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Abstract

The Internet combined with mobile technologies and wireless devices permit organizations to access widely distributed information that is not restricted by business-unit or organizational boundaries. Large volume and high frequency data exchange as well as a wide variety of data sources characterize the new Business-to-Business commerce environments. Supply chain management (SCM) is very important for businesses' success. In order to achieve effective and efficient SCM, information sharing is necessary among supply chain partners. This article addressed the business value of information sharing in the supply chain. Using an international manufacturer survey data set, we empirically tested the relationship between different patterns of information sharing in supply chain management and the business performance. Our finding showed that the greater level of information sharing with both suppliers and customers is positively associated with higher performance improvement. Conclusions, limitations and future research are also discussed.

Keywords: Information Technology, Supply Chain Management, Inter-organizational Information Sharing, Business Performance.

1. Introduction.

Information has value. Better access to information can reduce risk and opportunity cost, lead to better decision-making and then improve organizational efficiency and performance. Research topics in Information Systems (IS) field are very diversified (Benbasat and Weber 1996, Robey 1996). The role of IT/IS within organization is always a focus of IS research (Attewell and Rule 1984, Markus and Robey 1988, Orlikowski and Baroudi 1991). However, did IS researchers pay enough attention to inter-organizational information sharing? After reviewing literature of the IS research framework (Ives et al. 1980, Culnan 1987, Baskerville and Myers 2002), we feel something important is missing. Only Baskerville and Myers (2002) addressed the inter-organizational information sharing issue a little bit in the application level. When we consider that in the past two decades most IS were designed and implemented for intra-organizational usage, the overlook of inter-organizational information sharing began to make sense. Compared to the everyday intra-organizational management and coordination tasks of IT/IS, the inter-organizational information sharing might not be a significant issue in the past. But, that does not necessarily mean inter-organizational information sharing is a trivial research question. In the business-to-business (B-2-B) relationships information sharings play critical roles. Especially in the new millennium, the Internet combined with mobile technologies and wireless devices permit organizations to access widely distributed information that is not restricted by business-unit or organizational boundaries. The dynamic business environment is highlighted by more inter-organizational information exchanging activities broader and deeper than ever.

Supply chain management (SCM) is a very important activity of most business' daily operations. Information sharing helps mitigate the "Bullwhip effect" (Lee et al. 1997) so as to achieve better supply chain performance. Previous research in SCM theoretically addressed the importance of inter-organizational information sharing (Cachon and Fisher 1998; Chen, et al. 2000; Lee, et al. 2000). By use queuing theory and other sophisticated modeling methods in simulations, those papers illustrated the potential value of information sharing in improving the overall supply chain management performance. Although information sharing in supply chain can improve overall supply chain performance is generally accepted in academia, in the business world managers care much more about business unit's performance than the whole supply chain performance. However, according to our knowledge, by far no empirical study based on large sample size has been conducted to specifically illustrate the linkage between business unit's information sharing activities in SCM and its performance. (In an empirical research, Frohlich and Westbrook (2001) demonstrated how deferent types of supply chain integration affect the business performance. But their research did not specifically address the information sharing activities.)

In this paper, we tried to analyze the level of inter-organizational information sharing and its influence on the business performance in the supply chain management scenario. Using an international manufacturer survey data set, we empirically tested the relationship between different patterns of information sharing in supply chain management and the business performance. Our finding illustrated that the greater level of information sharing with both suppliers and customers is positively associated with higher performance improvement. The remainder of this paper is organized as follows. Section 2 presents an overview of the relevant literature. In section 3, we talk about research methods. The results are discussed in section 4. The discussion and the future research directions are presented in section 5.

2. Inter-Organizational Information Sharing in Supply Chain Management.

The basic function of supply chain is making merchandises move smoothly from upstream raw material suppliers to manufacturers, to downstream distributors, and finally to end users (customers). Simchi-levi (1999) defined supply chain management as how to integrate suppliers, factories, warehouses and stores efficiently so that right products are made and delivered in the right quantities, at the right time, and to the right place. The goal of supply chain management is achieving high customer service level with the lowest total supply chain cost.

In the supply chain, there are two types of flows: material flow and information flow. Behind the obvious material flow is the information flow, which consisted of all kinds of information sharings (such as order details, order status, delivery time etc.) between supply chain partners. Since the weakest link determines the whole chain's strength, the success of supply chain management depends on all partners' involvement. Similar to other systems, the operation of supply chain first needs integration (Bowersox et al. 2000, Simchi-levi et al. 1999). Integration means designing the whole system and linking different players into a network so that the whole "chain" can fulfill the basic requirement of material deliveries. In other words, integration is building the system architecture and making it physically workable. Another important factor for a successful supply chain management is collaboration. Collaboration among supply chain partners can greatly reduce the frictions and conflicts between them so as to accomplish smooth and efficient operation of the whole supply chain. For instance, inventory management is a key issue in supply chain management. In order to achieve the whole supply chain optimal, the isolate inventory management at each individual location is not sufficient; we need to manage the echelon inventory, which is the total inventory at both

upstream and downstream sites. Collaboration can be viewed as a managerial mechanism beyond the physical system architecture. The information sharing and coordinated decision-making in supply chain partners can improve the whole SCM efficiency (Corbett et al. 1999). In this sense, information is the "lubricant" in the supply chain to facilitate the higher-level inter-organizational collaborations.

In generally, there are two levels of information sharing in the supply chain. Transaction information sharing is the first level. Transaction information includes order details, shipment status, payment information, and so on. Transaction information sharing is necessary for SCM because both parties need transaction information as critical records. Transaction information sharing is directly associated with transaction cost. Supply chain partners used to share transaction information via mail, telegram and fax. In the last two decades, some big companies implemented electronic data interchange system (EDI) with their supply chain partners to reduce errors, delays, and costs of transaction information management. The higher level of information sharing in SCM is about decision support information, which includes upstream and downstream inventory levels, retailers' sales information and capacity information (production, logistics and storage capacity), to name a few. Conventionally, firms' boundaries constrained the accessibility of those information. Manufacturers don't know the inventory level at the wholesalers' sites, neither the real sales figure at the retailers' sites. However, in the supply chain management, the accurate demand information is critical for manufacture and logistics planning (Andel 1996; Cottrill 1997; Levy et al. 2000). Brynjolfsson and Hitt (2000: p28) vividly described the problem:

> *"Traditionally, manufacturers promoted products such as soap and laundry detergent by offering discount, rebates or even cash payments to retailers to stock and sell their product. Because many consumer products have long shelf lives, retailers tended to buy massive amounts during promotional periods, which increased volatility in manufacturing schedules and distorted manufacturers' view of their market."*

In the supply chain, the unwelcome phenomenon that demand order variabilities are amplified as they moved up the supply chain is called "the bullwhip effect" (Lee et al. 1997). The reason of the bullwhip effect is the distorted market demand information flow from downstream to upstream. It causes remarkable inefficiencies (e.g. overstock or understock inventory; unnecessary high production capability and storage capability, etc.) in the whole supply chain management. Lee, et al. (1997) argued that without better information coordination along the whole supply chain, the bullwhip effect is inevitable.

Since the goal of SCM is achieving the overall supply chain performance, in recent years, sharing decision support information became a new business practice. For instance, Wal-Mart shares its inventory and sales information with P&G. Having access to those information will help manufacturer plan and manage its operations better. In exchange, Wal-Mart gets lower prices and better inventory replenishment service from P&G (Ireland and Bruce 2000). Another example of decision support information sharing is the Toyota's lean manufacturer system. In order to cut cost, Toyota tries to eliminate as much inventory as possible by asking suppliers to deliver inventory Just-in-time (JIT). Without inventory and sales information sharing among its suppliers and customers, Toyota can't coordinate the inventory orders effectively; as a result, JIT is literally impossible.

The fast development of information technology (IT) facilitates decision support information sharing. IT reduces the information collection, transfer and processing cost and therefore

makes the information ownership more attractive and valuable. In the past, it was very difficult and expensive to exchange those decision support information across firm boundaries. In recent years, with the fast development of Internet and other advanced computing and communication technologies, it's technologically feasible and economically affordable to share the real time Point of Sale (POS) information among the whole supply chain.

Cost efficiency is an underlying reason as well as a primary goal of business activities (Williamson 1975, 1981). Barrett and Konsynski (1982) pointed out that the one major incentives of Inter-organizational information sharing system is reducing transaction-processing cost. Narayanan, et al. (1999) applied game theory approach to modeling manufacturer-retailer contracts and their impact on retail inventory levels and prices. Their research demonstrated that by having the retailers' inventory level information, manufacturers have better position to achieve optimal wholesale price. By use queuing theory and other sophisticated modeling methods in simulations, many research in Operation Management theoretically illustrated the potential value of information sharing in improving the overall supply chain management performance (Cachon and Fisher 1998; Chen, et al. 2000; Lee, et al. 2000). Therefore,

Hypothesis 1. Companies with the greatest extent of information sharing with both suppliers and customers will have the largest performance improvement.

3. Research Methods.

3.1 Data

The data set used in this research came from the 1998 year round of the International Manufacturing Strategy Survey (IMSS). The IMSS collected manufacturing practice and performance data from businesses in the International Standard Industrial Classification (ISIC) Division 38: manufacture of fabricated metal products, machinery and equipment (please refer to Voss and Blackmon 1998, Ettlie 1998 and Frohlich and Westbrook 2001 for more details on the IMSS). The response rate of the 1998 round IMSS is around 20%. The original data collected from 23 countries. Because of the existence of technology gap between developing countries and developed countries, the information sharing practice might not be popular in the developing countries at the time the data were collected. Since there were few variances in the independent variable (information sharing level) among the data from developing countries, we decided to use responses only from developed countries (total sample size is 517). As a result, the generalizibility of the results from this study is limited to the companies operated in the developed countries and in the industry of ISIC division 38.

Due to many missing values of performance measurements in the data set, only 187 of 517 samples are included in this research. Table 1 indicates that the regional distribution of the subset used in this research and original sample are proportionally similar. Furthermore, ANOVA was used to check for significant demographic differences between the subset and the total sample. No significant difference between two groups for size ($p = 0.726$) and ISIC code ($p = 0.451$) were found. Therefore, the use of subset with more completed performance measurements here did not introduce the selection bias.

Table 1 Sample Data by Region

Region	Sample used in this paper		Total survey sample	
	Number	%	Number	%
Asia/Pacific	46	24.6	167	32.3
Europe	108	57.8	268	51.8
North America	33	17.6	82	15.9
Total	187	100	517	100

3.2 Independent Variable

We use eight survey instruments to measure the extent of information sharing with customers and suppliers. The four instruments for suppliers and for customers respectively are: "To what extent do you organizationally integrate activities with your suppliers and customers? 1. Access to planning systems; 2. Sharing production plans; 3. Joint EDI access/network; 4. Knowledge of inventory mix/levels". The measurements are 5 points likert scale, in which 1 is "none" and 5 is "extensive". (See Table 2 for the statistical summary of the measurements)

Table 2. Independent variable measurements (sample size = 187)

Measurements	Customers		Suppliers	
	Mean	S.D.	Mean	S.D.
Access to planning systems	2.0642	1.1714	2.2941	1.1520
Sharing production plans	2.1176	1.2856	2.7326	1.2370
Joint EDI access/network	2.0963	1.2406	2.1658	1.1774
Knowledge of inventory mix/levels	2.1390	1.1602	2.4813	1.1328

Since this research is based on the secondary data, the content validity of the construct is inherited from the original research. First of all, those measurements have obvious face validity. The IMSS survey was designed by many experienced researchers. Moreover, those measurements were grounded in the field and pre-tested for the content validity (Voss and Blackmon 1998, Ettlie 1998 and Frohlich and Westbrook 2001).

The exploratory factor analysis supports that Information-sharing with suppliers and information sharing with customers are two different constructs. The Kaiser-Meyer-Olkin measure of sampling adequacy is 0.694, which is greater than the 0.50 benchmark to adequately use the factor analysis. The Bartlett's test of sphericity (Chi-square=529.4, $P<0.000$) also indicated the data is good for the factor analysis. Reliability analysis shows high internal consistency of each construct. The Cronbach's alphas for "information sharing with customers" and "information sharing with suppliers" are 0.792 and 0.750 respectively. Both are greater than the generally accepted benchmark: 0.70 (Nunnally 1978).

The two by two grouping by high or low value of two dimensions is widely used in business analysis. Based on the two aggregated scores of the four measurements of information sharing with customers and with suppliers respectively, in this research we separated the respondents into four categories. If the respondent's extent of information sharing falls in lower 50% in both customers' side and suppliers' side, it is an "information isolator". If extents of information sharing with both customers and suppliers are in higher 50% range, the respondent is an "information integrator". If the respondent has high level of information sharing (among top 50%) with customers but low level (among lower 50%) with suppliers, it is in "Customer oriented" group; if the opposite is true, the respondent is categorized as "Supplier oriented". Interestingly, the "information isolator" and "information integrator" are both around one third of the whole population. (Please see Table 3)

Table 3. Four categories of roles of information sharing in SCM

		Level of Information Sharing with suppliers	
		Low	High
Level of Information sharing with customers	Low	1) Information Isolator (64, 34.2%)[a]	2) Supplier Oriented (30, 16.0%)
	High	3) Customer Oriented (27, 14.4%)	4) Information Integrator (66, 35.3%)

[a] the first number in the parentheses is the total number of respondents in this category, the second number is the percentage. Total sample size=187.

Although the above two by two grouping criteria is arbitrary, we believe it reflects the major different roles of information sharing in supply chain reasonably well. In order to get further support for this four-category classification, we used two more methods to double-check its viability. First, we use the K-mean cluster analysis to separate the data into four groups. The K-mean cluster membership result is very similar to our original categories (See Table 4). 138 (64+28+20+26) out of 187 samples (74%) fell into the same groups. The correlations between K-mean cluster analysis result and original group membership is 0.836 and significant at 0.01 level.

Table 4 The K-mean cluster analysis result vs. original groups

		Four Groups by K-mean CLUSTER analysis				Total
		1.00	2.00	3.00	4.00	
Original four groups	1.00	64				64
	2.00	2	28			30
	3.00	7		20		27
	4.00		17	23	26	66
Total		73	45	43	26	187

Correlations between K-mean cluster analysis results and group4 is .836**

** Correlation is significant at the 0.01 level (2-tailed).

Secondly, we run the Discriminant analysis in SPSS. The result of discriminant analysis (As high as 89.3% of the respondents was classified correctly) further confirms our four-category classification is a good fit.

Table 5, Classification results by discriminant analysis[a]

			Predicted Group Membership by discriminant analysis				Total
			1.00	2.00	3.00	4.00	
Original group membership	Count	1.00	63	1	0	0	64
		2.00	1	29	0	0	30
		3.00	3	0	24	0	27
		4.00	0	9	6	51	66
	%	1.00	98.4	1.6	.0	.0	100.0
		2.00	3.3	96.7	.0	.0	100.0
		3.00	11.1	.0	88.9	.0	100.0
		4.00	.0	13.6	9.1	77.3	100.0

a 89.3% of original grouped cases correctly classified.

3.3 Dependent Variables

Organizational performance usually can be evaluated from two perspectives: financial performance and operational performance (Venkatraman et al. 1987). Multiple performance dimensions were measured in the IMSS. They are all self-reported business performance improvement comparing to previous year. Among them, two items are related with the financial performance: Profitability and ROI. The operational performance measurements include Inventory turnover rate, Average unit manufacturing cost, Procurement lead time, Delivery lead time, On-time delivery rate, etc. Those operational performance measurements are closely related to supply chain performance.

4. The Results.

We used ANOVA and LSD method to test the differences in the performance changes among the four groups: information isolator (group 1), supplier oriented (group 2), customer oriented (group 3) and information integrator (group 4). Many significant differences were found between different groups (see Table 6 for details). Customer satisfaction level, Inventory turnover rate are highly significant at the 0.01 level. Market share, ROI, Average unit manufacturing cost, On-time delivery rate are significant at the 0.05 level. The profitability and Delivery lead time are marginal significant at 0.1 level. Within four groups, the information integrator group has the highest performance improvement for all the measurements. For instance, the average inventory turnover rate improvement of information integrator group is 22.5%, significantly higher than 11.8% for Isolator group, 11.6% for Supplier oriented group and 7.7% for Customer oriented group (using Post Hoc LSD test). Therefore, Hypothesis 1: Companies with the greatest extent of information sharing with both suppliers and customers will have the largest performance improvement is strongly supported.

Table 6. ANOVA results for performance measures and Post Hoc LSD test results

Performance Indicator	Isolator (1)	Supplier oriented (2)	Customer Oriented (3)	Information Integrator (4)	Significance	Power
Market share	10.6%$^{(4)}$	13.9%	8.3%$^{(4)}$	20.3%$^{(1,3)}$	0.042*	0.67
Customer satisfaction	12.5$^{(4)}$	13.8$^{(4)}$	11.4$^{(4)}$	23.7$^{(1,2)}$	0.012**	0.80
Profitability	12.4$^{(4)}$	15.9	11.9	22.1$^{(1)}$	0.102^{+}	0.53
ROI	11.6$^{(4)}$	12.7	11.1$^{(4)}$	22.7$^{(1,3)}$	0.025*	0.73
Inventory turnover	11.8$^{(4)}$	11.6$^{(4)}$	7.7$^{(4)}$	22.5$^{(1,2,3)}$	0.002**	0.92
Average unit manufacturing cost	10.4$^{(4)}$	8.4$^{(4)}$	9.5$^{(4)}$	20.2$^{(1,2,3)}$	0.033*	0.70
Material and overhead costs	12.1	10.6	7.7$^{(4)}$	17.9$^{(3)}$	0.176	0.43
Procurement lead time	12.0	13.8	9.4	17.9	0.378	0.28
Delivery lead time	10.6$^{(4)}$	16.5	11.7	21.7$^{(1)}$	0.055^{+}	0.63
On-time delivery	14.9$^{(4)}$	15.8$^{(4)}$	15.2$^{(4)}$	26.0$^{(1,2,3)}$	0.025*	0.73

$^{+}$ Marginal significant at 0.1 level
* Significant at 0.05 level
** Significant at 0.01 level

Power analysis is very important for the statistical validity (Baroudi et al. 1989). We included power analysis results in Table 6. For performance measurements identified with significant difference ($a<0.05$), all the power values are reasonably good. In order to control the possible impact of business size, we included size as another independent variable in a separated ANOVA analysis. United States Small Business Administration (SBA) has established a size

standard for most industries in the economy. The size standards for small businesses are: less than 500 employees for most manufacturing and mining industries (www.sba.gov). Therefore, we divided the business size into two groups: small businesses (employees <500) and large businesses (employees >= 500). Excluded the missing value, the number of small businesses (88) and large businesses (82) are quite similar. In all new ANOVA analysis including size as control variable, no significant interaction effect between size and information sharing group factor was found, neither was any significant main size effect found. And the results on the information sharing group variable were very similar to the original results showed in Table 6. We also did the multiple regression with dummy variables representing the four categories. We got the same significance result as ANOVA. But in multiple regression, those categories did not account for a significant size of variances in most cases. This results is expected because business performance is a complex construct determined by many factors, the information sharing in SC alone should not explain a big amount variances of the business performance.

5. Discussions and Future Research.

This research is the first attempt to empirically analyze the business value of information sharing in SCM by using large sample survey data. The results illustrate that the greater level of information sharing with both suppliers and customers is positively associated with higher financial and operational performance improvement. We believe this research has both theoretical contribution and practical significance. Although no causal relationship can be claimed in this research, the empirical finding provides evidence to support previous theoretical argument that the adequate use of inter-organizational information sharing in the supply chain management could create value for the organizations. (Lee et al 1997, 2000; Cachon and Fisher 1998; Chen, et al. 2000). And the result shows interesting patterns asking for further investigation. For example, when we look at the group means of different performance measurements, customer oriented group has worst performance improvement in most cases. Supplier oriented group outperform information isolator group in most cases. Although statistically the ad hoc HSD test did not find any significant differences among those three groups, the above patterns need further research attentions. From practice perspective, this research also delivers a strong message to business managers: information-sharing practices could make considerable differences on business performance; keeping supply chain information private might not be a good strategy; and finding the right mechanism to exchange the information from both the upstream and downstream supply chain partners would benefit the business.

This research has some limitations. The quality of the research is constrained by the quality of the data used in the research. This research based on secondary data and ANOVA. The cross-sectional data were only collected from businesses in the ISIC Division 38: manufacture of fabricated metal products, machinery and equipment. The response rate around 20% is not high. And there were a lot of missing values in the data set so that we had to exclude many responses. All these factors limited the internal validity (ruling out the rival explanations) and external validity (the generalizibility). Therefore, we did not know whether this research result could be applied to other samples or extended to business in other industries. Another limitation of the data is the self-reported performance improvement measurements. Measuring independent variable and dependent variable in the same survey introduces Common-method variance. Although (Venkatraman et al. 1987) found high correlation between objective performance measurements and self-reported measurements, objective measurements are still good things to have. If we could have absolute value of

performance measurements, it would provide more straightforward performance comparisons.

The data used in this paper was collected in 1998 and only focused on manufacturers in one ISIC division. Business environment and practices may be changed in the past 6 years. To better understand the phenomenon, further research should be conducted. On one hand, we need to extend the research horizontally by surveying different industries. On the other hand, to better understand the role of information sharing in the whole supply chain, we need to expand the research scope vertically: including the whole seller, retailer, and raw material suppliers. New technologies are emerging to facilitate the information sharing in the supply chain management. For instance, the latest development of passive radio frequency ID (RFID) provides a great potential to track each single item in the supply chain with very low cost. However, history clearly tells us the technology itself is not a "silver bullet" to automatically solve any problem. The organizational issues in the inter-organizational information sharing is much more complex than the technology. Therefore, another important direction for future research is trying to find out the underlying logic how and why such phenomenon happened. Inter-organizational information sharing should be mutually beneficial. But in reality, how to split the benefit between all parties? What's the good incentive mechanism to facilitate the information sharing across firm boundary? Why businesses choose a specific pattern of information sharing?

Several theoretical perspectives can be incorporated into this future research direction. From information economics perspective, Information has value and it is business' asset (Brynjolfsson, 1994). Information asset is different from physical assets in terms of its duplicability. You can get the "same" information asset by fairly inexpensive "coping" from the original one. This property provides information asset some uniqueness. How to contract the information asset ownership is an interesting issue in the inter-organizational information sharing.

In the strategy research, both suppliers and customers are important entities in the I/O school's environmental analysis. They are two major players in Porter's five forces framework. Supply chain partners have competition-cooperation relationships. On one hand, they all want to grasp the lion share of the overall benefit of the supply chain. That's why players hold the choke point position in the supply chain often have the power to "exploit" their upstream and/or downstream partners. On the other hand, they need to find a dynamic balance between self-optimum and overall supply chain optimum, because more or less their long term success depends on supply chain partners. How the power dynamic influences the information sharing activities is still an unclear picture.

As we mentioned in the early part of this paper, inter-organizational information sharing has not received enough attention in IS research. This paper is an exploratory research on this topic. We hope more and more IS researchers pay attention to this research area and work together for the challenge.

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