling).

The existing insights in the procurement literature have shown that when the incumbent has advantage over an entrant due to existing investment or learning, it may be beneficial for the buyer to balance the suppliers’ competitiveness by intentionally lowering the investment (Dasgupta, 1990) or sourcing from the less efficient entrant (Deng and Elmaghraby, 2005; Klotz and Chatterjee, 1995; Lewis and Yildirim, 2002). Our result complements this insight, showing that when the buyer is able to extract the supplier’s future rent (by low-balling), the buyer actually wants to improve (instead of weaken as in those papers) the competitive position of the incumbent by investing in more initial capacity. This is because a better competitive position of the incumbent reduces the allocation inefficiency, which translates to the buyer’s gain due to the supplier low-balling.
6.4 Impact of product demand

In this subsection, we investigate how the demand distribution influences the selection of the sourcing mechanism. As shown in Lemma 5, the comparison between sole and second sourcing depends on not only supplier costs and capacity costs, which determine the marginal benefits of second sourcing from the covered and excessive demands, but also on product demand distribution, which affects the volumes of covered and excessive demands given the initial capacity investment.

**Proposition 4** If \( r > k + \max (J(c), r_E) \), and \( c_I \sim U(c - a, c) \), \( c_E \sim U(\mu_E - \Delta E/2, \mu_E + \Delta E/2) \), then, given two distributions for the second period demand \( G_1 \) and \( G_2 \), where \( G_2 \) is greater than \( G_1 \) in increasing convex order, changing the demand distribution from \( G_1 \) to \( G_2 \) can only turn the preferred mechanism from sole sourcing to second sourcing, but not the opposite.

Both higher mean and greater variance result in dominance in increasing convex order. Proposition 4 shows that when the mean or variability of future demand is higher, second sourcing becomes more favorable than sole sourcing, but not the other way around. Consistent with Proposition 4, Figure 4 demonstrates the regions of \( \mu_E \) and \( k \) values for which a second sourcing mechanism is preferred. The left panel varies the future demand level but keeps the variability constant. The right panel varies the demand uncertainty but keeps the mean constant.

![Figure 4](image-url)

Figure 4: Breakeven curves of \( \mu_E \) and \( k \) values with respect to sole sourcing and second sourcing profits for different future demand level and uncertainty. \( r = 3 \), \( c = 0.9 \), \( a = 0.3 \), \( \Delta E = 0.2 \), \( x_1 = 0.5 \). \( c_I \sim U(c - a, c) \), \( c_E \sim U(\mu_E - \Delta E/2, \mu_E + \Delta E/2) \). In the left panel, following the direction of the arrows, each pair of the curves represents the second period demand equal to 0.5, 0.6, 0.7 and 0.8 with no uncertainty. In the right panel, following the direction of the arrows, each pair of the curves represents the second period demand equal to 0.5 with no uncertainty, uniformly distributed on \([0.4, 0.6], [0.3, 0.7], \) and on \([0, 1] \).
The intuition for the result of Proposition 4 can be understood from Lemma 5. On one hand, a greater future demand level or variability increases the expected excessive demand but not the covered demand (the covered demand decreases when demand variability is higher) for a given initial capacity investment. On the other hand, when the buyer is indifferent between sole and second sourcing, the marginal benefit of second sourcing on the excessive demand can only be greater than on the covered demand (otherwise we can easily prove that both marginal benefits are negative and sole sourcing is strictly preferred). Thus, the influence of demand distribution on the volumes of excessive and covered demand, and comparison of the marginal benefits of second sourcing on these two parts of demand, jointly determine the impact of demand distribution.

The operations literature has studied dual sourcing problems in which a primary, cheaper supplier has fixed capacity (e.g., Tomlin, 2006) or requires long leadtime of delivery (e.g., Veeraraghavan and Scheller-Wolf, 2006), and a second, more expensive supplier provides flexibility of supply. In these papers the second source is used to absorb the variance of supply or demand, allowing better matching supply with demand. In our paper, we reach a consistent result that second sourcing is more valuable in a more volatile environment, but our reason is essentially different. In our model, while the buyer also benefits from the entrant supplier providing the excessive demand, it is not because the incumbent does not have immediate capacity for that supply (the capacity can be expanded with no leadtime), but because it is cheaper to source that demand from the entrant. Therefore, our reason for using second sourcing under demand uncertainty is that it lowers the procurement cost but not that it matches supply with demand.

Proposition 4 implies that although the alternative sourcing option is a measure to counter the uncertainty on the supply market, the value of such option is enhanced with more uncertainty on the demand. To this end, the supply cost uncertainty and demand uncertainty complement each other.

Proposition 4 also suggests that second sourcing becomes better if the buyer faces more market demand in the future. Therefore, second sourcing may be favorably considered for a new product with a growing market. But for a mature product with stable or declining demand, to source from a single supplier over time may be better. This seems to be consistent with the result revealed in the survey of Birou et al. (1997) that competitive bidding and dual/multiple sourcing should be used in the growth stage, and single sourcing should be used in the maturity stage of a product.
7 Extension

In order to obtain and explain analytical insights, we have kept our model relatively simple. In this section, we consider five extensions and summarize the results. For detailed analysis and formal results of the extensions, please see Appendix B.

In the first extension, we allow the incumbent’s first period cost $c$ to be uncertain and private information (but independent of the second period cost). In addition, we also allow the entrant’s cost $c_E$ to be private information. Then the introduction of private information on the incumbent’s first period cost reduces the buyer’s first period profit (as the buyer has to pay information rent) in both mechanisms. The introduction of private information on the entrant’s cost weakens the entrant’s competitiveness in a second sourcing mechanism. But neither of them qualitatively change the results of comparing the two mechanisms.

In the second extension, we examine the situation where the capacity is not contractible and hence the supplier decides the capacity. Although the incumbent can improve her competitive position in a second sourcing mechanism by investing in more capacity, we find that the incumbent will never invest in more capacity than the buyer’s demand. This is because with no revenue received from over-investment, the cost of over-investment dominates the benefit generated from an improved competitive position for the incumbent. Therefore, over-investment is only possible if induced by the buyer. The buyer can influence the supplier’s capacity decision by specifying an order quantity that the supplier must deliver. However, because the cost of inducing capacity investment is higher when contracting the order quantity than the capacity, we find that the buyer will never order more than what is demanded, and hence over-investment of capacity does not occur any more (assuming uniform cost distributions). Despite this difference with respect to capacity investment, we also find that the comparison of profits between sole and sourcing sourcing does not change qualitatively.

In the third extension, we relax the assumption of uniform cost distribution in the results by considering general cost distributions. In fact, the result that second sourcing may cause over-investment (Proposition 3) does not depend on the assumption of uniform distributions and so can be extended to general cost distributions. In addition, for $\mu_E$ very high or low, the result on selecting between the two mechanisms (Proposition 2) does not depend on uniform distributions either. For general $\mu_E$ values, by numerical examinations we find that the result holds in broad situations with general cost distributions.

In the fourth extension, we study a related but different situation in which the buyer produces
in-house in the first period but may outsource to multiple suppliers in the second period. In this situation, the buyer is also the incumbent and so the information asymmetry with respect to the incumbent’s cost does not exist any more. As a result, it is always optimal for the buyer to keep the option of outsourcing open. In addition, over-investment in the first period is never optimal. A larger number of suppliers generates more profit for the buyer, and when demand is uncertain, induces lower capacity in the first period. This indicates that information asymmetry is necessary to drive the results of selecting the sole sourcing mechanism and over-investing capacity in a second sourcing mechanism.

In the last extension, we consider endogenous learning due to the buyer endogenizing the volume sourced from the supplier or the supplier investing in cost reduction effort. The extension is based on certain demand. We find that second sourcing leads to a lower effort (purchased volume or investment) than sole sourcing. In addition, in both situations it remains true that lower $\mu_E$ or $k$ increases the preference of second sourcing. Based on supplier investment, we also find that sole sourcing is considered more favorably when investment is cheap, while second sourcing gains more advantage when investment is expensive.

8 Conclusion and discussion

Manufacturers increasingly rely on suppliers to create more added value by purchasing from them more complex components or systems. The set of potential suppliers may undergo quick changes; e.g., new suppliers with low costs may emerge as a result of supply base development in emerging economies or technology development. The dynamics of supply market bring buyers a critical decision: Should a long-term or short-term contract be used with current suppliers? For a buyer that sources critical non-commodity inputs, this decision has to take into consideration supplier capacity investment, future demand distribution of the inputs, cost reduction of a supplier through learning, and information asymmetry on a supplier’s cost. We develop an analytical model that helps to understand how to select between sole sourcing, i.e., committing to source from a single supplier over time, and second sourcing, i.e., keeping open the option of sourcing from a future entrant supplier.

We find that with demand uncertainty, both a low and higher capacity cost benefit second sourcing (under the condition that the entrant’s cost is relatively low): When the capacity cost is low, the buyer exclusively sources from the incumbent or entrant; when the capacity cost is high, the entrant is only used as a complementary supplier in a dual sourcing mode. We find that more volatility or a higher level of the future demand favors second sourcing. This provides a
new explanation for using second sourcing under demand uncertainty – not for the flexibility of matching supply with demand but for sourcing the demand exceeding the incumbent’s installed capacity (referred to as “excessive demand”) at a lower cost. We also show that the incumbent supplier will never invest in excess capacity in a sole sourcing mechanism, but may do so in a second sourcing mechanism, and that over-investment occurs only when sole sourcing dominates second sourcing for the buyer. This result extends the understanding of the role of capacity in supply chain management – not for countering demand uncertainty but for influencing future supplier competition and the buyer’s ability of rent extracting.

Our results imply that non-strategic inputs with few customized features and a low degree of supplier-buyer interdependence are good choices for a second sourcing mechanism, for capacity for these items can be easily adapted for other buyers or installed at low costs, which usually leads to low unit capacity costs. However, depending on the future product demand, it may also be significantly beneficial to leave the second sourcing option open for highly strategic inputs with high unit capacity costs. In that situation, the entrant supplier should only be used to provide for the demand exceeding the incumbent’s installed capacity. In addition, allowing the option of alternative sourcing, a measure of countering uncertainty on the supply market, also allows the buyer to counter demand uncertainty and benefit from growing product demand.

Our model develops optimal sourcing strategies over the long run. As supplier competition reduces the procurement cost, it may be tempting for managers to create a competitive supplier portfolio in the future, ignoring the effects this creates on the current supply base. But a supplier facing more competition in the future will press for a higher price, and hence increases the buyer’s cost in the short term. Therefore, to balance long-term and short-term profits, a manager should be proactive in shaping the future competition of suppliers. Investing more capacity improves the incumbent’s position and reduces the competition. Furthermore, committing to a single supplier eliminates the competition. Therefore, when committing to a single supplier is not credible, high capacity investment, even over-investment, can be used as a soft and non-perfect substitute of commitment to shape the future supplier competition.

Our results may be linked to the cyclic pattern of relationship types over time as observed in the automotive industry (Dyer, 2000). For example, Chrysler transitioned from multi-source competitive purchasing in the 1980s to a collaborative approach (long-term relationship) during the 1990s. However, after the Daimler merger in 2000, the organization reverted to a more competitive multi-supplier sourcing network. Ford had taken a multi-sourcing position until they started to cut the number of suppliers and form long-term relationships with some suppliers for key components in
Our result can be related to this phenomenon by linking information asymmetry and learning to new products or technologies. When there is great potential for a supplier to reduce costs for a new product or employing a new technology, sole sourcing may be selected for the buyer in order to extract high future rent. But after the product or technology becomes mature, the potential of supplier learning or the advantage of know-how is limited. In this case, the buyer may want to switch to second sourcing in order to take advantage of supplier competition and alternative sourcing opportunities. Therefore, over a horizon with multiple repetitions of new production introduction or technology change, the buyer may alternate between sole and second sourcing, exhibiting a cyclic pattern.

In the end, we discuss the impact of several modeling assumptions. We assume the buyer is the Stackelberg leader in the contracting mechanism by offering the supplier(s) a take-it-or-leave-it contract or a menu of contracts to select from, and a supplier will accept the contract or select the best contract if it generates him a profit no less than zero. This assumption is appropriate when the buyer dominates the supply chain, enjoying a technology or scale advantage over the suppliers, and hence has more bargaining power over the supplier. For example, in the automotive industry, the OEMs such as GM, Ford and Chrysler are more powerful than their suppliers. The situation where a supplier has more bargaining power and demands more profit (e.g., due to outside options) could be modeled with a positive reserve profit of a supplier in each period. This change would reduce the buyer’s profits while raising the supplier’s in both mechanisms, without altering the qualitative nature of the results.

We have ignored the time discount factor in the model. A discount factor would decrease the relative contribution of the future profit to the total expected profit for both the buyer and supplier, and hence lower the profit difference between sole sourcing and second sourcing. However, since a discount factor would not change the second period mechanism in either sourcing strategy, the selection between the sole sourcing and second sourcing would remain the same.

The assumption that the buyer knows the incumbent supplier’s initial cost allows us to focus on the optimal mechanism design in the second period, based on the selection of the sourcing mechanism in the first period. If the supplier’s initial cost is also private information and is correlated with the second period cost, then the design of the mechanisms in the two periods is concerned with the ratchet effect. To study dynamic sourcing mechanisms with correlated types over time is a stream of our future research.
References


