Supplier development or supplier switching?

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We study a firm’s cost-based sourcing decision of whether to invest in an incumbent supplier or switch to an alternative supplier in order to realise lower purchasing costs. In isolation, it can be shown that the development of an incumbent supplier (i.e., a cooperative investment) becomes more attractive, the higher the uncertainty about the price the buying firm can realise on the market and the incumbent supplier’s cost. Likewise, switching to an alternative supplier becomes more attractive, the higher the expected value of and the uncertainty about the buying firm’s market price. For comparing these two sourcing strategies simultaneously we provide a profit-maximising framework for the buying firm that shows that switching is less recommendable the higher the variance of the incumbent’s cost and if the uncertain maximum demand is negatively correlated with the uncertain incumbent supplier’s cost. Overall, our study substantially expands the frequently followed approach of basing supplier development versus supplier switching decisions merely on strategic and qualitative considerations.

Keywords: purchasing; cooperative investment; decision analysis; sourcing strategy; supplier development; supplier switching

1. Introduction

A fundamental concern in sourcing decisions is whether a supplier is able to provide the product that satisfies the buying firm’s needs along attributes such as cost, quality, delivery or service. In situations when a supplier is unable to satisfy these needs, the buying firm can principally follow one of two sourcing strategies. The first option is to switch the supplier, that is, to search for alternative sources of supply and purchase the product from a more capable supplier (Demski et al. 1987, Li et al. 2006). This option causes switching costs, that is, one-time costs upon switching from one supplier to another (Klemperer 1995, Lewis and Yildirim 2005) that have to be considered in the sourcing decision. The second option termed ‘supplier development’ consists of activities undertaken by a buying firm to improve the supplier’s cost, quality, delivery or service performance, or upgrade the supplier’s capabilities to meet the buying firm’s needs (Krause et al. 1998, Wagner 2010). The buying firm has to make a supplier-specific and (at least partially) cooperative investment (Che and Hausch 1999, McLaren 1999) that is idiosyncratic and cannot be easily transferred to another supplier or recovered in another buyer-supplier relationship.

Firms usually take the decision as to whether to develop or switch a supplier on a rather strategic level. They employ qualitative and quantitative criteria and assessment methods (e.g., Weber et al. 1991, De Boer et al. 2001), or use purchasing portfolio models (e.g., Kraljic 1983, Lee and Drake 2010) as a starting point to determine the relative importance of the supplier for the buying firm. Research explicitly recommends that suppliers of critical and strategic products are the ones that require or warrant supplier development investments. Implicitly it is stated that buying firms should not develop suppliers of non-critical and non-strategic products, that is, switch to a more capable source instead (Krause et al. 1998, Tang 1999).

However, a better and much deeper understanding in this area is necessary for two reasons. First, supply chain researchers have studied supplier development and supplier switching rather independently, that is, they have not taken into consideration that these are two complementary approaches which need to be considered together in sourcing decisions.

Second, if the ‘development or switching’ decision is merely based on the simplistic recommendations derived from portfolio norm strategies, important financial implications, that is, the impact of the sourcing strategy on the profit of the focal firm and the supply chain, might be overlooked (Gelderman and van Weele 2005). In his study of

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sourcing decisions Heijboer (2003, pp. 150–152) pointed out that qualitative criteria and sourcing strategy recommendations derived from the Kraljic (1983) purchasing portfolio are insufficient to thoroughly back up a sourcing decision. Instead, Heijboer recommended the development of more quantitative and normative models. Such models will help managers to better evaluate the suitability of the two sourcing strategies, ‘development or switching’. Along these lines, Talluri and Narasimhan (2004, p. 236) state that ‘methodologies in practice for strategic sourcing have mostly been subjective in nature’ and argue that objective decision models are limited to supplier evaluation, and do not cover other sourcing decisions, such as the development or elimination of suppliers.

Therefore, the goal of this research is to substantially expand the hitherto limited research on the important decision of whether to develop or switch a supplier for cost reasons and to develop a decision model. It seems vital to integrate supplier switching costs, supplier development investments, and expected returns from supplier development investments into the model if market prices of the purchased item are expected to vary.

The structure of this article is as follows. In Section 2 we provide a brief overview of the relevant literature on sourcing strategies, supplier development, and supplier switching. In Section 3 we develop the basic mathematical model for supplier development and supplier switching. Subsequently, we analyse the development decision in Section 4 and the switching decision in Section 5. Section 6 brings both approaches together to derive the optimal sourcing strategy based on a number of parameters. In the last section we conclude with a discussion of important findings and an outlook.

2. Review of the literature on sourcing strategies/decisions

There exists a significant amount of literature that discusses sourcing strategy choices and sourcing decisions, that is, firms’ choices for securing inputs from suppliers to their operations. Elmaghraby (2000) and Aissaoui et al. (2007) provide good reviews of the research in this field. To better position, compare, and contrast the research presented in this article, we discuss several relevant streams of literature in the sourcing strategy/decision context.

2.1 A broader perspective on sourcing strategies/decisions

With respect to sourcing decisions it can be distinguished whether the buying firm has one option to select a supplier (single selection period) or multiple options to select a supplier (multiple selection periods). Although we investigate a buying firm’s sourcing decision (“development or switching”) at a single point in time and develop a one-period model, this decision is embedded in multiple periods because the initial selection of the incumbent supplier has already been made, that is, we do not consider a ‘new buy’, but a ‘re-buy’ (Webster and Wind 1972).

Another distinction has to be made: the buying firm can purchase all similar products from only one supplier (single sourcing), can purchase the same set of products from multiple suppliers (multiple sourcing), or can single source each individual product but have different suppliers for similar products (parallel sourcing) (Richardson and Roumasset 1995). From a practical perspective, single sourcing follows Deming’s (1986) thinking that the optimal cost situation is determined by the quality of the input material and can be achieved through close and long-lasting buyer-supplier relationships. On the contrary, multiple sourcing follows Porter’s (1985) thinking that a firm’s purchasing costs can be minimised by instilling competition in the supply base and sourcing from multiple suppliers. Despite production inefficiencies due to lower economies of scale, multiple sourcing will allow the buying firm to realise lower purchasing costs due to competition.

From the models on procurement auctions (e.g., Seshadri et al. 1991, Stole 1994, Klotz and Chatterjee 1995, Klemperer 1999), supplier diversification under uncertainty (e.g., Anupindi and Akella 1993, Agrawal and Nahmias 1997, Swaminathan and Shanthikumar 1999), and the design of procurement contracts (e.g., Riordan and Sappington 1989, Laffont and Tirole 1993, McLaren 1999), numerous insights were generated to better understand the benefits of single and multiple sourcing under various conditions (e.g., pricing of the second supplier, information asymmetry, risk propensity of the buyer, link between procurement stages, incentives). Recently, Chung et al. (2010) studied a decentralised supply chain with one single buyer and two suppliers offering two different types of contracts. They identify areas where single sourcing is better than dual sourcing and find that ‘single sourcing appears to be, mostly, more favourable than dual sourcing’ (p. 640).

In our model we assume a single sourcing arrangement with the incumbent as well as the alternative supplier (in case the buying firm decides to switch to an alternative source), that is, the entire purchasing volume for the component required is not split among several suppliers. In our setting, single sourcing is the optimal strategy for the
buyer, since we do not model any benefits from having multiple suppliers, such as risk reduction or lower prices due to competition.

The sourcing strategy decision should be based on a set of criteria which must be aligned with the strategic and operational goals of the buying firm. In their analysis of single and multiple sourcing arrangements, Trevelen and Schweikhart (1988) describe the risks and benefits of each arrangement along five criteria, namely, disruption of supply, price, inventory and schedule, technology, and quality. Similarly to Richardson and Roumasset (1995), who compare the performance of various sourcing arrangements along the buying firm’s total cost, we optimise on price/cost in our model, while the other criteria are not explicitly considered.

2.2 Supplier development

Talluri and Narasimhan (2004) develop a strategic sourcing framework that deals with the effective management of the supply base through the identification and selection of supplier groups for the application of sourcing strategies, including establishment of strategic partnerships, involvement in buying firms’ supplier development activities, and pruning of suppliers from the supply base. Similarly, Araz and Ozkarahan (2007) propose a decision making tool for supplier evaluation and strategic sourcing decisions during product development. They use a multi-criterion sorting procedure to sort suppliers based on performance and capabilities. The buying firm can derive supplier classes and apply appropriate sourcing decisions, these being respectively: partnership suppliers, suppliers for supplier development programs, competitive suppliers, and suppliers to be eliminated. Talluri et al. (2010) analyse supplier development efforts in a multiple supplier environment. Moreover, they consider cooperation between two buyers when developing joint suppliers. They identify conditions in which both cooperation and non-cooperation between two buyers are beneficial. They also propose an optimal allocation of development investments among different suppliers to reduce risk. In contrast to these three approaches of optimising groups of suppliers or the entire supply base, we concentrate our investigation on one incumbent and one potential alternative supplier.

Other scholars did not explicitly study supplier development as a sourcing strategy option but investigated the role of buying firm investments on supplier performance. Cohen and Agrawal (1999) study analytically the interplay between investment, improvement opportunities, purchase price, and duration of supply contracts. They discuss conditions under which both short-term and long-term contracts respectively are preferred. Extending this research, Talluri and Lee (2010) present a mixed-integer programming model with multiple factors, including investments made to improve supplier performance and market price fluctuations.

Notwithstanding such exceptions, the operations research literature on sourcing strategies/decisions is relatively limited with respect to the development of suppliers as a strategic option. However, since a buying firm’s supplier development efforts require supplier-specific (or relation-specific) investments, we can draw on the literature on cooperative investments to gain insights into supplier development decisions. Cooperative investments are ‘[s]pecific investments that generate a direct benefit to the investor’s trading partner’ (Che and Chung 1999, p. 85). Che and Chung (1999) list many real-world examples of cooperative investments, including a typical supplier development approach of co-locating engineers from an automotive manufacturer to its supplier in order to provide support for the supplier’s innovation and R&D tasks (Nishiguchi, 1994). In supplier development decisions, we do not consider the extreme case where the buyer makes an investment that increases value only for the upstream supplier (e.g., decrease of production costs). Instead, we model cases where the buyer benefits from the investment (e.g., decrease of purchasing costs for input materials).

From the model of cooperative investment, Che and Hausch (1999) conclude that contracting has no value if the buyer and supplier cannot commit to not renegotiate the contract ex post if the original terms of the contract are rejected by either party. In our case of a cooperative investment by the buyer, it would be optimal not to write any ex ante contract. Specifically, they show that when commitment is not possible, then investment is inefficiently low in the absence of a contract because of holdup; and even the most efficient contract is not able to induce higher investments.

2.3 Supplier switching

While supplier switching has been studied by management and marketing scholars who investigated the size and structure of the consideration and choice set of incumbent and alternative suppliers (e.g., Heide and Weiss 1995, Sambandam and Lord 1995), antecedents and consequences of terminating interfirm relationships (e.g., Ping 1999,
Ellis 2006), or the inertia in supplier switching due to supplier switching costs (e.g., Jackson 1985, Li et al. 2006), supplier switching decisions in industrial buyer-supplier relationships have received little research attention in the operations research literature.

In extension to supplier selection models (e.g., Degraeve et al. 2005, Narasimhan et al. 2006, Ernst et al. 2007), Sucky (2007) includes the cost of selecting new suppliers and the costs of switching from existing to new suppliers (so-called ‘total relevant strategic costs’). Furthermore, supplier selection and supplier switching are modelled over several selection periods. From his stochastic dynamic supplier selection approach, which is based on hierarchical planning, he shows that the ‘total relevant strategic costs’ influence the selection decision sequences. While Sucky (2007) considers the price asked for by the suppliers as known and fixed, we model the effects of supplier development investments of the buying firm on the cost/price of the incumbent supplier and show that the optimal decision (stay with the incumbent or switch to the alternative supplier) depends on the effectiveness of the supplier development investment.

Murthy et al. (2007) study supplier switching when a buyer deals with two potential foreign suppliers in the presence of exchange rate uncertainty and supplier switching costs. From their continuous time model they conclude that the interplay between exchange rate uncertainty and switching significantly influences the buyer-supplier relationships. They show under which conditions equilibria prevail where both suppliers co-exist and those where one supplier captures the entire market.

Demski et al. (1987) develop a simple supplier switching model and find that the buying firm may be best off when the incumbent is replaced even when there is a cost disadvantage of the entrant. Wagner and Friedl (2007) extend their model and consider partial switching, economy of scale effects, and competitive reactions of the incumbent supplier. While price reactions are considered in their model, they are induced by competition and economies of scale, but not by the buying firm through supplier development investments.

Heijboer (2003, pp. 148–160) models the optimal renegotiation (i.e., switching) time of a contract for a commodity group (i.e., a group of products) taking into consideration the substitution of products within the commodity group, and discounts for the substituted versus the initial products as well as the costs to renegotiate.

In summary, our research is embedded in the broad stream of literature on sourcing strategies/decisions and in particular in the literature on supplier development and supplier switching as outlined above.

3. The model

We assume a one-period world and consider a model where a risk-neutral buyer (i.e., the focal firm) has a relationship with an incumbent supplier. The supplier delivers a component for a product to the buyer, which he in turn sells at the market. The market for the product has a linear inverse demand function \( p(q, \theta) \) with price \( p \) and demand \( q \) of the form

\[
p(q, \theta) = a(\theta) - 0.5bq,
\]

where \( \theta \in \Theta \) describes the different states of the world, and \( a(\theta) \) and \( b \) are two parameters with \( a(\theta), b > 0 \). While \( a(\theta) \) embodies all influences other than demand on the price level, \( b \) reflects the relationship between the level of price and demand. The coefficient of 0.5 is selected due to mathematical convenience and simplifies the subsequent calculations and expressions. This representation of demand is a standard assumption in the literature. Our representation of uncertainty is such that demand uncertainty only affects the overall price level but not the relationship between the level of price and demand. The buyer can always sell products to the market and the supplier can always produce and transfer components to the buyer. We assume that the buyer is unhappy with the status quo, possibly due to high purchasing costs for the components. In order to alter the status quo, the buyer has two options in our model. He can either choose to develop the incumbent supplier or he can switch to an alternative supplier.

If he decides to develop the incumbent supplier, the buyer invests a dollar amount \( w(d) = 0.5\gamma d^2 \), where \( w(d) \) is the scale of the investment. This investment reduces the incumbent supplier’s unit cost of the component by \( d \). The parameter \( \gamma \) describes the cost level associated with the buyer’s investment. A higher \( \gamma \) means that development costs are higher for one unit of cost reduction. Again, the coefficient of 0.5 is selected due to mathematical convenience and simplifies the subsequent calculations and expressions. Based on the buyer’s investment, the incumbent supplier’s unit cost is \( c(\theta) - d \) and depends on both the realisation of the uncertain state of the world and the buyer’s investment. While it is well known in the literature on incomplete contracting that there are instruments for inducing
the buyer to invest efficiently (for example by means of certain bargaining mechanisms; Edlin and Reichelstein 1996) to maximise the profit of the parties involved in the buyer-supplier relationship, we restrict attention to a very simple contracting arrangement between the buyer and the supplier. This is clearly a simplification, since there might be alternative contractual agreements with the incumbent supplier that yield higher profits for the buyer. Finding the optimal contract would involve many additional considerations and is beyond the scope of our research. We leave the question of the optimal contract in our setting for future research.

We assume that the buyer and incumbent supplier sign a contract in which the unit price \( p_d \) is based on realised cost \( c(\theta) \) and the cost savings due to the buyer’s investment are equally distributed between the buyer and the incumbent supplier. Hence the unit price is \( p_d(\theta, d) = c(\theta) - 0.5d \). The assumption of an equal sharing of cost savings between the buyer and the supplier is supported from a theoretical as well as an empirical perspective. First, the equality rule is a commonly used sharing principle in social psychological research (Deutsch 1975) that has been transferred to the buyer-supplier relationships context (Jap 2001). It specifies that both parties receive equal shares of the payoff. Deutsch (1975) proposes that equality is the dominant principle applied in cooperative relationships, and since supplier development requires and most likely occurs in cooperative buyer-supplier relationships (as opposed to arm’s length), our assumption of a 50/50 split of the cost savings is backed up. Second, the equal sharing of sales revenues for video tapes among Blockbuster and the movie suppliers introduced in the late 1990s provides a practical example of the feasibility and effectiveness of a 50/50 benefit sharing in buyer-supplier relationships (Cachon and Lariviere 2001). Likewise, in the Japanese automotive industry equal sharing of the benefits of cost reductions between manufacturers (e.g., Toyota, Honda, Nissan) and their suppliers has been the predominant practice (Nishiguchi 1994, pp. 126–128, Liker and Choi 2004, Sako, 2004).

As an alternative to developing the incumbent supplier, the buyer can switch to an alternative supplier. Switching comes with one-time switching costs \( s \), that is, costs that arise as a result of prior commitments to the incumbent supplier in terms of specific physical, informational, artificially-created, or psychological investments (Klemperer 1995). Costs for supply market research, supplier communication, preparing a request for quotation, evaluating the alternative suppliers’ offers, writing the contract, or for setting up an additional supplier in the firm’s Enterprise Resource Planning (ERP) system, among others, may occur. Furthermore, the buying firm may have to modify processes and procedures that have been installed for the delivery of products from the incumbent supplier (e.g., just-in-time delivery processes) or invest in know-how about using the alternative supplier’s product efficiently (Klemperer 1995).

The entrant supplier quotes a constant unit price \( p_s \) (Von Weizsäcker 1984, Murthy et al. 2007) and the buyer signs a contract which guarantees delivery of the component. This contract is fundamentally different from that with the incumbent supplier, since the purchasing price is fixed before uncertainty is resolved. Several studies show that the prior history of cooperation between the buying firm and a supplier determines the outcome of supplier development activities and conclude that for supplier development to be effective and to result in supplier firm improvements, the buyer-supplier relationship must not be at the outset of the relationship life-cycle (e.g., Kotabe et al. 2003, Wagner 2011). For that reason, we also make the realistic assumption that the buyer does not make a development investment in the incumbent supplier that would result in cost reductions, because the buyer would enter into a new relationship with the alternative supplier. To summarise our model formulation, the notation used in our model is shown below.

\[
\begin{align*}
  a(\theta) & \quad \text{Price level for zero demand (parameter of the linear inverse demand function)} \\
  b & \quad \text{Slope of the linear inverse demand function} \\
  c(\theta) & \quad \text{Incumbent supplier’s realised unit cost (without development investment)} \\
  d & \quad \text{Per-unit cost reduction of the development investment at the incumbent supplier} \\
  h(\theta) & \quad \text{Difference between the maximum price (when demand equals 0) and the unit cost} \\
  pq(\theta) & \quad \text{Market price for the product that the buyer sells (linear inverse demand function)} \\
  p_d & \quad \text{Incumbent supplier’s unit price} \\
  p_s & \quad \text{Entrant supplier’s unit price} \\
  q & \quad \text{Demand for the product that the buyer sells} \\
  q'(\theta) & \quad \text{Purchasing volume from the incumbent supplier} \\
  q'(\theta) & \quad \text{Purchasing volume from the entrant supplier} \\
  s & \quad \text{One-time switching costs} \\
  t(\theta, d) & \quad \text{Unit price paid to the incumbent supplier} \\
  w(d) & \quad \text{Buyer’s development investment (dollar amount)}
\end{align*}
\]
\[ \theta \in \Theta \quad \text{Different states of the world} \]
\[ \gamma \quad \text{Cost level associated with the buyer’s development investment} \]
\[ \pi_d \quad \text{Buyer’s profit when purchasing from the incumbent supplier} \]
\[ \pi_s \quad \text{Buyer’s profit when purchasing from the entrant supplier} \]

The sequence of the moves of the buyer’s decisions is as follows. In \( t = 1 \), the buyer decides whether he develops the incumbent supplier or he switches to an alternative supplier. If he decides to develop, he has to specify the supplier development investment \( w(d) \) in \( t = 2 \) and perform supplier development. Alternatively, if he decides to switch, he has to terminate the relationship with the incumbent and establish a relationship with the alternative supplier and pay the switching costs \( s \) in \( t = 2 \). In \( t = 3 \), uncertainty about demand and incumbent supplier’s cost resolves, and the buyer decides about the purchasing volume (i.e., the quantity or amount of components to purchase from the supplier). The variable \( t \) designates a step in a sequence of steps and not a time interval, indicating that the time for supplier development (for the measures to be implemented and effective) and supplier switching (for the transition processes until reliable delivery is secured) are assumed to be equal. Our setting could be easily extended to situations where the time for developing and switching suppliers is different by including discount factors in the analysis.

The sequence of the moves of the buyer’s decisions explains why we restrict our analysis to a single sourcing strategy, that is, the buyer either stays with the incumbent supplier or he entirely switches to the entrant supplier. In our setting, a dual sourcing strategy would never be the optimal, that is, profit-maximising, strategy. The reason is that the decision about the purchasing volume is the last decision in the sequence of moves. At this stage, the buyer does not benefit by splitting the purchasing volume between the two suppliers. For the buyer, it is always optimal to go with the cheaper supplier. Knowing this, the buyer makes his development or switching decision based on his expectations and he optimally decides for one of the two alternatives. It is worth comparing this setting to the model in Chung et al. (2010). They compare single sourcing and dual sourcing when there are two suppliers offering different types of contracts. One supplier offers a quantity flexibility contract, where the buyer is allowed to adjust the originally-ordered quantity to his actual demand. The other supplier offers a fixed-price contract with a cheaper price. The buyer has to consider the trade-off between cost savings and inventory risk-sharing. Here, under certain conditions, dual sourcing can be the optimal alternative, because after having decided on the purchasing volume, there is another move: the uncertain demand realises and the buyer has the option to react by returning unsold units to the first supplier and selling unsold units for their salvage value. This option makes a dual sourcing strategy sometimes valuable.

### 4. The development decision

We first analyse the case when the buyer has already decided to develop the incumbent supplier. In this case, the buyer invests a dollar-amount \( w(d) \) to realise cost reduction \( d \) and after the realisation of the uncertain state of the world, he decides on the exact purchasing volume \( q \). Starting with this last decision, the buyer chooses \( q \) so as to maximise

\[
q^d(\theta, d) = \arg \max_q \{ p(\theta, d)q - t(\theta, d)q - w(d) \},
\]

where \( t(\theta, d) = c(\theta) - 0.5d \) is the unit price paid to the incumbent supplier. This price includes two components. The first term, \( c(\theta) \), is the actual cost of the incumbent supplier including an accepted profit margin for the supplier. The second term, \( 0.5d \), is half of the cost savings due to the buyer’s investment, which reduces the purchasing price. Hence, the term on the right-hand side reflects the buyer’s profit when he has decided to develop his supplier. The superscript \( d \) denotes the purchasing volume, when developing occurs. Note that the buyer decides about the purchasing volume after the realisation of the uncertain state of the world. Solving this expression gives the profit-maximising purchasing volume

\[
q^d(\theta, d) = \frac{h(\theta) + 0.5d}{b},
\]

where \( h(\theta) = a(\theta) - c(\theta) \) is the difference between the maximum price (when demand equals 0) and the unit cost, which is assumed to be positive. The purchasing volume is increasing in \( a(\theta) \) and \( d \), and it is decreasing in \( c(\theta) \) and \( b \). Based on this purchasing volume, the buyer chooses his development investment so as to maximise
\[ d^* = \arg \max E[p(q^*(\theta, d), \theta)q^*(\theta, d) - t(\theta, d)q^*(\theta, d) - w(d)], \] (4)

where expectations are taken over \( \theta \). The first-order condition provides the profit-maximising investment level (see appendix)

\[ d^* = \frac{E[h(\theta)]}{2by - 0.5}, \] (5)

which is increasing in \( E[h(\theta)] \) and decreasing in \( \gamma \) and \( b \). Using this expression for the profit-maximising purchasing volume gives

\[ q^*(\theta, d^*) = \frac{h(\theta)}{b} + \frac{E[h(\theta)]}{b(4by - 1)}. \] (6)

The buyer’s corresponding profit can be obtained by using the optimal investment and purchasing levels in the buyer’s profit function

\[ \pi_\sigma(q(d), d) = E[p(q(\theta, d), \theta)q(\theta, d) - t(\theta, d)q(\theta, d) - w(d)]. \] (7)

We summarise the buyer’s profit in the following proposition:

**Proposition 1:** In case of developing the incumbent supplier, the buyer’s expected profit is characterised by the following expression:

\[ \pi_\sigma(q(d^*), d^*) = \frac{1}{2b} \left( \text{Var}[h(\theta)] + E[h(\theta)]^2 \left( \frac{4by}{4by - 1} \right) \right). \] (8)

The buyer’s expected profit is increasing in \( \text{Var}[h(\theta)] \). The reason is that the buyer determines his purchasing volume after the uncertain state of the world has been realised. If the buyer’s profit as the difference between revenues and costs is more volatile, the option to react to uncertainty is more valuable and consequently the buyer’s expected ex ante profit is higher. Developing suppliers becomes more attractive if uncertainty is higher. The buyer’s profit is decreasing in \( b \). The intuition for this result is straightforward. The buyer’s profit is lower if the demand function is steeper. Since there is less demand, prices, quantities, and, consequently, profits are lower. The buyer’s profit is decreasing in \( \gamma \) as well. If development costs are higher, developing the supplier becomes less attractive.

5. The switching decision
We now analyse the case when the buyer has decided to switch to the entrant supplier. Again starting with the buyer’s last decision, his purchasing volume will be chosen so as to maximise

\[ q^*(\theta) = \arg \max \{p(q(\theta, \theta)q - p, q\}, \] (9)

where the term on the right-hand side is the profit, when the decision to switch has already been made. The superscript \( s \) denotes the purchasing volume, when switching has occurred. Solving (9) gives the profit-maximising purchasing volume

\[ q^*(\theta) = \frac{a(\theta) - p_s}{b}. \] (10)

The buyer’s profit will be

\[ \pi_s(q^*(\theta), \theta, s) = E[p(q^*(\theta), \theta)q^*(\theta) - p_s q^*(\theta) - s], \] (11)

where \( s \) denotes the buyer’s one-time switching costs. Again, we summarise the buyer’s profit in the following proposition:

**Proposition 2:** In case of switching to an alternative supplier, the buyer’s expected profit is characterised by the following expression:

\[ \pi_s(q^*(\theta), \theta, s) = \frac{1}{2b} \left( \text{Var}[a(\theta)] + (E[a(\theta)] - p_s)^2 \right) - s, \] (12)
The buyer’s profit function has many intuitive features. If the buyer has decided to switch to the entrant supplier, his corresponding expected profit is increasing in $\text{Var}[a(\theta)]$. The reason is, as in the case above, that the buyer can react to the realisation of the uncertain state of the world, that is, the realisation of the demand function, by determining the corresponding profit-maximising purchasing volume. The buyer’s profit is also increasing in $E[a(\theta)]$ and decreasing in $b$, $p_1$, and $s$.

6. Comparing supplier development and supplier switching

6.1 Comparative statics of the optimal sourcing strategy

We now analyse the buyer’s initial decision, when he either decides to switch to an entrant supplier or to develop the incumbent supplier. Let $\Delta \pi \equiv \pi_s - \pi_d$ be the difference between the buyer’s expected profit when switching and the buyer’s expected profit when developing. Hence,

$$
\Delta \pi = \frac{1}{2b} \left( \text{Var}[a(\theta)] + (E[a(\theta)] - p_2)^2 \right) - s - \frac{1}{2b} \left( \text{Var}[h(\theta)] + E[h(\theta)]^2 \left( \frac{4by}{4by^2 - 1} \right) \right).
$$

(13)

Using this expression, we can make the following proposition:

**Proposition 3:** The buyer’s optimal sourcing strategy is determined by the following profit difference:

$$
\Delta \pi = \frac{1}{2b} \left( (E[a(\theta)] - p_2)^2 - \text{Var}[c(\theta)] + 2\text{Cov}[a(\theta), c(\theta)] - E[h(\theta)]^2 \left( \frac{4by}{4by^2 - 1} \right) \right) - s.
$$

(14)

If $\Delta \pi > 0$, then switching to the entrant supplier is the optimal sourcing strategy. Conversely, if $\Delta \pi < 0$, then development is optimal.

In order to understand the driving forces behind the optimal sourcing strategy, we provide its comparative statics. It is immediately clear that $\Delta \pi$ is decreasing in $\text{Var}[c(\theta)]$. Switching is less likely if the variance of the incumbent supplier’s cost is high. With higher uncertainty about the incumbent supplier’s cost, switching becomes a less attractive option. The reason for this surprising result is that there are different contractual arrangements for the entrant and the incumbent supplier. If the buyer develops the incumbent supplier, he can adjust the purchasing volume. However, the purchasing volume as well as the optimal development investment continues the relationship with the incumbent supplier, the per-unit price is based on the realised cost. If the realised cost is higher (lower) than expected, the buyer reduces (increases) the purchasing volume in order to maximise profits. This ability to react is more valuable if uncertainty is higher, which explains the result.

Closely related to this finding is the more subtle result that switching (developing) is more attractive if the uncertain maximum demand and the uncertain incumbent supplier’s cost are positively (negatively) correlated. In the case of switching to the entrant supplier, the correlation between $a(\theta)$ and $c(\theta)$ does not affect the subsequent decision on the purchasing volume. However, the purchasing volume as well as the optimal development investment is affected by this correlation in the case of developing the incumbent supplier. A negative correlation between the maximum demand and the incumbent supplier’s cost is associated with highly volatile profits approximated by the difference of $a(\theta)$ and $c(\theta)$. If the buyer develops the incumbent supplier, he can adjust the purchasing volume according to the realisation of $a(\theta)$ and $c(\theta)$. The option to adjust purchasing volume becomes more valuable when uncertainty is high. Conversely, if there is a positive correlation between the maximum demand and the incumbent supplier’s cost, the difference between $a(\theta)$ and $c(\theta)$ will be less volatile and the option to adjust the purchasing volume is less valuable. This result has powerful implications for sourcing decisions in different industries that we will discuss below. The boundary between the development and switching areas is obtained by setting $\Delta \pi$ in (14) to zero and solving for $\text{Var}[c(\theta)]$, which yields

$$
\text{Var}[c(\theta)] = 2\text{Cov}[a(\theta), c(\theta)] + (E[a(\theta)] - p_2)^2 - E[h(\theta)]^2 \left( \frac{4by}{4by^2 - 1} \right) - 2bs.
$$

(15)

Figure 1 shows the development and switching area as a function of the variance of the incumbent supplier’s cost and the correlation between the maximum demand and the incumbent supplier’s cost.

To complete the comparative statics analysis, $\Delta \pi$ is decreasing in $p_2$, $s$ and $E[a(\theta) - c(\theta)]$, and increasing in $E[a(\theta)]$. Hence, switching is the better choice if the expected maximum demand takes higher values.
Contrarily, development is more attractive if the switching costs, the price of the entrant supplier or the expected value of the difference between the maximum demand and the incumbent supplier’s cost is high.

Since in our model the buyer decides upon the purchasing volume, it is advisable to compare the different purchasing volumes in the case of development and switching. Defining this difference as $D_q \equiv q_d(\theta) - q_s(\theta)$, we arrive at the following expression:

$$D_q = \frac{c(\theta) - 0.5d^*}{b} - \frac{p_s}{b} = \frac{1}{b}(t(\theta, d^*) - p_s).$$  \hspace{1cm} (16)

From an ex post perspective, the purchasing volume is the same if the incumbent supplier’s new price equals the entrant supplier’s price. Note that the incumbent supplier’s cost $c(\theta) - d^*$ is not equal to the incumbent supplier’s price $t(\theta, d^*)$, since we have assumed that half of the cost saving due to the development investment is captured by the incumbent supplier.

### Special cases

In order to provide a more detailed intuition for our results, we consider two special cases. We start with the case when the incumbent supplier’s costs are certain, that is, $c(\theta) = c^\theta$. Then the difference between the buyer’s expected profit when switching and the buyer’s expected profit when developing reduces to

$$\Delta \pi = \frac{1}{2b} \left( (E[a(\theta)] - p_s)^2 - E[a(\theta) - c]^2 \left( \frac{4by}{4by - 1} \right) \right) - s. \hspace{1cm} (17)$$

If there is no uncertainty about the incumbent supplier’s cost, the decision as to whether to switch or to develop does not depend on the degree of uncertainty. It only depends on the (expected) values of the parameters and can be easily calculated.

As the second special case we assume that the maximum demand is certain. The only kind of uncertainty now stems from the incumbent supplier’s cost. Then the difference between the buyer’s expected profit when switching and the buyer’s expected profit when developing is

$$\Delta \pi = \frac{1}{2b} \left( -\text{Var}[c(\theta)] + (a - p_s)^2 - E[a - c(\theta)]^2 \left( \frac{4by}{4by - 1} \right) \right) - s. \hspace{1cm} (18)$$

Now the degree of uncertainty becomes crucial for the decision to switch or to develop. With increasing uncertainty, developing the incumbent supplier is the better choice and dominates the switching alternative.
7. Discussion and outlook

Research on supplier development decisions has largely remained on the ‘strategic and qualitative level’ of analysis and recommends that supplier development investments by the buying firm are warranted for suppliers of critical and strategic components, while buying firms should switch to an alternatively available source and not develop suppliers of non-critical and non-strategic components (Kraljic 1983, Krause et al. 1998, Tang 1999). We argue that quantitative and more in-depth analyses for the decision to either develop or switch a supplier and effective contracting arrangements between the buyer and the incumbent or alternative supplier are necessary. Such analyses should take into account the price that the buyer can realise on his product market, supplier development investments, cost savings realised as a consequence of the supplier development investment, costs of the incumbent and alternative supplier, and supplier switching costs. Supplier development (at least partially) involves cooperative specific investments that need to be supported by effective contracts between the buyer and supplier firm (Che and Hausch 1999, McLaren 1999). Several results of our study warrant an additional discussion.

First, the buyer should develop the incumbent supplier when the variance of the incumbent’s costs is high. Each time the incumbent supplier reduces his costs, whether due to the buyer’s supplier development program, or as a result of supplier internal cost reduction measures, the buyer will be able to benefit from the incumbent supplier’s lower costs. In the case of switching, the buyer would sign a fixed-price contract with the entrant supplier for a certain period of time. In many industries, such as automotive, it is common practice to implement annual contracts. Cost reductions (due to varying costs of the supplier) would be forgone for the buyer (Joskow 1990).

Second, the buyer should develop the incumbent supplier when the uncertain maximum demand is negatively correlated with the uncertain incumbent supplier’s cost and switch to an alternative supplier in the case of a positive correlation. An example of the latter would be situations when the buyer and the supplier operate in the same industry, such as high-tech electronics, and the incumbent supplier provides integrated circuits to the buyer in the computer industry. When the industry booms, the buyer is able to sell higher quantities for higher prices. The incumbent supplier may experience shortages on the supply market due to the high demand in the industry, and may also have to purchase his raw material for a higher price. In this case, it is advantageous for the buyer to switch to a supplier who is able to access different, low cost supply sources and bear the one-time switching costs.

Third, the buyer should develop the incumbent supplier if the switching costs, the price of the entrant supplier or the expected value of the difference between the maximum demand and the incumbent supplier’s cost are high. It is well established in the literature that high switching costs are a disincentive for supplier switching (e.g., Demski et al. 1987, Klemperer 1995).

Fourth, our finding that total supply chain-spanning (i.e., supplier–buyer–customer) welfare could be improved if the buyer were to choose to develop the incumbent instead of switching to an alternative supplier supports the view promoted by Chopra and Meindl (2010), namely, that if stages of a supply chain coordinate their strategies and actions closely to best meet the customers’ needs, they can maximise supply chain surplus. For such an alignment to happen the firms must establish closer and more collaborative buyer-supplier relationships and share risks, costs, and rewards equitably (Lee 2004). By choosing the more cooperative option of developing the supplier instead of terminating the relationship, the buying firm would, in our case, act for the advantage of the incumbent supplier as well as the established supply chain’s customers.

Since we use a formal modelling approach, our results and conclusions rely heavily on the assumptions of our model which could be relaxed in future research. First, while it might be useful to consider alternative representations of the variable to optimise, we have chosen to maximise on the buyer’s purchasing volume. Second, we assumed a one-period world. Since other research introduced interesting perspectives on multi-period investments with sequential cash outflows (e.g., Friedl 2002), or switching costs in ongoing multi-period procurements (e.g., Lewis and Yildirim 2005), it might be worthwhile to extend the decision rules derived in our research to a multi-period setting. Third, future research could investigate alternative contractual arrangements with the incumbent supplier and how they influence the sourcing decision. Fourth, we motivated the focus on the alternatives supplier development and supplier switching by assuming that components are produced by a supplier and products are sold to the market by the buying (focal) firm. Hence neither do we alter the buying firm’s outsourcing decision (e.g., Chalos and Sung 1998) nor allow that a supplier sells products directly to the market.
References


Appendix

Proof of equation (5)
We use the optimal purchasing volume \( q^*(\theta, d) = \frac{h(\theta) + 0.5d}{b} \), \( t(\theta, d) = c(\theta) - 0.5d \), \( w(d) = 0.5yd^2 \), and \( p(q, \theta) = a(\theta) - 0.5bq \) in Equation (4), which yields

\[
d^* = \arg \max E \left[ \left( a(\theta) - 0.5b \left( \frac{h(\theta) + 0.5d}{b} \right) \right) \left( \frac{h(\theta) + 0.5d}{b} \right) - (c(\theta) - 0.5d) \left( \frac{h(\theta) + 0.5d}{b} \right) - 0.5yd^2 \right]. \tag{A1}\]

Simplifying gives

\[
d^* = \arg \max E \left[ \frac{1}{2b} \left( \frac{h(\theta) + 0.5d}{b} \right)^2 - 0.5yd^2 \right]. \tag{A2}\]

From the first order condition

\[
\frac{E[h(\theta)]}{2b} + \frac{0.5d^*}{2b} - \gamma d^* = 0, \tag{A3}\]

it follows that

\[
d^* = \frac{E[h(\theta)]}{2b\gamma - 0.5}. \tag{A4}\]

Proof of proposition 1
Using \( q^*(\theta, d^*) = \frac{h(\theta)}{b} + \frac{E[h(\theta)]}{b(4b\gamma - 1)} \), \( t(\theta, d) = c(\theta) - 0.5d \), \( w(d) = 0.5yd^2 \), \( d^* = \frac{E[h(\theta)]}{2b\gamma - 0.5} \), and \( p(q, \theta) = a(\theta) - 0.5bq \) in Equation (7) gives

\[
\pi_\delta(q(\theta, d^*), \theta, d^*) = E \left[ \frac{1}{2b} \left( h(\theta) + \frac{E[h(\theta)]}{4b\gamma - 1} \right)^2 - 0.5\gamma \left( \frac{E[h(\theta)]}{2b\gamma - 0.5} \right)^2 \right]. \tag{A5}\]

Simplifying and rearranging yields

\[
\pi_\delta(q(\theta, d^*), \theta, d^*) = \frac{E[(h(\theta))^2]}{2b} + \frac{E[(h(\theta))^2]}{2b(4b\gamma - 1)} \tag{A6}\]

or

\[
\pi_\delta(q(\theta, d^*), \theta, d^*) = \frac{1}{2b} \left( \text{Var}[h(\theta)] + \left( \frac{4b\gamma}{4b\gamma - 1} \right) E[h(\theta)]^2 \right). \tag{A7}\]

Proof of proposition 2
Using \( q^*(\theta) = \frac{h(\theta)}{b} \), in Equation (11) gives

\[
\pi_*(q^*(\theta), \theta, s) = E \left[ \frac{(a(\theta) - p_s)^2}{2b} - s \right]. \tag{A8}\]

Simplifying and rearranging terms yields

\[
\pi_*(q^*(\theta), \theta, s) = \frac{1}{2b} \left( \text{Var}[a(\theta)] + (E[a(\theta)] - p_s)^2 \right) - s. \tag{A9}\]
Proof of proposition 3

\[
\Delta \pi = \frac{1}{2} \left[ \text{Var}[a(\theta)] + (E[a(\theta)] - p_s)^2 \right] - s - \frac{1}{2b} \left( \text{Var}[h(\theta)] + E[h(\theta)]^2 \left( \frac{4bh}{4by - 1} \right) \right)
\]

\[
= \frac{1}{2b} \left( \text{Var}[a(\theta)] + (E[a(\theta)] - p_s)^2 \right) - s
\]

\[
- \frac{1}{2b} \left( \text{Var}[a(\theta)] + \text{Var}[c(\theta)] - 2\text{Cov}[a(\theta), c(\theta)] + E[h(\theta)]^2 \left( \frac{4bh}{4by - 1} \right) \right)
\]

\[
= \frac{1}{2b} \left( (E[a(\theta)] - p_s)^2 - \text{Var}[c(\theta)] + 2\text{Cov}[a(\theta), c(\theta)] - E[h(\theta)]^2 \left( \frac{4bh}{4by - 1} \right) \right) - s
\]  

(A10)