需求變異對自製或外購決策的影響

郭瑞基
東吳大學

摘要

在傳統的自製或外購決策的定量分析中，係假設未來材料或零組件的需求量為已知且確定的。於是，在瞭解有關自製所需投入的固定與變動成本，以及取得外購的可能價格與折扣等相關資訊後，即可對自製或外購決策，進行適當的定量分析。然而，未來係充滿不確定性的，成本面的資訊或許容易估計，而外購價格亦可透過議價協商而預知，惟材料或零組件的需求量，往往受到最終產品市場變化影響，而無法事前準確預估。是以本研究即著眼於不確定需求的前提，探討需求變異的改變，對於自製或外購決策定量分析的影響。研究結果顯示，需求變異的擴大，將可能導致對外購的代案有利，且該需求變異擴大對外購代案所產生的有利影響，亦將隨需求變異的增加而遞增。

關鍵詞：定量分析、需求變異、自製或外購
The Impact of Demand Variance on Make-or-Buy Decision

Ruey-Ji Guo
Soochow University

Abstract

In the quantitative analysis of make-or-buy decision, the decision maker is faced with the variety of uncertain factors. Since the demand for parts or components is derived from the demand for the related final product, the uncertainty of demand for the final product becomes one of the important uncertain factors in make-or-buy decision. This paper intends to find the insight into how demand variance influences the firm’s make-or-buy decision. Under the basic assumptions and setting, the paper shows that the enlargement of demand variance will induce the firm to outsource the parts or components rather than to produce them. Moreover, it is found that a faster change in the marginal cost of self-making or outsourcing (e.g., a fast increasing penalty cost or a fast increasing quantity discount) will make the decision much more sensitive to the change in demand uncertainty.

Keywords: Quantitative Analysis, Demand Variance, Make-or-Buy
1. INTRODUCTION

In the field of management accounting, there exist a lot of literatures on discussing the “make or buy” decisions of parts or components. The issue becomes so important due to not only cost-facet but also strategic considerations. While the discussion in this paper is concerned with the make-versus-buy decisions of parts or components, it can be easily extended to the similar decisions of services acquisition. Essentially, the make-or-buy decisions are involved with whether a firm will produce parts or components herself or purchase them from outside vendors. Generally, the process of purchasing parts or components from outside vendors is called outsourcing, and producing them within the firm is called insourcing.

Similar to the other management decisions, the analysis of make-or-buy decision also includes quantitative as well as qualitative considerations. Basically, we believe that the quality of management decision will be improved if the quantitative analysis can play a much more prominent role in the whole decision analysis. Of course, it is still possible that qualitative factors can dictate management’s make-or-buy decision. For example, some firms must buy parts or components from outside suppliers because they do not own the related know-how or technology to make them; on the other hand, there also exist some firms that prefer to produce parts or components in-house to retain control of the parts or components and the related technology.

As Horngren, Datar, and Foster (2003) state that surveys of companies indicate they consider the most important factors in the make-or-buy decision to be quality, dependability of suppliers, and cost. In addition, Carter and Usry (2002) further pinpoint that, faced with a make-or-buy decision, management should do the following:

(1) Consider the quantity, quality, and dependability of supply of the items as well as the technical know-how required to produce them, weighing such requirements for both the short-run and long-run period.

(2) Compare the cost of making the items with the cost of buying them.

(3) Consider whether, if the items are purchased rather than made, there may be other, more profitable alternative uses for the firm’s own facilities.

(4) Consider differences in the required capital investment and the timing of cash flows.

(5) Adopt a course of action consistent with the firm’s overall policies. Customers’ and suppliers’ reactions often play a part in these decisions. Retaliation or ill will can result from inconsistent treatment of customers and suppliers. Whether it is profitable to make or buy depends on the circumstances surrounding the individual situation.
In spite of the importance of qualitative analyses, this paper assumes that quantitative analyses predominate in the make-or-buy decisions and focuses on the consideration of measurable or quantifiable factors. Specifically, the uncertainty of demand for parts or components will be properly addressed in this paper to demonstrate its potential impact on management’s make-or-buy decision. In traditional management accounting textbooks, the quantitative analyses of make-or-buy decisions are generally undertaken by assuming the demand for parts or components in the forthcoming period is known and ascertained. Thus, with the related cost information, we can straightforwardly compare the insourcing costs with the outsourcing costs or analyze the differential costs to make an optimal make-or-buy decision.

However, the demand for those parts or components is uncertain before the actual demand is realized. If we consider the demand to be certain or just use the expected demand in the analysis of make-or-buy decision, the implication in the decision of demand uncertainty can be wholly neglected and, finally, the firm must incur the consequence of the wrong decision. Therefore, in this paper, the uncertainty of demand variance will be featured in the analytical model. The purposes of this study not only provide the results of theoretical analyses but also demonstrate the possible application in practices of those results by virtue of numerical illustration. The remainder of the paper is organized as follows. The second section reviews related literature. The third characterizes the basic assumptions and setting of the model. The fourth describes the types of make-or-buy decisions and the analysis, while the numerical illustration is presented in the fifth section. Finally, the sixth section discusses the results and concludes.

2. RELATED LITERATURE

With respect to the effect of uncertain demand on management decision, there exist a lot of researches contributing to the resolution of related issues. For example, when investing in a new machine, one must estimate the reduced labor costs. In the past, this was done in a deterministic way, assuming that one has an accurate point estimation of demand rates and the reduction in labor costs is proportional to the reduction in labor hours. However, if demand rates of products are known probabilistically, the expected reduction in labor hours will follow a probability distribution. Hence, Jang and Liu (1993) present a procedure to estimate the distribution of the reduction in labor hours from a new machine under uncertain demand. By a numerical example, it is shown that the estimation error of this procedure is very small even with a relatively rough estimation procedure.

Next, determining the product mix for a given period of time is one of the
important production decisions. The objective is to utilize the limited resources to maximize the net value of the output from the production facilities. Fundamentally, the product mix decision is dependent upon the production capacities of facilities, demand for various products, and the revenue as well as variable costs concerning each product. In the Kasilingam’s (1995) research, the product mix problem in the presence of alternate process plans under uncertain demand is formulated as a non-linear programming model. Then, he presents a heuristic solution procedure to resolve the related decision problem.

As for the pricing decisions, the demand uncertainty also plays a critical role. Raman and Chatterjee (1995) examine pricing policy for a monopolist facing uncertain demand in a market. They find that, in general, the degree of impact of demand uncertainty on the optimal pricing policy is determined by the interaction among uncertainty, demand and cost dynamics, and the firm’s discount rate. Thus, they suggest that farsighted firms operating under dynamic market conditions with high demand uncertainty should attach particular importance to the formal consideration of uncertainty in their long run pricing decisions.

Facing uncertain demand, manufacturers may induce distributors to carry ample stocks of their products by agreeing to accept returns of unsold goods for credit. Regarding the issue, Marvel and Peck (1995) present a model of manufacturer’s decision to accept returns, showing that this decision depends crucially on the nature of the demand uncertainty. In addition, it’s well-known that retailers selling products such as new fashion items or new toys often face considerable uncertainty in demand. Hence, Subrahmanyan and Shoemaker (1996) develop a model for use by retailers. The model incorporates learning or updating of demand, and assists the retailers in determining the optimal pricing as well as stocking policies.

In management accounting, the analysis of cost and benefit is always an important principle for making an adequate management decision. Unexceptionally, the make-or-buy decision is faced with similar consideration. As the introduction mentions, while the qualitative factors can dictate management’s make-or-buy decision, a well-doing quantitative analysis should be able to raise the quality of decision. Two papers are closely related to this issue and my work.

Gardiner and Blackstone, Jr. (1991) examine the financial impact of the make-or-buy decision due to plant capacity. They argue that many current make-or-buy decisions are made improperly and that capacity-sensitive decision procedures are needed. In their article, the standard cost method, a make-or-buy decision method based on the standard cost system, is compared with the contribution per constraint minute (CPCM) and maximum permissible component price (MPCP) methods, which are based
on the TOC philosophy. They conclude that the standard cost method, when strictly applied, ignores the revenue component of the decision and does not consistently yield the most profitable decision. The CPCM and MPCP methods are offered as procedures that consistently choose the more profitable decision. There are two important differences between their article and my work. First, I allow the demand for parts or components to be uncertain rather than one certain number. Second, I assume the capacity for making internally needs to be set up after the firm chooses the “making” alternative instead of coming from the currently available capacity. Hence, there exists no problem of capacity constraint in this paper.

On the other hand, Yoon and Naadimuthu (1994) address the problem of imprecise information in the make-or-buy decisions. They claim that most of input cost data in the make-or-buy decision needs to be estimated in advance, and an estimate error may not be avoided. Thus the conventional make-or-buy decision with certainty assumption may not be realistic. They present a decision rule in order to make more precise discriminations between two competing alternatives expressed in imprecise ways. First, they introduce a propagation of errors technique to capture the most probable aggregate error of a function owing to individual estimation errors. Next, they present a simple make-or-buy model balancing fixed and variable costs, and finally formulate a more complex model by way of lot-sizing method. In their article, they show that the first model determines the minimum demand where the “make” option is preferred (i.e. break-even point), whereas the second model determines the preferred option with the given demand level.

The fundamental difference between theirs and my work is what they address is the imprecise information but I address is the uncertainty of demand variance. The former involves the measurement error problem, and the latter is concerned with the business risk one. Furthermore, this paper classifies the make-or-buy decisions as some possible types, and analyzes how the uncertainty of demand variance influences the optimal make-or-buy decision. In terms of methodology, while this paper doesn’t take into account the variability of other variables related to the make-or-buy decisions, it allow much more flexibility on the variance of demand uncertainty.

3. THE MODEL

Time horizon is an important factor in determining whether costs are relevant or not for decision-making. Some costs, which are fixed in the short-run decision, can be adjusted in the long-run decision. For example, in make-or-buy decision, the fixed costs related to personnel and equipment can be unavoidable or not adjustable in the short-run, and can be considered irrelevant costs. However, in the long-run decision, those costs
can become avoidable and even adjustable. In that case, they will be relevant costs and should be taken into account while making decision.

As for the outsourcing costs, in addition to the costs of parts or components directly paid to suppliers, they also include the costs related to the purchasing or receiving operations. Some of those costs can be unit-related variable costs, but there exist still some of them, which are order-related variable costs or purely fixed costs in the short-run. In fact, those fixed costs related to outsourcing alternative, such as the facility-sustaining costs of purchasing and receiving departments, can also be allowable for adequate adjustment in the long-run.

In this context, I don’t intend to distinguish short-run decision from long-run decision. It is simply assumed that the whole decision-relevant costs can be classified either fixed ones or variable ones, and the fixed costs related to insourcing alternative will be more than those related to outsourcing alternative. Since the self-making capacity can be set up after make-or-buy decision, those fixed costs related to insourcing alternative are mainly involved with the establishment and maintenance of production facilities. Subject to the capacity constraint, the firm will be unable to produce parts or components more than the maximum capacity. However, it is assumed that it is favorable for the firm to satisfy the whole demand for parts or components by outsourcing those cannot be produced inside. Of course, the marginal costs of outsourcing will be larger than those of producing inside while capacity is available.

To simplify the analysis, it is assumed the cost behavior of self-making follows a quadric convex function, i.e., $C_s = F_s + s_1 \cdot q + s_2 \cdot q^2$, where $F_s$ is the fixed costs for self-making, $q$ is the production quantity, and $s_1$ as well as $s_2$ refer to the related parameters of cost function for self-making. Also, it is assumed $F_s > 0$, $s_1 > 0$, $s_2 > 0$, and $q \geq 0$. Due to the popular production automation, the learning curve effect will not be considered in this context.

On the other hand, if the firm decides to outsource the parts or components, the overall purchasing costs will include both variable costs and fixed costs. In consideration of quantity discounts, it is assumed the cost behavior of outsourcing follows a quadric concave function, i.e., $C_o = F_o + o_1 \cdot q - o_2 \cdot q^2$, where $F_o$ is the fixed costs for outsourcing, $q$ is the purchasing quantity, and $o_1$ as well as $o_2$ refer to the related parameters of cost function for outsourcing. Also, it is assumed

---

1 Kaplan and Atkinson (1998) refer to the fixed costs as “committed costs”.
2 The increased cost due to the actual demand over than the maximum capacity is called the “penalty cost” by Banker and Hughes (1994).
0 < F_o < F_1, \, o_1 > 0, \, o_2 > 0, \text{ and } 0 \leq q < \frac{o_1}{2o_2}. ^3 

Since the demand for parts or components is derived from the demand for the related final product, the uncertainty of demand for the final product becomes one of the important uncertain factors in “make or buy” decision. In order to analyze the potential impact on “make-or-buy” decision of the uncertainty of the derived demand, it is assumed the demand for parts or components follows a uniform distribution; i.e., 

\[ q \sim \text{UNI}(\underline{q}, \bar{q}). \] ^4 In the later analysis, I use \( \underline{q} \) and \( \bar{q} \) to refer to the lower bound and the upper bound of demand for parts and components, respectively. Moreover, 

\[ D(q) = C_s(q) - C_o(q) \] 

reflects the difference between the self-making cost and the outsourcing cost while the demand is \( q \). It is reasonable that the outsourcing alternative will dominate the self-making one if \( D(q) > 0 \); and vice versa.

4. THE ANALYSIS

According to the assumptions above-mentioned, the total self-making cost is convex in the quantity of demand for parts or components, but the total outsourcing cost is concave in that. Hence, the relative relation between the self-making cost function and the outsourcing cost function becomes an important determinant of make-or-buy decision. Essentially, any make-or-buy decision can be assigned to one of the following three types; i.e.,

(1) For-outsourcing type:

Under some situations, the initial investment or the fixed committed costs can be large enough so that the self-making cost curve is always above the outsourcing cost curve for the possible range of demand, i.e. \( q \in [\underline{q}, \bar{q}] \), for parts or components. In that case, the decision maker will take the outsourcing alternative unless the result of qualitative analysis dominates that of quantitative analysis. This type of decision can be referred to as for-outsourcing type of decision.

(2) For-insourcing type:

In this type of decision, the self-making cost curve is always below the outsourcing cost curve for the possible range of demand for parts or components. Hence, the self-making alternative becomes the optimal solution of make-or-buy decision unless

---

^3 The \( q < \frac{o_1}{2o_2} \) is used to ensure the marginal cost of outsourcing be positive.

^4 In practice, it is not necessary for the demand to follow uniform distribution. While this paper adopts the uniform distribution assumption for analytical consideration, the results can be extended to other pattern of probability distribution without too much loss of generality.
the result of qualitative analysis dominates that of quantitative analysis. This type of
decision can be referred to as for-insourcing type of decision.

(3) General type:

Generally, the self-making cost curve may be not always above or below the
outsourcing cost curve for the possible range of demand for parts or components. In
other words, for some possible demand for parts or components, the total self-making
costs can be larger than the total outsourcing costs; however, for other possible demand
for parts or components, the total self-making costs can be smaller than the total
outsourcing costs. Therefore, the future level of demand becomes the prominent
determinant of make-or-buy decision. Conventionally, in the quantitative analysis of
make-or-buy decision, it is assumed the future demand is certain and known; even not
so, it is assumed at least there exists an expected demand that can be incorporated into
the decision model. In that case, the quantitative analysis will result in an optimal
decision either for self-making or for outsourcing alternative.

However, even though the expected demand can be reasonably estimated, the
problem of the uncertainty of demand remains there. For example, two make-or-buy
decisions with the same expected demand can imply a wholly different uncertainty of
demand. This paper will dwell on how the difference in demand variance influences the
make-or-buy decisions and brings about different optimal alternatives. In the context, it
is assumed the demand follows some uniform distribution. Hence, the more the
difference between the lower bound and the upper bound of demand for parts and
components, the more uncertain the demand that decision maker is faced with.

Following some simple mathematical analyses, we can find a few of propositions
to characterize the properties of make-or-buy decisions under uncertain demand.5 First
of all, if the increased fixed cost required by choosing self-making alternative instead of
outsourcing alternative is over than a certain amount, the decision will be favorable for
outsourcing alternative. That is,

Proposition 1:

\[ \Delta F = F_s - F_o > 0 \quad \text{and} \quad \Delta F > \frac{(o_1 - s_1)^2}{4(o_2 + s_2)} , \quad \text{then} \quad D(q) = C_s(q) - C_o(q) > 0 \]

\[ \forall q \in [q_1, q_2] \] , and the optimal alternative is to outsource the parts or components needed.

It is not difficult to see that, provided the fixed costs required by self-making is
over than that required by outsourcing, a decrease in the initial marginal cost of

---

5 If needed, please contact the author for the proofs of propositions.
outsourcing (i.e., a smaller $o_1$), or an increase in the initial marginal cost of self-making (i.e., a larger $s_1$), coupled with a faster decrease in the marginal cost of outsourcing (i.e., a larger $o_2$) or a faster increase in the marginal cost of self-making (i.e., a larger $s_2$), will result in a make-or-buy decision favorable for the outsourcing alternative. In other words, the lower the initial outsourcing price (without quantity discount) and the more the quantity discounts, or the higher the initial variable cost of self-making as well as the larger the penalty cost while the capacity is not enough, the more favorable for the outsourcing alternative is the make-or-buy decision.

However, if the increased fixed cost required by self-making instead of outsourcing is not up to a certain amount, the decision will turn out another situation and will be characterized in the following proposition.

Proposition 2:

Assume $\Delta F \equiv F_s - F_o > 0$ as well as $o_1 > s_1$, and let

$$q_1 \equiv \frac{1}{2} \left[ \frac{o_1 - s_1}{o_1 + s_1} - \sqrt{\frac{(o_1 - s_1)^2}{(o_1 + s_1)^2} - 4 \cdot \Delta F} \right] \quad \text{and} \quad q_2 \equiv \frac{1}{2} \left[ \frac{o_1 - s_1}{o_1 + s_1} + \sqrt{\frac{(o_1 - s_1)^2}{(o_1 + s_1)^2} - 4 \cdot \Delta F} \right].$$

Provided $\Delta F < \frac{(o_1 - s_1)^2}{4(o_2 + s_2)}$ as well as $q \sim \text{UNI}(q, \bar{q})$, the optimal alternative is to self-make the parts or components needed if $q_1 < q < \bar{q} < q_2$, but the optimal alternative is to outsource the parts or components needed if $\bar{q} < q_1$ or $q > q_2$.

By proposition 2, it is shown that the optimal make-or-buy decision will depend on where the possible demand is located if the increased fixed cost required by self-making instead of outsourcing is not up to a certain amount, $\frac{(o_1 - s_1)^2}{4(o_2 + s_2)}$. It is indicated that the optimal alternative is self-making if the possible demand $q \in (q_1, q_2)$ so that the expected self-making cost is less than the expected outsourcing cost. Nevertheless, the optimal alternative becomes outsourcing if the possible demand $q \not\in (q_1, q_2)$ so that the expected self-making cost is over than the expected outsourcing cost.

On the other hand, an increase in the initial marginal cost of outsourcing (i.e., a larger $o_1$), or a decrease in the initial marginal cost of self-making (i.e., a smaller $s_1$), will enlarge the demand range which is favorable for self-making alternative. In addition, a slower increase in the marginal cost of self-making (i.e., a smaller $s_2$), a slower decrease in the marginal cost of outsourcing (i.e., a smaller $o_2$), or a decrease in the differential fixed cost between self-making and outsourcing (i.e., a smaller $\Delta F$), will also have the same effect.
Basically, the effect comes from two factors. Firstly, since the average cost of self-making is equal to that of outsourcing as the demand \( q = q_1 \), but the marginal cost of self-making remains less than that of outsourcing therein, a slower increase in the marginal cost of self-making (e.g., a slow increasing penalty cost) or a slower decrease in the marginal cost of outsourcing (e.g., a slow increasing quantity discount) will make the advantage of self-making to persist until a higher demand level. Secondly, a reduction in the differential fixed cost between self-making and outsourcing, an increase in the initial marginal cost of outsourcing, and a decrease in the initial marginal cost of self-making are all helpful to reduce the indifference demand level, \( q_1 \), and will enlarge the demand range which is favorable for self-making alternative.

The aforementioned inferences are based on \( \Delta F < \frac{(o_1 - s_1)^2}{4(o_2 + s_2)} \) and \( q \sim \text{UNI}(q, q) \), but \( q \) and \( q \) are subject to a few of constraints. Generally, in the possible demand range, some demand levels can be favorable for self-making alternative, but other demand levels can be favorable for outsourcing alternative. Hence, it is necessary for us to analyze the expected differential cost, \( E(D) \), between self-making and outsourcing. The related results are summarized in proposition 3.

Proposition 3:

Assume \( \Delta F \equiv F_s - F_o > 0 \) as well as \( o_1 > s_1 \), and let

\[
q_1 = \frac{1}{2} \left[ \frac{o_1 - s_1}{o_1 + s_1} - \sqrt{\frac{(o_1 - s_1)^2}{o_1 + s_1} - \frac{4 \cdot \Delta F}{o_1 + s_1}} \right] \quad \text{and} \quad q_2 = \frac{1}{2} \left[ \frac{o_1 - s_1}{o_1 + s_1} + \sqrt{\frac{(o_1 - s_1)^2}{o_1 + s_1} - \frac{4 \cdot \Delta F}{o_1 + s_1}} \right].
\]

Provided \( \Delta F < \frac{(o_1 - s_1)^2}{4(o_2 + s_2)} \) as well as \( q \sim \text{UNI}(q, q) \), the optimal make-or-buy decision will depend on the expected differential cost, \( E(D) \equiv \int_{q_1}^{q_2} (C_s - C_o) f(q) dq \), between self-making and outsourcing if \( q \) and \( q \) satisfy one of the following conditions: \( q < q_1 < q_2 < q \), \( q < q_1 < q < q_2 \), or \( q_i < q < q_2 < q \). That is, the optimal alternative is to self-make the parts or components needed if \( E(D) < 0 \), but the optimal alternative is to outsource the parts or components needed if \( E(D) > 0 \).

While the expected differential cost can serve as a decision rule as demand is uncertain, its value is actually subject to the effect of demand variance rather than expected demand. To obtain the insight into how the change in the demand variance influences make-or-buy decision, the paper sets up proposition 4 and proposition 5.
Proposition 4:

Assume \( \Delta F \equiv F_o - F_s > 0 \), \( o_i > s_1 \), and \( \Delta F < \frac{(o_i - s_i)^2}{4(o_2 + s_2)} \). Meanwhile, let \( q \sim \text{UNI}(\underline{q}, \bar{q}) \) and \( q' \sim \text{UNI}(q - \varepsilon, \bar{q} + \varepsilon) \), where \( \varepsilon \) is a positive integer.

If \( E(D) \) and \( E(D') \) are respectively defined as \( E(D) = \int_{\underline{q}}^{\bar{q}} (C_s - C_o) f(q) dq \) and \( E(D') = \int_{\underline{q} - \varepsilon}^{\bar{q} + \varepsilon} (C_s - C_o) f(q') dq' \), then the following results can be obtained, i.e.,

1. \( \partial E(D')/\partial \varepsilon > 0 \),
2. \( \partial^2 E(D')/\partial \varepsilon^2 > 0 \),
3. \( \partial^2 E(D')/\partial s_2 \partial \varepsilon = \partial^2 E(D')/\partial o_2 \partial \varepsilon > 0 \),
4. \( \partial^2 E(D')/\partial (\bar{q} - q) \partial \varepsilon > 0 \).

In proposition 4, \( \varepsilon \) is used to measure the extent of demand variance. Economically, \( \partial E(D')/\partial \varepsilon > 0 \) implies the enlargement of demand variance will be favorable for the outsourcing alternative. By the way, \( \partial^2 E(D')/\partial \varepsilon^2 > 0 \) assures the favorable effect will increase in demand variance. Hence, the optimal make-or-buy decision probably changes from self-making to outsourcing only due to the enlargement of demand variance, or demand uncertainty. In terms of practice, the higher the risk of final product, the more favorable for outsourcing her parts or components is the make-or-buy decision.

On the other hand, \( \partial^2 E(D')/\partial s_2 \partial \varepsilon = \partial^2 E(D')/\partial o_2 \partial \varepsilon > 0 \) implies a faster change in marginal cost of either self-making or outsourcing (e.g., a fast increasing penalty cost or a fast increasing quantity discount) will raise the influence that change in demand variance has on make-or-buy decision. Besides, it is also shown by \( \partial^2 E(D')/\partial (\bar{q} - q) \partial \varepsilon > 0 \) that the larger the original demand variance, the more the influence of change in demand variance. The effect is actually similar to that implied by \( \partial^2 E(D')/\partial \varepsilon^2 > 0 \).

Proposition 5:

Let \( \varepsilon_0 = -\frac{(\bar{q} - q)}{2} + \sqrt{\left\{\frac{(\bar{q} - q)^2}{4} - \frac{3E(D)}{s_2 + o_2}\right\}} \). Under the assumptions in proposition 4, if \( E(D) < 0 \) in the beginning and the demand variance is enlarged up to the extent of \( \varepsilon > \varepsilon_0 \), it will result in \( E(D') > 0 \), and the optimal alternative will change from
self-making to outsourcing; on the contrary, if \( E(D) > 0 \) in the beginning and the
demand variance is narrowed down to the extent of \( \varepsilon < \varepsilon_0 \), it will result in \( E(D') < 0 \),
and the optimal alternative will change from outsourcing to self-making.

Furthermore, since \( \frac{\partial \varepsilon_0}{\partial s_2} = \frac{\partial \varepsilon_0}{\partial o_2} = \frac{3E(D)}{2(s_2 + o_2)^2} \cdot \sqrt{\frac{(\hat{q} - q)^2}{4} - \frac{3E(D)}{s_2 + o_2}} < 0 \), the larger
\( s_2 \) or \( o_2 \) is, the smaller is \( \varepsilon_0 \).

As mentioned in the previous proposition, the optimal make-or-buy decision can
change from self-making to outsourcing due to the enlargement of demand variance.
Proposition 5 further points out the level of change in demand variance, \( \varepsilon_0 \), that makes
self-making and outsourcing alternatives to be indifferent. Also, in the proposition, it is
indicated a faster change in the marginal cost of either self-making or outsourcing (e.g.,
a fast increasing penalty cost or a fast increasing quantity discount) will reduce \( \varepsilon_0 \).
That implies the make-or-buy decision will become more sensitive to the change in
demand uncertainty. In that scenario, decision maker must much more prudently address
the problem of demand uncertainty in make-or-buy decision.

5. NUMERICAL ILLUSTRATION

In this section, an example of numerical analysis will be used to demonstrate how
the change in demand variance influences the make-or-buy decision. For the practical
application, the preceding model will be slightly modified and simplified without loss of
decision insight.

In the numerical analysis, it is assumed the fixed costs required by self-making is
over than that required by outsourcing, and the increased fixed cost required by
self-making instead of outsourcing is \( \Delta F \). The corresponding upper bound of capacity
is \( \hat{q} \). Hence, it is assumed that the unit variable cost of self-making is \( v \) if actual
demand \( q \) is less than \( \hat{q} \), but the unit variable cost of self-making becomes \( p_1 \) for
the portion of demand over than capacity if \( q > \hat{q} \).

As for the outsourcing alternative, in addition to the fixed cost, it is assumed the
unit variable cost of outsourcing is \( p_1 \) if actual demand or purchasing quantity \( q \) is
less than \( \hat{q} \). However, due to quantity discount, the unit variable cost of outsourcing
will be reduced to \( p_2 \) for the portion of purchasing quantity over than \( \hat{q} \), where
\( v < p_2 < p_1 \). In the later analyses, some numbers are assigned to the related variables,
i.e., \( \Delta F = $100,000 \), \( v = $50 \), \( p_1 = $300 \), \( p_2 = $200 \), \( \hat{q} = 500 \).
Besides, the demand uncertainty is simulated by a certain uniform probability distribution with mean \( E(q) = 500 \) units. For the control of demand variance, the lower bound and upper bound of demand are changed step by step from \( q = 450 \) and \( \bar{q} = 550 \) to \( q = 0 \) and \( \bar{q} = 1,000 \). The demand range is increased by 100 units each time. Under each uniform distribution corresponding to a certain demand variance, 1,000 demand quantities are produced by the computer, and the amount of self-making cost over than outsourcing cost, \( D \), is calculated for each demand quantity produced. Then the average value of 1,000 \( D \)s is also calculated. The process is repeated for ten times, and the average of 10 average values is used to analyze make-or-buy decision. If the final average value is negative, the optimal alternative will be self-making; otherwise, the optimal alternative will be outsourcing.

By the results of numerical analyses, it is not difficult to find that demand variance does have an effect on make-or-buy decision. As demand variance is enlarged, the optimal alternative has changed from self-making to outsourcing. (Refer to table 1.)
### Table 1: Summary of Numerical Analyses*

<table>
<thead>
<tr>
<th>Maximum Demand</th>
<th>Max $q = 550$</th>
<th>Max $q = 600$</th>
<th>Max $q = 650$</th>
<th>Max $q = 700$</th>
<th>Max $q = 750$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Demand</td>
<td>$\min q = 450$</td>
<td>$\min q = 400$</td>
<td>$\min q = 350$</td>
<td>$\min q = 300$</td>
<td>$\min q = 250$</td>
</tr>
<tr>
<td>Average D value for #1 simulation</td>
<td>($20,503$)</td>
<td>($16,350$)</td>
<td>($11,454$)</td>
<td>($7,174$)</td>
<td>($4,347$)</td>
</tr>
<tr>
<td>Average D value for #2 simulation</td>
<td>($20,701$)</td>
<td>($16,083$)</td>
<td>($12,051$)</td>
<td>($6,757$)</td>
<td>($2,472$)</td>
</tr>
<tr>
<td>Average D value for #3 simulation</td>
<td>($20,524$)</td>
<td>($16,232$)</td>
<td>($11,460$)</td>
<td>($8,051$)</td>
<td>($3,417$)</td>
</tr>
<tr>
<td>Average D value for #4 simulation</td>
<td>($20,437$)</td>
<td>($16,057$)</td>
<td>($11,778$)</td>
<td>($7,596$)</td>
<td>($2,928$)</td>
</tr>
<tr>
<td>Average D value for #5 simulation</td>
<td>($20,660$)</td>
<td>($15,832$)</td>
<td>($11,543$)</td>
<td>($8,351$)</td>
<td>($3,628$)</td>
</tr>
<tr>
<td>Average D value for #6 simulation</td>
<td>($20,617$)</td>
<td>($16,268$)</td>
<td>($11,929$)</td>
<td>($8,137$)</td>
<td>($2,983$)</td>
</tr>
<tr>
<td>Average D value for #7 simulation</td>
<td>($20,437$)</td>
<td>($16,490$)</td>
<td>($12,074$)</td>
<td>($7,853$)</td>
<td>($3,494$)</td>
</tr>
<tr>
<td>Average D value for #8 simulation</td>
<td>($20,554$)</td>
<td>($16,266$)</td>
<td>($11,632$)</td>
<td>($7,162$)</td>
<td>($3,704$)</td>
</tr>
<tr>
<td>Average D value for #9 simulation</td>
<td>($20,566$)</td>
<td>($16,227$)</td>
<td>($11,291$)</td>
<td>($7,449$)</td>
<td>($2,386$)</td>
</tr>
<tr>
<td>Average D value for #10 simulation</td>
<td>($20,584$)</td>
<td>($15,980$)</td>
<td>($11,684$)</td>
<td>($7,168$)</td>
<td>($2,904$)</td>
</tr>
<tr>
<td>Average D value for 10 simulations</td>
<td>($20,558$)</td>
<td>($16,179$)</td>
<td>($11,690$)</td>
<td>($7,570$)</td>
<td>($3,226$)</td>
</tr>
</tbody>
</table>

**Optimal Alternative**

<table>
<thead>
<tr>
<th>Maximum Demand</th>
<th>Max $q = 800$</th>
<th>Max $q = 850$</th>
<th>Max $q = 900$</th>
<th>Max $q = 950$</th>
<th>Max $q = 1000$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Demand</td>
<td>$\min q = 200$</td>
<td>$\min q = 150$</td>
<td>$\min q = 100$</td>
<td>$\min q = 50$</td>
<td>$\min q = 0$</td>
</tr>
<tr>
<td>Average D value for #1 simulation</td>
<td>$1,983$</td>
<td>$5,563$</td>
<td>$9,753$</td>
<td>$13,461$</td>
<td>$19,232$</td>
</tr>
<tr>
<td>Average D value for #2 simulation</td>
<td>$1,264$</td>
<td>$5,937$</td>
<td>$10,033$</td>
<td>$15,942$</td>
<td>$19,765$</td>
</tr>
<tr>
<td>Average D value for #3 simulation</td>
<td>$194$</td>
<td>$5,620$</td>
<td>$8,775$</td>
<td>$14,951$</td>
<td>$18,490$</td>
</tr>
<tr>
<td>Average D value for #4 simulation</td>
<td>$1,077$</td>
<td>$5,414$</td>
<td>$9,667$</td>
<td>$15,075$</td>
<td>$17,999$</td>
</tr>
<tr>
<td>Average D value for #5 simulation</td>
<td>$1,279$</td>
<td>$4,789$</td>
<td>$10,557$</td>
<td>$13,754$</td>
<td>$19,462$</td>
</tr>
<tr>
<td>Average D value for #6 simulation</td>
<td>$1,936$</td>
<td>$6,429$</td>
<td>$10,166$</td>
<td>$14,908$</td>
<td>$20,605$</td>
</tr>
<tr>
<td>Average D value for #7 simulation</td>
<td>$2,043$</td>
<td>$6,524$</td>
<td>$10,458$</td>
<td>$13,466$</td>
<td>$19,297$</td>
</tr>
<tr>
<td>Average D value for #8 simulation</td>
<td>$1,852$</td>
<td>$6,404$</td>
<td>$10,543$</td>
<td>$15,516$</td>
<td>$19,508$</td>
</tr>
<tr>
<td>Average D value for #9 simulation</td>
<td>$586$</td>
<td>$6,117$</td>
<td>$9,791$</td>
<td>$14,355$</td>
<td>$20,557$</td>
</tr>
<tr>
<td>Average D value for #10 simulation</td>
<td>$1,929$</td>
<td>$6,251$</td>
<td>$8,104$</td>
<td>$15,541$</td>
<td>$17,323$</td>
</tr>
<tr>
<td>Average D value for 10 simulations</td>
<td>$1,414$</td>
<td>$5,905$</td>
<td>$9,785$</td>
<td>$14,697$</td>
<td>$19,224$</td>
</tr>
</tbody>
</table>

**Optimal Alternative**

- Outsourcing
- Outsourcing
- Outsourcing
- Outsourcing
- Outsourcing

It’s assumed the demand follows a certain uniform distribution with mean 500, and $D(q) = C_3(q) - C_2(q)$. 

6. CONCLUSION

Subject to measurability and cost of information, management decision-maker should consider both quantitative analyses and qualitative analyses. However, for raising the quality of decision, it is worthwhile to try to increase the portion of quantitative analyses in decision. In that way, a decision-maker will be able to relatively make a more rational and objective judgment, and thus the loss of decision error can be reduced as low as possible. Hence, assuming that quantitative analyses predominate in the make-or-buy decisions, this paper focuses on the quantitative analyses and considers a couple of measurable or quantifiable factors in the decision. Specifically, the uncertainty of demand for parts or components is a key issue of this paper and addressed properly to demonstrate its potential impact on management’s make-or-buy decision.

Following a process of model analysis, it is indicated that the enlargement of demand variance will induce the firm to outsource the parts or components rather than to self-make them. Meanwhile, the favorable influence on outsourcing alternative increases in the enlargement of demand variance. That implies that the make-or-buy decision maker should watch out the risk of final product produced from the parts or components of interest. Furthermore, it is found that a faster change in the marginal cost of either self-making or outsourcing (e.g., a fast increasing penalty cost or a fast increasing quantity discount) will make the decision more sensitive to the change in demand uncertainty. That implies the decision maker needs to much more prudently deal with the problem of demand uncertainty in make-or-buy decision.

In addition, the numerical analysis is used not only to illustrate the basic insight of the preceding model analysis but also to demonstrate the possible application in practice of the related concepts. Assuming the demand follows some uniform distribution, it is also shown that the optimal alternative changes from self-making to outsourcing as demand variance is enlarged. Of course, the inference of this paper is essentially subject to the constraint of its basic assumptions. Therefore, we must carefully examine the related assumptions if we intend to extend the results to other decision situation. For example, in this context, it is simply assumed that the total cost function of self-making is convex in the demand quantity for parts or components mainly due to the consideration of penalty cost, and the total cost function of outsourcing is concave in the demand quantity mainly due to the purchasing quantity discount. These assumptions are actually rather strict in that they imply the two key factors dominate the other factors, and thus need to be checked before making decision.

While the whole analysis of make-or-buy decision is based on a single period in this paper, it is believed that the similar inference can be extended to a situation of multiple periods. Certainly, the issue will become more complicated and more
interesting. For example, in one period, there is only one time to set up the capacity of production; however, in multiple periods, there are a lot of times to establish or adjust the capacity. Hence, the consideration of self-making cost will become much more difficult. Similarly, in multiple periods, the change in the market of parts or components will also make the estimation of outsourcing cost much more challenging.
References


