RELATIVE IMPORTANCE, SPECIFICITY OF INVESTMENTS AND OWNERSHIP IN INTERORGANIZATIONAL SYSTEMS

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INTRODUCTION

Worldwide B2B e-commerce revenues are expected to reach $2.7 trillion by the end of 2004. At the center of this dramatic growth are interorganizational information systems (IOS), which are information systems (IS) that facilitate the exchange of products, services and information between firms. Examples of IOS include EDI systems in a supply chain, B2B electronic marketplaces, and systems for information sharing in financial services. According to the theory of incomplete contracts (Grossman and Hart, 1986; Hart and Moore, 1990), IOS ownership is important because it determines the value created from the IOS by affecting the participants’ investments.

In this study, we define an IOS as a set of IT assets that support business relationships. IOS Ownership structure means which participant owns the IOS assets. We investigate how IOS participants should decide on the ownership structure of their IOS to maximize the value they can capture from the IOS in various situations. We have argued that relative importance of participants’ investments, defined as the relative magnitude of the contribution of participants’ incremental investments to the IOS relationship, is an increasingly significant determinant of optimal (i.e., value-maximizing) IOS ownership structures (Han, Kauffman, and Nault, 2004). In this study, using specific functional forms and comparative statics, we examine the mechanism by which relative importance of participants’ investments determines which IOS ownership structure is optimal for the IOS relationship. We also investigate the role of specificity of IOS investments, a loss in the value of the IOS investments outside the current relationship, in determining optimal ownership structures. We show that specificity of IOS investments mediate the relationship between relative importance of investment and optimal ownership structures. We also show that ownership may have a negative impact on the owner’s investment incentives when IOS investments reduce the value that the participants can receive outside the current relationship. Further, we analyze a case where positive externalities (i.e., complementarities) exist between participants’ investments.

THEORETICAL BACKGROUND

Ownership of an asset is important because it is impossible to specify every possible future circumstance in a contract (Williamson, 1985). According to the theory of incomplete contracts, asset ownership implies the right to decide what to do with the asset – including the right to exclude other participants from using that asset – in circumstances not covered by a contract (Grossman and Hart, 1986; Hart and Moore, 1990). Thus, the asset owner has stronger bargaining power relative to non-owners, and can capture a larger share of the value created from the asset. This value affects the participants’ incentives for investments. Asset ownership determines the value created from the asset by affecting the participants’ levels of investment.

The theory suggests that there are four major determinants of optimal asset ownership structures: the complementarities between assets, the essentiality of an asset to a participant, the indispensability of a participant to an asset, and the relative importance of participants’ investments. (See Table 1 for definitions.) We define the relative importance of participants’ investments as the ranking of the coalition’s marginal return to each participant’s IOS investment. This definition emphasizes that the participant with the greatest relative importance is the participant whose incremental investment can create the most value for the coalition it belongs to.
Table 1. Determinants of Optimal Ownership Structure for IOS Assets

<table>
<thead>
<tr>
<th>DETERMINANTS</th>
<th>DESCRIPTION</th>
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<tbody>
<tr>
<td>Complementarities</td>
<td>Two IT assets are strictly complementary if either one of the assets cannot create value without the other.</td>
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<tr>
<td>Essentiality</td>
<td>An IT asset is essential to a participant if the participant’s investments cannot create any value without the asset.</td>
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<tr>
<td>Indispensability</td>
<td>A participant is indispensable to an IT asset if the without the participant in the coalition the coalition’s investments cannot create any value without the asset.</td>
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<tr>
<td>Relative Importance of Investment</td>
<td>The relative magnitude of the value to the coalition created by participants’ incremental investment.</td>
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Prior work in Economics and IS focused on complementarities, essentiality, and indispensability (e.g., Hart and Moore, 1990; Brynjolfsson, 1994; Bakos and Nault, 1997). The increasing standardization of IT has made these three determinants less significant, however, while making relative importance of participants’ investment an increasingly critical determinant of optimal ownership structures. In this study, we focus on the role of relative importance of participants’ investments in determining optimal ownership structures, and assume that no participant is indispensable to the assets.1

We argue that the most critical source of relative importance is the difference in the participants’ specific knowledge about how to create value for the coalition—an information asset that is not transferable (Jensen and Meckling, 1992; Brynjolfsson, 1994). When one participant possesses greater or more important specific knowledge about how to create value for the coalition, it is optimal to give that participant ownership of the coalition’s assets.

ILLUSTRATION: VENDOR-MANAGED INVENTORY (VMI)

We use VMI in supply chain management to show how relative importance of investments impacts optimal ownership structures. VMI is one of the most widely-adopted supply chain initiatives for improving efficiency between a supplier (manufacturer) and buyers (retailers or distributors). In VMI, the supplier is responsible for managing the buyer’s inventory, and makes inventory replenishment decisions for the buyer based on demand and inventory information sent by the buyer.

The VMI system asset consists of network technologies and EDI for communication and data sharing, forecasting software for market demand forecasting and placing orders based on sales and inventory data, and point-of-sale and retail inventory systems for gathering sales and inventory data. Both participants must invest in implementation activities, including integrating these new systems with their existing internal systems, such as their enterprise resource planning and inventory management systems.

A MODEL FOR INVESTMENTS AND OWNERSHIP IN VMI

We use an incomplete contracting model for two-person bargaining. Drawing upon Bakos and Brynjolfsson (1993) and Bakos and Nault (1997), we employ specific functional forms to analyze the impact of relative importance and specificity of IOS investments on the participants’ equilibrium investments and optimal ownership structures.

The buyer \( (b) \) makes investment \( x_b \), and the supplier \( (s) \) makes investment \( x_s \). These are investments in implementation activities such as data synchronization and process redesign, and these investments are non-contractible. When the buyer and the supplier remain in the IOS, they can jointly create value \( V(x_b, x_s) \) for the relationship from their VMI system (e.g., reduced inventory levels and increased sales). The buyer and the supplier incur costs \( c_b(x_b) \) and \( c_s(x_s) \) for their investments. These costs are increasing at an increasing rate in IOS investments.2 We denote the value generated by the buyer’s and supplier’s

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1 In the presence of an indispensable participant, it is always optimal for the participant to own the assets regardless of the relative importance.

2 We will assume \( c_i(x_i) = c(x_i) = \frac{1}{2} x_i^2, \ i \in \{b, s\} \) for all three of the cases that we will shortly lay out.
investments outside the relationship as \( r_b(x_b|a) \) and \( r_s(x_s|a) \), where \( a \) represent whether the corresponding participant (the buyer and the supplier respectively) owns the VMI asset (\( a = 1 \)) or not (\( a = 0 \)). This means that if a participant does not own the VMI asset, then it cannot create any value outside the relationship. \( V, r_b, \) and \( r_s \) all are increasing at a decreasing rate in IOS investments. We refer to \( r_b, \) and \( r_s, \) the values outside the relationship, as the disagreement payoffs. They represent the value participants receive when agreement cannot be reached in bargaining.

Because a complete contract for value sharing cannot be written, the supplier and buyer divide the value through bargaining. As in Clemons and Kleindorfer (1992), we use the Nash bargaining solution for surplus distribution between the IOS participants. The two participants engaged in bargaining divide the incremental profit evenly so each receives half of the incremental profit, as follows:

\[
\text{Buyer’s Payoff:} \quad r_b(x_b) + \frac{1}{2} [V(x_b, x_s) - r_b(x_b) - r_s(x_s)] - c(x_b)
\]

\[
\text{Supplier’s Payoff:} \quad r_s(x_s) + \frac{1}{2} [V(x_b, x_s) - r_b(x_b) - r_s(x_s)] - c(x_s)
\]

We consider two ownership structures for VMI asset: supplier ownership and buyer ownership. We do not analyze joint ownership because the payoffs to joint ownership are lower than these two alternatives. As a benchmark, we analyze the first-best case where an integrated firm owns the asset. We first analyze a case without investment externalities, and then perform analysis on a case in the presence of externalities. In the first two cases, we assume that IOS investment increases not only the value of the assets within the relationship but also that outside the relationship. In the third case, we analyze a case where IOS investments may reduce the value of disagreement payoffs to get additional insights.

In each case, we first calculate the participants’ equilibrium levels of investments (for integrated firm ownership, supplier ownership, and buyer ownership). Then, we determine which ownership structure is optimal by comparing the equilibrium investment levels under various conditions. The ownership structure that entails the greatest investment for both participants is optimal. We summarize our main results in the Discussion and Conclusions section instead of presenting the detailed results in each case.

**Case 1: No Investment Externalities**

Here, in contrast to Hart and Moore’s model, we assume there are no positive or negative externalities arising from participants’ investments. We use the following functional forms:

\[ V(x_b, x_s) = \alpha x_b^\omega + (1 - \omega) x_s^\beta, \quad 0 \leq \alpha, \beta, \omega \leq 1. \]

\[ r_b(x_b) = a0(1 - \theta_b) x_b^\omega \quad \text{and} \quad r_s(x_s) = a(1 - \omega)(1 - \theta_s) x_s^\beta, \quad a \in [0,1], 0 \leq \theta_b, \theta_s \leq 1. \]

We defined the relative importance of investments as whose incremental investment makes a greater contribution to the value of the overall relationship. We can see that relative importance is determined by two factors: \( \omega \) and the relative magnitude of \( \alpha \) and \( \beta \). \( \omega \) represents the contribution of the buyer’s investment to the total value relative to the supplier’s investment. \( \alpha \) and \( \beta \) represent how productive (or efficient) each participant’s investment is. They can be interpreted as each participant’s capability, expertise or knowledge to create value from their investments. \( \alpha \) and \( \beta \) can be considered to be “returns to scale” parameters in investments.

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3 Because the Hessian matrices of the payoff functions are symmetric and negative definite, we can take the first derivative of the payoff functions with respect to the investments to calculate equilibrium investment levels.

4 The functional form for \( V \) is similar to the one used by Bakos and Brynjolfsson (1993). It is characterized by declining marginal returns of investment and the parameter \( \omega \) that characterizes the relative contribution of buyer’s investment. In the functional forms for \( r_b \) and \( r_s \), the specificity of investment is modeled as a loss in investment value: the value of participant \( i \)'s IOS investment is reduced by \( \theta_i \) when the IOS is used outside the relationship (e.g., due to customization and specialization of technologies).

5 Formally, relative importance of investment can be represented as \( \frac{\partial V}{\partial x_b} = \omega \alpha x_b^{\omega-1} \quad \frac{\partial V}{\partial x_s} = (1 - \omega) \beta x_s^{\beta-1} \).
Case 2: Positive Investment Externalities

Here, we add an assumption that there exist positive externalities between investments by different participants. This means the buyer’s and the supplier’s investments are complementary, enriching each other. Following Bakos and Nault (1997), we incorporate positive externalities as the product of the two participants’ investments in the $V$ function as follows:

$$V(x_b, x_s) = \omega x_b^\alpha + (1-\omega)x_s^\beta + \mu x_b^\alpha x_s^\beta, \quad 0 \leq \alpha, \beta, \omega, \mu \leq 1,$$

where $\mu$ represents the size of the positive externalities between the two participants’ IOS investments.

Case 3: Negative Impact of Investments on the Value of Disagreement Payoffs

Now, we assume that participants’ investments may reduce the value of IOS investments outside the relationship—the disagreement payoffs. To focus on the impact of disagreement payoffs, we assume there are no investment externalities as in Case 1. So, we use the following functional form:

$$r_b(x_b) = a_0 x_b^{\alpha_0}, \quad r_s(x_s) = a_1 x_s^{\beta_0}, \quad 0 \leq \alpha_0, \beta_0, \theta_b, \theta_s \leq 1.$$ 

To permit comparisons to be made, we analyze two sub-cases: $\alpha < \theta_b, \beta < \theta_s$ (i.e., $r_b'(x_b) < 0$) and $\alpha > \theta_b, \beta > \theta_s$ (i.e., $r_s'(x_s) > 0$). In the former, both the buyer’s and the supplier’s investments in the VMI asset reduce the value of the asset outside the relationship, whereas in the latter, their investments increase the value. We found Hart and Moore’s result (i.e., positive impact of ownership on the owner’s investment incentives) does not hold in the former although we get the results that are consistent with Hart and Moore in the latter.

DISCUSSION AND CONCLUSIONS

Our analysis of the three cases shows how relative importance, specificity, and externalities in IOS investments affect equilibrium investments and optimal ownership structures. First, some of our results are consistent with the prior incomplete contracting literature:

- IOS participants underinvest relative to the first-best (an integrated firm) levels in all three cases. This is because each participant cannot capture full marginal return from its investment.
- A participant’s investment is greater (1) when the relative contribution or weight of its investment to the total value is greater (greater $\omega$ for the buyer and smaller $\omega$ for the supplier); (2) when its investment is more efficient (greater $\alpha$ and $\beta$); (3) when its investment is less specific (smaller $\theta_b$ and $\theta_s$); and (4) when the positive investment externalities are stronger (greater $\mu$).  

Second, we found interesting interrelationship between relative importance, specificity, and externalities in IOS investments. We showed that a participant’s IOS investment increases in the relative importance of its investment. However, our analysis reveals that the relationship between relative importance and optimal ownership structure is mediated by the specificity of participants’ investments:

- When both participants’ investments are totally specific to the relationship ($\theta_b = \theta_s = 1$) it does not matter who the owner is, regardless of the relative importance of their investments.
- When one participants’ investment is totally specific and the other’s investment is non-specific (e.g., $\theta_b = 1, \theta_s = 0$) it is optimal for the participant with non-specific investment (e.g., the buyer) to own the IOS (regardless of the relative importance of their investments).

These results imply that specificity of investment may be a more important determinant of optimal ownership structure than relative importance of investment. In the context of VMI, specificity of investment can be interpreted in terms of how many alternative trading partners (i.e., outside options) the participants have.
buyer and the supplier have with whom they can reuse the VMI asset. If the buyer (e.g., WalMart) has a large number of suppliers with whom it can reuse the VMI system asset (e.g., by forcing them to comply with it), its specificity of investment is low. In contrast, the supplier’s investment is highly specific if the supplier does not have many trading partners or if every buyer has different system specifications and requirements that the supplier needs to comply with. Our model suggests that it is optimal for the buyer to own the VMI asset in such a case.

Third and most important, Hart and Moore (1990) suggest that a participant’s investment always increases when it is the owner compared with when it is not. However, we show this may not be the case under at least two conditions:

- When both participants’ investments are non-specific and positive externalities are very strong (Case 2), it is possible that the allocation of asset ownership to the participant with the most important investments can increase investments of all the participants (including those of non-owners). Due to the strong positive externalities, not only the owner’s but also the non-owner’s investments increase. This can happen because the decrease in investment by the participant that does not own assets is offset by the increase in investments due to the positive externalities. This suggests that in the presence of strong investment externalities, relative importance becomes even more critical.

- When participants’ investments reduce the value of their disagreement payoffs (i.e., the value they can get outside the current business relationship) (Case 3), IOS ownership reduces their investment incentives. Therefore, it is optimal to give ownership to the participant with the least important investment; doing so will mitigate the negative impact of asset ownership on investment incentives.

In our VMI example, the value of disagreement payoffs will decrease when the buyer and the supplier make “irreversible” or costly-to-undo investments in their VMI system (e.g., systems integration and database schema changes). Our model suggests that participants should be careful when they make these investment decisions because they will lose opportunities for alternative uses of the VMI asset. This reduces their investment incentives and the total value from the asset. If the buyer and the supplier have to make those investments, the participant whose investment makes the least contribution to the total value should be the owner. This will minimize the negative impact of irreversible investments.

REFERENCES


