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Abstract

Supply chain integration is one of the key vocabularies in supply chain management research. Supply chain integration seems to be a 'must-have-virtue' in supply chain literature. The effective and efficient management of supply chain requires integration of business processes internally within a firm and externally across suppliers and customers. Benefits of supply chain integration have been widely researched and confirmed by a lot of research results. They include maximization of supply chain performance, reduction of ordering cost, cycle time, inventory level, business uncertainty, to just name a few. However, to discuss the benefits of integration, it becomes necessary to define range of integration. This range depends not only on the nature of business and product, but also on the competitive environment. In this paper, we examine SCI focusing on different range of integration. More concretely, we will compare 3 steel firms' integration strategies, 1 in Japan and 2 in South Korea, and will compare what brought those differences in SCI range and patterns.

Keywords: supply chain integration, flexibility, uncertainty, steel industry

1. Introduction

The term ‘integration’ is one of the key vocabularies in supply chain management research. The effective and efficient management of supply chain requires integration of business processes internally within a firm and externally across suppliers and customers. Supply chain integration can be defined as a process of interaction and collaboration in which firms in a supply chain work together in a cooperative way to get mutually acceptable outcomes (Pagell, 2004). Benefits of supply chain integration (SCI) have been researched and confirmed by a lot of research results. They include maximization of supply chain performance, reduction of ordering cost, cycle time, inventory level, business uncertainty, to just name a few. And some other researchers tried to examine the benefits of SCI from the perspective of diversification and competitive performance (Narasimhan and Kim, 2002).

According to Sabath (1995), non-integrated supply chain has at least two critical disadvantages. First, at each echelon backwards in the supply chain, forecast accuracy will decrease because of the increase in demand uncertainty as a result of the disconnected information flows. Second, non-integrated supply chain usually reacts slowly to demand changes because business processes are not seamlessly linked. And the disconnection across supply chains is one of the main factors which cause bullwhip effect (Lee et al., 1997).

To discuss the benefits of integration, it becomes necessary to define range of integration. This range depends not only on the nature of business and product, but also on the competitive environment.

In this paper, we examine SCI focusing on different range of integration. More concretely, we will compare 3 steel firms’ integration strategies, 1 in Japan and 2 in South Korea, and will compare what brought those differences in SCI range and patterns.

2. Literature review and theoretical framework

SCI seems to be a ‘virtue’ in supply chain literature. That is, SCI is required internally within and across functions, as well as externally across suppliers and customers. And other types of integration include vertical integration and virtual integration. Virtual integration is the integration across suppliers and customers based on long term collaborating relationship rather than governing by capital.

To consider all different types of SCI, this paper has included internal integration, external

integration, vertical integration, virtual integration and customer integration.

2.1 Types of Supply Chain Integration

It is necessary to integrate all the supply chain players for the effective management of all the supply chain internally and externally (Vlachos et al., 2008). For this supply chain integration, integrating capability of supply chain should be considered in all supply chain networks (Bidhandi, et al., 2009; Braunscheidel & Suresh, 2009; Flynn et al., 2010; Zhao et al., 2011; Park & Hong, 2012). In particular, the capability to seek the right partners for the supply chain integration for the integrating knowledge within the supply chain network and directing the goals of the supply chain network is extremely crucial (Erhun et al., 2008; Singh and Chand, 2009; Meehan and Bryde, 2011; Tomino et al., 2012). All key supply chain stakeholders such as the suppliers, manufacturers and customers need to be integrated with each other using synchronization of supply chains (Singh and Chand, 2009).

First, internal and external integration are necessary for SCI. Internal supply chain process involves multiple functions within companies such as product development, production, distribution and sales. It is obvious that a company's performance would be enhanced by the integration of these functions. Even though, there has been no consensus on how integration is to be defined, Basnet (2013) suggests three dimensions of internal integration were identified, that is, coordination, communication, and affective relationship.

Second, vertical integration is also essential for SCI. Virtual integration is the integration across suppliers and customers based on long term collaborating relationship rather than governing by capital. The enabling factors for supply chain integration include not only integration of internal functions, but also extension beyond organizations' boundaries incorporating their whole supply chains (Vlachos et al., 2008; Meehan and Bryde, 2011; Tomino et al., 2012). Relating to vertical integration, virtual integration can be mentioned. For example, Michael Dell has sought how to combine the individual pieces of the strategy-customer focus, supplier partnerships, mass customization, just-in-time manufacturing. Technology is enabling coordination across company boundaries to achieve new levels of efficiency and productivity, as well as extraordinary returns to investors. Magretta (1998) defines that virtual integration harnesses the economic benefits of two very different business models. It offers the advantages of a tightly coordinated supply chain that have traditionally come through vertical integration. At the same time, it benefits from the focus and

specialization that drive virtual corporations. The initial business model within the computer industry essentially had to create all the components themselves. They had to manufacture disk drives and memory chips and application software; all the various pieces of the industry had to be vertically integrated within one firm. As a small start-up, however, Dell couldn't afford to create every piece of the value chain. He thought it was better off to leverage the investments others have made and to focus on delivering solutions and systems to customers. Through collaboration and utilization of a variety of supply chain players, virtual integration can be attained.

2.2 Factors Affecting Supply Chain Integration

There are a number of factors affecting SCI and this is another stream of research. Uncertainty has been identified as one of factors. As explained by the Transaction Cost Theory, high level of business uncertainty tends to drive firms towards a vertical integration strategy (Williamson, 1975). Dealing with uncertainty has been one of the critical issues also in business strategies field (Barney, 2002). It is particularly important under conditions of high uncertainty to retain 'flexibility' as strategic alternatives. When there is no uncertainty, in this setting, a firm can apply the strategic tools to anticipate the competitive implications of its decisions. In this setting (no uncertainty), retaining flexibility is unnecessary. However, in the real world, uncertainty is a main reason for a firm to think and act strategically.

Flexibility does not come without costs. As previously mentioned case, indeed in that extreme case, if there are any costs associated with retaining flexibility, not retaining flexibility will be preferred over retaining flexibility. Because there are significant costs associated with implementing a strategy of flexibility, an important question becomes balancing costs related to retaining flexibility and relaxing environmental uncertainty as total.

Before we move to SCI as a strategic alternative, defining 'flexibility' is required. According to Upton(1994) and Simchi-Levi(2011), flexibility is an ability to respond to change without increasing operational and supply chain costs and with little or no delay in response time. In this definition, change refers to change in demand volume and mix, commodity prices, labor costs, exchange rates, technology, equipment availability, market conditions, or the production and logistics environment. And this definition includes the three keywords which are change, cost, and time. Ceteris Paribus, implementing flexibility should help the firm reduce long run operational costs or improve response time or both. The flexibility gained can create a source

of competitive advantage by improving along multiple dimensions. They can be operational cost, response time, service levels and ultimately customer experience.

In retailing, flexibility cures a merchant's two biggest headaches: having too little of the right products and too much of the wrong ones(Fisher, 2010). The grocery industry has formulated a concept called CPFR(collaborative planning, forecasting, and replenishment) that offers guidelines for cooperating to forecast demand and plan supply. Also retailers in other industries can work with their suppliers to create the some sort of flexibility. Our definition focuses on the fact that 'flexibility comes at a cost'. Flexibility is a strategic option to respond to change. And this 'change' is uncertainty a firm recognize, which means this change may occur under the certain circumstances but we do not know exactly when it occurs. A firm can respond to uncertainty by SCI.

The most important question is that 'how much flexibility a firm needs'. Creating a flexible supply chain requires a big commitment of effort over a long period of time. As Simchi-levi(2011) pointed out, long supply chains perform better than many short supply chains because they 'pool' more plants and products and thus deal with uncertainty more effectively than short chains. In our discussion, longer chain can be translated into SCI from a manufacturer, distribution centers, and forward, possibly customers too. According to Jordan and Graves(1995), flexibility can be achieved through system design. If each plant is focused upon on one product family, plants typically are far from market demand, which increases costs. Though this system design concept is based on plant and product, we think longer chains from a different point of view, SCI. This discussion leads us to SCI as an important strategic tool.

2.3 Supply Chain Integration as a strategic alternative

Two keywords, flexibility and uncertainty in supply chain literature have broad meaning. We will look into those two concepts briefly to develop suitable definition.

It is already widely known that uncertainty is not equal to risk. Risk is only a part of uncertainty when it comes to results. From the perspective of SCI, especially the need to integrate across supply chain, uncertainty can be translated into uncertainty of both demand side and supply side. For example, uncertainty of demand side includes changing price and quantity of products as results of negotiation with customers. And uncertainty of supply side means changing or fluctuating price and quantity of parts or raw materials from suppliers.

For those uncertainties, the actions a firm takes can create more than one type of flexibility. One of the costs associated with retaining flexibility may be the limited ability to differentiate one's products or services. In a supply chain, typically 'flexibility' can be understood as number of channels through which a firm sells its products, number of products, and of course, number of customers or suppliers.

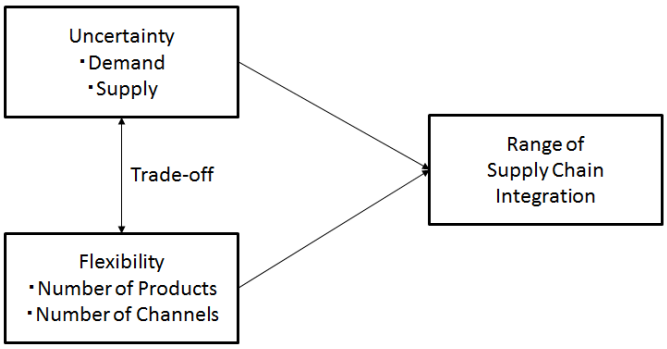
The important part of this uncertainty and flexibility, not all firms recognize their uncertainty in the same way and take strategic alternatives. And that means not every firm recognizes the same cost required for flexibility. Some firms prefer longer supply chains over short chains even though it entails more costs.

Longer supply chain, by which we mean SCI across supply chain members, sometimes requires huge investment. In extreme case, a manufacturer vertically integrates distribution centers, and customers themselves. Longer supply chain possibly contributes to mitigating the uncertainty 'that firm recognizes' but because this type of SCI dedicates to a few customers, it brings low flexibility. In some cases, it causes 'lock-in problems', because a manufacturer is dedicated to certain customers. Compared with this, shorter supply chain has advantages in investment costs(fewer investments in SCI) and flexibility in numbers of distribution channels, however, this type of supply chain can be more vulnerable to uncertainty(change in demand volume and mix).

2.4 Research Framework

Overall review indicates that high level of uncertainty tends to drive firms towards a vertical integration strategy, and high level of flexibility requires more investments. The key question to answer is what determines the range of supply chain integration. In other words, the level of uncertainty a firm recognize can bring the different range of SCI to deal with uncertainty. The problem is that more integration of supply chain, which means a longer supply chain is directly related with less flexibility since it requires more investments in vertical integration and sometimes lock-in problems. Uncertainty has a trade-off relationship with the cost of flexibility and because firms' balancing between uncertainty and flexibility are strategic options, there can be various ranges of SCI. Fig. 1 depicts our research framework and in next section we will look into three types of SCI in steel industry.

<Fig. 1 Research framework>



3. Case Studies

In this section, we will elaborate on 3 case studies of steel companies in Korea and Japan, and compare those companies, more concretely three different types of SCI.

The supply chain of steel industry is typically very long, time consuming and has complicated structures. Since it deals with heavy weight products, division of works and cooperation among supply chain members are important. We focus on supply chain members of steel industry which are a steel manufacturer, a steel processing center, and a customer. The data collection for this research is carried out through a series of semi-structured interviews and field research. Table 1 shows profiles of case study companies.

<Table 1. Profiles of the three case study companies>

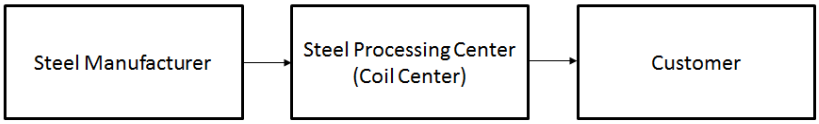
Company	Nationality	Position in supply chain	Established	Production volume(million tonne as of 2014)
POSCO	South Korea	steel manufacturer	1968	41.4
Hyundai Steel	South Korea	steel manufacturer	1953	20.6
NSSMC	Japan	steel manufacturer	1934	49.3

Before we move to case studies, it is worth to take a look at supply chain structure of steel industry. As Fig 2 Shows, in a supply chain of steel industry, there are three supply chain

members which are a steel manufacturer, steel processing centers(or coil centers) and customers such as automobile manufacturers, ship building companies, construction companies, etc. Of course, before steel manufacturers, there must be suppliers who supply the raw materials to make steel, for example, iron ore and coal. Out of those three supply chain members, steel processing centers may require more explanation.

Steel processing center plays the role of push-pull boundary point because steel manufacturer switches its supply chain strategy at this point. The portion of supply chain prior to steel processing center operates based on the push supply chain strategy. To minimize cost and maximize efficiency, a steel manufacturer pushes out its products based on long-term demand forecast to this point. In this stage, finished goods are not yet done in physical shape from customers. Customer demand for a specific end product typically has higher level of uncertainty than aggregate demand. Demand for the generic product is an aggregation of demand for all its corresponding end products, forecasts are more accurate, and inventory levels are reduced. The differentiation in steel product's physical shape (size, width, length, etc.) is delayed until there are requests for those specifications. Thereby manufacturers deploy push supply chain strategy by the point of steel processing center, and then steel processing centre employs pull supply chain strategy by coordinating with true customer demand rather than forecast demand. Automobile manufacturers request processing service to fit to their specific size, width and length. Hence, from steel processing center, steel manufacturer's supply chain strategy shifts over to pull strategy. As soon as automobile manufacturer orders certain specs, then steel processing center starts processing steel coils to specific shape like doors of a car. In this stage, steel manufacturer's objective is also changed over maximizing service level, that is, responsiveness and order fulfilment. If customer's production is just-in-time system based, steel processing center should focus on responsiveness. Steel processing center as push-pull boundary is depicted schematically in Fig 2.

<Fig 2. Supply Chain Structure of Steel Industry>



3. Case Studies

3.1 NSSMC

NSSMC(Nippon Steel and Sumitomo Metal Corporation) is a Japanese steel manufacturer and one of the oldest in Asia. With its long history(the company established in 1934, however its business started around early 1900s) and reputation in high quality products, most of Japanese automobile manufacturers including Toyota has long been its main customers.

NSSMC has very strong reputation in high grade steel, for example, steel sheets for automobiles and electronic appliances(hot-dip coated steel sheets, electroplated steel sheets, electrical steel sheets and etc.) and steel plate for shipbuilding(Thermo-Mechanical Control Process etc.) . However, NSSMC's products are not constrained to high grade ones, it has almost a full spectrum of steel products a steel manufacturer can have. In addition to steel plates and steel sheets, NSSMC manufactures bar and rod materials, structural steels, pipe and tubes, titanium, stainless steel and even steels for rail ways and machinery parts.

From the point of view of supply chain structure, NSSMC is a highly focused manufacturer, literally it focuses in manufacturing not in steel processing centers(coil centers). Distributions and processing of steel products are not main jobs of NSSMC although there exist high level of cooperation among supply chain members, Japanese trading companies own and operate processing centers. Almost no vertical integration can be observed in NSSMC's supply chain, but high level of partnership and cooperation among supply chain members known as 'virtual integration'(Byun & Lee, 2015).

From flexibility point, full spectrum of product lines brings high level of flexibility. NSSMC can possibly respond to most of demand mix. And also, since there are many supply chain partners of distribution and processing, complicated distribution channels leads to many customers regardless which industries they belong.

NSSMC's strategic choices are keeping high level of flexibility in product mix to deal with demand uncertainty and almost no supply chain integration(at least no or very few capitally integrated one).

3.2 POSCO

POSCO(Pohang Iron and Steel Company) is the biggest steel manufacturer in South Korea and as of 2014, POSCO is the 5^{th} biggest steel manufacturer in the world. Manufacturing quality steel products is not the only management purpose of POSCO. What POSCO is

emphasizes is ‘solution marketing’ which means that POSCO supplies not only products but also ‘how to use them’ knowledge to customers. To do this, POSCO deploys most of processing centers nearby customers manufacturing sites in overseas market. Placing own processing centers nearby customers has couple of strategic importance and this also contributes to differentiate POSCO from other steel manufacturers. It requires vertical integration from POSCO to processing centers but POSCO can listen to customers’ voices and feedbacks directly and applies this valuable information to product development and quality improvement. Second, it also contributes to lower product price since there exist no commission fees for the 3rd party of processing and shorter delivery time due to direct monitoring on production process.

From flexibility point, since POSCO vertically integrates processing centers around world(almost 50 processing centers around worlds exist, mostly in China, Japan and ASEAN area), distribution channels are quite focused on specific markets and customers. Product mix is almost same level or slightly less than NSSMC.

3.3 Hyundai Steel

Hyundai Steel is one of the youngest steel manufacturers in the world, but its growth in steel market is worthy of attention. Since it started making iron and steel from 2010, Hyundai steel became the 14th biggest steel manufacturer in the world as of 2014. There can be two explanations for this. The first one is that Hyundai Steel is a ‘completely’ vertically integrated steel manufacturer. It owns steel processing centers as well as customers, Hyundai automobile, Hyundai construction and other Hyundai group companies. Though Hyundai Steel is not capitally related, Hyundai Heavy Industry is another huge customer of steel plates for shipbuilding. This ‘already-there-customers’ is the powerful source of stable operation of steel manufacturer, and also it’s been one of the ideal condition not only from steel manufacturer but also from automobile manufacturers. This reminds us of Ford who was once totally integrated company from steel, glass, rubber to automobile manufacturing. The second explanation for the rapid growth of Hyundai Steel is that it focuses on certain products(at least for the time being). Steel sheets for automobile and steel plates for shipbuilding and construction are main product mix.

From flexibility point, Hyundai Steel is highly focused to its specific customers, which means almost no other customers. In that meaning, flexibility is the lowest of three case study

companies, and there exists ‘lock-in problem’. Hyundai Steel has longest supply chain, highest level of SCI and as a result, lowest uncertainty in demand. To deal with this low flexibility, Hyundai Steel is focusing on certain product items and targets of maximizing production efficiency.

3.4 Summary of Case Studies

Table 2 summarizes our finding in case studies. First of all, when it comes to the range of SCI, Hyundai Steel is totally vertically integrated. Its SCI covers manufacturing, processing and distribution and customers. On the other hand, NSSME’s SCI is minimal. It only has manufacturing function and other supply chain members work cooperatively. In the middle position, POSCO comes. POSCO’s SCI stops at processing centers.

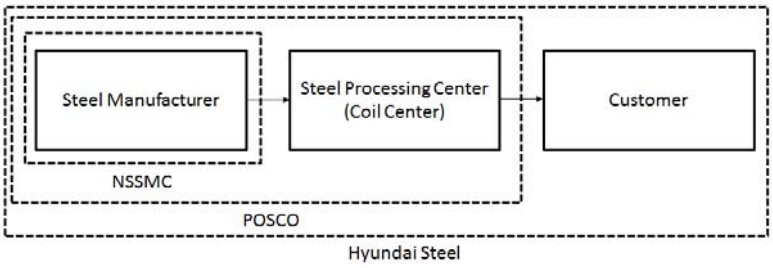
Secondly, we can summarize the level of flexibility in two points, one is the product number and mix, the other is the number of customers. Compared with other two steel manufacturers, Hyundai Steel’s customers are very limited, Hyundai affiliated companies. This can be the source of lock-in problem. To deal with this low flexibility, Hyundai Steel strategically concentrates on certain products to maximize production efficiency. On the other hand, NSSMC has full spectrum of products and various customers, which we translate into high flexibility, however definitely this strategy has higher uncertainty in demand than Hyundai Steel’s case. POSCO has as many products as NSSMC or less than it, and the number of customers is alike. Fig 3 compares the range of SCI among three companies.

<Table 2. Summary of Findings>

	range of SCI	number of customers	number of channels	number of products
NSSMC	minimal(almost no integration with other supply chain members)	various	various(trading companies’ steel processing channel)	highly diversified
POSCO	moderate(vertical integration of steel processing	various or moderate	moderate(own steel processing	moderately diversified

	center)		channel)	
Hyundai Steel	wide(total vertical integration)	Hyundai affiliated	limited	limited(on purpose)

<Fig 3. Comparison of SCI in the three steel firms>



4. Implications

How much flexibility is enough for a firm? To answer this question, one should consider three keywords in the same context as well as at the same time in supply chain; flexibility, uncertainty and integration. And there exists trade-off relationships between the cost of flexibility and uncertainty. The question ‘how much flexibility a firm wants’ is the same question of ‘how much uncertainty a firm recognizes’ and those answers depends on strategic choice of that firm. As a result, that strategic choice shapes and determines the range of SCI as we have seen in three companies.

Without question, SCI is one of the most important management issues in supply chain literature. It almost sounds like ‘must-have-virtue’ in this research stream, but what is more important is that the explanation for different types of SCI, even in the same industry. Balancing supply chain flexibility and uncertainty comes at a cost, and like we reviewed, Ford-reminding vertical integration can be also a strategic result. Though they are not all, this paper contributes to explain some of the important determinants of the range of SCI, and this can be applied to other industries.

Of course, the benefits of SCI have multiple dimensions. Though this study considered flexibility and uncertainty only, there also can be response time, service levels, and ultimately customer experience. Those keywords lead to future research.

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