Marketplaces or Web Services?
Alternate Business Models for Electronic B2B Transactions

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Abstract
There are two popular forms of B2B marketplaces: public marketplaces and private channels based on web services. We study why firms choose either or both of these B2B channels. Using a real-options framework, we explain firms’ choice of B2B channels as a hedging strategy and as a method of obtaining greater managerial flexibility for the future. We show that uncertainty can precipitate the creation of public marketplaces. The level of information technology (IT) capability and spending is an important factor in firms’ decision-making. When a firm chooses its level of IT investment simultaneously with the decision about which B2B channel(s) to use, the firm that chooses both channels selects the highest level of IT capability and the firm that implements only the private channel selects the lowest level of IT capability. We also show that risk aversion in a firm offsets the preference for using public marketplaces.

1. Introduction
The recent competition between HD-DVD and Blu-ray illustrates the uncertain evolution of technological standards. Firms in different industries had to decide whether to support Blu-ray or HD-DVD, or both or neither. Content producers such as Warner Brothers and Universal Studios, retailers such as Wal-mart and Amazon, video rental stores such as Blockbuster and Hollywood Video, and technology companies such as Apple and Toshiba were forced to take a stand on competing standards. Firms have to make similar decisions under uncertainty in many different contexts. In this paper we analyze the choices available to firms engaged in Business to Business (B2B) e-commerce using a real-options approach. We study the impact of several factors, such as the size of the firm, its information technology (IT) capability, the specificity of the product, and the effect of being able to customize processes on the firm’s choice of a web services–enabled private channel or a public B2B channel, or both.

B2B markets have become increasingly important, with firms focusing on their core competency and outsourcing non-strategic parts of their business. The revenue from B2B electronic commerce is expected to grow from $9.5 trillion in 2007 to $15 trillion in 2010. [16] B2B marketplaces facilitate the meeting of buyers and suppliers and provide infrastructure for B2B transactions. However, the uncertainties associated with B2B marketplaces are similar to those with B2C (Business to Consumer) electronic commerce in 1990s. Of the 1,500 marketplaces that existed in 2000, only about 200 marketplaces survived in 2008.[16]

Electronic B2B channels can be categorized into two types: public marketplaces and private channels based on web services. A private web service is owned by one firm and used only by that firm and its partners. A public marketplace is owned by many firms and used by them and their partners. While public marketplaces allow firms to save on procurement costs by drawing on a larger base of suppliers and buyers, the strength of the private web service channel is the efficiency of customized transaction processes for only one supplier or buyer.

This study seeks to analyze the effect of various factors that influence a firm’s choice between joining a public marketplace and creating a private web services channel. Thus the present study contributes to our understanding of B2B marketplace adoption. We develop a framework for understanding a firms’ decision to adopt a B2B marketplace by combining game-theoretic analysis with a real-options approach. We find that firms with higher IT capability make greater use of both public marketplaces and private web services and firms that make use of both kinds of channels invest more in IT. When the level of IT capability is chosen simultaneously with the decision on B2B channels, the firm that chooses to implement both channels selects the highest level of IT capability and the firm that implements only the private channel selects the lowest level of IT capability. We also show...
that the existence of risk aversion offsets the preference for using public marketplaces.

Prior research has analyzed several factors associated with B2B business models, such as the size of the firm and the fragmentation level of industries; however, strategic uncertainty about the future has not been considered in previous research on electronic B2B channels. Even though B2B marketplaces are valued for their enormous potential to increase firms’ profits, opportunistic behavior by some firms has also been observed.[25] Opportunistic firms profess to cooperate in creating public marketplaces while simultaneously establishing and using their own private channels based on web services, thus reducing their commitment to the success of public marketplaces. This behavior is due to the strategic uncertainty inherent in public B2B marketplaces. Because firms cannot predict whether their competitors will cooperate in using public B2B marketplaces or compete by using private channels, the innovative firm may choose to do both. This can be viewed as a hedging strategy to reduce risk. The real-options view sees uncertainty as an opportunity that can be exploited by using IT.[1] The common assumption is that firms invest less when uncertainty increases; using the real-options framework, we are able to quantify the managerial flexibility that is so valuable in an uncertain world. Further, we can study the impact of IT on managerial flexibility. In this paper, we analyze the impact of this option on decision-making by firms. We provide a literature review in Section 2. Section 3 describes the model, and the results are discussed in Section 4. Finally, the significance and directions for further research are discussed in Section 5.

2. Literature review

There is a significant literature on the economic factors that affect organizational structure. Coase [3] points out that, as transaction costs are reduced, the benefits from markets increase. Williamson [26] introduced the importance of transaction cost economics in firms’ organizational choices under different conditions. He explains the impact of transaction cost economics in determining the form and size of organizations with the concept of ‘asset specificity.’ Researchers studying B2B electronic commerce have identified the role of transaction costs in this field.

Other research into B2B electronic commerce includes Walden and Subramani [24], who find empirical evidence to support the value of B2B electronic commerce. They identify the extent of positive impact of B2B electronic commerce on different types of firms -- pure Internet firms and brick-and-mortar companies, and on different types of products -- digital products and tangible products. Kauffman and Mohtadi [15] see the size of firms as an important factor in choosing between private marketplaces, which are exclusively owned by a supplier or a buyer, and public marketplaces, which are open to all suppliers and buyers in industries. They expect that larger firms will be inclined to use private marketplaces. Dai and Kauffman [4] find that the desired gains from lower search and operation costs, the importance of information sharing, and competition are important factors in deciding between public and private marketplaces. Information transparency and the cost of sharing information are also recognized as important factors affecting the firm’s choice between public and private channels.[21]

While there are several studies of B2B channels, strategic uncertainty about the future has not been considered in research related to B2B channels. B2B channels are normally praised for their potential to increase the profit of firms, but opportunistic behaviors by some firms have also been observed.[25] Although opportunistic firms claim they will cooperate in creating public marketplaces, the uncertainty about B2B public marketplaces leads them to also use private channels based on web services. They do this because they are unsure whether their competitors will cooperate in the public marketplaces or act individually against each other. Firms cannot be certain of the performance or the liquidity of other firms, or about the technologies used in B2B marketplaces. Unlike the uncertainties of supply and demand, these strategic uncertainties have not been studied in B2B marketplaces.

A firm that simultaneously develops private and public channels can be viewed as adopting a hedging strategy to manage risk. Prior literature has used this view to evaluate capital investments as real options, especially when there is significant uncertainty about the future and when investments open up more alternatives in the future [22]. Van Alstyne [23] discusses the value of information itself as an option, with the cost of action as its strike price. An investment in IT is a good example of an investment that can be seen as an option because it involves a great deal of uncertainty at the time of the investment. The value of managerial flexibility can be interpreted as an option for hedging risk due to uncertainty. This value is called a “real option” to differentiate if from a “financial option.” Different categories of strategies can be seen as real options in different ways. Roberts and Weitzman [19] see the quick investment as a real option that is valuable because it allows firms to collect information from early investment. McDonald and
Siegel [17] see the quick investment as a real option because it allows investors to take great benefits when the investment is successful while just to lose the amount they invest.

The real-options approach has been used by several information systems researchers. Dos Santos [6] asserts that the real-options approach is better than traditional investment evaluation methods such as net present value (NPV) because it is able to consider the value of managerial flexibility. Fichman [9] applies the real-options view to evaluating IT investments on IT platform technologies. He discusses characteristics of projects and organizations that affect the option value of investments in the technologies. Dai et al. [5] use an analytical model to explain the value of IT investments as providing potential leverage for further applications. Benaroch and Kauffman [2] provide an example of the evaluation of IT investments using real options. Tallon et al. [20] review the status of IT research on the real-options approach and discuss possible further research questions. They suggest that future studies consider decision, simulation, and game-theoretic models to provide insights into IT investment processes. By considering the uncertainty factor and network externalities in B2B channels as well as various possible scenarios, our research seeks to explain current phenomena in the real world and the likely direction of B2B channels in the future.

3. Model

Following the categorization of Kaplan and Sawney [14], in this study we focus on manufacturing related products and processes in individual industry areas, which compose 90% of total procurements [7] and not on other supporting activities. For supporting activities, we expect there to be horizontal marketplaces across industry areas instead of vertical marketplaces for each industry area.

Our model considers several factors at three levels: those of the product, the firm, and the industry. Specificity of the product (θ) is a product-level factor. A highly specific product can only be used for particular purposes, while products with low specificity, such as commodity products, can be used widely for general purposes. Firm-level factors include the size of the firm (n) and the firm’s expertise in information technology (λ), which can provide advantages in using and adjusting to the external environment. Customization and information security (ε) are two of the advantages of private channels based on web services. Since private channels are available only to the firm and its business partners, the firm’s business processes can be easily customized.

Also, information related to the business processes is more secure because the marketplace is used exclusively by the firm and its partners. At the industry level, the current status of B2B marketplaces in an industry affects the firm’s choice of a business model. The expected size of the public marketplace (N) is one industry-level factor. The greater the size of a public marketplace in an industry, the more likely a firm is to choose it since it can provide larger benefits to its participants with more liquidity.

We model the firm’s choice of B2B channels using a simplified two-stage model. At the first stage, the firm decides which channel it will implement: private or public or both. At that point the firm does not know what level of cooperation exists among firms (N) in the public marketplace. At the second stage, when the uncertainty about cooperation in the public marketplace is resolved, the firm decides which channel to continue using. However, if the firm chose to implement only one of the two channels, the firm can only use the channel it implemented at the first stage. Using a non-cooperative game model, we examine which B2B channel, public or private, the firm will choose. For this work, let pb denote ‘public’ and pr denote ‘private’ channels. We assume that products can be ordered based on their specificity (θ), which is uniformly distributed between 0 (commodity) and 1 (customized product):

\[ θ \sim U(0,1) \] (1)

3.1. Cost factors

There are several costs incurred by buyers and suppliers during B2B transaction processes. Prior studies have proposed different ways of categorizing the cost factors related to B2B transactions. [8][15] We describe several of those cost factors below. We assume that firm size (n) can be used as a proxy for the number of transactions.

Buyers face six types of costs: those associated with (1) searching products and business partners, (2) collecting information, (3) decision-making, (4) bargaining, (5) writing contracts, and (6) enforcing contract provisions.

There are five types of suppliers' costs: those associated with transactions, managing workflow, inventory, production, and shipping.

These costs may further be categorized as fixed costs or variable costs depending on whether they change with the number of transactions. For example, search costs are incurred for each transaction and are considered to be variable costs. However, implementation and maintenance costs for the channels are fixed costs that are not affected by the number of
transactions. In this study, we permit firms to be buyers or suppliers or both.

3.2. Alternative 1: private channel only

This is the case in which a firm uses its private channel only. For example, Volkswagen continued to use their private channel only while its rivals such as GM and Ford built and joined Covisint, a public marketplace in the automotive industry. For the private channel, it is assumed that per product savings is the sum of the benefits from customization and general IT, as in (2).

\[
b_{pr}(\lambda, e, \theta) = (\lambda + e) \cdot 1 \quad (2)
\]

Thus, the aggregate profit (\(\Pi\)) can be calculated for the private marketplaces as in (3), where \(C_{pr}(n, \lambda)\) denotes the total fixed costs and variable costs depending on the size of the firm \((n)\) implementing the private channel. We assume that the per product savings increases with the efficiency of the general IT expertise level of each firm \((\lambda)\), as well as with the benefit of customization and information security \((e)\) in the private channel. We also assume that the benefit is linearly related to firm size. In other words, it is assumed that the size of the firm is the proxy for the size of expected transactions and benefits in using the private channel. The profit from the private channel can be defined as in (4) following all of the assumptions we have made. As assumed in Section 1, costs are categorized as fixed costs in the first stage for implementing the private marketplace and in the second stage for maintaining the marketplace \((f_{pr1}, f_{pr2})\), and as variable costs \((v_{pr}, n)\).

\[
\Pi_{pr}(n, \lambda, e) = n \int_0^1 b_{pr}(\lambda, e, \theta) d\theta - C_{pr}
\]

\[= n(\lambda + e) - (f_{pr1} + f_{pr2} + v_{pr} \cdot n) \quad (4)
\]

3.3. Alternative 2: public marketplace only

This is the case when a firm only uses public marketplace without building its own private marketplace. Many small and medium sized firms favor to use public marketplace while they do not want to invest on private web services and use their traditional B2B channels. For the public marketplace, per product savings in procurement can be calculated as in (5), where the per product benefit decreases when the specificity \((s)\) increases and increases when the size of public market increases. The reason why customization and information security parameter, \(e\), in the private channel is included in the benefit level of the public channel is to make the comparison of benefit levels of private and public levels a fair one. Equation 5 has been designed so that the benefit from the public marketplace is equal to the benefit from the private marketplace when the size of public marketplace is at the level which makes the profits from using those two equal if the costs of using two markets are equal.

\[
b_{pb}(N, \lambda, e, \theta) = k\lambda[s(1/2 - \theta) + 1] + k\lambda(N-k) \quad (5)
\]

Where

\[
k = \frac{(\lambda + e)}{\lambda}
\]

There is an inherent uncertainty about cooperation in the public marketplace. Firms get savings when they use public marketplaces. Based on the extent of external conditions (shock or volatility defined here), firms decide whether to invest or not. For simplicity, we assume that the extent of cooperation is uniformly distributed around the average \(\bar{N}\), as in (6), with the range of \(2\varepsilon\). This scope, \(\varepsilon\), represents the degree of uncertainty at stage 1 about the extent of cooperation in the public marketplace. It is assumed that the non-participation of a firm of size \((n)\) reduces the level of cooperation:

\[
N^* = U(\bar{N} - \varepsilon - n, \bar{N} + \varepsilon - n) \quad \text{if the firm (n) does not join}
\]

\[
N^* = U(\bar{N} - \varepsilon, \bar{N} + \varepsilon) \quad \text{if the firm (n) joins} \quad (6)
\]

The aggregate profit (\(\Pi\)) can be calculated for public marketplaces as in (7). The total profit from products is the size of the firm \((n)\) multiplied by the average profit per product. \(C_{pb}\) denotes the sum of fixed costs and variable costs proportional to the size of the firm to use the public marketplace. We expect the per product savings to increase with each firm’s level of expertise and the level of participation of others. When more participants join the public marketplace, the possibility of finding better matches and lower prices increases, and therefore the value of the public marketplace increases as well. As assumed in Section 3.1, costs are categorized as fixed costs in the first and second stages \((f_{pb1}, f_{pb2})\), and as variable costs \((v_{pb}, n)\).

\[
E(\Pi_{pb}(N, n, e, \lambda)) = n \int_0^1 b_{pb}(\lambda, e, \theta) d\theta - C_{pb}
\]

\[= n\bar{N}\lambda - (f_{pb1} + f_{pb2} + v_{pb} \cdot n) \quad (7)
\]

Thus we can calculate the cooperation level, \(N^*\), where the profits from using the private and the public channels are equal. When the profits of private and public channels are compared, there is a trade-off between more benefits from customization and security \((e)\) and network effects of public channel from more participation of business partners \((N)\). If there is more participation expected than \(N^*\) for public channel, the firm will choose the public over the private channel.
At $N^* = \frac{\lambda + e}{n \lambda} n - (C_{pb} - C_{pr}), \Pi_{pr} = \Pi_{pb}$ (8)

3.4. Alternative 3: both channels

Also considered is the case in which a firm uses both channels at the same time. For example, many companies in the health care industry use GHX as a public marketplace while they also use their own private channels.

For simplicity, we start with the case in which a firm implements both channels at the first stage and then chooses to use a single channel (the one that has proven to be more profitable) in the second stage, as in (9). We call this strategy the ‘pick’ strategy.

$$E(\Pi_{pick}) = E(\max \{\Pi_{pr} + C_{pr}, \Pi_{pb} + C_{pb}\}) - C_{both} = \{\Pi_{pr} + C_{pr}\} \cdot P(Pr) + \{\Pi_{pb} + C_{pb}\}(1 - P(Pr)) - C_{pick}$$ (9)

Where,

$$P(Pr) = \frac{N - (N - e)}{2e}$$

At the first stage, the firm invests in both channels if $E(\Pi_{pick}) > \max \{\Pi_{pr}, E(\Pi_{pb})\}$ (10)

Thus we can calculate the net option value of implementing both channels and having the flexibility to choose the more favorable channel later, as in (11):

$$v(option) = \max[\min\{E(\Pi_{pick}) - E(\Pi_{pr}), E(\Pi_{pick}) - E(\Pi_{pb})\}, 0]$$ (11)

The price of the option is the amount of added costs incurred to implement both channels at the same time rather than implementing either of the two channels exclusively, as in (12):

$$p(option | \Pi_{pick}) = C_{pick} - C_{pb} = f_{pr1}$$ if $\Pi_{pb} > \Pi_{pr}$ or

$$= C_{pick} - C_{pr} = f_{pb1}$$ if $\Pi_{pr} > \Pi_{pb}$ (12)

At the second stage, the firm chooses to use only the channel, that produces higher profits.

$$\Pi_{pick} = \Pi_{pb}$$ if $N > N^*$

$$\Pi_{pick} = \Pi_{pr}$$ if $N < N^*$

As can be seen in Fig. 1, when a firm chooses to create both channels at the first stage, at the second stage it will choose the public marketplace only if it produced more profit than the private channel. If a firm implements both channels at the first stage and thereby invests more, the profit in the private channel will be the minimum profit the firm could earn at the second stage. The dashed line is the adjusted probability distribution of the profit from the public marketplace truncated at the profit level of the private channel. The managerial flexibility of having two channels in place gives the firm the option to choose the more favorable channel in the second stage.

3.5. Decision

The decision of the firm is among three alternatives: implementing only the public channel, implementing only the private channel, or implementing both and using one exclusively later. The firm will choose the alternative that it expects to yield the maximum profit. The problem can be summarized as in (13):

$$\max\{\Pi_{pr}(N, n, \lambda, e), \Pi_{pb}(n, \lambda, e), E(\Pi_{pick}(N, n, \lambda, e))\}$$ (13)

4. Results

We now present the results of our analysis. We start with comparative statics from a model that assumes that the level of IT spending is determined exogenously. We relax this assumption in section 4.2. In section 4.3 we examine the case in which the firm implements both channels.

4.1. Comparative analysis

The following results illustrate the impact of changes in deciding which channel to choose.

Proposition 1 The impact of an increase in the level of information technology ($\lambda$) on the choice of private or public channels depends on implementation costs and customization technology levels. When the fixed cost differential between public and private marketplaces is small and there is a sufficiently high degree of customization available in the private channel, then increasing the level of IT capability will favor private channels.
Proof. An increase in the level of information technology improves the efficiency of private and public channels.

\[ \frac{\partial \Pi_{pr}}{\partial \lambda} > 0, \frac{\partial \Pi_{pb}}{\partial \lambda} > 0 \]  (14)

\[ \frac{\partial N^*}{\partial e} > 0 \]  (15)

\[ \frac{\partial N^*}{\partial \lambda} \geq 0 \text{ if } e \cdot n - (C_{pr} - C_{pb}) < 0 \]  (16)

\[ \frac{\partial N^*}{\partial \lambda} < 0 \text{ otherwise} \]

As in (14), more advanced IT within a firm benefits both channels. The impact of advanced IT on customization (increases e) will favor the use of private channels as in (15). However, the effect of general information technology on B2B channels, such as better WAN technology and greater bandwidth (increases \( \lambda \)), is not deterministic. As in (16), the impact depends on cost structure and level of customization, similar to the findings of Whang and Gurbaxani [11] on the impact of IT on organizations. The impact depends on the trade-offs between internal and external economic conditions faced by the firm.

Proposition 2 When the difference in the expected profit resulting from the two channels is greater, the value of creating both as an option is lower.

Proof. The value of choosing both marketplaces at the stage 1 is lower when the difference in expected profits between the two is greater. In other words, when the expected cooperation level (\( N^* \)) is farther from \( N^* \) in either direction, the choice of one marketplace will be preferred and will occur with a higher probability. As seen in Fig. 2, we consider two factors in decision-making: the expected cooperation level and the magnitude of implementation costs for two marketplaces. The firm will invest in both when the implementation costs (\( f_{pb1}, f_{pr1} \)) are small and the expected cooperation level is close to \( N^* \), and where the expected profits from the two channels are the same. Intuitively, when one marketplace is much more advantageous, the value of the option to choose between two channels decreases. \( N_i \) and \( N_f \) are the limits of the cooperation levels. The firm need not implement both channels if cooperation is higher or lower than these limits, even though there are no fixed costs (\( f_{pr1}, f_{pb1} \)) at the first stage.

Proposition 3 When the level of uncertainty (\( \varepsilon \)) regarding a B2B channel is higher, the benefit to the firm from implementing both channels is greater. Thus the probability of implementing both channels at the first stage is higher.

Proof. As we see in section 3.4, when there is greater uncertainty (\( \varepsilon \)) at stage 1, there is a greater probability that firms will choose to implement both channels as in (17). The conditions assume that there is an interior solution of the network level (\( N^* \)) that makes the profit from the public and private channels the same.

\[ \frac{\partial E(\Pi_{box})}{\partial \varepsilon} = \frac{\partial v(option)}{\partial \varepsilon} > 0 \]  (17)

if \( f_{pr1} = f_{pb1}, f_{pr2} = f_{pb2}, \forall pr = \forall pb \) and \( \varepsilon > \left| N - N^* \right| \)

Figure 2. Strategy chosen (depending on the magnitude of implementation costs and expected cooperation level)

The value of flexibility when the successful formation among members of public marketplace and the size of the marketplace is uncertain, the option value, as in (11), increases when uncertainty increases. It is difficult to measure the magnitude of uncertainty in electronic business-to-business (B2B) commerce. However, since we know that uncertainty in public marketplaces is very high because the environment of B2B e-commerce is unstable, firms that are able to increase their future flexibility by implementing both channels will do so based on their assessment of the uncertainty level. This explains the behavior of major firms who invest in both private and public channels at the same time.[25] These firms might intend to use both channels for certain activities, or they might be seeking to hedge their bets in the event that the public marketplace rewards the firm's equity and investments. However, this does not mean that the firms will continue to use public marketplaces when the uncertainty decreases. They are likely to stop using the public marketplaces if conditions favor the use of private channels.

4.2. Endogenous IT

Up to now, we have treated IT factors, \( \lambda \) and \( e \), as exogenous variables. However, from the view of
firms, IT factors are important strategic factors that can be decided by firms. We therefore define IT factors with convex cost functions, as in (19).

\[ C_{IT} = \alpha z^2 + \beta e^2 \]  

(19)

It is assumed that the more IT capacity the firm has, the more the costs to implement the channel will decrease, as in (20), because more advanced IT makes it easier for the firm to implement channels. Meanwhile, the benefit from channels increases with more IT capacity.

\[ f_{pbi} = a_{pbi} - b_{pbi} \cdot \lambda \]  

(20)

\[ f_{pri} = a_{pri} - b_{pri} \cdot \lambda \]  

where \( i = 1 \) or \( 2 \)

The adjusted profit functions when IT factors are endogenized are as follows.

\[ \Pi_{IT} = \Pi - C_{IT} \]  

\[ \Pi_{IT} = \Pi - C_{IT} \]

\[ \Pi_{pick} = \Pi - C_{IT} \]

Then we can find interesting results from the endogenous IT factors.

**Proposition 4** The optimal level of general IT capability (\( \lambda \)) is greater when the firm chooses to implement both marketplaces relative to the IT capability when the firm chooses to implement either public or private channel only.

**Proof.** When we simplify the costs of implementing the channels

\[ (f_{p1} + f_{p2}) = (f_{pbi} + f_{pri}) = f = a - b\lambda \]

the results are as follows:

\[ \frac{\partial \Pi_{p1}}{\partial \lambda} = 0 \rightarrow \lambda_{p1}^* = \frac{b + n}{2\alpha} \]

\[ \frac{\partial \Pi_{p2}}{\partial \lambda} = 0 \rightarrow \lambda_{p2}^* = \frac{b + n N}{2\alpha} \]

\[ \frac{\partial \Pi_{pick}}{\partial \lambda} = 0 \rightarrow \lambda_{pick}^* = \frac{2b + n(N' + (N-e)) + n(N' + N + e)(1 - (N' - (N-e)))}{2\alpha} \]

\[ \lambda_{pick}^* > \lambda_{p1}^*, \lambda_{p2}^* \] if the “pick” strategy chosen

Thus the IT level implemented by firms will be higher when they choose to implement both channels compared to the cases where firms choose to implement only one channel.

**4.3. Simultaneous use of both marketplaces**

The ‘pick’ strategy above eliminates the possibility of the firm using both channels at the same time. The strategy of using both channels at the same time is called the ‘both’ strategy.

As in Fig. 3, it is assumed that the unit profit from the public marketplace decreases with an increase in product specificity. Meanwhile, the unit profit of the private channel stays the same. Thus the firm uses the public marketplace only for products whose procurement is more profitable via the public marketplace. For example, United Technologies may use the public marketplace for less specific products (\( 0 < \theta < \theta' \)) while using the private channel for highly specific products (\( \theta' < \theta < 1 \)). The costs of using both will then be a combination of the two, as in (21). The optimal use of the public marketplace (\( \theta' \)) is decided at the second stage.

\[ E(\Pi_{both}) = \int_{0}^{\theta'} b_{pr}(n, \lambda, \theta) d\theta + \int_{\theta'}^{1} b_{pb}(N, n, \lambda, \theta) d\theta - C_{both} \]

where \( \Pi_{both} = \Pi_{pr} \cdot \Pi_{pb} \)

\[ (21) \]

![Figure 3. Changes in unit profit from the public marketplace, depending on the cooperation level](image)

From Fig. 4, by comparing the unit profits from the public and private channels, we can see that the net gain of using the ‘both’ strategy is the smaller of the two shaded areas (efficiency gain from 0 to \( \theta' \) or \( \theta' \) to 1) minus the price of the real option to implement both channels. Thus the value of the option, as in (11), can be rewritten as in (22):

\[ v(option) = \min\{s \cdot \theta', s \cdot (1 - \theta')\} \]

(22)

Compared to the ‘pick’ strategy, the ‘both’ strategy incurs more costs by maintaining and using two channels at the same time. So, the price of the ‘both’ option is as follows:

\[ p(option|\Pi_{both}) = C_{both} - C_{pr} \text{ or } C_{both} - C_{pb} \]

(23)
or if \[pb_{pr} \neq \Pi \neq pb_{pr} \] or \[pb_{pr} \neq \Pi \neq pb_{pr} \]

\[\begin{align*}
\text{Private} \quad & N + \omega \\
\text{Public} \quad & N - \omega \\
\text{Invest on Both} \quad & N' + \omega \\
\text{No Marketplace} \quad & N' - \omega
\end{align*}\]

Figure 4. Comparison of unit profits if procured by the public or the private marketplace

The decision depends on the level of cooperation \((N)\). As in Fig. 3, when there are more benefits resulting from greater cooperation, more products will be procured via the public marketplace. Then when the ‘both’ strategy of using two channels together in the second stage is also considered, the area of implementing both at the first stage is larger, as in Fig. 5, than the area of implementing both at the first stage when only the ‘pick’ strategy of choosing only one channel in the second stage is considered. When the degree of uncertainty \((\epsilon)\) includes the optimal choice of the ‘both’ strategy in the second stage, we set this at zero implementation costs as \(\Omega\).

At the second stage, we denote the ex-post profit by adding subscripts to \(N\). The firm chooses to use only one channel \((\Pi_{pick})\) if,

\[\Pi_{both} > \Pi_{pick} N\]

where \(\Pi_{pick} N = \Pi_{pr} N - f_{pb} N\) if \(\Pi_{pr} N > \Pi_{pb} N\)

\[\Pi_{pick} N = \Pi_{pb} N - f_{pe} N\) if \(\Pi_{pr} N < \Pi_{pb} N\)

In this subsection, we assume the firm is small, and therefore we disregard the impact of the firm’s decision to use both channels or only one channel on the cooperation level.

Insofar as there is an area for the ‘both’ strategy, that area is flanked by the ‘pick’ strategy. In addition, the area of the ‘both’ strategy can be so large that it usurps and therefore replaces the entire area of the ‘pick’ strategy, as in Fig. 6.

The width of the region of the ‘pick’ strategy from \(N\) for one side (ex ante) is as in (24).

\[\epsilon = -\frac{2\sqrt{\epsilon \sqrt{f_1}}}{\sqrt{n}} \quad \text{when} \quad f_{pe} = f_{pb} = f_{pr1} = f_{pr2} = f_{pb2} = f_2 \] (24)

Thus the two limits implementing both channels at the first stage are as follows:

\[N_i = N' - \left(\epsilon - \frac{2\sqrt{\epsilon \sqrt{f_1}}}{\sqrt{n}}\right)\] (25)

\[N_h = N' + \left(\epsilon + \frac{2\sqrt{\epsilon \sqrt{f_1}}}{\sqrt{n}}\right)\] (26)

At the point where the profits from the public and private channels are the same \((N')\), the benefit of using both channels is the greatest:

\[f_{pb} = f_{pr} = f_1\]

Figure 6. Ex-post Area of Decisions Chosen

4.3.1. Exogenous N case (small firm). If the firm invests in both marketplaces at the first stage, the outer boundaries of the decision area is decided by either the ‘both’ strategy or the ‘pick’ strategy (see Fig. 5). The decision depends on the benefit of the ‘both’ strategy \((f_{pb} 2, f_{pr} 2)\) and the costs of maintaining both \((f_{pb} N, f_{pr} N)\) channels at the second stage. So, the range of \(\Pi_{both}\) can be either larger or narrower than that of \(\Pi_{pick}\).
The profit function of the 'both' strategy depends on the ex post cooperation level. The profit function is different when the cooperation level is higher than \(N^*(\Pi_{both})\) and when the cooperation level is lower than \(N^*(\Pi_{pick})\):

\[
\Pi_{both}|v = \Pi_{pick}|v + n(1-\theta^*) \cdot \frac{s}{2} - f_{pr2}
\]

\[
= \{\Pi_{pick}|v - f_{pr1}\} + n(1-\theta^*) \cdot \frac{s}{2} - f_{pr2}
\]

if \(N > N^*, v_{pick} = v\)

\[
\Pi_{both}|N = \Pi_{pick}|N + n(1-\theta^*) \cdot \frac{s}{2} - f_{pr2}
\]

\[
= \{\Pi_{pr}|N - f_{pr1}\} + n\theta^* \cdot \frac{s}{2} - f_{pr2}
\]

if \(N < N^*, v_{pick} = v\)

Thus the width of the 'both' strategy area from \(N^*\) for one side (\(\Pi_{pick}|v = \Pi_{both}|v\)) can be calculated as below:

\[
\min\{n(1-\theta^*) \cdot \frac{s}{2}, n\theta^* \cdot \frac{s}{2}\}
\]

\[
\theta^* = \frac{N\lambda - (e + \lambda)}{N^*s} + 1 \cdot \frac{\partial \theta^*}{\partial N} = \frac{1}{N^*s}
\]

\[
\theta^* = \frac{1}{2} \text{ if } f_{pr1} = f_{pr2}
\]

The profit function of the 'both' strategy depends on the ex post cooperation level. The profit function is different when the cooperation level is higher than \(N^*(\Pi_{both})\) and when the cooperation level is lower than \(N^*(\Pi_{pick})\):

\[
\Pi_{both}|N = \Pi_{pick}|N + n(1-\theta^*) \cdot \frac{s}{2} - f_{pr2}
\]

\[
= \{\Pi_{pick}|N - f_{pr1}\} + n(1-\theta^*) \cdot \frac{s}{2} - f_{pr2}
\]

if \(N > N^*, v_{pick} = v\)

\[
\Pi_{both}|N = \Pi_{pick}|N + n(1-\theta^*) \cdot \frac{s}{2} - f_{pr2}
\]

\[
= \{\Pi_{pr}|N - f_{pr1}\} + n\theta^* \cdot \frac{s}{2} - f_{pr2}
\]

if \(N < N^*, v_{pick} = v\)

Thus the width of the 'both' strategy area from \(N^*\) for one side (\(\Pi_{pick}|v = \Pi_{both}|v\)) can be calculated as below:

\[
\frac{1}{2n\lambda}(ns - 4f2)(e + \lambda)
\]

when \(f_{pr1} = f_{pr2} = f\)

There is no area for the 'pick' strategy if the 'both' strategy area is greater than the size of the ex ante area for implementing both channels and the width of uncertainty, as in (27).

\[
\frac{1}{2n\lambda}(ns - 4f2)(e + \lambda) > (e + \omega)
\]

Finally, the decision whether to implement both channels or only one channel at the first stage depends on the expected value from implementing both and implementing only one, as in (28).

\[
\Pi_{pick} > E(\max\{\Pi_{both}, \Pi_{pick}\})
\]

or \(E(\Pi_{pick}) > E(\max\{\Pi_{both}, \Pi_{pick}\})\)

where \(E(\max\{\Pi_{both}, \Pi_{pick}\}) = \int_{\mathbb{N}} \max\{\Pi_{both}|v, \Pi_{pick}|v\}dN + \int_{\mathbb{N}} \max\{\Pi_{both}|N, \Pi_{pick}|v\}dN\)

4.3.2. Endogenous N case (big firm). When a firm is large enough to affect the size of the channel itself, the firm’s decision will affect the level of cooperation and the benefit of the public marketplace. Thus we define the cooperation level affected by the firm itself as \(N^*_e:\)

\[
N^*_e = N^* - (1 - \theta^*)n
\]

This cooperation level (\(N^*_e\)) means that, when the ‘both’ strategy is chosen, the use of the public marketplace is reduced. If we compare the profit function of the ‘both’ strategy to the single choices (public or private only), it can be arranged as follows:

\[
\Pi_{both}|k = \Pi_{pick} - n(1-\theta^*) \cdot n\theta^* \cdot \lambda + n(1-\theta^*) \cdot \frac{s}{2} - f_{pr2}
\]

\[
= \Pi_{pr} - n(1-\theta^*) \cdot n\lambda + n\theta^* \cdot \frac{s}{2} - f_{pr2}
\]

if \(N > N^*_e\)

\[
\Pi_{both}|k = \Pi_{pick} - n(1-\theta^*) \cdot n\theta^* \cdot \lambda + n(1-\theta^*) \cdot \frac{s}{2} - f_{pr2}
\]

\[
= \Pi_{pr} - n(1-\theta^*) \cdot n\lambda + n\theta^* \cdot \frac{s}{2} - f_{pr2}
\]

if \(N < N^*_e\)

\[
\text{Proposition 5} \text{ The larger the size of the firm, the less it will use the public marketplace.}
\]

The decreasing network effects on the public market by a firm’s self-imposed departure reduce the overall power of the public marketplace, as well as the probability that both channels will be implemented. Furthermore, when the size of the firm (\(n\)) is greater, the use of the public marketplace (\(\theta^*_e\)) becomes less. The incentive for larger firms to use public marketplaces is reduced partly because of their partial commitment to the public marketplaces. However, it is indeterministic whether the endogenous network effect increases the portion of firms using the ‘both’ or ‘pick’ strategy. The decision depends on the ex post network level (\(N\)). For example, when the ex post network level is greater than \(N^*_e\), the reduction in network level results in a higher probability that firms will choose the ‘both’ strategy.

\[
\theta^*_e = \frac{nN^*_e - N^* + N^*(n\lambda + \frac{1}{2}ns\lambda) - n(e + \lambda)}{\lambda \cdot nN^*_e - N^* + N^*(n\lambda + \frac{1}{2}ns\lambda) - n(e + \lambda)}
\]

\[
\rightarrow \theta^*_e < \theta^*
\]

5. Conclusion

Currently there exist thousands of industrial marketplaces, but only a small number are expected to survive.[13] Because of the unique characteristics of each industry, practitioners and academic researchers expect that different business models, such as private channels and public marketplaces, will be used in
In this paper we used the real-options perspective to explain firms’ reasons for building private channels and public marketplaces. We find that firms act opportunistically by investing in both public and private channels and that, when there is uncertainty about the prospects for success in the public marketplace, this opportunistic behavior increases. We also show that, with information technology, a firm can derive more benefit by using both channels -- public as well as private. Increasing IT does not always favor one type of channel over the other. However, when the level of IT spending is chosen simultaneously with the decision about which channel to implement, the firm that chooses to implement both channels selects the highest level of IT spending and the firms that implements only the private channel selects the lowest level of IT spending.

We reached the above conclusions using a two-period model with a specific distribution of uncertainty. However, we would expect the results to hold for most probability distributions, including the normal distribution. Further research is expected to extend these results to the Black-Sholes continuous time-based option pricing model. The empirical validation of our analytical results is another likely future extension of this research.

6. References