Developing Competitive Price and Production Postponement Strategies

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This paper focuses on duopolistic competition under price and production postponement for two differentiable products that share component commonality. Both price and production postponement are benchmarked in order to investigate the component commonality effect on profit and also their appropriateness in different competition situations. The results show that production postponement is appropriate in situations of market expansion, price postponement to meet customer wants, and integrated price and production postponement for highly customized products. Price and production postponements offer an alternative way for managers to decide how to create products as fighting and mass-customized products. Innovative price and production postponement models represent the new contribution of this paper.

Introduction

Price and production are two strategic decision areas that product managers will face over time (Biller et al., 2006; Fine & Freund, 1990). Both of these decisions offer opportunities to achieve the delivery of products in a timely and cost-effective manner by enabling flexible production at an affordable price, which is often designed and managed separately. Indeed, they can directly increase a company’s profitability while giving companies time to react to demand change and gain a competitive edge over their competitors.

The discussion of production line and price flexibility leads us to a definition of the term postponement, which was coined by Alderson (1950) as a way of delaying product differentiation (Bucklin, 1965). Zinn and Bowersox (1988) later divided postponement strategies into five types: (1) labeling, (2) packaging, (3) manufacturing, (4) assembly, and (5) time. Postponement was then analyzed further in terms of product and process redesign (Lee, 1996), which represent time and form postponement. Time and form postponement need a common platform either in product or process, or even both, to achieve production line flexibility (Ma et al, 2002). Indeed, production line flexibility influences price flexibility because most price changes can be accounted for by changes in direct costs for labor and materials (Yance, 1960), and it signifies the importance of component commonality to improve process flexibility.

In addition to time and form postponement, other forms of postponement strategies, specifically price and production postponement, also influence the strategic investment decision of the firm and its value (Miegham & Dada, 1999). Price postponement is believed to be a reliable strategy to hedge against demand uncertainty, and it is good for investment and production decisions in terms of production capacity and inventory level. Some situations, for example, need production postponement to influence customer purchasing behavior. However, changing the prices of various products simultaneously necessitates much
more complex consumer choice models, with demand diversions being a major influence (Biller et al., 2006). Demand diversion is said to occur when a customer chooses to buy an alternate product on finding that the first choice is unavailable or the utility of the alternative(s) is higher than the original choice. In our current models, demand diversion is represented by product substitutability that, on the contrary, linearly affects the pricing decision. In meeting demand diversity, our models propose component commonality to increase production flexibility. We allow that higher component commonality is required for lower product substitutability to make higher product diversity. Finally, because the buyers are not monopolists, changes in demand are assumed to be independent of price decisions.

The next section introduces the background for the research on postponement and component commonality. The analytical models section starts by analyzing production postponement, price postponement, and integrated production price postponement strategies in terms of their profitability. The problem example section presents and discusses the analysis results, which are concluded in terms of its application to managerial decision making in managerial implication section. Finally, Conclusion and further research directions section provides the overall conclusions of the paper and Section 6 looks at further research considerations.

Background for the research

Research on postponement strategies has been widely spread into different channels. Some literature discusses its applications in three different areas: (1) manufacturing, (2) logistics, and (3) marketing channels (see Table 1). Table 1 shows that postponement has been investigated in different ways, but they share some common ground.

1. Postponement in the manufacturing channel increases production flexibility through the application of product platform modularity or commonality (Zinn & Bowersox, 1988; Lee, 1996; Johnson & Anderson, 2000; Swaminathan & Lee, 2003).

2. Postponement in the logistics channel tries to minimize the total costs of the logistics channel by allocating inventory such that it minimizes total inventory costs and lead times and at the same time guarantees the product availability (Bucklin, 1965; Zinn & Bowersox, 1988; Pagh & Cooper, 1998; Yang & Burns, 2003).

3. Postponement in the marketing channel tries to minimize the effect of poor investment decisions (production quantity and inventory level) and market constraints (geographical dispersion) by managing the price to reduce waste (Alderson, 1950; Miegham & Dada, 1999; Yang & Burns, 2003; Biller et al., 2006).

Price and production postponements offer an alternative way for managers to decide how to create products as fighting and mass customized products by considering product substitutability degree.

It is important to note from the literature that postponement is intended to strengthen the marketing position by increasing product proliferation, at the same time avoiding manufacturing channel turmoil by creating production flexibility.

However, some of the literature insists on the importance of component commonality and product modularity in supporting postponement strategies by providing the required production flexibility. Modularity, as laid out in Evans’s work on modular design (1963, 1970), was described as the problem of determining the best configuration of small multi-use parts (in Evans’s case, kits of screws) to satisfy a variety of demands. Commonality, in contrast, was the idea of using identical components in a one-per-product setting, but in different products. Downward compatibility (Rutenberg, 1971) allowed the use of one type of component in multiple products. Twenty years later, Thomas (1991) viewed commonality as a partitioning problem and suggested clustering techniques for its solution. More recently, the commonality optimization approach suggested by Thonemann and Brandeau (2000) uses a logic that strives for common parts to be identical, often also implying downward compatibility.

Competitive postponement strategies are introduced in this paper. The reasons for applying competition into the postponement decision are twofold. First, the competition level influences the strategic investment decision (production capacity and inventory level) of the firm and its value result. Second, the higher level of competition therefore increases the value of the postponement decision (Miegham & Dada, 1999). Thus, a higher competitive level induces postponement strategies to increase their value by carrying out customization at the final manufacturing stage in a shorter period, for example, when a manufacturer is introducing a new product. After investing in capacity, the firm announces either production quantity or price information. Then, in response to the revealed market demand, an appropriate production quantity or price is set.

This paper applies duopolistic game theory to represent competition between two products that share the same component at a certain commonality degree. This situation is taken into consideration in order to give the general description of the
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<td>Alderson (1959)</td>
<td>Marketing channel</td>
<td>Postponement is used to reduce various marketing costs because of the product itself and/or the geographical dispersion of inventories.</td>
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<td>Bucklin (1965)</td>
<td>Logistics channel</td>
<td>A combination between postponement and speculation is used to reduce total inventory costs across supply chains. A speculative inventory at each point in a distribution channel is allocated whenever its costs are less than the net savings of postponement to both buyer and seller.</td>
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<td>Zinn &amp; Bowersox (1988)</td>
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methodology. In practices, competition should be focused on the strongest competitor. The most important thing is how to decide the optimum price or quantity policies to maximize profit. In general, the relationship between one supplier and two buyers can be described as follows.

In addition to recent literature, the Cournot and the Bertrand games are special cases of postponed prices and production decisions. The motivation to use the Cournot and the Bertrand games are that these new approaches are quite different to previous methods used for price and production postponement (Fine & Freund, 1986, 1990; Miegham, 1998; Miegham & Dada, 1999), when the decision is assumed to depend merely on the demand level and its uncertainty without considering whether the products are substitutable or not. These new approaches are also quite different to Birge et al. (1988), in which price and production postponement are based on the demand interdependency of two products. The effect of the Birge et al. (1988) approach is that a firm can apply price postponement for one product and production postponement for another based on their cross-price elasticity principle. Thus, the supplier role is ignored in the model. However, this paper adds to Birge et al. (1988) by extending the discussion on price and production postponement in a supply chain perspective. This extension optimizes the supply chain profit by collusion setting in the Bertrand price or Cournot production quantity optimization and Stackelberg game in optimizing supplier component price.

The analytical models

Suppose that two buyers (buyer 1 and buyer 2; see Figure 1) compete on the price and production quantity and ascertain postponed price or production later as a flexible decision. To align our discussion with product varieties, we introduce to represent product substitutability across varieties; a

Figure 1
Duopolistic competition of the existence of product commonality

![Figure 1](image-url)
increase in imposes a greater utility loss from consuming idiosyncratically large or small quantities of particular product, therefore enhancing consumer response to price differences across industry producers due to lower product substitutability. Furthermore, a decrease in motivates buyers to use higher component commonality to induce production flexibility. As \( \gamma \rightarrow 1 \), substitutability becomes perfect: only the total quantity of industry varieties consumed—not its composition—affects utility. Thus, we use the behavior of to investigate whether price postponement has a bigger impact at a lower and conversely production postponement at a higher.

To gather a general understanding for this concept, both postponement concepts will be discussed separately and then the general concept will be developed. The analytical models for each postponement strategy are detailed in the following.

Case A: Illustrative example 1 (production postponement)

This case is subject to postponing the buyer production quantity decision just after the actual price \( p_A \) at actual demand \( d \) is known. In production postponement strategy we need to set production capacity \( b_A \) and optimum price \( p_A \) as a function of market share \( q_A \) to reduce underutilization or overutilization (Bertrand model (the buyer’s production capacity and price settings subsection)). Market share is the allocated customer demand of either buyer 1 or 2 as a function of total market size \( D \). The Ministry of Trade of a given country can provide the market size information that is annually reported to the public. Hereafter, price postponement is analyzed to hedge against actual demand (Stackelberg model (the buyers set their selling price according to supplier component price subsection)).

Production capacity and price settings

This section discusses market share setting and product prices decisions. Market share setting is important in planning the required production capacity. Production capacity decisions are typically made under the assumption of a predetermined fixed price (we will show this argument in the following sections). The main concern in the market is product availability, in which price becomes less sensitive to customers to satisfy their utility. Thus buyers can apply the fixed price policy. Buyers optimize their fixed prices just after they get information on the supplier product price. We assume that the supplier can supply at market size \( D \) at a fixed component price. Thus, there are two scenarios in this section. The first scenario is the Bertrand game for deciding optimal prices for the buyers and the second is the Stackelberg game for deciding optimal buyer prices based on the supplier component price. The question is how this assumption affects the firm’s profits.

Bertrand model (the buyer’s production capacity and price settings)

First the buyers set their optimum selling price \( \overline{p_A} = p_A \) according to predetermined buyers’ capacity \( b_A \) and by following supplier component price \( c \). We consider a Bertrand duopoly model (Gibbons, 1992) with a price function for buyers given by

\[
Q = q_A = D - e_1 p_1 + e_2 \gamma p_2
\]  

where \( Q \) equilibrium is the buyers’ market shares, \( D \) is the total market size for buyers and \( 2, e_1 \) is demand elasticity, and \( p_1 \) and \( p_2 \) is the price of product from buyer 1 and buyer 2, and \( \gamma \) is the product substitutability degree.

In the Bertrand model, each buyer assumes that the price of the product does not affect the price of the other. In this approach, buyer 1 assumes an optimal price of the product of buyer 2, \( p_2 \) as a parameter in the first order condition (FOC) of buyer 1 profit maximization. Buyer 2 follows the same procedure to obtain a price with \( p_1 \) as a parameter. The procedure in Equations (2) to (5) is shown as follows.

\[
\max_{p_1} (D - p_1 + \gamma p_2 (p_1 - m)) \quad (2)
\]

where \( m \) is the component price from the supplier and it is assumed equal for the two buyers by considering that the two buyers buy from the same supplier. Furthermore, because the components from the supplier share commonality at a certain degree (represented by product substitutability \( \gamma \) where higher value denotes lower commonality), we can assume that both buyers have similar costs. Thus, the FOC for the first buyer is

\[
D - 2p_1 + \gamma p_2 + m = 0 \quad (3)
\]

Similarly, the FOC from the second buyer is

\[
D - 2p_2 + \gamma p_1 + m = 0 \quad (4)
\]

Solving these two equations simultaneously, one obtains

\[
p_{1*} = p_{2*} = p_1 = \frac{(m + D)}{(2 - \gamma)} \quad (5)
\]

Equation (5), called pair pricing strategies, satisfies an equilibrium condition in which each buyer’s predicted price strategy must be that buyer’s best response to the predicted pricing strategies of the other buyer. Such a prediction could be called strategically stable or self-enforcing, because no single buyer wants to deviate from the predicted strategy. We will call such a prediction a Nash Equilibrium (NE). Thus, the buyers’ market share \( q_{A*} \) can be formulated as follows:

\[
Q = \overline{q}_A = D - (1 - \gamma) p_{1*} \quad (6)
\]

Equation (6) shows us that market share depends on the buyers’ optimum price \( \overline{p_A} \). The buyers then set their capacity as equal to their market share. Thus, we can prove that production capacity decisions are typically made under the assumption of a predetermined fixed price.

Furthermore, Stackelberg proposed a dynamic model of duopoly in which a dominant (or leader) firm
moves first and a subordinate (or follower) firm moves second. At some points in the history of the U.S. automobile industry, for example, General Motors has seemed to play such a leadership role. (It is simple to extend what follows to allow for more than one following firm, such as Ford, Chrysler, and so on.) Using Stackelberg’s theories, in the following section we will develop the model under the assumption that the buyers choose prices, as in the Bertrand model (where the buyers’ choices are simultaneous, rather than sequential as here), and are based on the supplier component price.

Stackelberg model (the buyers set their selling price according to supplier component price)

In the Stackelberg model, buyers follow the supplier component lead in setting price $m$ and its total costs $c$ as follows:

$$\max = (D - p_1 + \gamma \cdot p_2)(m - c)$$

(7)

Optimizing Equation (7) against and inserting Equation (5) into Equation (7), we get:

$$\max = \left( D + \left( \frac{\gamma - 1}{2 - \gamma} \right)(m + D) \right)(m - c)$$

(8)

$$m = \frac{D + \left( \frac{\gamma - 1}{2 - \gamma} \right)(m + D)}{1 - \gamma}$$

(9)

Equation (9) describes how higher product substitutability $\gamma$ increases the supplier price considerably. We can see that if product substitutability increases, then the supplier price also increases. Furthermore, we also see that increasing $c$ also increases $m$. Thus, reducing component commonality affects the higher component price $m$. Hereafter, production quantity at optimum price $q_d^*$ is decided by using the following relationship:

$$q_d^* = D - p_1 + \gamma \cdot p_2 = D - \left( \frac{\gamma - 1}{2 - \gamma} \right)p_1$$

(10)

Introducing Equation (5) into Equation (10), we then have:

$$q_d^* = D - \left( \frac{\gamma - 1}{2 - \gamma} \right)\left( m + D \right)$$

(11)

We can see that increasing reduces the market share. It implies that higher component commonality (lower product substitutability degree) opens up an opportunity for obtaining a bigger market share for buyers because they have a more diverse product variety. Furthermore, a higher $D$ shows an increased buyers’ market share. Section 3.1.2 guides managers in deciding on how many products should be produced in order to maximize the profit.

**Buyer production decision (price postponement)**

In this section, the production quantity decision is made just after the real demand $d_2$ is known. First we find the final stage of postponed production quantity $q_2$ at actual demand level as follows:

$$q_2 = \overline{q}_2 + e_2 \cdot d_2$$

(12)

The formula for demand elasticity is given by $e_2 = \frac{\Delta q_2}{q_2} = \frac{\Delta d}{d} = \frac{\Delta q_1 + d_2}{\Delta q_1}$

Since then can be represented as

$$e_2 = \frac{\Delta q_2}{d_1} = \frac{\Delta q_1 + d_2}{d_2}$$

Thus, Equation (12) can be reformulated as

$$q_2 = \overline{q}_2 + \frac{\Delta q_1}{d_2} = q_1 + \frac{\Delta q_1}{d_2}$$

(13)

Equation (13) shows that the buyers’ production decision depends on because the market share elasticity is a function of actual demand.

**Production postponement profit**

Production postponement can be calculated by summing together buyer 1, buyer 2, and supplier profits as follows:

$$\pi_1 = 2\left( q_1(\gamma - m) + 2q_1(\gamma - c) \right) = 2q_1(\gamma - c)$$

(14)

We can see that higher product substitutability $\gamma$ (lower component commonality) spoils the supply chain profits. Furthermore, supply chain profits also depend on the supplier material cost $c$. Thus, we can conclude that production postponement supports higher product substitutability by developing dedicated production lines.

**Illustrative example 2**

(price postponement)

This section sets capacity and production quantity decisions. Capacity decisions are typically made under the assumption of predetermined fixed production quantities. The main concern in the market is product price, in which product availability becomes less sensitive to customers to satisfy their utility. Thus buyers can apply the fixed production capacity policy. To consider fixed production quantity, the buyers optimize their fixed production quantities just after they get information on supplier’s product price. Similar to production postponement, we assume that the supplier can supply at a total market size $D$ at a fixed component price. Thus, there are two scenarios in this section. The first is the Cournot game for deciding optimal production quantities for the buyers and the second is the Stackelberg game for deciding optimal buyer quantities based on the supplier component price. The question is how this assumption affects the profits of supply chains (buyers and supplier).

**Cournot model (the buyers’ production capacity and supplier price settings)**

This model is subjected to postponing the buyer price just after the actual demand is known. In price postponement strategy we need to optimize the buyers’ market share to set production capacity $q_0^*$ as a function of market size $D$ (Section 3.2.1). Then in Section 3.2.2 price postponement is analyzed to hedge against actual demand.

**Production capacity and quantity settings**

We will use Equation (5) for determining the market share that is assumed to be equal to
production capacity $q_B$. In price postponement, production quantity decision is set at full capacity to meet the maximum possible consumer demands at the buyers’ market share $q_B$.

According to the maximum acceptable market price at the standard deviation $z_p$ of market price due to price $\sigma_p$ postponement, the production capacity $q_B$ can be obtained from the Cournot game as in Equation (15) following:

$$\text{Max} \pi = (q - 2q_B - c) \beta_B$$

The choice of indicates how frequently the manager is willing to resort to other pricing tactics to cover demand variability. The maximum acceptable market price is equal to $a = \beta_B + z_p \sigma_p \beta_B$ is the ideal price at optimum production quantity $q_B$ to meet maximum demand level $D$.

In the Cournot model, each buyer assumes that the production quantity of the product does not affect the production quantity of the other. In this approach, buyer 1 assumes an optimal production quantity of the products of buyer 2, $q_2$, as a parameter in the FOC of the profit maximization of buyer 1. Buyer 2 follows the same procedure to obtain a production quantity with $q_1$ as a parameter. We will see the procedure in Equation (16) to Equation (19).

By assuming equal costs function $c$ we therefore modify Equation (14) according to the Cournot duopoly inversion as follows:

$$\text{Max} \pi = \frac{a}{|1 + \gamma|} \frac{1}{1 - \gamma^2} q_B q_1 = 0 \text{ (16)}$$

Equation (16) describes the total revenue consisting of the total profit for two buyers minus their total costs; thus, the FOC for Equation (16) is

$$\frac{a}{|1 + \gamma|} \frac{q_1}{1 - \gamma^2} - \frac{\gamma q_2}{1 - \gamma^2} = 0 \text{ (17)}$$

Similarly, the FOC for the second buyer is

$$\frac{a}{|1 + \gamma|} \frac{q_2}{1 - \gamma^2} - \frac{\gamma q_1}{1 - \gamma^2} = 0 \text{ (18)}$$

We can solve Equation (17) and Equation (18) simultaneously to be

$$q_1 = q_2 = q_i = \left(\frac{a}{|1 + \gamma|} \frac{1}{1 - \gamma^2} \frac{m}{1 + 2\gamma}\right)^{1/\gamma} \text{ (19)}$$

Equation (19) shows that each buyer’s predicted production strategy must be that buyer’s best response to the predicted production strategies of the other buyer. This is also an NE prediction for the buyers’ production quantities.

We recognize $m_B$ in Equation (19) as representing the supplier selling price decision. This implies that the buyers can set their production quantity just after they receive $m_B$ information from the supplier.

Similar to the production postponement procedure, in the following section we will develop the model under the assumption that the buyers choose production quantities, as in the Bertrand model (where the buyers’ choices are simultaneous, rather than sequential, as here) based on the supplier component price.

Stackelberg model (buyers choose production quantities according to the supplier component price decision)

At the first stage we can use Equation (19) in order to calculate supplier profit as follows:

$$\text{Max} \pi = \frac{a}{|1 + \gamma|} \frac{1}{1 - \gamma^2} q_B (0) \text{ (20)}$$

To calculate the FOC of Equation (20) according to $m_B$ then we have

$$m_B = \left(\frac{a}{|1 + \gamma|} \frac{1}{1 - \gamma^2} \frac{m}{1 + 2\gamma}\right) \left(\frac{1}{1 + \gamma} \left(\frac{1}{1 - \gamma^2} \frac{1}{1 + 2\gamma}\right)\right) \text{ (21)}$$

Equation (21) shows that higher product substitutability (lower component commonality) reduces the component price $c_2$ from the supplier. Similar to production postponement, we also see that the increasing of supplier material price encourages the increasing of $m_B$. This implies that less common components are cheaper than highly modular components. Finally, Equation (21) is used to refine Equation (19) as follows:

$$q_1 = q_2 = q_i = \left(\frac{a}{|1 + \gamma|} \frac{1}{1 - \gamma^2} \frac{m}{1 + 2\gamma}\right)^{1/\gamma} \text{ (22)}$$

Equation (22) shows that higher product substitutability reduces buyer market shares and production quantities. Section 3.2.2 guides managers in deciding on the price elasticity of demand in order to maximize the profit. Beforehand, we need to find the optimum buyers’ price at $q_B$ as a basis of our price postponement decision; then we have the optimum price for this production quantity $p = p_1 = p_2$ as follows:

$$p_i = \frac{z \sigma_p c_i}{1 + \gamma^2} \frac{1}{1 - \gamma^2} \frac{1}{1 + \gamma^2} \frac{1}{1 + \gamma} \text{ (23)}$$

$e_i$ in Equation (24) is the price elasticity of demand. By considering $a = \beta_B + z \sigma_p$ then Equation (23) can be reformulated as

$$p_i = \frac{\frac{z \sigma_p c_i}{1 + \gamma^2} \frac{1}{1 - \gamma^2} \frac{1}{1 + \gamma^2} \frac{1}{1 + \gamma}}{1 + \gamma^2} \text{ (24)}$$

In reality, demand can change and we need price postponement to adjust so that it maintains the supply chain profits (buyers and supplier).

**Buyer price decision (price postponement decision)**

In this section, the price decision is made just after the real demand is known. First we need to find the final stage of postponed price $p$ at actual demand level $d$ as follows:

$$p_i = p_1 + e_i d \text{ (25)}$$

Equation (25) shows that the buyers’ prices depend on $e_i$ because the price elasticity as a function of demand change from $d_1$ to $d_2$. $p_1$ and $p_B$ is the initial stage price at the optimum production quantity $q_B$ at a certain level of product substitutability degree. The formula for price elasticity of demand is given by

$$e_i = \frac{\Delta q}{\Delta p} \frac{\Delta p}{\Delta q} \frac{\Delta q}{\Delta p} \frac{\Delta q}{\Delta p} \frac{\Delta q}{\Delta p} \frac{\Delta q}{\Delta p}$$

. Since $\Delta q = d_1 - q_i$, $\Delta p = p_2 - p_1$, then can be represented as

$$e_i = \frac{d_1 - q_i}{p_2 - p_1} \frac{p_2 + p_1}{q_i + p_1}$$

. Thus, Equation (25) can be reformulated as
**Price postponement profit**

Price postponement can be calculated by summing together buyer 1, buyer 2, and supplier profit as follows:

\[
\pi_s = 2\left(p_2 - p_1 - q_2 + q_1\right) + 2q_1\left(m - c\right) - 2q_2\left(m - c\right) (27)
\]

We can see that higher product substitutability (lower component commonality) spoils the supply chain profits. Thus, we can conclude that production postponement supports lower product substitutability by developing higher component commonality.

**Case C: Illustrative example 3 (integrated production and price postponement)**

This section is describes capacity decisions and postpones both price and production quantity decisions. The buyers optimize their production quantities and prices at maximum demand before demand uncertainty is resolved. Once demand uncertainty is resolved, the product prices and production quantities are adjusted accordingly. Thus, we solve simultaneously the Cournot and the Bertrand games to optimize the buyers’ production quantities and prices at the maximum demand.

Similar to price postponement and production postponement, integrated price and production postponement must set the production capacity \( b_j \) in advance by using Equation (5) before dealing with demand uncertainty. Thus, we need to determine optimum price \( \overline{p} \) and production quantity \( \overline{q} \) simultaneously. We need to utilize Equation (11) and Equation (24) and solve them simultaneously. This implies that solving Equation (11) and Equation (24) simultaneously produces the results \( \overline{q} = \overline{q}_A = \overline{q}_B \) and \( \overline{p} = \overline{p}_A = \overline{p}_B \).

Thus, we insert Equation (24) into Equation (11) by changing \( \overline{p} \) with \( p = \frac{a}{1 + \gamma} \frac{1 + \gamma - \overline{q}}{1 + \gamma - q} \) and similarly, Equation (11) informs us that \( \overline{q} = D - (1 - \gamma)p \), so then we also have

\[
a = D - q \left(1 + \frac{1 + \gamma}{1 - \gamma}\right)
\]

Furthermore, \( p = \frac{a}{1 + \gamma} \frac{1 + \gamma - \overline{q}}{1 + \gamma - q} \) inserting into \( \overline{q} = D - (1 - \gamma)p \) gives us

\[
a = D - q \left(1 + \frac{1 + \gamma}{1 - \gamma}\right)
\]

Thus, we can find

\[
\overline{q} = \frac{D - q}{1 + \gamma} \left(1 + \frac{1 + \gamma}{1 - \gamma}\right)
\]

Furthermore, by considering the actual demand at level \( \xi \), the postponed and are formulated as Equation (13) and Equation (26), respectively. Thus, we have the following price and production quantity decisions:

\[
p_i = \overline{p} + \epsilon_i d_i
\]

\[
q_i = \overline{q} + \epsilon_i d_i
\]

Because the production quantities and prices decisions are postponed, we exclude the Stackelberg game in this postponement type. The reason is that from Equation (30) and Equation (31) neither the production quantities nor product prices depend on the supplier component price. This informs us that supply chain collaboration in this postponement type is smallest among other two previous postponement types.

**Integrated price and production postponement profit**

Integrated price and production postponement can be calculated by summing together buyer 1, buyer 2, and supplier profit as follows:

\[
\pi_c = 2\left[p - m\right] + 2q\left[m - c\right] = 2q\overline{p} - 2q\epsilon (32)
\]

We can see that higher product substitutability \( -\gamma \) (lower component commonality) spoils the supply chain profits. Thus, we can conclude that production postponement supports lower product substitutability by developing higher component commonality.

**The problem example and results**

Studies on price and production postponement have been able to shed light on the supply chain as a dynamic system. In addition, they have underscored the importance of such long-term stability as values, meanings, and commitments and paved the way for more elaborate research on the interface between supply chain and revenue management.

The example is developed into two steps: the first step investigates the effect of decision timing on the profit when both the price and the production decision are postponed. The second step investigates the appropriateness of the price, production, or integrated price and production postponements on different levels of component commonality.

The first step can be summarized as follows:
1. Calculate the buyers’ production capacity that is equal to the buyers’ market share at a predetermined market size \( D \) according to price elasticity of demand and demand elasticity at a certain product substitutability degree.
2. Buyer production quantity \( q_A \) and \( q_B \) price at market share and product substitutability \( \gamma \) are determined in advance by using Equation (12) and Equation (23) for production quantity and price postponement, respectively, and Equation (27) and Equation (28) for integrated price and production quantity postponement, respectively. These values are then used to determine production quantity...
and price at different demand level \(d_2\) by applying Equation (14) and Equation (24) for production quantity and price postponement, respectively, and Equation (29) and Equation (30) for integrated price and production quantity postponement, respectively.

3. Net revenues for production and price postponement are calculated from Equation (15), Equation (26), and Equation (31) for integrated price and production postponement.

4. The analysis will compare profits among different postponement strategies.

The results are summarized in Tables 3 to 5.

First, when buyers can delay the production process and must set product prices in advance, we suggest that they produce more substitutable products in order to affect consumers’ purchasing behavior by maximizing their utility through product availability. Producing and postponing more substitutable products is beneficial to the buyers because they can sell their products at a higher unit price. This situation is possible because at a higher substitutability degree, as compared to price and combination of price and production postponement, the profitability of the buyers in production postponement (Table 3) is higher at all levels of product substitutability. This implies that production postponement is the best postponement strategy. Specifically, the benefit for the manufacturer all transfers to those who can maximize the effect of product substitutability as a result of higher component commonality. This situation implies that buyers should use production postponement for producing more substitutable products (for instance, a competition between margarine and butter). The reason is that by postponing margarine and butter production, the price elasticity of demand \(e_x\) is lower because consumers only consider product availability instead of varieties. With highly substitutable products, only the total quantity of industry varieties consumed—not their composition—affects utility.

Second, Table 4 shows that price postponement is appropriate when both buyers sold highly differentiable products. This postponement strategy is intended to meet customer demand with higher varieties in which the firm production capability is not sufficient. With low substitutable products, only the product composition—not the total quantity of industry varieties consumed-

<table>
<thead>
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<th>Table 3</th>
<th>Production postponement calculation at different product substitutability</th>
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affects utility. An example of least substitutable products is a competition between gasoline and liquid petroleum gas (LPG) for car fuel. Because both fuels are used for different types of engines, the producers can postpone price without worrying about consumers switching to another producer.

Third, Table 5 shows that integrated price and production postponement is not a good solution to reduce the effect of either product varieties or product substitutability. A buyer must commit to at least one decision in advance under uncertainty in order to obtain an advantage by attracting customers using either a promised price or a production decision. If integrated price and production postponement must be pursued, then it only fits with highly customized products. Thus, it also requires postponement of a price decision, which depends on the level of customization because consumers are willing to pay at any cost (shown in Table 5 by the high value of the price elasticity of demand $e_p$). An example of this application is that of competition between tour and travel operators. Because both tour and travel operators offer highly specialized tour packages to customers, they can postpone the package prices and schedule depending on the holiday season.

In conclusion, Tables 3 to 5 show that production postponement with more substitutable products and price postponement with less substitutable products are useful for attracting customers who have different preferences and are sensitive to variety and availability. However, these two kinds of consumers always exist in the market.

**Managerial implication**

In this section, we will highlight some of the managerial implications regarding the effects of platforming strategy on strategic management decisions.

Most postponement strategies undoubtedly focus on minimizing the effect of customization (Lee, 1996) by delaying product differentiation. This suggests that the allocation of a strategic safety stock to decide on push-pull CODP is idiosyncratic to a particular demand uncertainty. Manufacturing process performance is based on the level of inventory in the supply chain. This paper, however, gives new insight into postponement strategies by incorporating the competitor into the decision-making process, in which product substitutability is another factor that should be considered for making the postponement decision. For practitioners, competitive price and production postponements are valuable because they highlight various managerial and strategic implications for product development decisions. These decisions are usually based on the firm’s vision of design reusability, in which lower product substitutability refers to a shorter product life cycle because there are more chances to make innovations and to offer more varieties with different prices. That is why lower product substitutability has a higher profit in price postponement (Jiao et al., 2007). When the framework of mapping out a dynamic and structured approach for developing sustainable product design is understood in a systematic manner, price and production postponement models facilitate decision making with regard to product, company, and supply chain factors. The decision-making process facilitates coordination between the manufacturing process and the product development department so as to enhance knowledge sharing and trust.

In terms of price and production postponement usability, it is useful for managers to segment their products. This segmentation helps to determine which product prices should be postponed and which product production should be postponed. For instance, it is possible to apply price postponement in the case of LPG versus gasoline because LPG versus other LPG products can be managed according to production postponement. Thus, some LPG product production is postponed and other LPG products are kept in the warehouse.

In addition to strategic decisions on

**Table 5**

Integrated production and price postponement calculation at different product substitutability

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product development and manufacturing strategy, this paper gives new insight into managing production lines as well as product design. We suggest production postponement by using a high degree of component commonality for producing product varieties. However, we suggest price postponement for a single or dedicated production line in which the objective is that of covering more market size with the buyer product to fight with competitors. The reason is that the price postponement is intended to bar entry to competitors’ products (Porter, 1980). Furthermore, integrated production and price postponement is valuable for selling highly customized products in which many customization efforts are needed. Adjusting the production price and production quantity ensure the product will be more customizable by the customers.

Conclusions and future research considerations

This paper has discussed price or production postponement decisions and the attendant outsourcing decisions according to single or dual sourcing. We summarize the results derived from the model as follows:

1. Component commonality has a significant effect on price and production postponement. Lower component commonality creates higher substitutability and provides a positive effect on production postponement and a negative one on price postponement. This conclusion implies that price postponement is favorable for higher component commonality, and is better to hedge against customer who accentuates product differentiation to maximize their utility. However, production postponement gives the reverse effect.

2. Price postponement is favorable for reconfigurable products by offering more product variety, and production postponement is favorable for dedicated products and for covering as large a market size as possible. Furthermore, integrated price and production postponement is favorable for highly customized products by considering that customers are willing to pay at any cost due to product customization and to negotiate the way of product delivery.

3. The substitutability degree of both products is the main factor in choosing between price or production postponement when they are used separately or integrated. This conclusion is at odds with the conclusion reached by Miegham and Dada (1999). This discrepancy is caused by the fact that Miegham and Dada’s conclusion did not consider the employment of product commonality and its effect on the suppliers. Their paper concentrated on the effect of product variability and manufacturing cost. This paper, however, tries to drive the buyers' mind-set in terms of segmenting their products against their competitors in a certain market share.

In terms of future research direction, the oligopoly model should be considered for development according to future market demand, which is determined by how closely the customer requirements are met, so that in the future the oligopoly model of product family competition could be represented. From this result, an optimum product substitutability degree should be determined by considering customer requirements, such as order lead times and market power, so that manufacturers can decide on their postponement decision with some confidence. Finally, future research should include strategic decisions, for instance procurement and product development, in price and production postponement to create supply chain-based postponement strategies (Van Hoek, 2001).

References


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About the author

Yohanes Kristianto now is a doctoral student and project researcher at the University of Vaasa, Finland. His research interests are in the area of supply-chain strategy/management and production/operations management. Prior to his academic career, he worked for the quality function department of a multinational company. He has published in national and international publications.