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Abstract

Companies that seek to build buyer-based B2B e-commerce systems face a challenge to estimate the investment value while the attitude of suppliers toward the participation is full of uncertainty. This research provides an game-based option valuation approach that clarifies the uncertainties of each investment timing strategies by analyzing the expected revenue, cost, project risks, and time to the market for both buyers and sellers, which the buyer can take as a guideline while designing the B2B e-commerce systems. Although the potential of option pricing models on evaluating IT value is discussed in prior literature, the models are never applied to evaluating the investment strategy, which the success of the investment depends on the participation of multiple parties. The model developed examined the effect of counteractions between the supplier and the buyer underlies a number of findings with potential to assist managers designing a "win-win" investment strategy.

Keywords: Compound option model, B2B electronic commerce, IT investment, supplier participation, game theory

Introduction

In the context of EDI, there is some evidence to indicate that power and dependence existed in the relationship between the firm and the partners may have some role in EDI adoption decision (Wey and Gibson, 1991, Saunders and Clarks, 1992, and Hart and Saunders, 1998). In the buyer-based B2B electronic commerce systems, this power and dependence is usually reflected by the degree of supplier participation. Whether the supplier decides to immediately join or defer its participation may critically affect the value of B2B e-commerce systems investment.

However, many buyer-based B2B e-commerce systems have less success to attract suppliers than they expect, because for most of the suppliers, whether the participation makes economic sense is still a question mark. Although suppliers can gain access to new customers and reduce transaction costs by participation, they are forced to compete mainly on price, which puts intense pressure on their margin. They also have to pay the marketplace operators a commission for the privilege of selling. In addition to that, sharing their product and marketing information through the third party can be harmful to their brand equity. As a result, some suppliers may decide to defer their participation until most of the uncertainties become clearer.

Since the suppliers' attitude toward the participation is full of uncertainties, especially in the initial stage of system development, it causes a lot of problems for the organization to estimate their investment value. First, the predicted benefits may not occur if the supplier participation is not enough. However, the traditional capital budgeting method, such as NPV assumes all the predicted benefits will actually occur, not allowing for problems with conversion effectiveness (Locus 1999). Second, NPV assumes that the interest rate is constant and has no variability. However, if we view the development of B2B e-commerce systems as a form of 'two-stage project', whether the supplier chooses to use the system (second stage investment) adds value to the owner company's infrastructure investment (first stage investment). The variability in the supplier side should be different from the developer side. Thus, the organization is easily biased against funding the B2B e-commerce systems by using NPV analysis. To solve the problem, a more promising evaluation approach with the concern of supplier participation uncertainties should be built. But before that, we need to clearly define the different types of uncertainties and their determinants in the development process of buyer-based B2B e-commerce systems.

Three research questions are expected to answer in this paper:

(1) What are the important determinants of supplier participation in buyer-based B2B e-commerce systems?
(2) Is there any effective approach to estimate the investment value of buyer-based B2B e-commerce systems while taking the supplier action and competition pressure into concern?
(3) What is the best investment strategy that the developer can choose to enhance the overall payoff for both buyers and suppliers?

The impact of supplier participation on buyer-based B2B e-commerce investment strategy

Table 1 gives taxonomy of three buyer-based B2B e-commerce systems. The buyer-based web procurement systems creates direct computer links to a company's dedicated suppliers so order forms and catalogs are readily accessible online. The focus is put on a single, well-established buyer, such as Procter & Gamble, that develops a web-enabled procurement system to integrate its entire procurement process with selected suppliers. Since the relationship between suppliers and buyers are already built under a long-term contract, the environment uncertainty is relative low, however the suppliers may often face high lock-in costs.

Buyer's own e-marketplaces are implemented by the buyers that do their purchases through their own B2B e-commerce centers. Many of the best-known players in this arena, such as Wal-Mart's RetailLink, started out by developing their own B2B e-market and aggregating suppliers to compete on price. These e-marketplaces are easier to build and operate because there is a clear leader in the technical and business development. It also has the financial backing of the dominant company, which enables them to move ahead quickly without worrying so much about short-term profits. However, they are less democratic and whether the pricing mechanism is fair to suppliers is often questioned. Buyer-jointed industrial e-marketplaces, such as the auto industry's Covisint, were developed by groups of buyers in the same industry. Jointly owned by the largest industry players, they have the advantage of aggregating purchasing power, however they also have their challenges. Suppliers may struggle to collaborate while competing fiercely for customers, because most of them are not willing to reveal sensitive or proprietary information to their competitors. In addition, the e-marketplace itself is often the target of government anti-trust claims.

Based on those concerns, we summarize three uncertainties related with supplier participation: uncertainty about the participation, uncertainty about the connection costs, and uncertainty about the time to participate.

<u>Participation uncertainty</u>: The participation uncertainty directly affects whether the expected revenue will be achieved. The environment surrounding the supplier and the organization relationship may force or encourage the participation. We discuss three sources of such participation uncertainty. First is the switch cost. As the supplier has a lot of investments highly specific to the relationship, it is costly for the supplier to switch to another buyer. Second is the length of the contract. If the supplier has a long-term relationship with the company, it means there exist a direct or indirect promise of guaranteed volumes and repeat business, which reduces the supplier risk to participate. The last is the ownership participation. The higher the ratio is, the deeper engagement is between the supplier and the buyer, and the less risk for suppliers to participate.

<u>Cost uncertainty</u>: The flexibility of the supplier IT resource, such as network/telecomm connectivity, platform compatibility, and data/application modularity, and the level of intra-process or inner-process information sharing affect the cost and time to incorporate the e-commerce systems into the organization IT infrastructure, and thus affect the value realization of participation. We discuss two uncertainties related with supplier IT infrastructure: (1) the flexibility of IT and (2) the level of information sharing.

<u>Time uncertainty</u>: After supplier decides to participate, the next question for them is when is the best time to join. The time may vary depending upon the trusting climates between the supplier and the buyer. A good trusting climate can reduce the supplier's doubt about the buyer proposed benefits and therefore shorten the time to participate. The trusting climate can be measured by the number of training programs offered to the suppliers for using the B2B e-commerce systems, the availability of incentives offered to the suppliers to adopt the systems, and the average responding time to supplier's technical requests.

Table 1. Taxonomy of Three Buyer-Based B2B E-Commerce Systems

Buyer-based B2B E-Commerce System	Features	Example	Supplier's participation risks
Buyer-based Web Procurement Systems	• Building direct links with dedicated suppliers • Low uncertain about the revenue • Low development costs • High connection costs	P&G, Dell	• High lock-in costs • Decreased bargaining power against buyers • Integration issues with back-end systems
Buyer's own e-marketplaces	• Owned and operated by a single, dominant buyer • Mid uncertain about the revenue • High development cost • Low connection cost	Wal-Mart's RetailLink	• Less democratic, one buyer decides the technical and business development • Intense pressure on price margins • Pay a commission for the privilege of selling
E-marketplace by a consortium of buyers	• Developed by groups of buyers in the same industry • High uncertain about the revenue • Medium development cost • Low connection cost	Covisint, Transora	• Intense pressure on price margins • Pay a commission for the privilege of selling • Reluctant to share planning and inventory information • Turning over their connection to their customers to the exchange

Those uncertainties directly affect how the buyers design their investment strategies. There are several key decisions involved in the development process of buyer-based B2B e-commerce systems. The buyer has to decide when to develop the system and estimate the expected return after the supplier participates. There are also two decisions for the supplier: the time to participate the systems and the connection costs to the e-commerce systems. Both supplier and buyer will choose the strategy, which can bring her the best payoffs. The advantage for each timing strategy is summarized in Figure 1.

Modeling the Supplier Participation as Corporate Real Options

Intuitively, if the buyer can predict the payoff for each timing strategy, the buyer is able to design the system which both the buyers and suppliers can gain the highest payoff from the participation. However, the payoff for each decision depends on the business and environmental conditions and creates the uncertainties as we estimate the investment value. Since the NPV approach has problems in dealing with all these different uncertainties, we think the option pricing models will treat the problems better with their ability to model asymmetric returns and to recognize the value of deferral investment (Benaroch, Kauffman 1999). By analogy, an investment in a B2B e-commerce system can be considered as a all on a call compound option on a stock.

Similar as the first call option will give its holder the right to buy the second call option by paying the fist striking price, investment in a B2B e-commerce infrastructure will give the buyer the ability to attract suppliers to join by paying development costs. Just as the second call option gives the holder the right to acquire the stock by paying the second strike price, the supplier participation will give the buyer expected revenues by paying the connection costs. Further, just as the investor can choose not to exercise the option on the first exercise date (if the option on that date is lower than the first strike price) or on the second exercise date (if the option on that date is lower than the second strike price), a manager can decide not to undertake the infrastructure development and the supplier can choose not to participate. Thus, the supplier participation is equivalent to the stock on which the compound option is written, while the investment in the B2B e-commerce system is similar as purchasing the right to write an option contract.

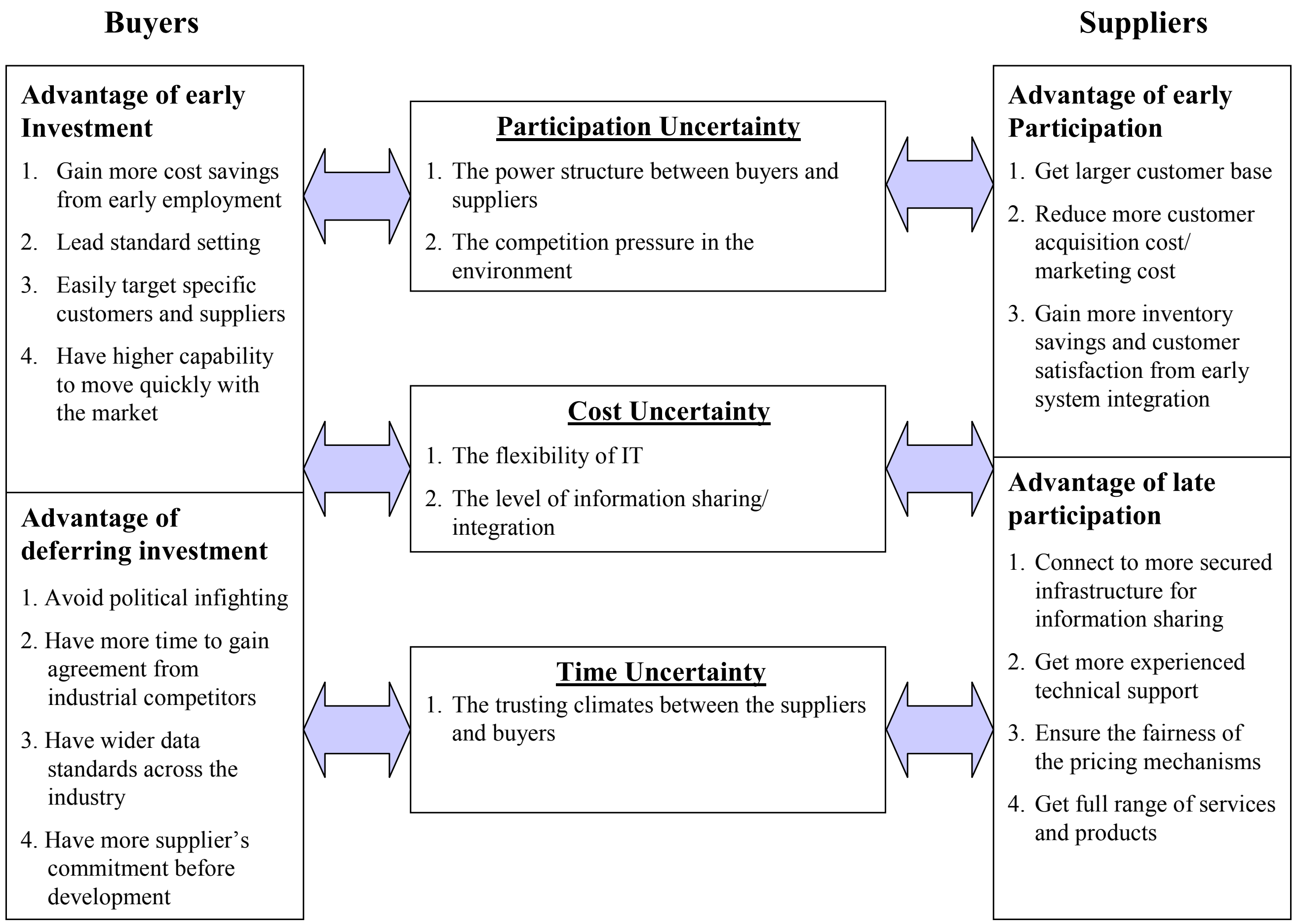

Figure 1. The Summary of Advantages for Alternative Investment Strategies

There have been a lot of attempts made to apply option theory to IT investments. Dos Santos (1991) applied Margrabe exchange option model (1978) to determine the value of econd-stage IT projects. Two years later, Kambil, Henderson and Mohsenzadeh (1993) introduced the option perspective to establish a linkage between many categories of IT investments and business value. Kumar (1996) made a note to compare the difference between Black-Scholes model (1973) and Margrabe model in the treatment of the cost of the econd-stage project. Zhu (1999) introduced Geske compound option model (1979) to treat IT investment projects as a sequence of growth options. The most current development is from Benaroch and Kauffman (1999, 2000). They applied Cox and Robinstein binomial option pricing model (1985) and Black-Scholes models to evaluate IT investment, with a real case study on the Yankee-24 electronic banking network. The summaries of those models and their limitations are shown in the Table 2.

Table 2. The Summary of Alternative Investment Valuation Models

Investment Valuation Models	**Advantages**	**Limitations**
1. NPV Model	- Simple calculation, more straightforward	- Constant risk-adjusted discount rate with no variability - No deferral option
2. Black-Scholes Model	- Stochastic expected returns - The deferral option	- Constant interest rate - Deterministic development costs
3. Margrabe Model	- Stochastic expected returns and development costs - The deferral option	- Requiring an understanding of how the expected returns and development costs are related
4. Cox and Robinstein Model	- Conceptual simplicity	- Immediately matured option - Open-form solution, difficult to conduct sensitivity analysis
5. Geske Model	- Nested options	- Computational complexity - Deterministic development costs

Since the B2B e-commerce investment can be linked to a compound option, we use Geske Model as our basis. With the reference of Santos proposed approach, we add the supplier connection cost variability into the model and eliminate the constant interest rate. We also consider the time variability and competition pressure in supplier participation. There is little literature discusses the estimation of alternative variability and this problem has been recognized as a limitation of option pricing models. We attempt to propose a measure system to combine the user-oriented valuation studies (, which the focus is on ser-oriented benefits and costs with the option valuation models. The model is described as follows:

$$V_C = B_2 N_2(d_1 + \sigma_2\sqrt{t_1}, d_2 + \sigma_2\sqrt{t_2}; \rho) - C_2 N_2(d_1, d_2; \rho) - C_1 N_1(d_1)$$

$$d_1 = \frac{\ln(d^{\sqrt{t_2}} B_2 / B_2^*) + \frac{1}{2}\sigma_2^2 t_1}{\sigma\sqrt{t_1}} \qquad d_2 = \frac{\ln(d^{\sqrt{t_2}} B_2 / C_2) + \frac{1}{2}\sigma_2^2 t_2}{\sigma\sqrt{t_2}} \qquad \rho = \sqrt{t_1/t_2}$$

B_2^* = that value of B_2 such that $B_2 N_1(d_2 + \sigma_2\sqrt{t_2 - t_1}) - C_2 N_1(d_2) - C_1 = 0$

V_C: the value of the compound option (i.e. the value of e-marketplace investment)

B_2: the current value of second-stage project (i.e. the value of supplier participation)

C_1: the strike price for the first-stage project (i.e. the anticipated development costs for e-marketplace infrastructure)

C_2: the strike price for the second-stage project (i.e. the anticipated development costs for supplier connection costs)

σ_2^2: the variance of the expected revenue from the second-stage project (i.e. supplier participation), computed as $\sigma_2^2{}_{B2} + \sigma_2^2{}_{C2}$ 2 $\sigma_{B2}\ \sigma_{C2}\ r_{B2C2}$; σ^2_{B2} is variance of the rate of change of development costs of the second-stage project, σ^2_{C2} is variance of the rate of change of revenues of the second-stage project, and r_{B2C2} is correlation between development costs and revenues for the second-stage project[1]

t_1: The first exercise date (i.e. the time before which the option to develop the e-marketplace infrastructure must be exercised)

t_2: The second exercise date (i.e. the time before which the option for the supplier to connect to the e-marketplace must be exercised). We consider it as a normal distribution with the mean t_2 and the variance σ^2_{t2} (i.e. $t_2 \sim N(\overline{t_2}, \sigma^2_{t2})$)

d: is a discounted factor while considering the competitive pressure in the industry

The function, N_1, is the cumulative normal distribution, and N_2 is the cumulative bivariate normal distribution function with correlation coefficient r. The variable B_2^* is the threshold value of B above which the compound option should be exercised.[2] Other notation is explained below:

If we assume the variation in B_2 and C_2 is normally distributed, the σ^2_{B2} and σ^2_{C2} can be estimated by the following function:

$$\sigma^2_{B2} = n_B * p_B (1-p_B)$$
$$\sigma^2_{C2} = n_C * p_C (1-p_C)$$

where n_B is the percentage of the fluctuation within the expectation, p_B is the percentage of change above or below the expected value (i.e. B_2), and p_C is the percentage of change above or below the development costs (i.e. C_2).[3] We canexpress n_B as an implicit function $n_B = n_B (a_1, a_2, a_3, a_4, \ldots, a_m)$, where a_i (i=1 to m) is the environmental factor affecting the fluctuation of prediction, the same as $n_C = n_C (b_1, b_2, b_3, b_4, \ldots, b_k)$, where b_i (i=1 to k) is the environmental factor affecting the fluctuation of supplier connection costs.

Based on the discussion in section three, $n_B = n_B$ (switch cost, ownership ratio, contract length) and $n_C = n_C$ (IT flexibility, level of integration). If we assume each factor of our interest has equal contribution and are the only sources to the variability, we can calculate the variability using Cobb-Douglas function:[4]

$$n_B = S^{\frac{1}{3}} O^{\frac{1}{3}} C^{\frac{1}{3}} \qquad F = \frac{Con + Com + Mod}{3}$$
$$n_C = F^{\frac{1}{2}} I^{\frac{1}{2}} \text{, where} \qquad I = \frac{Int + Ext}{2}$$

S is the switch cost, *O* is ownership ratio, and *C* is contract length. The IT flexibility is computed by three resources:

(1) *Con* is the extent of connectivity, measured by the percentage of end users inside the supplier company are planned to connect to the e-marketplace.

(2) *Com* is the platform compatibility, measured by the percentage of hardware inside the supplier company can support the e-marketplace.

(3) *Mod* is the modularity of data, measured by the percentage of applications software inside the supplier company can be transported and reused across the e-marketplace.

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[1]The value of r_{B2C2} depends on how much revenue draws from the supplier connection costs. Since the connect costs is determined by the fixed supplier IT infrastructure (i.e. the flexibility of the existed system and the scope of use), we expect there is a low correlation between connection costs and revenue. To simplify the computation, we assume it is zero.

[2]B^* is the value of supplier participation at time t_1, for which the compound option value (V) at time t_1 equals X_1. If the actual B is above B^* at time t_1, the first option will be exercised; if it is not above B^*, the option expires worthless (Hull, 2000).

[3]p_B and p_C can be obtained from the subjective estimate of the system development staff.

[4]The values of those three factors are normalized, which means each value represents a relative importance of buyer-based B2B e-commerce to all the other IT projects for the supplier.

The level of IT integration is computed by two resources:

(1) *Int* is the extent of the internal integration, measured by the extent of integration of the e-marketplace with the back-end supplier system.

(2) *Ext* is the extent of the external integration, measured by the percentage of transactions implemented via the e-marketplace.

The variability of time can be measured using the similar approach.

$$\sigma_{t2}^2 = (1 - Tra)^{\frac{1}{3}}(1 - Inc)^{\frac{1}{3}}(1 - \mathrm{Re}\,q)^{\frac{1}{3}}$$

We assume good trusting climates between organization and the supplier contribute to the reduction of time variability. *Tra* represents the availability of the training programs, *Inc* is the availability of the incentives, and *Req* is the average responding time to supplier's technical requests.

Applying Game Concepts to Buyer-Based B2B E-Commerce Investment Options

The proposed compound option model provides us an estimate of B2B e-commerce system investment when both the buyer and the supplier have the option to defer their investment. However it still doesn't solve the question: what is the effect of counteractions between the supplier and the buyer on the investment timing decision? The option models consider the uncertainties most related with the assets and resources that the firm already has, but doing the option may invite competition reaction which can turn back to affect the value of the option. For instance, the buyer can always adopt a "wait-and-see" approach to gain the option value of waiting. However, its wait may give other competitors the chance to invite the supplier. The same strategic concern can be applied to the supplier too. The supplier can always wait till the condition becomes more certain and positive, but during its wait, other suppliers who participate earlier then get more access to the buyer. To address this issue, we use a game-theoretic approach that records the possible move on either side under the competitive pressure.

Based on the discussion in section 2, we define four investment-timing scenarios and show the payoff in Figure 2.

(1) *The buyer decides to invest the infrastructure immediately and the supplier then decides to participate immediately after the infrastructure is built:*
Both players don't consider deferred entry: there is no deferral option in both sides. That means both options are exercised immediately. Past literature (Cox and Rubinstein 1985, Santos 1991, Benaroch and Kauffman 1999) formulated this scenario as a Cox and Rubinstein binomial option pricing problem, assuming both options are matured immediately and the payoff on a second-stage project is the maximum of zero if development expenditures exceed its benefits (i.e. the supplier will not participate if revenues do not exceed connection costs). V_B represents the investment value in this scenario (Figure 2 (I)). B_1 is the expected revenue from the infrastructure development, independent from the revenue of supplier participation; p_i is the probability of supplier participation; B_{2i} is the value that will actually be realized for each possible outcome of supplier participation; r is risk-based discount rate for the investment. We assume the buyer and the supplier share the option value equally, resulting in a ($V_B/2$, $V_B/2$) payoff for each firm.

(2) *The buyer decides to defer its investment while considering the uncertainties of supplier participation, but once the investment is made, the supplier participates immediately:*
Only the buyer considers deferred entry: the investment possesses only one deferral option at buyer side. Because the development cost is fixed at the time the buyer decides to invest in the B2B e-commerce system, we don't need to consider the variability of the development costs happened in the company side. It makes more sense to employ Black-Scholes model for its assumed deterministic exercise price and plain option (no nested options involved). V_S represents the investment value in this scenario (Figure 2 (II)). σ_1^2 is the variance in its expected return of the infrastructure investment and e^{-rt1} is the present value factor for risk-neutral investors. The payoff for each firm is ($V_S/2$, $V_S/2$).

(3) *The buyer invests the infrastructure immediately, but the supplier defers its participation under uncertainty*
In this scenario, the supplier participation is viewed as an option, while the exercise of this option leads to the acquisition of a technology. Different from scenario II, the supplier connection cost is uncertain at the time the B2B e-commerce system

infrastructure starts to build. Thus, we can't take the development cost of the supplier participation as a deterministic value. It is more suitable to employ Margrabe model, which determines the value of an option to exchange one risky asset for another using stochastic development costs. V_M represents the investment value in this scenario (Figure 2 (III)). The payoff for each firm is ($V_M/2$, V_M /2), where is the Margrabe option value plus the expected cash flow from the B2B e-commerce system infrastructure investment.

(4) *The buyer decides to defer its investment, same as the supplier*
When both company and supplier decide to wait, it can be seen as a compound option, which has been discussed in section three. Both firms are able to employ deferral option, where the connection costs of supplier participation is uncertain. V_C represents the investment value in this scenario (Figure 2 (IV)). The payoff for each firm is ($V_C/2$, V_C /2).

	Supplier Invest	**Supplier** Wait
Buyer Invest	(I) $V_B = -C_1 + \frac{B_1}{(1+r)^{T_1}} + \sum_{i=1}^{n} p_i Max[0, (B_{2i}/(1+r)^{T_1+T_2}) - C_2]$ $(\frac{V_B}{2}, \frac{V_B}{2})$	(III) $V_M = -C_1 + \frac{B_1}{(1+r)^{T_1}} + B_2 N(\frac{\ln(d^{\sqrt{t_2}} B_2/C_2) + \sigma_2{}^2 t_2/2}{\sigma_2\sqrt{t_2}}) - C_2 N(\frac{\ln(d^{\sqrt{t_2}} B_2/C_2) + \sigma_2^2 t_2/2}{\sigma_2\sqrt{t_2}} - \sigma_2\sqrt{t_2})$ $(\frac{V_W}{2}, \frac{V_W}{2})$
Wait	(II) $V_S = B_1 N(\frac{\ln(B_1/C_1) r t_1}{\sigma_1\sqrt{t_1}} + 0.5\sigma_1\sqrt{t_1}) - C_1 e^{-rt_1} N(\frac{\ln(B_1/C_1) r t_1}{\sigma_1\sqrt{t_1}} + 0.5\sigma_1\sqrt{t_1} - \sigma_1\sqrt{t_1}) - C_2 + \frac{d^{\sqrt{t_1}} B_2}{(1+r)^{t_1+T_1+T_2}}$ $(\frac{V_S}{2}, \frac{V_S}{2})$	(IV) $V_C = B_2 N_2(d_1 + \sigma_2\sqrt{t_1}, d_2 + \sigma_2\sqrt{t_2}; \rho) - C_2 N_2(d_1, d_2; \rho) - C_1 N_1(d_1)$ $(\frac{V_C}{2}, \frac{V_C}{2})$

Figure 2. Payoffs for Company and Supplier in Four Investment-timing Scenarios

A Case for Using the Game-Based Option Model to Justify E-Marketplace Investment

In this section, we use the proposed game-based option model to do a *post hoc* analysis of a decision by manufacturers in consumer packaged good (CPG) industry on whether and when to develop an industrial e-marketplace Transora while taking the supplier response and competitive pressure into account. We simplified this decision as a one buyer (manufacturer in CPG industry) and one supplier game, where the buyer invests the e-marketplace infrastructure and invites the supplier to participate. That is, we only consider the impact of supplier participation on the success of Transora. To analyze the investment decision the manufacturer faced in 2000, we used the predicted data from Transora public Web site (Figure 3) to require all the parameters we need for each model. Based on the Forrester research, 4.7% of industrial sales will go through e-marketplace. We assume the CPG industry will apply the same adoption rate.

The payoffs for the manufacturer and the supplier in four investment-timing scenarios are shown in Figure 4. When manufacturer adopts a deferral option and supplier chooses to participate immediately, both parties can have highest payoffs.

The logic behind the results is as follows. The development of Transora involved considerable uncertainty. First is about the participation uncertainties. The ingredients are not easily interchangeable, which makes producers very picky and specific. The pepper from one supplier, for example, can be very different from others. Second comes from cost uncertainties. The high level of supplier fragmentation makes document standardization and process synchronization, such as for ordering and invoicing, across tens or even hundreds of different information systems a daunting task. For example, a cake producer needs to buy each ingredient milk, sugar, floor, chocolate, etc. from numerous distributors located across the globe. In addition, the characteristics of ingredients are hard to describe and lack of standardization, creating additional challenge for data and application modulation. For example, a case of tomatoes carries with many variables and can have a long list of description like how big they are, what color they are, whether they are organically grown, etc. A third source of uncertainty is time uncertainty. Suppliers may fear that online marketplaces will break up long-standing relationships between them and their customers, which can seriously delay the time they decide to participate. Those uncertainties may make suppliers to adopt a deferral option. As a result, to make both parties better off, the analysis tells us the manufacturers should have more time to gain the consensus from the suppliers and have more supplier commitment before development. Manufacturer deferral option can digest most supplier uncertainty and encourage their participation.

Current Performance of Transora

• Number of total manufacturers	56
• Initial capital investment	250M
• Number of active users per total members (acquisition effectiveness)	25%
• Total sales revenue (half of the industry)	600B
• Software development cost	180M
• Average transaction fee per dollar of transaction	5%
• Number of employees	250

Expected transaction revenue
600B*25%*5%*4.7%= 353M

Overall average cost for all entries across industries (2000 survey from www.hwdco.com)

	% of Sales
Transportation	3.54%
Warehousing	2.39%
Order Entry	0.76%
Administration	0.85%
Inventory carrying	2.03%

Estimated hosting support requirement for collaboration (from Transora)

Large manufacturer	4-6

Overall E-market Performance
(Forrester Research)

• Percentage of U.S. industry sales going through e-market (Adoption of E-market)	4.7%

Perceived Benefits

• Error reduction	
Forecast accuracy improvement	10-40%
Inventory accuracy improvement	5-15%
• Reduced operating cost	
Inventory reduction	30-70%
In stock improvement	1-4%
Catalog production cost	20-35%
Customer acquisition cost (Promotion cost)	18%
Distribution cost	50%-90%
• Improved quality	
Sales growth	2-25%
Service level improvement	0.5-2%

Expected cost reduction (in million)

• Error reduction: 0.06*14*[(4,6)*(0.1,0.4)+(4,6)*(0.05-0.15)]	0.51-2.78
• Operating cost reduction	
Inventory reduction: 150,000*2.03%*(0.3,0.7)	913.5-2,131.5
In stock improvement: 150,000*2.39%*(0.01-0.04)	35.85-143.40
Catalog production cost: 150,000*0.76%*(0.2-0.35)	228.00-399.00
Customer acquisition cost: 6,000*0.5*0.18	54
Distribution cost 150,000*3.54%*(0.5-0.9)	2,655-4,779
• Improved quality	
Sales growth:150,000*(0.02-0.25)	3,000-37,500
Service level improvement 150,000*0.85%*(0.05-0.02)	6.375-25.5

Total perceived benefits (Manufacturers) 6.89B-45.03B

Figure 3. Current Performance and Perceived Benefits from Transora

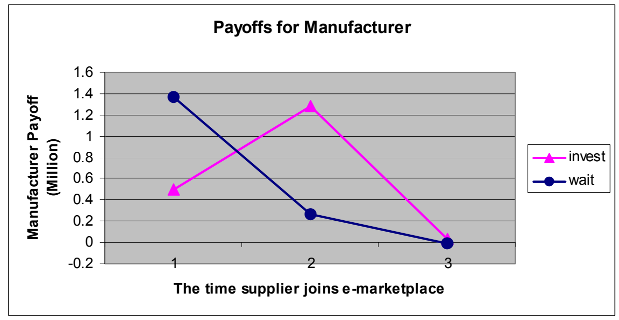
Discussion

Here, we are interested in using sensitivity analysis to determine the impact of different input values on investment opportunities.

Manufacturer Development costs: In the buyer-jointed industrial e-marketplace, one feature is relatively low development costs compared with buyer own private e-marketplace or e-procurement systems. Some of the smaller companies who don have such deep pockets can take advantage of someone else bearing the cost of that capability. As a result, while evaluating the investment strategies for other buyer-based e-marketplaces, let us assume that the infrastructure development costs rise by a certain percentage (e.g., C1 changes from 8.1 million to 10.1 million). Would the investment strategy applied to Transora still make sense? The result is showed in Figure 5, which the solid line shows Transora case, and the dotted line shows the case with higher development costs. The figure tells us the higher development costs decreases the overall payoffs for each party and the decrease is larger in invest strategy than wait strategy (b>a). In addition, the higher development costs make supplier attempt to delay the participation as well (the angle d is larger than angle c, which means supplier becomes less interested in immediate investment).

Supplier

Manufacturer	Invest	Wait
Invest	(I) (0.5, 0.5)	(III) Long wait (0.03, 0.03) Short wait (1.28, 1.28)
Wait	(II) (1.37, 1.37)**	(IV) Long wait (-0.11,-0.11) Short wait (0.27,0.27)



Assumption:

1. The infrastructure development costs (C1): capital investment + software investment+employee salary (Assume each manufacturer has equal investment) – (250M+180M)/56+250*30,000)=15.5M
2. B1 -- transaction revenues: 25%*600000M*0.05*0.047=353M, 353M/56=6.3M
3. R: 7% risk-free interest rate
4. Connection cost: $400*5*12*100+100*30,000=4.4M (Assume 100 employees worked on this project. The monthly software subscription fee is $400 for each application.)
5.The expected revenue: 6890M/750=9.2M (Suppose 750 participants)
6. T1=2years
7. T2=0.5 year
8. t1= 1year
9. t2= 2year± z(0.975)* σ t2=0.5±1.96* σ t2
10. σ: Pb--75% (conservative prediction), Pc=0.5, s:0.1, c:0.1, o:0.1, con:0.1, com:0.1, mod: 0.1, int:0.1, ext:0.1, tra: 0.1, inc: 0.1, req: 0.1
11. d=0.25

Figure 4. The Payoffs Calculated for the Manufacturer and the Supplier in Four Investment-Timing Scenarios Using Data from Transora

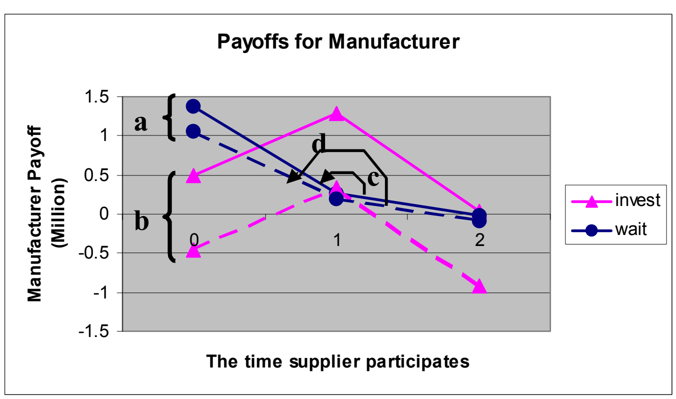


Figure 5. Sensitivity Analysis for Higher Infrastructure Development Costs

The change points out that the complicated infrastructure makes the option to defer entry more preferable. For the manufacturer, it means that it is more important to solve the conflicts between the parties and gain more commitment before the development than to gain more market share by quick entry and wide service provision. For the suppliers, they put more concern on security, integration, and trust during the transaction.

Supplier connection costs: In the industry e-marketplace, the connection costs, or lock-in costs are moderate compared with buyer-based e-procurement system. The reason is the public e-marketplace setting is often more standardized and less specialized than private e-marketplace setting. We are interested in whether the high connection costs will change the decision we made for Transora. To see the impact of connection costs, we include the result in Figure 6 for the connection costs C2, changing from 4.4 M to 5.4 M. The result shows that, although the supplier has the lock-in cost concern, if the manufacturer can enter into the market as soon as possible, providing services corresponding to the market change, the cost savings from early employment can outweigh the high lock-in costs. Both manufacturers and suppliers will be better off (the highest payoff changes from A to B).

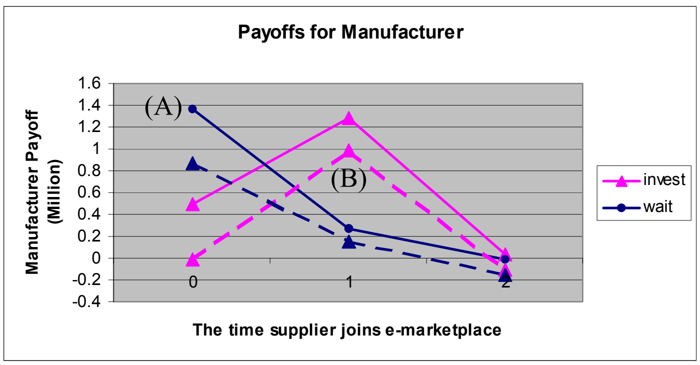


Figure 6. Sensitivity Analysis for Higher Supplier Connection Costs

Environmental variability: In section three, we discussed three uncertainties involved in the investment decisions. In some industries, manufacturers and suppliers are more certain about the expected benefits and costs than in CPG market. For example, the relationship between suppliers and buyers in auto industry are more dedicated, which means the relationship involves high switch costs and long coordination history. As a result, the investment strategy derived from Transora may not be applied to auto industry. To see the impact of those uncertainties on the investment decisions, we change the variability from 0.5 to 0.2 and the result is shown in Figure 7. It is interesting to note that as supplier is more certain about the expected revenue and cost, which means information sharing between the two parties is more symmetric, the manufacturer will become more careful to evaluate its entry strategy and may delay its investment. From the Figure 7, we can see the low variability decreases the payoff of investment strategy but increases the payoff of wait-and-see strategy. Suppliers become even more eager to participate (the angle d is larger than the angle c). As a result, to make both parties better off, manufacturer has to focus on providing variety of service to give the suppliers promising benefits and at the same time avoid the political infighting among different interest groups.

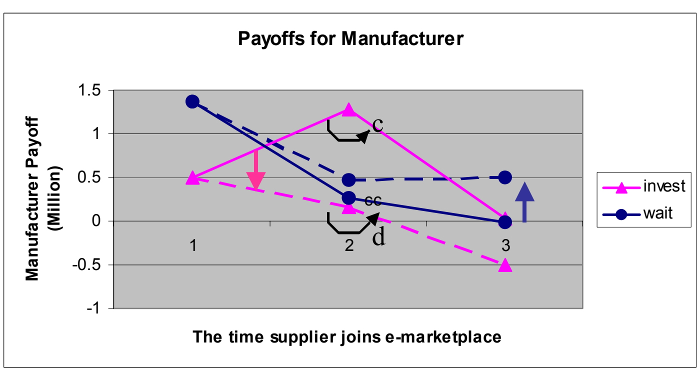


Figure 7. Sensitivity Analysis for Lower Supplier Uncertainty

The summary of the impact of each factor on the determination of investment decision is shown in the following table.

Table 2. Summary of the Effect of Input Variables and its Implications

Factor	Effect on invest strategies	Implication for practice
Development costs	Complicated infrastructure design favors the wait strategy for both parties.	As the infrastructure is complicated, expanding service provision may not be the best strategy to attract supplier participation. Getting the high payoff depends on whether the B2B e-commerce can provide secured, integrated, and private transaction environment.
Connection costs	High lock-in costs encourages manufacturer early entry, but supplier may prefer deferral option	As the lock-in costs are high, although the supplier is tentative to participate, it may not be preferable for manufacturers to wait till getting more commitment from suppliers. The high payoff depends on manufacturer capability to move quickly with the market and provide promising services to suppliers.
Cost and benefit uncertainties	Low uncertainties encourages supplier participation, but manufacturers may prefer deferral option	As the supplier is more certain about the costs and benefits, it may not be preferable for manufacturers to enter into the market quickly. The high payoff depends on whether the manufacturer can ensure the promising benefits and gain agreement from different parties, avoiding unnecessary political infighting

Conclusion and Future Research

This paper examines the impact of supplier participation uncertainty on evaluating the investment value of buyer-based e-commerce systems through a game-based option valuation model. The contribution of this research is multi-folded: First, the research applies the compound option model to improve the pitfalls of traditional NPV approach and plain option models (ex: Black and Schole model), so uncertainties can be considered both in the buyer side and the supplier side, which is more related with B2B e-commerce system investment. Besides that, we also enhance the original compound option model by adding the time variability and development cost variability, so the uncertainties related with supplier lock-in costs and time to the market can be considered while estimating the investment value. In addition, we develop a measurement system to estimate the variability, linking the user-oriented benefit/cost studies with the option models. For example, to effectively estimate the variability of expected revenues in the option model, we suggest the use of three measures: switch costs, ownership ratio, and contract length. Although the validity of those measures has to be further justified, the approach provides a practical way to estimate multiple variances in the option model. At last, we add the dimension of competitive advantage by using the game theories, which gives us a way to evaluate the counteraction between the suppliers and buyers.

This research demonstrates that the timing of supplier participation is determined by the locking costs, the complication of system infrastructure, and environmental uncertainties including participation uncertainty, cost uncertainty, and time uncertainty. Buyer should be carefully to choose right investment strategy so both the supplier and buyer can be better off. For example, although the CPG industry exists high participation and cost uncertainties, supplier is willing to participate early if the manufacturer can adopt a deferral strategy to get more time to gain the agreement from different parties, to design wide scope of services, and to gain more supplier commitment before the development.

However, the model has its limitations. We have to assume the buyer and the supplier have the same reasoning of thinking. In the traditional compound option model, the first option and the second option is bought by the same company, but now the first option is from the buyer and the second option is from the supplier. Since it is common in the economic theory to assume everyone will choose the behavior that is best to herself. This assumption should not affect our evaluation results too much. Secondly, we only consider the competition and uncertainty in the supplier side. However, for some e-marketplaces, the founders are the competitors in the same industries. The uncertainties and the competition among those industrial competitors should also affect the investment decisions. As a result, the model presented here can be extended to a two-stage games in the future where the competition between the buyers can be viewed as the first stage game and the equilibrium derived affects the second stage game that is the competition between the suppliers.

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