Determinants of EDI (Electronic Data Interchange) Adoption and Integration in the US and Japanese Automobile Suppliers

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Abstract --This paper examines determinants of EDI adoption and integration in the US and Japanese automobile suppliers. The paper constructs several hypotheses based on the transaction-cost and resource-dependence approaches, and tests these hypotheses by using data from the automobile suppliers. Our study shows: (1) the resource-dependence approach seemed more effective in explaining EDI adoption, while the transaction-cost approach seemed more effective in explaining EDI integration; (2) the transaction-cost approach seemed more suited to the US context, while the resource-dependence approach seemed more suited to the Japanese context; (3) EDI adoption and EDI integration had positive impacts on EDI performance in the US, suggesting the higher validity of our framework in the US.

Index Terms: Electronic Data Interchange (EDI), Business-to-Business Electronic Commerce, Automotive Industry, Automobile Suppliers, Technology Adoption

1. INTRODUCTION

EDI is defined as "direct computer-to-computer communication between organization and its trading partners of business documents and information in a machine-readable, structured format that permits data to be processed by the receiver without rekeying" (Premkumar, *et al.* 1997).

EDI, as an important component of business-to-business electronic commerce, has become a key element of corporate strategies for creating value by providing closer linkages among companies. Advancements and lower costs in technologies such as the Internet and telecommunications have helped increase the number of companies using EDI (Iacovou, *et al.* 1995).

EDI allows buyers and sellers to exchange information, automate processes, and integrate information. As a result, multiple procurement processes can be turned into a single seamless process. Today, EDI has proved especially popular among companies in the automotive industry because of its inherent ability to facilitate Just-In-Time (JIT) practices that are widely used by automakers (Cooke 2002).

However, previous studies showed that the EDI adoption and integration among the US automobile suppliers were not high, especially in those in lower tier, in spite of final auto assemblers' promotional efforts (Rassameethes, *et al.* 2000; Iskandar, *et al.* 2001). Thus, this paper attempts to understand why this is so and to analyze factors affecting suppliers' EDI adoption and integration by surveying the US and Japanese auto suppliers.

There are four major sections. First, we review the literature on EDI in the US and Japanese automobile industries. Second, we construct several hypotheses by reviewing the

relevant theoretical literature. Third, the paper tests these hypotheses by using data from automobile suppliers in the US and Japan. Finally, we conclude with discussions, managerial implications, and observations on further research.

2. EDI IN THE AUTOMOBILE INDUSTRY

In the US, EDI application began in the 1960s with the transportation industry using an EDI standard developed by the Transportation Data Coordination Committee (Sokol 1989). EDI spread widely as computer applications and communication costs declined, and by the 1980s EDI was being used in a wide range of industries, including automotive, retail, healthcare and government sectors (Zimmerman 1996; Kalakota and Whinston 1996).

In the US automobile industry, there is a strong competitive pressure that delays in transit of information and goods need to be eliminated in the industry's JIT environment. Thus, the Big Three have been strongly encouraging their suppliers to communicate with them via EDI, especially since mid 90s. It was rumored that suppliers who cannot comply with EDI may lose business with the Big Three (AIAG, 1997).

For example, GM has a substantial track record in supplying complete automation systems using EDI to its vendors. The company runs a global network called *EDSNET* linking more than 30 GM data processing centers with over 2,000 suppliers via EDI. Ford lunched the Ford Supplier Network (FSN) in 1998, which consists of 80 custom applications, supports more than 4,200 suppliers, and has approximately 42,000 end users globally. Recently, Ford is said to be converting FSN to a new Web-based and XML-based application, called "eVerest" (Messmer 2002). DaimlerChrysler has the *Extended Enterprise Network*, an Internet-based system that

allows suppliers to access information on purchasing, delivery schedules, invoices, and products. The company is also considering the new Web-based and XML-based application, instead of traditional communication methods (Zuckerman, 2002).

However, previous studies on EDI use in the US auto suppliers showed: (1) "final assemblers' push" seemed to be the most significant reason for suppliers' EDI adoption (Rassameethes, *et al.* 2000); (2) Final assemblers are directing first-tier suppliers to use EDI, yet first-tier suppliers have not been able to enforce its use by their suppliers (Iskandar, *et al.* 2001); and (3) EDI adoption among second-tier suppliers was low, primarily because of perceptions of low benefits and high costs and asymmetric benefits in favor of buyers—i.e., final assemblers and first-tier suppliers (Iskandar, *et al.* 2001).[1]

Japanese automakers have been members of integrated groups known as *keiretsu* for decades. These are based on personal relationships, equity sharing, and exchange of managers and engineers (Gerlach, 1992). In traditional *keiretsu*, suppliers served only one manufacturer. Manufacturers and suppliers still often share the cost of technological improvements, and suppliers provide high standards of quality and delivery performance in order to minimize the need for inspection and finished components inventory on the part of auto manufacturers (Dyer, 1997).

However, EDI is also beginning to be used within these keiretsu groups. For example, Toyota has been using a network call *Toyota Network System* (TNS) that links together different local area networks since 1985. Toyota uses TNS to communicate with its offices and some suppliers around the world. It is said that Toyota completed all the transaction with its first-tier

[1] We define a first-tier supplier as a company that supplies its products directly to OEMs (Original Equipment Manufacturers, i.e., final assemblers), while a second-tier supplier is a company that supplies its products directly to first-tier suppliers and does not supply its products directly to OEMs.

suppliers by EDI in 2001.[2] Nissan started an EDI system called "ANSWER" in 1991, by emphasizing "shortening lead time to customers." In 1998, Nissan shifted its proprietary EDI to Web-based EDI, called "NET23," as a first Japanese automaker. It is reported that 90% of Nissan's first-tier suppliers (more than 200 suppliers) are using NET-3 (Gozai and Fujimoto, 2001; SBFC 2002). Honda used to use multiple proprietary EDI systems for planning schedules, ordering, exchanging engineering data, and so on. In October 2001, Honda started an integrated EDI system, called "IMPACT-III," by connecting its 370 suppliers. It is said that Honda's suppliers reduced 40 % of their EDI cost (Nikkei Computer 2001; Nikkei Information & Strategy 2002).

However, there is no study on EDI use in the Japanese auto industry, except for Bensaou's survey conducted in the early 90s (Bensaou, 1996). Based on our intensive interviews with managers and IT engineers, we had impressions that EDI use in the Japanese auto industry seemed to lag behind the US for a year or two.[3] Especially, EDI use in the Japanese second- and third-tier suppliers seems to be very low. The reason for such unpopularity of EDI use in Japan may stem partially from "Kanban" system widely used in the Japanese auto industry, which can replace a part of EDI's functions (Hayashi 2000).

According to our extensive literature review on EDI in the automobile industry, we found some studies on automobile first-tier supplier's EDI with final assemblers—e.g., Bensaou (1997), Rassameethes, *et al.* (2000). However, to our knowledge, there is no systematic study on the relationship between first-tier suppliers and second-tier suppliers.

[2] Based on interviews with several managers at Toyota (April 1999) and email communications with these mangers thereafter.
[3] Based on interviews with more than 30 engineers and managers. To name a few, we interviews at Nissan on April 2001), at Denso on September 2000, and at Calsonic on August 2000, and Honda on June 2000.

Thus, based on our observation of EDI in the US and Japanese auto industries and our literature review, we have the following research questions: (1) what kinds of theoretical approaches can explain EDI use?; (2) what factors affect a first-tier automotive supplier's decision to use EDI with their (second-tier) suppliers in the US and Japan?; (3) what are differences and similarities of EDI use between the US and Japanese first-tier suppliers?; and (4) what are the key factors of success for EDI use in these suppliers?[4]

3. BUYER-SUPPLIER RELATIONSHIP

In our study, we focus not only on a supplier's decision on EDI adoption—i.e., adopt or not—but also on the level of its EDI adoption—we call it "*EDI Integration*." Premkumar, *et al.* (1997) claims that EDI integrations are necessary to transfer information seamlessly across organizational functions and to gain "economies of scale" and become cost effective.[5] By following Cash and Konsynski's (1985) argument that information technologies can redraw competitive boundaries, we define *EDI integration* as the extent that EDI is used to communicate with trading partners seamlessly across organizational boundaries.

Our interviews with IT managers also revealed a unanimous belief that the benefits of EDI are greatest if it is used to communicate with a wide-range of external trading partners (as well as internal divisions) that are involved in the supply chain. This is especially true in the automobile industry where JIT business practices prevail. A firm that uses EDI only with its customers will potentially gain process improvement only in the out-flows of its end products,

[4] In this paper, we will use "buyers" mainly as first-tier suppliers, and "sellers" mainly as second-tier suppliers, henceforth.

[5] "Economies of scale" can be defined as lower costs due to increased utilization of hardware. (See Shapiro and Varian 1998).

but not with the in-flows from suppliers, because higher inventories of input materials/components are necessary to compensate this imbalance.

There are a variety of levels of EDI usage. For example, a firm may use EDI with a supplier just for informing the supplier of anticipated part requirements. Another firm may use EDI not only for informing the supplier of anticipated part requirements, but also for notifying trading partners that there are changes in previous orders, for letting customers know the arrival time and the quantity of products to be delivered to the customer site, for informing the supplier of discrepancies between an advance shipping notice and the actual shipment received, etc. We believe that the benefits of EDI are greatest if EDI can link trading partners intensively and extensively.[6]

In our analysis, we focus on buyer-seller relationships in the process of EDI adoption and integration. Our reasons are that EDI can improve buyer-seller coordination through improving the flow of information, and that it can also change buyer-seller bargaining power positions (Clemons, *et al.* 1993, Young, *et al.* 1999). According to Bergeron and Raymond (1997), EDI can be used to develop a privileged relationship with a specific seller. Premkumar, *et al.* (1994) also found that EDI has also been used to lock in trading partners. Thus, we assume that buyer-seller relationships tend to affect significantly the supplier's decision to adopt and integrate EDI.

In analyzing such buyer-seller relationships, the transaction-cost approach and resource-dependence approach have been frequently applied (Bensaou 1999; Dyer 1997; Reekers and Smithson 1994; Walker and Weber 1984). The transaction-cost approach primarily discusses the "governance structure" (hierarchy, market or intermediate form) of economic transactions from a viewpoint of vertical integration (Williamson 1975 and 1979; Teece 1987). On the other hand,

the resource-dependence approach primarily concerns the relationships between an organization and its environment in order for the organization to secure the supplies of the resources needed for its survival (Auster 1994; Pfeffer and Salancik 1978; Pfeffer 1987).[7]

In the transaction-cost approach, there are three major dimensions : (1) asset specificity, which implies the investment in specific assets required for exchange; (2) uncertainty embedded in the transaction process; and (3) frequency of occurrence or the degree of exchange intensity. In transactions with a level of uncertainty, both a higher degree of asset specificity and more frequent transactions encourage a "hierarchical mechanism," which will perform more efficiently than market mechanisms. In a market mechanism, coordination is difficult to accomplish, although it does offer lower acquisition costs due to the higher competition (Pitelis 1993; Williamson 1975).

Partnership is considered as the mode of inter-organizational transactions between the market and hierarchy (ownership). A partnership offers more effective coordination than market mechanisms, while it also offers lower risks of investment than ownership (Ring, *et al.* 1992). A partnership is strongly driven by "reciprocal interdependency," suggesting that the exchanges are considered essential by both parties. This creates higher incentives for both parties to safeguard the relationship. Thus, partnerships require "trustworthy" relationships. This is important for both parties in order to reduce the risks due to a partner's opportunistic behavior, especially in the decision to invest in long-term assets, such as EDI (Hart and Saunders 1998).

From a buyer's (first-tier supplier's) viewpoint, a more transaction specific investments, such as special equipment, into a seller (second-tier supplier) will create a higher dependency on

[6] Another reason why we focus on decision-makings on both EDI adoption and EDI integration is that we attempt to identify different factors affecting these decision-makings. Hart and Saunders (1998) found that factors affecting EDI adoption are different from those affecting EDI integration, which requires a long-term commitment.

the seller due to the higher switching cost of changing sellers. From a seller's (second-tier supplier's) viewpoint, accepting transaction specific investments increases the barrier to exit due to the higher sunk cost (Staw 1981; Whyte 1993). Therefore, increasing transaction specific investments significantly increases the possibility that a buyer integrates transactions by using EDI. Accordingly, we propose our first hypothesis as follows:

> **Hypothesis 1:** *The higher the degree of transaction specific investments, the more likely a firm (first-tier supplier) is to adopt EDI and integrate the EDI system with its (second-tier) suppliers*.[8]

The second dimension in the transaction cost approach is "*uncertainty*" (Williamson 1975 and 1979). Butler and Carney (1983) claim that there are two dimensions in *uncertainty*: *performance ambiguity* and *environmental unpredictability. Performance ambiguity* refers to the extent to which the final value or output of a transaction cannot be determined in advance, while *environmental unpredictability* is the uncertainty of the events and problems that generally arise during the course of a transaction. In our analysis, we focus only on the latter dimension, *environmental unpredictability,* since EDI deals with products with clear performance definitions (Iskandar, *et al*. 2001). According to the transaction cost approach, it is assumed: the higher uncertainty is involved in a transaction, the more likely a buyer (first-tier supplier) is to integrate its sellers (second-tier suppliers). Thus, by applying this assumption to EDI adoption and integration, we have the following hypothesis:

> **Hypothesis 2:** *The higher uncertainty, the more likely a firm (a first-tier supplier) is to adopt EDI and integrate the EDI system with its (second-tier) suppliers*.

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[7] Reekers and Smithson (1994) claim that "network" approach is also useful for explaining such buyer-seller relationships.

[8] Here, we assume that EDI systems are generally very specific to specific buyers. According to our interviews with IT managers in the auto industry, suppliers face the "translation hell," because final assemblers and first-tier suppliers are likely to force their suppliers to use their own EDI systems.

According to the transaction-cost approach, a high transaction frequency reflects the importance of a seller's (second-supplier's) product for a buyer's (first-tier supplier's) operations process. Higher transaction frequencies provide higher incentives for both buyers and sellers to improve their coordination. EDI can be used to decrease transaction costs and increase potential benefits (primarily to the buyer). Thus, we propose the following hypothesis:

> **Hypothesis 3**: *The higher the frequency of transactions between a firm (a first-tier supplier) and its (second-tier) supplier, the more likely the firm (the first-tier supplier) is to adopt EDI and integrate the EDI system with its (second-tier) suppliers*.

Although the above three hypotheses are concerned with the transaction cost approach, the following four hypotheses are mainly concerned with the resource-dependence approach. The resource-dependence approach claim that organizational actions are constrained by dependencies on environment by emphasizing "power relations" (Pfeffer and Salancik 1978). According to this approach, organizations with power advantages tend to exploit their situation in order to secure necessary resources, by manipulating and controlling other organizations that have the resources they need (Cook 1977; Emerson 1962).

The opportunity to sell products is also considered as a resource (Pfeffer 1987; Pfeffer and Salanciik 1978). For example, opportunities to sell car-seat materials such as springs are the resources that spring suppliers are concerned with. On the other hand, springs are resources for car seat manufacturers.

A seller's (second-tier supplier's) decision to adopt EDI will be influenced by its dependency on its buyer (first-tier supplier). Actually, many studies have indicated that sellers are likely to adopt EDI because of their buyers' (as EDI promoters) pressures to encourage their sellers to use EDI (Iskandar, *et al.* 2001; Premkumar, *et al.* 1997; Iacovou, *et al.* 1995).

Increasing a seller's (second-tier supplier's) percentage of sales to a buyer (first-tier supplier's) will increase the buyer's power advantage over the seller. A buyer's greater power advantage over a seller lowers the seller's resistance to EDI promoted by the buyer.[9]

Accordingly, we propose the following hypothesis:

> **Hypothesis 4:** *The greater the proportion that a firm (a first-tier supplier) purchases products from a few (second-tier) suppliers, the more likely the firm (the first-tier supplier) is to adopt EDI and integrate the EDI system with its (second-tier) suppliers.*[10]

As Porter (1985) claims, there are a variety of competitive forces driving industrial behavior. In the automotive industry, there is high pressure to reduce the "supplier base" (Rassameethes, *et al.* 2000). Final assemblers and first-tier suppliers are likely to use EDI capability as a supplier selection criterion (Mukhopadhyay, *et al.* 1995). We expect that the number of a first-tier supplier's competitors will have a significant impact on its EDI adoption and integration with their second-tier suppliers.

When a first-tier supplier has more competitors, by definition, a second-tier supplier as a seller has more buyers (including both the current and potential buyers). The more buyers a seller has, the greater the effort needed by the buyer to promote EDI to the seller. From the seller's perspective, the buyer's power for EDI promotion will be "diluted" or reduced in strength, because the seller has many buyers to choose. Thus, we propose the following hypothesis:

> **Hypothesis 5:** *The greater the number of competitors a firm (a first-tier supplier) has, the less likely it is to adopt EDI and integrate the EDI system with its (second-tier) suppliers.*[11]

[9] O'Callagham, *et al.* (1992) found a reverse causal relationship—i.e., a seller's EDI adoption is likely to increase the seller's dependence on a buyer.

[10] However, there is a possibility for the few suppliers behave opportunistically. The few suppliers also need to be assured that the first-tier supplier will commit to their business relation in the long-run (Bakos and Brynjolfsson 1993).

[11] Number of competitors can be considered as a horizontal competitive force from Porter's perspective. However,

The above five hypotheses were concerned with relationships between first-tier suppliers (buyer) and second-tier suppliers (sellers). The following two hypotheses, however, are concerned with relationships between first-tier suppliers and their buyers—i.e., final assemblers. Since the main purpose of EDI is to coordinate the supply chain, its benefits are obviously greater when seamlessly integrated by all parties involved. This is not only true from a final assembler's perspective but also from a supplier's perspective (Iskandar, *et al.* 2001).[12]

As we discussed when constructing Hypothesis 4, the greater the proportion that a seller (first-tier supplier in this context) sells products to a few buyers (final assemblers in this context), the more likely the buyers are to integrate transactions with its sellers (first-tier suppliers) by using EDI. When the seller (first-tier supplier) has EDI connections with their buyers (final assemblers), the seller (first-tier supplier) is likely to integrate transactions with its second-tier suppliers by using EDI, as well. This is because increasing a seller's (first-tier supplier) percentage of sales to a buyer (final assemblers) will increase the buyer's power advantage over the first-tier supplier and the second-tier suppliers. The final assembler's greater power advantage over the first-tier and second-tier suppliers lowers the suppliers' resistance to EDI promoted by the final assembler, as well as by the first-tier supplier.[13]

Accordingly, we propose the following hypothesis:

> **Hypothesis 6:** *The greater the proportion that a firm (a first-tier supplier) sells products to a few buyers (final assemblers), the more likely the firm (the first-tier supplier) is to adopt EDI and integrate the EDI system with its (second-tier) suppliers*.

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in constructing Hypothesis 5, we emphasized more buyers' "diluted" power for EDI promotion than Porter's competitive force, based on our interviews with IT managers in the auto industry.

[12] To our knowledge, however, no study has examined this point empirically.

[13] There is also the merit stemmed from the seamless integration—i.e., "scale economy" and "network externalities." "Network externalities" can be defined as higher utility due to use with a larger number of other related firms (see Shapiro and Varian 1998).

Based on a similar argument as in the above hypothesis, it is needless to say that a first-tier supplier with EDI connection with final assemblers is likely to adopt EDI and integrate the EDI system with its second-tier suppliers. This is because of the final assembler's "enhanced" power advantage over the first-tier and second-tier suppliers lowers the second-tier suppliers' resistance to EDI promoted by the final assembler and first-tier supplier. Thus, we also hypothesize:

> **Hypothesis 7:** *The more EDI integration with buyers (final assemblers), the more likely a firm (a first-tier supplier) is to adopt EDI and integrate the EDI system with its (second-tier) suppliers.*[14]

Large companies usually have greater slack resources than small companies (Simon 1957). Thus, large companies may be more inclined to integrate their transaction by EDI. On the other hand, smaller companies may be more innovative, flexible, responsive, and less bureaucratic and therefore may have greater incentive to adopt and integrate EDI. Thus, we will include *Size* as a control variable in our following analyses. The control variable is likely to "bias" EDI adoption and integration decisions (Cook and Campbell 1979).[15]

Figure 1 summarizes the relationships among our focused variable, *EDI Adoption*, *EDI Integration* and the seven hypothesized variables. As discussed, our focus is on the EDI integration between first- and second-tier suppliers. Factors affecting the EDI integration may be classified into the following five categories: (1) factors between first- and second-tier suppliers—*Asset Specificity, Uncertainty,* and *Frequency of Transaction*, (2) a factor related to first-suppliers—*Degree of Competition*, (3) a factor related to second-tier suppliers—*Seller (Supplier) Concentration*, (4) a factor related to final assemblers—*Buyer* (*Assembler*)

[14] There is also the merit stemmed from "scale economy" and "network externalities."

Concentration, (5) a factor between final assemblers and first-tier suppliers—*EDI Integration with Buyer* (*Assemblers*).[16]

Insert Fig. 1. around here.
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4. RESEARCH METHOD

To test our hypotheses, the cross-sectional approach was selected as the research design, in which the target population is evaluated at one point in time (Krathwohl 1993). Compared with a longitudinal study approach, in which data are generally collected from a limited number of samples, the cross-sectional approach is likely to have a higher external validity (Cook and Campbell 1979). The unit of our analysis is a first-tier supplier level—i.e., focusing on a first-tier supplier's decision on: to what extent the first-tier supplier is likely to use EDI with its second-tier suppliers. In order to control the population, we focused only on first-tier automobile suppliers who have EDI connection with final assemblers in the US and Japan.

For our survey to the US first-tier suppliers, we addressed to managers who are in charge of EDI, electronic commerce or ITs. We conducted a pilot study by making phone calls to seven companies randomly selected from automotive first-tier suppliers listed in the *Elm Guide to Automotive Sourcing* (1999). These managers are asked to fill out our survey instrument. After the surveys were received, follow-up calls were made to solicit comments. Based on the pilot survey and follow-up calls, we revised some of the wording of the questions.

Our finalized survey was sent to 670 U.S. automotive first-tier suppliers by using the same directory. Seventy-six firms responded to our mailing in 1999, resulting in the overall

[15] Banerjee and Golhar (1994) found that large companies were more likely to adopt EDI than small companies.
[16] A control variable, *Size*, was excluded from Figure 1 for simplicity.

response rate, 11.3 percent. Our survey was also mailed to managers in 372 Japanese automotive first-tier suppliers listed in the *Nihon Jidousha Buhin Sangyou no Jittai (The Japanese Automobile Parts Industry)* in 2000. Ninety-three firms responded to our survey resulting in 25% response rate in Japan. Average number of employees in the US respondents was 1,229 and that in the Japanese respondents was 1,331.

We checked non-respondent bias by observing the size of the firms that did not respond to our survey to first- suppliers in the US, as well as the Japanese firms. We found that non-responding firms have no statistically significant difference in size from those who did respond.

Our interviews with managers and IT engineers in the US and Japanese auto suppliers suggested that the distinction between first-tier and second-tier suppliers were becoming blur. Thus, we included a self-reported tier classification question in our survey. Although we carefully selected first-tier suppliers based on the directories, we found that 27.6% of US respondents and 16.9% of Japanese respondents were reported to be second-tier suppliers. Thus, we included a control variable, *Tier,* in the following analyses, although our hypotheses were generic and "tier-free" in the sense that the hypotheses focus on general buyer-seller relationships.

5. MEASUREMENT

The dependent variables are *EDI Adoption* and *EDI integration*. The value of *EDI Adoption* is "1" for the respondents who developed EDI links only with their suppliers, and "0" for those who did not. We measure *EDI Integration* by identifying the extent (level) that EDI is used to communicate with their suppliers. By consulting with IT managers in the auto industry

in the US and Japan, we identified five most commonly used EDI transactions: (1) *application advice,* (2) *planning schedules,* (3) *advance shipping notices,* (4) *receiving advice,* and (5) *shipping schedules.*

Application advice (824) is used to notify trading partners that there are changes in previous orders. Customers transmit *planning schedules* (830) to suppliers to inform them of anticipated component requirements. *Advance shipping notices* (856) let customers know the arrival time and the quantity of products to be delivered to the customer site. *Receiving advice* (861) is used to inform suppliers of discrepancies between an advance shipping notice and the actual shipment received. *Shipping schedules* (862) are used to assist trading partners in planning and executing their shipments.[17]

The value of *EDI Integration* is "1" for respondents who developed EDI communication with their average suppliers by using one of the five EDI transactions, and "5" for respondents who developed EDI communication with their average suppliers by using all the five EDI transactions.

We have seven independent variables: *Asset Specificity, Uncertainty, Frequency of Transactions, Seller Concentration, Buyer Concentration, Number of Competitors, EDI Integration with Buyers,* and two control variables: *Size* and *Tier*. The measurements of these variables are as follows.

Asset Specificity was measured by asking respondents: Do you make specific investments in your "average" suppliers—e.g., special equipment, equity? (1 = not at all; 2 = very little; 3 = moderately; 4 = very much; 5 = greatly). *Uncertainty* was indexed by asking: How has the market of your core business changed for the last five years? (1=highly stable, stable, 2=stable

[17] A *functional acknowledgment* (997) is commonly used in the US to confirm the information received. However, it is not well used in Japan, simply because of its redundancy in the Japanese business practices.

3= neutral, 4= unstable, 5=highly unstable). *Frequency of Transactions was* measured by asking respondents: How often do your "average" suppliers deliver their products to you? (1= several times a year, 2= several times a month, 3= once a week, 4= several times a week, 5= several times a day).

Supplier Concentration was measured by using Herfindahl-Hirschman Index among five largest suppliers.[18] The index ranges from 0 (no concentration) to 1 (a pure monopoly). *Customer Concentration* was also measured by using Herfindahl-Hirschman Index among five largest customers. *Number of Competition* was measured simply by asking respondent about the number of their competitor.

EDI Integration with Buyers was indexed by using a similar method to *EDI Integration.* Namely, the value of *EDI Integration with Buyers* is "1" for respondents who developed EDI communication with their buyers by using one of the five EDI transactions, and "5" " for respondents who developed EDI communication with their customers by using all the five EDI transactions.

As we discussed earlier, we included *Size* and *Tier* as control variables. The value for *Size* was measured by taking a natural logarithm of number of employees in the responding firms.[19] *Tier* was simply measured by asking respondents which tier they belong to (1=first-tier suppliers, 0=second-tier suppliers).

[18] The formula is: H-H Index = $S_1^2 + S_2^2 + S_3^2 + S_4^2 + S_5^2$, where S_i is the market share of the i^{th} firm. See (Hirschman 1964).

6. RESULTS

Table 1 (column 1) shows the means and standard deviations of all variables used in our analyses. We also divided the total sample into two sub-samples—i.e., the US suppliers (columns 2 in the table) and Japanese suppliers (columns 3 in the table)—and conduct t-tests to check statistically significant *mean* differences of defined variables between the two countries.

Insert Table 1. around here.

As seen in Column 1 of table, fifty-seven percent of all the responding firms had EDI-based transactions with their (second-tier) suppliers. However, there was a statistically significant difference between the US and Japanese firms. Namely, 42.1 percent of the US respondents had EDI transactions, while 68.5% of the Japanese respondents had EDI transaction. Such a difference can be explained partially by earlier (a year) data collection in the US than that in Japan. The difference can also be explained partially by a slightly larger size of Japanese respondents than that of the US respondents, as seen in *Size* in the table.

The mean of another dependent variable, *EDI Integration*, was 2.03 for all the respondents (Column 1 of the table) and there was no statistically significant difference between the two countries. This indicates that the US and Japanese auto suppliers use, on average, two of the EDI transactions.

Regarding the three variables related with the transaction-cost approach (*Asset Specificity*, *Uncertainty* and *Frequency*), there were also significant differences between the two countries. *Asset Specificity* in the Japanese suppliers is higher than that in the US firms (3.11 in Japan, 2.31

[19] We also measured "annual sales" in the previous year. Since there was a high correlation between the two indices, we used only number of employees.

in the US). This must be attributed to the tendency that Japanese auto suppliers are likely to be linked with "*keiretsu*" relationship (Bensaou 1997; Gerlach 1992).

Uncertainty was higher in Japan (3.36 in Column 3) than in the US (2.27 in Column 2), suggesting that the US market is more predictable than the Japanese market or that the Japanese suppliers are more likely to perceive (or sense) *uncertainty*. *Frequency* was significantly higher in Japan (4.17 in Column 3) than in the US (3.41 in Column 2), implying that the Japanese smaller suppliers tend to deliver their products much more frequently. This finding is inline with other studies (Cusumano and Takeishi 1991; Bensaou 1997).

Seller Concentration showed a higher average score in the US (0.22 in Column 2) than in Japan (0.08 in Column 3), suggesting that the US firms tend to buy the majority of their parts from a rather limited number of suppliers than Japanese firms do. This can be attributed to the fact that the Japanese suppliers are slightly larger in size than the US firms (assuming the larger firms tend to have more suppliers), and that American firms tend to make more modularized parts than the Japanese firms (Fujimoto 1998).

Buyer Concentration showed similar values in the two countries—0.31 in the US and 0.27 in Japan. However, *EDI USE with Buyers* showed a significant difference between the US and Japan—3.97 in the US (Column 2) and 3.33 (Column 3) in Japan. The higher use of EDI with buyers in the US (in spite of a year earlier data collection) support our interviews with managers.[20]

[20] Most of the managers said, "the use of EDI in the US is generally a year and half ahead of Japan."

Number of Competitors also showed a statistically significant difference—i.e., 34.8 in the US and 13.2 in Japan—suggesting generally the more competitive auto suppler market in the US than in Japan. [21]

Since there were structural differences between the US and Japanese firms, we conducted F-tests in order to see whether separate regressions must be estimated or not. The result indicated that F-tests for cross-country differences of *EDI Integration* in the regression slopes were both not significant at the five percent level, but both were significant at the ten percent level. This suggests that separate regressions are necessary for each country. Thus, the total sample was divided into subsamples according to country, so as to investigate the country-specific bias of our framework. Table 2a, 2b and 2c shows the intercorrelations for the defined variables in the total sample, the US subsample, and the Japanese subsample, respectively.

Insert Table 2a, 2b and 2c around here.

In Table 2a (the total sample), there are many statistically significant correlations among the defined independent and control variables. However, most of the high correlations are between a dummy variable, *Country* (US=1, Japan=0), and the defined variables, as expected from Table 1.

In the US subsample (Table2b), there is a highly negative correlation between *Asset Specificity* and *Uncertainty* (-.0.435), suggesting a possibility that American suppliers tend to reduce their transactional uncertainty by investing specialized assets in their suppliers. Highly positive correlations among *Frequency*, *Buyer Concentration* and *EDI Integration with Buyer*

[21] Accordingly, Table 1 showed that all the three variable related with the transaction-cost approach (*Asset Specificity, Uncertainty* and *Frequency*) had statistically higher means in the Japanese subsample than in the US subsample. The table also showed that three of the four variables related with the resource-dependence approach

(0.280, 0.200) can be attributed to the tendency that American firms, with a few major customers with EDI transactions, deliver their products very frequently to their customers.

A high association between *Buyer Concentration* and *Seller Concentration* (0.427) may imply the existence of two types of *positioning strategies* in the US suppliers—"a few suppliers with a few buyers," or "many suppliers with many buyers." It should also be noted that *EDI USE with Buyers* had high correlations with *Size* and *Tier*, suggesting that large first-tier suppliers tend to use more EDI with their buyers than small second-tier suppliers do.

In the Japanese subsample (see Table 2c), there are also several statistically significant correlations among the defined variables. High associations among *Asset Specificity, Seller Concentration, EDI USE with Buyers* and *Size* (-0.416, 0.220, and 0.280) can be explained by the fact that the Japanese large firms with a low supplier concentration and a high EDI connection with buyers tend to invest specific assets in their suppliers. High associations among *Seller Concentration, Buyer Concentration, EDI USE with Buyers* and *Size* (0.284, -0.223, -0.421) may imply that the Japanese firms with a few buyers and a few suppliers tend to be small and not EDI connected with their buyers, as well as the existence of two types of the *positioning strategies.*

These rather high associations will be examined further by the following multiple regression analyses. However, Table 2a, 2b and 2c generally seem to indicate that such correlations tended to be not very high, suggesting that multicollinearity is not a serious concern in the following multiple variable analyses.

(*Seller Concentration, Number of Competitors, EDI USE with Buyers*) had statistically higher means in the US subsample than in the Japanese subsample.

In analyzing the determinants of *EDI adoption*, we conducted logit regressions, instead of linear regression, since the values of dependent variables are binary.[22] The results of logit regression analysis for *EDI adoption* are presented in Column 1 (total sample), Column 2 (US subsample), and Column 3 (Japanese subsample) of Table 3.

We also conducted linear regression in analyzing the effects of independent and control variables on the degree of *EDI integration*, because the values of the dependent variables are multiple and can be safely considered as continuous variables (Larsen and Marx 1981). The results of the linear regression for EDI *Integration* are presented in Column 4 (total sample), Column 5 (US subsample), and Column 6 (Japanese subsample) of Table 3. We will examine the effects of each independent and control variable on *EDI Adoption* and *EDI Integration*.

Insert Table 3. around here.

Asset Specificity shows no association with *EDI Adoption* as seen in Column 1, 2, and 3. However, it shows statistically significant *beta* with *EDI Integration* in the total sample (0.233) and in the US sabsumple (0.504). The results partially support **Hypothesis 1**: *The higher the degree of transaction specific investments, the more likely a firm (first-tier supplier) is to adopt EDI and integrate the EDI system with its (second-tier) suppliers*. These results may also imply that transaction specific investments in suppliers are not sufficient in adopting EDI with the suppliers, but sufficient in integrating EDI with the suppliers, only in the US.

Uncertainty does not show any statistically significant association with *EDI Adoption, as well as* with *EDI Integration*, thus lending no support to **Hypothesis 2**: *The higher uncertainty,*

[22] In general, logistic regression is more appropriate for observational studies, whereas probit analysis is appropriate

the more likely a firm (a first-tier supplier) is to adopt EDI and integrate the EDI system with its (second-tier) suppliers. The reason for such an unsupported hypothesis could stem from the general difficulty in measuring the level of uncertainty, as suggested by many studies—e.g., Butler and Carney (1983), Tatikonda and Rosenthal (2000).

Frequency does not show any association with *EDI Integration.* However, it shows statistically significant associations with *EDI Adoption* both in the US firms (0.078 in Column 2) and Japanese firms (-.0.811 in Column 3). A higher frequency of transactions leads to more EDI adoption in the US, thus partially supporting **Hypothesis 3**: *The higher the frequency of transactions between a firm (a first-tier supplier) and its (second-tier) supplier, the more likely the firm (the first-tier supplier) is to adopt EDI and integrate the EDI system with its (second-tier) suppliers*.

On the contrary, a higher frequency of transactions leads to less EDI adoption in Japan, conflicting with our hypothesis! Such a conflicting result in Japan could be attributed to their non-EDI communication methods available for replacing frequent transactions, such as physical closeness to their suppliers, long-term business relationship or *Kanban* system (Fujimoto 1998).

Seller Concentration does not show any statistically significant coefficient with *EDI Adoption*. However, *Seller Concentration* shows a statistically significant association with *EDI Integration* only in the Japanese subsample, thus partially supporting **Hypothesis 4:** *The greater the proportion that a firm (a first-tier supplier) purchases products from a few (second-tier) suppliers, the more likely the firm (the first-tier supplier) is to adopt EDI and integrate the EDI system with its (second-tier) suppliers.* The reason for the lack of support for the hypothesis, especially in the US, could be that sellers' market power is generally weaker than buyers' market

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for designed experiments. See Pindyck and Rubinfeld (1981).

power in forcing suppliers to adopt and integrate EDI. Such an argument was also made by Baksuki, *et al.* (2001).

Number of competitors has significant associations with *EDI Adoption* in the total sample (-.010 in Column 1) and in the Japanese subsample (-0.025 in Column 3), thus partially supporting **Hypothesis 5:** *The greater the number of competitors a firm (a first-tier supplier) has, the less likely it is to adopt EDI and integrate the EDI system with its (second-tier) suppliers*. However, *Number of Competitors* has no effect on *EDI Integration*, as seen in Column 4, 5, and 6 of Table3. The reason for this could be that the "diluted" buyer's power for EDI promotion has only an indirect (or trivial) effect on *EDI Integration* after EDI was adopted. Such an argument is in line with Hart and Saunders (1998).[23]

Buyer Concentration shows statistically significant association with *EDI Adoption* in the total sample (1.383 in Column 1), partially supporting **Hypothesis 6**: *The greater the proportion that a firm (a first-tier supplier) sells products to a few buyers (final assemblers), the more likely the firm (the first-tier supplier) is to adopt EDI and integrate the EDI system with its (second-tier) suppliers*. However, *Buyer Concentration* shows no statistically significant association with *EDI Integration* in the total sample, as well as in the US and Japanese subsample. The reason for the lack of support for the hypothesis in *EDI Integration* may stem from the possibility that buyers' market power is generally effective in forcing their suppliers to adopt EDI, but not effective in encouraging their suppliers to further integrate their EDI with suppliers. Hart and Saunders (1998) and Baksuki, *et al.* (2001) support such an argument.

[23] Our finding that Hypothesis 5 (*Number of Competitors*) was supported on *EDI Adoption* by the total sample confirms our assumption that "buyers' pressure" is more important that Porter's horizontal pressure. Vertical pressures (Porter 1980)—i.e., customers' requests and, to a lesser extent, suppliers' requests—seem to be more

EDI Integration with Buyers shows a statistically significant association with *EDI Adoption* in the US subsample (0.072 in Column 2), and with *EDI Integration* in the total sample (0.290 in Column 4) and in the Japanese subsample (0.448 in Column 6). These results partially support **Hypotheses 7**: *The more EDI integration with buyers (final assemblers), the more likely a firm (a first-tier supplier) is to adopt EDI and integrate the EDI system with its (second-tier) suppliers*.

Size has statistically significant associations with *EDI Adoption* in the total sample (0.288 in Column 1) and the Japanese subsample (0.575 in Column 3). It also shows a statistically significant association with *EDI Integration* only in the Japanese subsample (0.228 in Column 6), suggesting that larger firms are likely to adopt EDI and integrate EDI with their suppliers (Banerjee and Golhar 1994).

Tier shows a significant association with *EDI Adoption* only in the Japanese subsample (0.575 in Column 3), implying: the higher a supplier's tier is, the more likely the supplier is to adopt EDI. However, *Tier* does not show any association with *EDI Integration.* These results may come from a sample bias that more EDI-active suppliers were likely to respond to our survey.

Finally, the six regression equations in Table 3 show different explanatory powers. Cox and Snell's R^2 in our logit regression equation in the total sample (Column 1) was 0.147, implying that 14.7 % of the variance of *EDI adoption* can be explained by the defined variables. Adjusted R^2 in our regression equation in the total sample (Column 4) was 0.134. Thus, it can be said that the defined variables explained the variance of *EDI Adoption* more than that of *EDI Integration.*

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important than horizontal pressures from competitors in encouraging EDI adoption and integration in the automobile industry.

Cox and Snell's R^2 in the US subsample (Column 2) was 0.135, while adjusted R^2 in the US subsample (Column 5) was 0.089. On the other hand, Cox and Snell's R^2 in the Japanese subsample (Column 3) was 0.148, while adjusted R^2 in the Japanese subsample (Column 6) was 0.264. Thus, it can be said that our framework on *EDI Adoption* is more suited to the US context and that our framework on *EDI Integration* is more suited to the Japanese context.[24]

7. EDI PERFORMANCE

In order to examine effectiveness of our framework, we measured *EDI Performance* by asking respondents the extent to which they agree with the following nine statements by using five-point Likert-scales (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree): (1) EDI helps lower your cost of general management activities (e.g., accounting, manufacturing, distributing, finance); (2) EDI helps lower your cost of delivering products to buyers; (3) EDI helps lower your cost of purchasing raw materials; (4) EDI helps reduce inventory levels; (5) EDI helps reduce your response time to customers; (6) EDI improves your company's product and manufacturing processes; (7) EDI helps expand your customer base; (8) EDI helps expand your supplier base; and (9) EDI improves your overall performance.[25]

We ran a reliability test among the above nine performance indices in the two nations, and found that the Cronbach alpha was .890 in the US and .880 in Japan. Thus, we took average scores among the nine indices in the two countries. We call them *EDI Performance*, henceforth. Since we did not hypothesize any clear relationship between *EDI Performance* and

[24] Here, we considered our finding that Japanese data conflicted with Hypothesis 3 (*Frequency)*.
[25] We asked these questions to both those who have EDI connections with its suppliers and those who do not.

the defined variables, we simply report the results of our correlation analyses between *EDI Performance* and the defined variables (see Table 4).

Insert Table 4. around here.

As seen in Table 4, *EDI Adoption* and *EDI Integration* show positive and statistically significant correlations with *EDI Performance* in the US (0.271 and 0.308 in Column1), suggesting: t*he higher EDI Adoption* and *EDI Integration*, the higher *EDI performance.* However, there was no statistically significant correlation in the Japanese subsample. The reason for this could be that the Japanese firms do not really enjoy potential benefits of EDI. Actually the average score of *EDI Performance* in Japan was significantly lower than that in US—3.40 in the US versus 3.30 in Japan. Another reason could be Japanese rather narrower variance in EDI Performance, thus showing low correlations.[26] Such a tendency is well reported in many comparative management studies. Furthermore, non-EDI communication methods prevailed in Japan—e.g., physical closeness to suppliers, long-term relationship or *Kanban* system—could be another reason (Bensaou 1994). Table 4 also indicates that *Number of Competitors* and *Tier* had statistically significant correlations with *EDI Performance* in the US, implying that American first-tier suppliers in a highly competitive situation are likely to enjoy benefits of EDI.[27]

[26] The standard deviation in Japanese *EDI performance* was 3.55 in the US and 3.33 in Japan. Our F-test analysis showed that variances in the two countries are statistically different.

[27] Although not reported here, we separated the total samples into two sub-samples (high performers and low performer) by their using median of EDI Performance in each country. The results generally showed that regression coefficients in the high performers tended to have higher values than those in the low performers, suggesting the validity of our framework.

8. DISCUSSION

In order to examine factors affecting EDI adoption and EDI integration in the US and Japanese auto suppliers, we constructed seven hypotheses based on the transaction-cost approach and the resource-dependency approach. Table 5 summarized our results. Among the three hypotheses on the transaction-cost approach (Hypothesis 1, 2 and 3), we found a support for Hypothesis 1 (*Asset Specificity*) by the total sample, as well as by the US data. Hypothesis 2 (*Uncertainty*) was not supported at all by any of our data.

Insert Table 5. around here.

Hypothesis 3 (*Frequency*) was not supported by the total sample—i.e., although it was supported by the US data, it conflicted with the Japanese data. Such a conflicting result may suggest an inappropriateness of *Frequency* when applied to electronic commerce (EC). Namely, in "brick and mortal" worlds, frequency of transactions tends to increase its transaction cost. However, with EDI, a buyer can automate its repetitive transactions with sellers, thus even lowering its transaction costs. Accordingly, the importance of *frequency of transaction* in the transaction-cost approach seems to be diminished when applied to EC.

Since we found a support only for Hypothesis 1 (*Asset Specificity*) in the total sample among the three hypotheses on the transaction-cost approach, it can be claimed said that *Asset Specificity* is the most important dimension among the three dimensions of the approach. Such a claim can be substantiated by the high correlation coefficient between *Asset Specificity* and *EDI Performance in* the US, as seen in Table 4.

In constructing our hypotheses, we assumed that the transaction-cost approach emphasizes more "efficiency" in transactions, while the resource-dependence approach

emphasizes more "power relations" in transactions. However, *Asset Specificity*, one of the three dimensions in the transaction-cost approach, seems to include a component of the power relations. For example, a firm may invest in special equipment with a specific supplier in order to tie the supplier in the ling-term transactional relation, by increasing its switching cost. Thus, it is understandable that only *Asset Specificity* showed an impact on *EDI Integration* in the US auto industry where the power relation plays an important role (Iskandar, *et al*. 2001). Our argument is in line with Hart and Saunders (1998).

It was also found that the transaction-cost approach was more suited to the US contest than to the Japanese context, because any of the three hypotheses on the transaction-cost approach was not supported by the Japanese data—actually, the Japanese data on Hypothesis 3 (*Frequency*) conflicted with the approach!

In his study on the US and Japanese automobile industry, Bensaou (1997) also suggests an invalidity of the transaction-cost approach in the Japanese context. He found that the Japanese auto companies tended to emphasize more trustworthy relations between final assemblers and first-tier suppliers in their uses of ITs, rather than a dichotomous thinking of "market or hierarchy."

Regarding the four hypotheses on the resource-dependence approach (Hypothesis 4, 5, 6 and 7), it is understandable that the resource-dependence approach is more applicable to *EDI Adoption* than to *EDI Integration* (see Table 5). This is because two of the hypotheses (Hypothesis 5 and 6) were supported on *EDI Adoption* by the total sample, while none of the resource-dependence-related hypotheses was supported on *EDI Integration* by the total sample. The "power relation" implied in the resource-dependence approach may favor *EDI Adoption*

rather than *EDI Integration* among (second-tier) suppliers, because "long-term trust" will be needed to integrate EDI further (Hart and Saunders 1998).

Only Hypothesis 7 (*EDI Use with Buyers*) was supported by the US data, while three hypotheses (Hypotheses 4, 5, and 7) were supported by the Japanese data, as seen Table 5. Thus, it can also be claimed that the resource dependency approach is more suited to the Japanese context than to the US context. Table 1 (descriptive analysis) showed that the Japanese respondents face fewer competitors than the US respondents do—i.e., 13.2 in Japan and 34.8 in the US. Thus, our claim is consistent with the assumption the resource-dependence approach has—i.e., oligopolistic markets rather than perfect markets (Pfeffer and Salancik 1978).[28]

Finally, although Mukhopadhyay, *et al.* (1995) states that measuring benefits from EDI investments is difficult, we measured *EDI Performance* by nine indicators, as discussed. We found that *EDI Adoption* and *EDI Integration* were significantly associated with *EDI Performance* in the US data. These results may imply a higher validity of our framework in the US than in Japan.

9. CONCLUSIONS

This paper examines determinants of EDI adoption and integration in the automobile suppliers. The paper constructs seven hypotheses from the transaction-cost and resource-dependence approaches, and tests these hypotheses by using data from the US and Japanese automobile suppliers.

[28] Our interviews also confirmed this data. For example, one manger in a Japanese transplant in the US said, "US auto suppliers are something like small sesna flying freely without a radar, while Japanese suppliers are something like a jet with a radar. We can't fly freely because we must watch carefully our customers and suppliers with our radar."

There are many studies on EDI adoption. However, our study is unique in the following four points: (1) we focused on not only EDI adoption—i.e., "adopt or not"—but also EDI integration—i.e., "to what extent"; (2) we studied first-tier suppliers' decisions on EDI adoption and integration with their suppliers; (3) we examined both upsteam and downstream competitive forces by using *Buyer Concentration* and *Seller Concentration*; (4) we surveyed both the US and Japanese suppliers in order to increase the external validity of our framework.

In summary, our study shows: (1) the resource-dependence approach seemed more effective in explaining EDI adoption, while the transaction-cost approach seemed more effective in explaining EDI integration; (2) the transaction-cost approach seemed more suited to the US context, while the resource-dependence approach seemed more suited to the Japanese context; (3) EDI adoption and integration had positive impacts on EDI performance in the US, but not in Japan, suggesting the higher validity of our framework in the US.

This study has practical implications for managers in change of EDI and supply chains. We found that the resource-dependence approach explained more EDI adoption, while the transaction-cost approach explained more EDI integration. These results suggest managers who are in charge of EDI promotion among their suppliers take a delicate approach. For example, a power-based approach may encourage suppliers to adopt EDI but may endanger trustable relations with the suppliers, which are needed to further integrate EDI integration in the long run. We also found that the transaction-cost approach was more suited in the US context, while the resource-dependence approach was more suited to the Japanese context. For example, American managers in charge of EDI and supply chains may need to emphasize more power-oriented approach to Japanese transplant suppliers in the US.

The findings in this paper, however, must be interpreted with care, as they stem from cross-sectional data and therefore cannot validate causal predictions. Thus, the long-term effects of the defined variables on EDI adoption and EDI integration, as well as the reverse effect—i.e., the impact of EDI adoption and integration on the defined variables—have not yet been ascertained.

Thus, the opportunity for further research into the phenomena of EDI adoption and integration is great. For example, in-depth case studies will further clarify the relationships among the variables defined in this study. Research with respect to different industry will also broaden our understanding of this subject. Without such research, it is uncertain whether these findings are specific to the automobile suppliers in the current study or if they represent firms in general.

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Figure 1. Factors Affecting EDI Adoption and EDI Integration

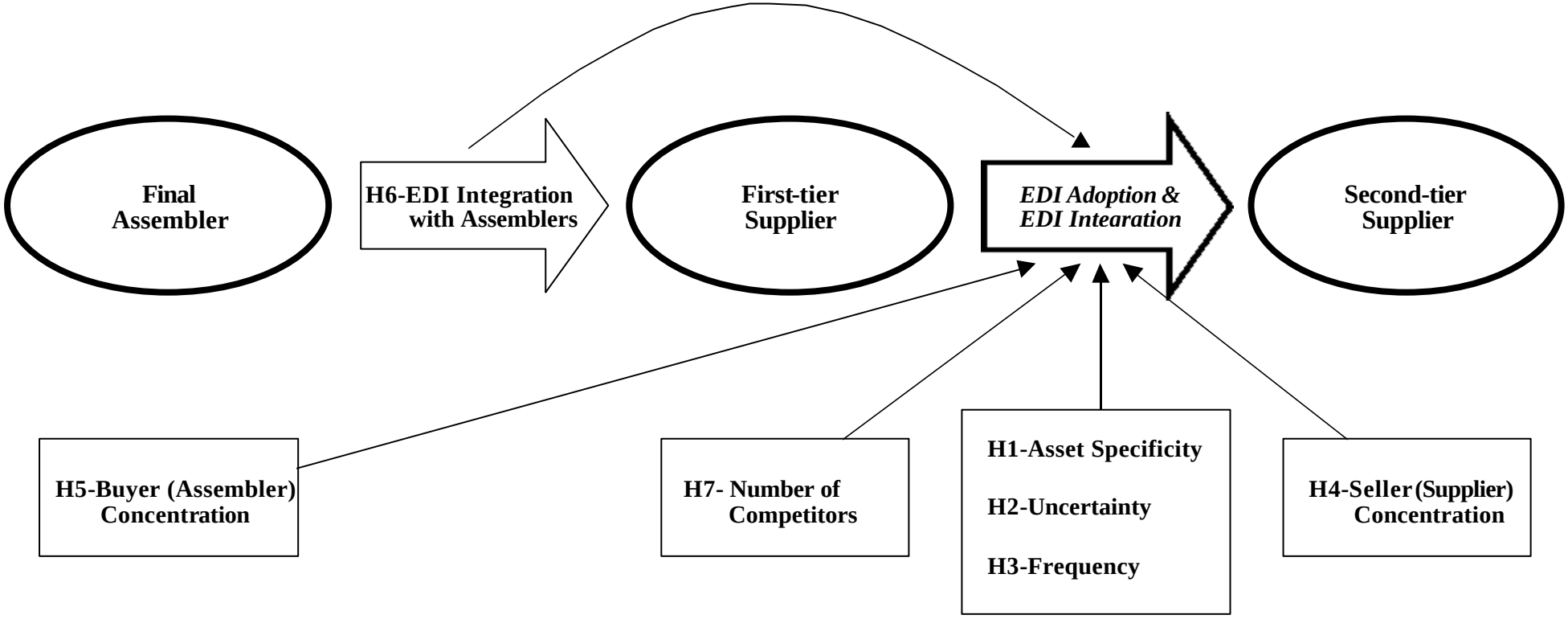

Table 1. Description of Defined Variables

		All [1]	US [2]	Japan [3]
		Mean *[SD]* (N=169)	**Mean** *[SD]* (N=76)	**Mean** *[SD]* (N=93)
Dependent Variables				
1	EDI Adoption	**0.57***** *[0.50]*	**0.42** *[0.50]*	**0.69** *[0.47]*
2	EDI Integration	**2.03** *[1.14]*	**1.91** *[1.26]*	**2.09** *[1.08]*
Independent Varibles				
3	Asset Specificity	**2.73**** *[1.06]*	**2.31** *[0.98]*	**3.11** *[1.00]*
4	Uncertainty	**2.88**** *[0.86]*	**2.27** *[0.78]*	**3.36** *[0.80]*
5	Frequency	**3.81**** *[0.98]*	**3.41** *[1.06]*	**4.17** *[0.74]*
6	Seller Concentration	**0.15**** *[0.19]*	**0.22** *[0.22]*	**0.08** *[0.09]*
7	# of Competitors	**23.21*** *[61.43]*	**34.80** *[87.09]*	**13.21** *[17.98]*
8	Buyer Concentration	**0.34** *[0.28]*	**0.31** *[0.24]*	**0.37** *[0.31]*
9	EDI Use with Buyers	**3.62**** *[1.17]*	**3.97** *[1.26]*	**3.33** *[1.00]*
Control Variables				
10	Size	**6.43**** *[1.17]*	**6.10** *[1.34]*	**6.70** *[0.94]*
11	Tier	**0.74** *[0.44]*	**0.78** *[0.41]*	**0.71** *[0.46]*

*Note: Two-tailed significant level: *p<0.05, **p<0.01*

Table 2a. Correlation Matrix in the Total Sample

		1	2	3	4	5	6	7	8
1	Asset Specificity								
2	Uncertainty	-0.005							
3	Frequency	0.083	0.051						
4	Seller Concentration	-0.416***	-0.027	-0.042					
5	# of Competitors	0.066	0.032	-0.021	0.148				
6	Buyer Concentration	-0.177	0.099	0.041	0.284**	-0.209*			
7	EDI Integration with Buyers	0.220**	0.129	-0.136	-0.223*	0.022	-0.038		
8	Size	0.280**	-0.006	0.145	-0.421***	0.168	-0.203*	0.046	
9	Tier	0.030	-0.047	-0.048	-0.157	0.092	0.249*	-0.077	0.073

Numbers are Pearson correlation coefficients: *p<0.10, **p<0.05, ***p<0.01(two-tailed)

Table 2a. Correlation Matrix in the US Suppliers

		1	2	3	4	5	6	7	8
1	Asset Specificity								
2	Uncertainty	-0.435***							
3	Frequency	0.102	-0.192						
4	Seller Concentration	-0.151	-0.063	0.006					
5	# of Competitors	0.000	0.163	0.049	-0.098				
6	Buyer Concentration	0.018	-0.031	0.280**	0.427***	-0.035			
7	EDI Use with Buyers	0.083	-0.102	0.200*	0.074	-0.051	0.059		
8	Size	0.126	-0.043	0.004	-0.075	0.231*	0.161	0.332***	
9	Tier	-0.068	0.016	-0.047	-0.019	0.118	0.122	0.299**	0.202*

Numbers are Pearson correlation coefficients: *p<0.10, **p<0.05, ***p<0.01(two-tailed)

Table 2b. Correlation Matrix in the Japanese Suppliers

		1	2	3	4	5	6	7	8
1	Asset Specificity								
2	Uncertainty	-0.005							
3	Frequency	0.083	0.051						
4	Seller Concentration	-0.416***	-0.027	-0.042					
5	# of Competitors	0.066	0.032	-0.021	0.148				
6	Buyer Concentration	-0.177	0.099	0.041	0.284**	-0.209*			
7	EDI Integration with Buyers	0.220**	0.129	-0.136	-0.223*	0.022	-0.038		
8	Size	0.280**	-0.006	0.145	-0.421***	0.168	-0.203*	0.046	
9	Tier	0.030	-0.047	-0.048	-0.157	0.092	0.249*	-0.077	0.073

Numbers are Pearson correlation coefficients: *p<0.10, **p<0.05, ***p<0.01(two-tailed)

Table 3. EDI Adoption and Integration

	EDI Adoption			EDI Integration		
	All [1] *N=169*	***US*** [2] *N=76*	***Japan*** [3] *N=93*	***All*** [4] *N=96*	***US*** [5] *N=32*	***Japan*** [6] *N=64*
Independent Variables						
1 Asset Specificity	**0.178**	**0.240**	**0.274**	**0.233****	**0.504****	**0.148**
2 Uncertainty	**-0.014**	**0.534**	**-0.355**	**0.109**	**0.349**	**-0.007**
3 Frequency	**-0.135**	**0.078***	**-0.811***	**0.054**	**0.287**	**0.111**
4 Seller Concentration	**-1.526**	**-1.931**	**1.688**	**0.062**	**-0.160**	**0.322****
5 # of Competitors	**-0.010***	**-0.010**	**-0.025***	**0.053**	**-0.117**	**0.018**
6 Buyer Concentration	**1.383***	**2.249**	**0.710**	**0.158**	**0.013**	**0.155**
7 EDI Integration with Buyers	**0.007**	**0.072***	**0.089**	**0.290*****	**0.113**	**0.488*****
Control Variables						
8 Size	**0.288***	**0.214**	**0.575***	**0.044**	**0.144**	**0.228***
9 Tier	**0.230**	**-0.464**	**0.927***	**-0.054**	**-0.309**	**0.079**
10 Country	**-0.557**			**-0.028**		
Cox & Snell R^2	**0.147**	**0.135**	**0.148**			
Adjusted R^2				**0.134**	**0.089**	**0.264**

Note: One-tailed significant level: * p<0.10, **p<0.05, ***p<0.01
[1][2][3]: Logistic Regressions with dependent variable, EDI Adoption
[4][5][6]: Linear Regressions with dependent variable, EDI Integration

Table 4. Correlation analyses

Variables		US [1]	Japan [2]
		Correlation with Perforamnce	Correlation with Perforamnce
1	EDI Adoption	**0.271****	**-0.078**
2	EDI Integration	**0.308***	**0.129**
3	Asset Specificity	**0.225***	**0.085**
4	Uncertainty	**0.023**	**0.091**
5	Frequency	**0.166**	**0.148**
6	Seller Concentration	**0.004**	**-0.036**
7	# of Competitors	**0.316*****	**0.170**
8	Buyer Concentration	**0.104**	**0.091**
9	EDI Integration with Buyers	**0.183**	**0.022**
10	Size	**0.133**	**0.176**
11	Tier	**0.276****	**0.169**

*Numbers are Pearson correlation coefficients: *p<0.10, **p<0.05, ***p<0.01(two-tailed)*

Table 5. Summary of Results

Theoretical Approach	#	**Summary of Hypotheses**	***EDI Adoption* in Total**	***EDI Adoption* in US**	***EDI Adoption* in Japan**	***EDI Integration* in Total**	***EDI Integration* in US**	***EDI Integration* in Japan**
Transaction-Cost	H1	Hi *Asset Specificity* Hi *EDI Adop. & Int.*				Supported	Supported	
	H2	Hi *Uncertainty* Hi *EDI Adop. & Int.*						
	H3	Hi *Frequency* Hi *EDI Adop. & Int.*		Supported	(Conflict)			
Resource-Dependence	H4	Hi *Seller Concentration* Hi *EDI Adop. & Int.*						Supported
	H5	Hi *Number of Competitors* Lo *EDI Adop. & Int.*	Supported		Supported			
	H6	Hi *Buyer Concentration* Hi *EDI Adop. & Int.*	Supported					
	H7	Hi *EDI Use with Buyer* Hi *EDI Adop. & Int.*		Supported		Supported		Supported