Supply Chain Collaboration - Next Steps and Beyond

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Abstract

Collaboration in supply chain is looked upon as the need of the hour. It focuses on the coordination and integration of processes between the partners of supply chain. Collaboration has further been extended to explore possibilities of integration between members of parallel supply chains. The extant literature suggests that supply chain collaboration has multiple benefits. It can help organisations acquire market intelligence and achieve economies of scale. The present paper analyses the different types of collaborations on the basis of current practices in the industry. Developing on this, it further elaborates on the areas within supply chain that can be explored for collaboration. The paper later showcases mathematical models for vertical and horizontal collaboration where it can be concluded that collaboration can have positive effects on collective profit of the partners. Horizontal collaboration is only seen from a viewpoint of manufacturing and much is still there to be explored in this field. The paper finally concludes by reiterating the fact that proper contracts must be in place while firms pursue collaboration. The paper also suggests a model on which a collaboration contract can be formulated.

Keywords: Vertical Integration, Horizontal Collaboration, Supply Chain, Contracts, Manufacturing, Logistics

Introduction

A number of challenges are being faced by supply chains today. The world has become a consumer-driven economy and there is a continuous demand for new products. Hence, continuous innovation is desired in order to make the existing supply chain more and more effective as suggested by Toby Brzoznowski, co-founder & EVP – Michigan-based supply chain design firm. Speaking to Inbound Logistics, he highlighted that evolution in supply chain today has become an integral part of business and this is where design is integrated into supply chain management as one of its pillars (O'Reilly, 2015). To keep pace, manufacturers need to innovate and keep pace with the fast progressing technology. Manufacturers, even competitors can collaborate to mutually help each other in R&D and innovation. According to Katz (1986), collaborations among product market competitors may result in firms reducing their R&D expenditures because each firm's research contributions lower its partner's or rival's costs. Manufacturers can even cater to larger demands by collaborating. The benefits achieved from these collaborations are economies of scale through larger volumes shipped and better customer service (Shepperd and Seidman, 2001). One of the major objectives of supply chain collaboration is reducing uncertainty via transparency of information flow.

Majority of the supply chain systems are affected as there is lack of information sharing while in some cases, manufacturers forget the capabilities of their suppliers ending up either under-estimating or over estimating forecasted demand. The most common problems faced by Logistic Service Providers (LSP) are low capacity utilisation, empty haulage and declining profit margins (Verstrepen, Cools, Cruijssen, & Dullaert, 2005). It is also mentioned that the main causes for such problems are the stiff competition in global markets, high fixed costs, rising fuel and labour prices, the entry of products with shorter life cycles and the ever increasing expectations of consumers. Through horizontal collaboration, the LSPs aim at increasing productivity directly affecting the KPIs mentioned above to increase the competitiveness of and

reduce losses from their logistics networks (Cruijssen & Dullaert, 2005). DHL, in its white paper titled "Horizontal Collaboration in Healthcare Supply Chain" suggests that if a supply chain does not present a specific market opportunity, then companies should avoid investing additional funds in this area; implying that activities can be outsourced to third party.

Background of the Study

The financial crisis faced by the global economy in the years 2008-2010 (Hoberg & Alicke, 2014), short product life cycles of today (Horn, 2012), highly competitive global markets (Kale, 2007) and sky high expectations from customers have somewhat caused organisations' profit margins to shrink. In order to avoid shrinking profit margins, organisations today are left with one way to go and that is reducing costs. Organisations today are looking at decreasing costs of non-value adding activities, such as distribution and warehousing which necessitates redesigning of the logistics processes. In doing so, the most fundamental choice that organisations face is whether to outsource, keep logistics in-house, or seek collaboration with like organisations to exploit economies of scale or synergies (Razzaque & Sheng, 1998). Organisations now realise the importance of transforming traditional supply chains from linear, sequential processes into adaptive supply chain networks. Here, consortia of customer centric, demand-driven organisations share knowledge while adapting intelligently to changing market conditions and responding proactively to shorter, less-predictable life cycles (Supply Chain Collaboration: The Key to Success in a Global Economy, SAP). An adaptive supply chain has the ability to change its behaviour for preservation of KPIs, their improvements or acquisitions of new characteristics for the achievement of supply chain goals in the changing conditions of environment while relying on information which is generally incomplete (Ivanov, Sokolov, & Kaeschel, 2009). As shown in Fig. 1, an adaptive supply chain is superior to the traditional linear supply chain through its agility which is brought in by its responsiveness and a technological platform for receiving feedback from its customers. Further, it showcases better sustainability by focussing to build longer product lifecycles.

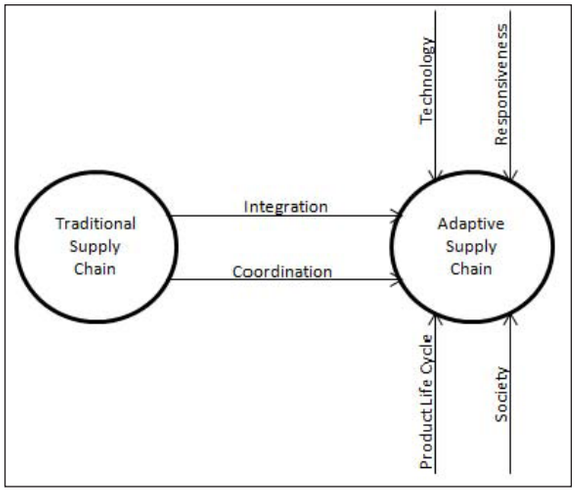

Fig. 1: From Traditional to Adaptive Supply Chain (Adapted from Ivanov *et al*., 2009)

In supply chain collaboration, organisations that are part of the same supply chain or parallel supply chains come together and share information, resources with a view to innovate and reduce costs. Collaboration can help drive market share, sales, and product adoption. It can also maximise your return on assets and return on investment. Supply chain members must work as a team. All the members need a clear set of objectives that they can focus on, but their actions have to be coordinated towards the overall supply chain goal. Having an extremely efficient player will not make other members of the supply chain efficient and lack of coordination or effort can easily hamper performance of the system.

Motivation for the Study

Today, an intriguing question is waiting to be answered by industries working towards maximising efficiencies of their supply chain performance. A supply chain consists of a number of organisations. For a supply chain to be efficient overall, will it work if only one member of the supply chain network is efficient? Or is it mandatory for all members of the supply chain network to be efficient? In line with these questions, there are manufacturers today who showcase efficiency by having optimum inventory levels and excellent productivity; but all this is often done at the cost of their suppliers. A classic example would be a Vendor Managed Inventory (VMI) system in vendor's premises located close to the manufacturer. The

manufacturer in this case will have minimum inventory levels for the raw material, but what about the supplier? The manufacturer surely has succeeded in reducing its inventory level but the inventory in the supply chain is still high. Organisations today have to look beyond such agreements and collaborate to form a synchronous supply chain where there is sharing of information. A collaborative environment can provide an organisation the visibility of its performance as well as its partner's performance.

The effectiveness of supply chain collaboration can be said to be directly proportional to the level to which internal and external operations are integrated and the level of efforts that are invested in aligning the supply chain variables in terms of the geographical dispersion, the demand pattern and the product characteristics (Holweg, Disney, Holmström, & Småros, 2005). Collaboration in the supply chain has a common goal: to create a transparent, visible demand pattern that runs the entire supply chain. The best example showcasing success of vertical collaboration would be the Japanese manufacturing model which is largely attributed to their collaborative approach and tight integration of suppliers in Just-in-Time systems (Liker & Wu, 2000).

Some examples of changes brought about with respect to manufacturers are reducing inventory levels in stores, defining standard operating procedures to reduce errors and re-work, outsourcing fabrication to expand manufacturing capacity and collaborating with third party for equipment configuration and servicing. However, it is now time to look beyond just process improvements. The paper is motivated towards reduction of operating cost through a collaborative supply chain. It would be apt to say that an organisation cannot do everything; at least it cannot do everything optimally. For this, it is essential for any organisation to find suitable partners who can provide niche assistance at the minimum cost with minimum resources.

Outline of the Study

This section is generally about introduction of the topic and the need for research in the field of collaboration. It sets the framework for the paper while the second section will mainly highlight the research conducted with respect to the journals and books referred. It will convey the implied ideas of a number of authors in their work on studying collaborations between organisations. The third section will stress of types of collaboration and also the current scenario in the industry. It will also include the possible opportunities that can be exploited in this field to mutual benefit of partners in collaboration. The fourth section will showcase a mathematical model of a collaborative supply chain system using which the key advantages of collaboration will be highlighted. Conclusion of the paper will be presented in the fifth and final section along with final proposition.

Literature Review

Basic Concepts and Definitions

Supply Chain

The term "Supply Chain" is composed of the words - supply and chain. Supply refers to meeting the demand in the market while chain refers to the link formed to connect the raw material suppliers downstream towards the consumer market. Chopra and Meindl (2007) defined supply chain so as to include every party directly or in-directly involved in fulfilling a customer request. This would include the raw material suppliers, manufacturers, distributors, customers and the logistic service providers involved in connecting the abovementioned entities. As shown in Fig. 2, a typical supply chain starts with obtaining raw materials generally from nature. These are then transported to component supplier for manufacturing sub-components of the final product. The sub-components are converted into the final product which reaches the consumer market either directly or through distributors. There is logistics involved in between every stage of the supply chain as depicted in Fig. 2.

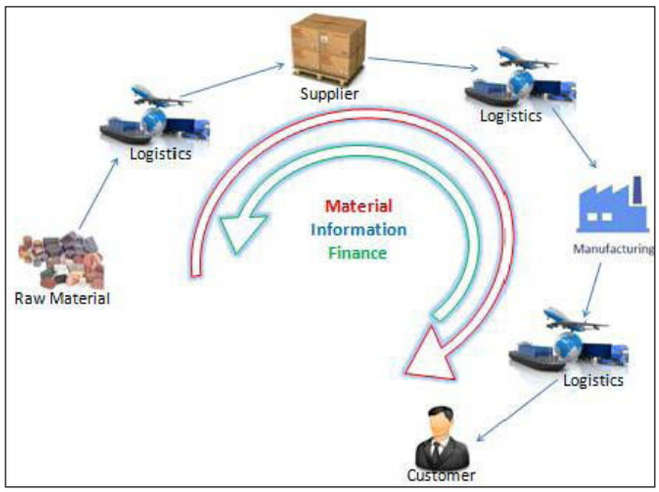

Fig. 2: A Typical Supply Chain

Supply Chain Management

Supply chain management is related to transporting goods from the raw material stage to the consumer (Zigiaris, 2000). It is a set of approaches utilised to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that final product is produced and distributed in the right quantities, to the right locations and at the right time in order to minimise on the system-wide costs while satisfying service level requirements (Simchi-Levi, Kaminsky, Simchi-Levi, & Shankar, 2008. Supply chain management is an overview of the flow of material, information and finance in between suppliers, manufacturers, distributors and customers inclusive of the logistics involved to connect the different parties. The flow of material is downstream from raw material extraction to delivering the final product to the consumer. Finance flows upstream from the consumer towards the raw material suppliers. Information generally flows in both directions.

Collaboration

Collaboration includes two or more independent companies that partner to achieve more profits and to guide the operations toward common goals (Ince & Ozkan, 2015). As defined by Cruijssen, Dullaert, and Fleuren (2007), collaboration is an alliance of multiple companies that offer their products or services in a specific sector of industry against collective tariffs and identical service levels. While Liao and Kuo (2014) defined supply chain collaboration as a collective process which depends on numerous interactions within an organisation. The authors also added that collaboration also involves organisation's relationship with its external environment, including suppliers, customers, governing agencies and training bodies.

Types of Collaborations

Simatupang and Sridharan (2002) mentioned that collaboration can occur in many ways and it is generally characterised by its structure: vertical, horizontal, and lateral. Vertical collaboration in simple terms is an integration of manufacturer with suppliers as well as the customers where sharing of information and others resources is essential between the members for each of their mutual benefit (Argus, 2010). Horizontal collaboration means to cooperate across the supply chain rather than along it and this partnership can be composed of both competing as well as non-competing organisations (Bjornfot & Torjussen, 2012). Lateral collaboration is observed when organisations are involved in a combination of vertical as well as horizontal collaborations to gain more flexibility (Kumar, Banerjee, Meena, & Ganguly, 2017).

Framework for Collaboration

There is extant literature that stresses upon the importance of diversity in nature of the firms that collaborate. It has been highlighted that in case the collaborating partners' technological bases are similar, it can actually have a negative effect on learning and innovation. It could also result in stagnation of technological development, in the sense that similar knowledge bases limit the chances of innovation or new market possibilities (Knoben & Oerlemans, 2006). Alliances with partners having a dissimilar knowledge base will provide firms access to diverse information and knowledge which could be independent of the structure of its local network (Phelps, 2010). Diversity in technological knowledge bases can be an important condition to collaborate in R&D since it can allow partners to explore new and distinctive resources and capabilities (Petruzzelli, 2009). The exposure to partners' different cognitive and technological frames may actually yield novel insights, as firms would benefit from "external economies of cognitive scope" (Nooteboom, 1999). Funding gains from alliances are likely to be higher where collaboration partners have different kinds of resources which are able to provide a wider spectrum of services to their clientele (Arya & Lin, 2007).

Authors have given their suggestions regarding the type of industries that would be inclined to collaborate as against the ones that might be averse to. Levin, Klevorick, Nelson, and Winter (1987) noted that firms in industries with weak property rights tend to favour trade secret rather than patents to protect their intellectual assets, whereas firms in industries with strong property rights tend to use relatively more patent protection. This argument implies that firms in former type of industry might be less likely to collaborate as it is difficult to protect their intellectual property when compared to the firms in the latter type of industry. Talking about having appropriate contracts in place while collaborating, Majewski (2008) noted that the concerned firms while considering involvement in collaboration should study the anti-trust laws of the nation and have a contract in place to leverage the national policies but also cautioned that the same anti-trust laws might not be applicable outside the national boundaries.

There is extensive literature that mentions trust as one of the most important criteria for successful collaborations and that there is more to collaboration than just sharing information, revenue and risks. One of the primary assumptions for existence of trust in an alliance is that the chain members interact repeatedly with each other (Sridharan & Simatupang, 2013). Boyce, Mano, and Kent (2016) stress that one of the most critical aspects of supply chain collaboration is the dimension of trust and commitment. Arsenyan, Buyukozkan, and Feyzioglu (2011) suggest that implication of collaboration goes beyond just sharing of revenues and also engenders knowledge sharing and innovation. Successful collaborations are not only characterised by a tough, business economics reality, but there also exists a soft component in emotional or psychological relations (Ring & van de Ven, 1994). At a conference co-hosted by Global Commerce Initiative and Capgemini titled "Future Supply Chain 2016", it was pointed out that information transparency is essential for supply chain collaboration; especially for collaborative approaches to improve on-shelf availability. It was further mentioned that in order to prevent stock-outs, timely sharing of demand-signal data is extremely important and also, information about item location, quantity and status must be shared without any deviations. Unpredictable or tampered demand patterns generally cause artificial demand amplification which is also termed as the 'bullwhip' or 'whiplash' effect (Holweg *et al*., 2005). Further to this, Cachon and Lariviere (2001) warned that firms often have diverging interests in the short term which could mitigate the commitment of supply chain collaboration and complete sharing of demand information.

Vertical Collaboration

Vertical collaboration involves members of the supply chain like the manufacturer, supplier, wholesale distributor and customer working together - as depicted in Fig. 3 based on a contractual agreement in order to optimise chain for mutual benefit of all parties involved. The biggest advantage is that it creates visibility across the entire supply chain.

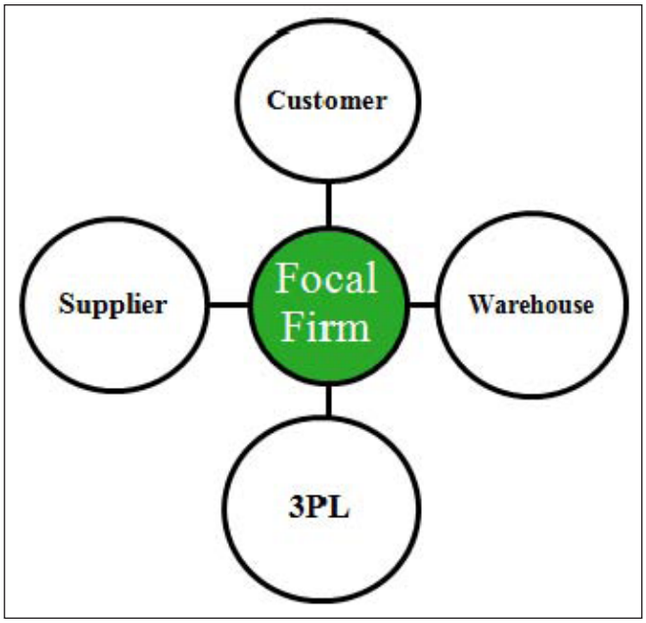

Fig. 3: Vertical Collaboration

This extended visibility provides manufacturers with the flexibility of prioritising or delaying replenishment at customer's end based on the demand (Waller, Johnson, & Davis, 1999). In collaboration between manufacturer and supplier, the supplier is enabled with a better understanding and capability to cope with demand variability (Holweg *et al*., 2005). Talking about relationship with customers, McLaren, Head, and Yuan (2002) noted that if strategic information like finished products "available to promise" is visible to customers, it will boost trust and also increase mutual gains of the firms involved. Members of a supply chain need to work collaboratively to assure mutual benefits and savings. This means that every member has to extend its line of sight across the entire supply chain to view and evaluate the performance of activities and organisations that are not under their direct control (Supply Chain Collaboration: The Key to Success in a Global Economy, SAP). The manufacturer, distributors and retailers can share information about the customers thus leading to a high level of market intelligence in the supply chain (Anderson & Lee, 1999).

Horizontal Collaboration

A collaboration where different entities operating generally in similar segments and at the same level come together, share information, resources in order to achieve mutual benefit can be termed as horizontal collaboration. As shown in Fig. 4, horizontal collaboration occurs between partners at the same level in the industry, where the benefits of collaborative manufacturing/ purchasing/ logistics include lower prices due to aggregated quantities, reduced supply risk, reduced administration cost due to centralised operations and networking benefits as group members communicate and interact with each other (Tella & Virolainen, 2005).

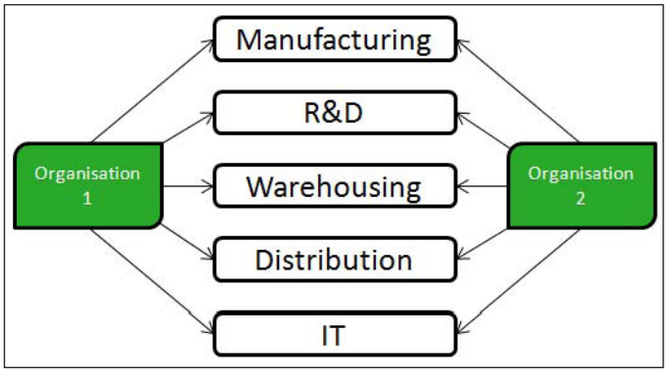

Fig. 4: Horizontal Collaboration

Horizontal collaboration can be defined as a business agreement between two or more companies at the same level in the supply chain or network in order to allow greater ease of work and cooperation towards achieving a common objective (Bahinipati, Kanda, & Deshmukh, 2009). They have no relation like suppliers and customers; they could however be competitors. Verstrepen *et al*. (2005) have classified horizontal collaboration based on the goals for which the concerned entities come together.

Operational cooperation is mainly practical in nature and involves sharing of operational information and jointly executing the activities. It is generally associated with logistic collaborations and has short-term goals.

Tactical cooperation involves more intensive planning and substantial investments. It relates to achieving mid-term objectives and can include servicing a market together and sharing of resources.

Strategic cooperation is purely about achieving long-term objectives. It involves intensive planning and has close resemblance to the mission statement. The planning is carried out in way to leverage core activities and core competences of the company. Organisations here get involved in joint development of concepts and joint investments.

To measure the success of a horizontal collaboration and to improve where needed, the entities involved need to agree on a set of appropriate key performance indicators (KPIs) (Kaplan & Norton, 1996). The research on horizontal collaboration is still in infancy and the proposition of sharing information with possible competitors is deterring organisations to step into this new and unexplored horizon.

Current Scenario and Opportunities

Vertical Collaboration

Current Scenario

Today, a number of organisations have formed collaborations with their suppliers and customers in the fields of manufacturing, e-commerce, consumer goods and others. Manufacturers encourage collaboration internally between design and manufacturing teams and externally with customers with intention of developing products which are easy to use and manufacture. The organisations look up to customers for their requirements or preferences. Design team can call for inputs from the manufacturing team to check manufacturing feasibility before releasing the design of a product. Supply chain of consumer goods industry relies on visibility of demand for efficient forecasting at every level. This means that the demand at every retailer is visible to the distributor and further up the chain to respective distribution centre and finally to the manufacturer. This helps in optimum forecasting. Any misleading data in the chain can lead to bullwhip effect or unexpected stock-outs.

Opportunities

Though well thought out in theoretical/ simulation models, in practice the issue of how to benefit from external collaboration and use demand visibility to improve capacity utilisation and inventory turnover is still not well-understood (Lapide, 2001). Organisations today can leverage the idea of collaborating with other supply chain members to improve KPIs related to costs, efficiency, service level, waste reduction and asset utilisation. For example, with clear figures related to demand, the manufacturer can have a set plan to meet the requirement. They can decide whether additional

working hours are required and also if outsourcing is needed to meet the demand. More often than not, today manufacturers are employing guesswork to estimate the demand and are working additional hours sometimes and remaining idle the rest. Sharing of information in the chain can help all members maintain a balance thus reducing costs. The biggest impact vertical collaboration can have – is in modern trade. The manufacturer and retailer can do Collaborative Planning, Forecasting and Replenishment (CPFR). The manufacturer if given the shelf data of the retailer and the warehouse can even look at the possibilities of automatic replenishment. Regarding safety stock, maintaining it at every level will only lead to bullwhip effect. Safety stock should be maintained at only one level of supply chain from which retailers can be replenished in case demand exceeds the forecast. Holweg *et al*. (2005) have classified collaborations into 4 types depending on the sharing of information and inventory management. They call the traditional supply chain as type 0 and classify others as shown in Fig. 5.

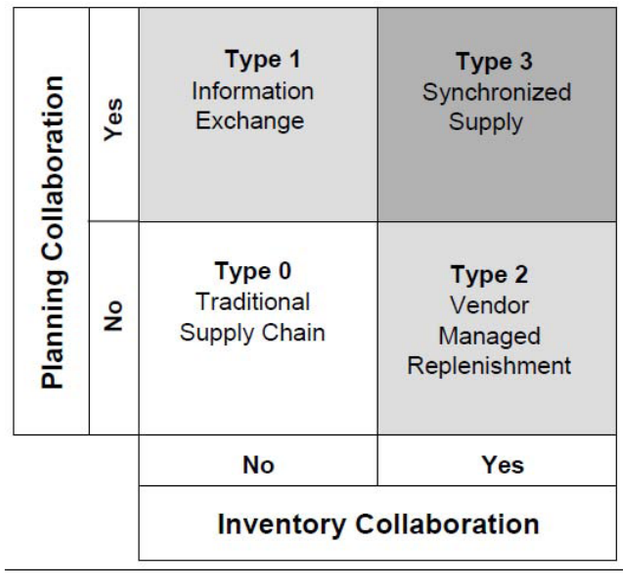

Fig. 5: Basic Supply Chain Configurations for Collaboration (Holweg *et al*., 2005)

They call for a large, multi-national supplier to focus on a Type 3 system bringing their demand in sync with the supply. Similarly, a centrally located manufacturer who supplies regionally into many markets will have to be efficient with forecasting and hence should focus on obtaining accurate demand information by going for a Type 1 system. Type 2 configuration are commonly seen in the manufacturing industries where standard and fast moving elements are generally stored by the supplier and then dispatched as and when required by the manufacturer.

Horizontal Collaboration

Current Scenario

Horizontal collaboration took birth in the 1970s when the survival of the American semiconductor industry was put in jeopardy by their Japanese counterparts on quantity, quality and pricing. This led to formation of Semiconductor Industry Association (SIA) by 5 semiconductor or microelectronics pioneer companies, which was later joined by a number of other organisations. The alliance included giants like IBM, AT&T and Texas Instruments. The SIA along with the American government tackled the issues of technology and also forced the Japanese to allow entry into their market and give up on predatory pricing.

Today, semiconductor industry in the USA is collaborating with Chinese industry which manufactures wafers for them. The American companies today are concentrating only on R&D and at the same time providing the required technology to their Chinese partners for manufacturing. This collaborative strategy gives some companies capacity whereas others benefit by transferring the investment cost of machinery. The ever reducing size of the wafers requires superior technology and higher investment for machinery. Semiconductor companies, rather than individually procuring such machinery outsource manufacturing to the Chinese industry and also lend them assistance with finance and technology to set up fabrication plants.

Other industries like aviation have also explored the prospects of collaborating. Airbus and Singapore based SIA Engineering Company (SIAEC) have entered into an agreement according to which SIAEC will provide maintenance and training services for aircrafts in Singapore (Chong, 2016). SIAEC will be equipped with Airbus standards, tools and teaching techniques based on which it will provide manufacturer backed training to personnel in the region. Airbus also has a similar agreement with Hong Kong based Hong Kong Aircraft Engineering Company (HAECO) for maintenance and training related services in China and South-east Asia (Luxford, 2015).

The technology of industrial Internet which is still only in its budding stages has a consortium, formed by over 100 organisations. The aim of this consortium is to accelerate growth by identifying best standards and practices. Kalundborg Symbiosis is a public-private partnership in Denmark with top companies in the enzymes and fertiliser business as its members (Turiera & Cros, 2013). It collects waste from all its members and converts it into usable raw material. They also help in energy transfer where outgoing

heat from some members is purchased by other members resulting in huge decrease in CO_2 emissions.

Opportunities

There are huge costs associated with a supply chain for every organisation. The different areas of product life-cycle or different areas of supply chain in which organisations operate are R&D, manufacturing, procurement, warehousing, and distribution. Each of these requires significant investment on part of the organisation in terms of capital as well as manpower. A lucrative opportunity exists for these organisations if they collaborate on even one of the areas. For example, similar electronic equipment manufacturing companies can collaborate on R&D and share the new designs for product development. Similarly, organisations can have common warehouses to store their products and distribution activities can be carried out through such centres. This will not only save on the investments but also improve KPIs like capacity utilisation, productivity and cycle time. According to Verstrepen *et al*. (2005), for organisations to come together and collaborate, there has to be some motivation and this could either be internal or external as mentioned below:

Internal motives:

- Increase in productivity of core activities
- Cost reduction in non-core activities
- Reduction in purchasing costs
- Better quality service at lower costs

External motives:

- Broadening of services or products
- Bidding for larger contracts
- Protecting market share

R&D collaboration can be considered by organisations manufacturing similar products. Setting up R&D laboratories calls for huge investment on the facility and machinery involved. It will also involve talented but expensive manpower. Organisations can save costs by collaborating and using the same facility and resources. Further to saving costs, a collaborative approach essentially means convergence of ideas and this can be looked upon as leveraging best of both worlds. R&D collaboration can even be extended to academia where input from experienced faculty and fresh from the books graduates can add another dimension to an organisation's R&D efforts.

Collaborating in logistics is the need of the hour. Organisations delay shipments in order to ensure full truck-load dispatch or incur higher costs in case of less-than truck-load shipments. Besides cost, efficiency also suffers in case demand does not meet the truck capacity. To overcome this, shared distribution can be employed by organisations which can improve capacity utilisation as well as ensure timely deliveries. Furthermore, collaboration can improve the reach of a logistics service provider (LSP) where it can collaborate with another LSP servicing an area outside its scope as depicted in Fig. 6.

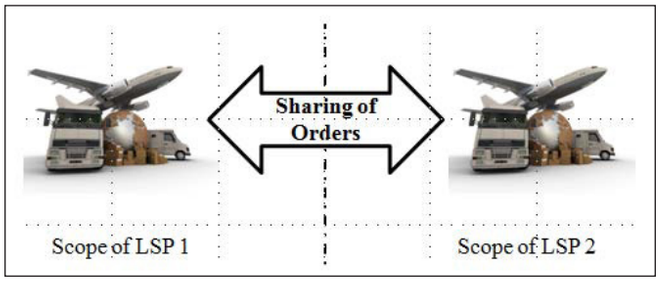

Fig. 6: Logistics Collaboration to Expand Reach

Firms collaborating in manufacturing can look at the possibility of sharing a common manufacturing setup. The pre-requisites for this would be similar products and capacity of the setup to meet the demand of the collaborating organisations. Manufacturing collaborations can also enable R&D firms to focus on their core competency by outsourcing manufacturing. This strategy is currently employed by the semiconductor industries of the USA where the manufacturing is outsourced to China. The USA based industries provide their Chinese counterparts with finance and technology. Firms intending to expand capacities can also look at outsourcing manufacturing temporarily.

Other fields where organisations can consider collaboration could be information technology or even sales & marketing. Currently, it is common for organisations to outsource IT support. The alternative could be that firms can collaborate and form one common team for IT support servicing all organisations. A common S&M team can promote products of the participating organisations. This type of strategy could be feasible in case of organisations having different products.

Word of Caution

Collaboration like any other process is not smooth. There are some barriers to effective collaboration. For instance, let us assume that companies collaborating work on different platforms. To overcome this, there are readymade EDIs available in the market but in case one of the organisations is so small that they have no ERP system available, bringing such organisations on board could be extremely costly. Another reason could be that collaborating organisations have different KPIs or differ in the way their respective performance is measured. This could call for discussions and negotiations such that they can agree upon producing a common performance level. Finally, when sharing of sensitive data is concerned, security and safety will always form a prime topic for concern in any organisation.

Organisations entering collaboration have to ensure that proper contracts are in place and that they consist of clauses related to sharing of investments, revenue and risks. The goals and objectives of the participating organisations shall be clearly mapped and shall be in alignment with all participants. The contract shall call for consistent performance level through the collaboration in case customers at same level are being serviced. This would help partner organisations secure themselves against their image being tarnished. Drafting of a contract acceptable to all participants can be a tedious task and it could also become an obstacle to collaboration. But, such a contract would help tremendously during a scenario in which the collaboration has to be dissolved. It can save organisations from getting into unwanted discussions or arguments over assets.

Model and Findings

After discussing the opportunities that lie in both vertical and horizontal collaborations, the respective collaborations have been modelled by assuming the possible collaborative conditions. The assumptions have been stated along with the respective models. The models will be followed by the resulting findings supported by tables and graphs. The demand functions depicted in the models have been derived on the basis of study by Chiang, Chhajed, and Hess (2003). The horizontal collaboration has been modelled based on the model by Webster and Mitra (2007) on new and remanufactured products. The models have been used to show the advantages of collaboration to the companies in terms of profits.

Vertical Collaboration

Collaboration between a manufacturer and a distributor is modelled where the product is sold by manufacturer to the distributor who sells the product further downstream with little or no value addition. While selling the product to the distributor, it is assumed that the manufacturer will keep some margin on his cost and similarly will the distributor while selling it further downstream.

Model

Following are the variables considered in the model:

$Cm \rightarrow$ Cost incurred by manufacturer to make the finished product

$Cd \rightarrow$ Price at which the distributor buys the product from manufacturer

$P \rightarrow$ Price at which the product is sold by the distributor

$Q \rightarrow$ Quantity demanded in the market

$\Pi \rightarrow$ Total profit of both firms

$\Pi m \rightarrow$ Profit of manufacturer

$\Pi d \rightarrow$ Profit of distributor

Case I: Without collaboration (Double marginalisation)

$Q = 1 - P$

$$\Pi d = (P - Cd) * (1 - P) \quad \ldots(1)$$

Differentiating the above equation and equating it to zero.

$$\Pi d' = (1 - P) - (P - Cd) = 1 + Cd - 2P$$

It is evident from above that $\Pi d'' < 0$. Hence, equating to zero will result in price which maximises Πd.

$P = (1 + Cd)/2$

Hence,

$$\Pi d = (1 - Cd)^2/4 \quad \ldots(2)$$

Also,

$$\Pi m = (Cd - Cm) * (1 - P) \quad \ldots(3)$$

Differentiating the above equation and equating it to zero gives

$$Cd = (1 + Cm)/2 \quad \ldots(4)$$

Substituting above equation in (3) will give maximum value of .

Hence,

$\Pi m = (1 - Cm)^2/8$ …(5)

Also from (2) and (4),

$\Pi d = (1 - Cm)^2/16$ …(6)

For (5) and (6), we get total profit as

$\Pi = 3*(1 - Cm)^2/16$ …(I)

Case II: With collaboration (Vertical Integration)

$Q = 1 - P$

$\Pi d = (P - Cm) * (1 - P)$ …(7)

Note that is cost price for manufacturer and the product is sold to the distributor at the same price.

Differentiating equation (7) and equating it to zero gives

$\Pi d' = (1 - P) - (P - Cm) = 1 + Cm - 2P$

It is evident from above that $\Pi d'' < 0$. Hence, equating $\Pi d'$ to zero will result in price which maximises Πd.

$P = (1 + Cm)/2$

Hence,

$\Pi d = (1 - Cm)^2/4$ …(8)

Now, since manufacturer sells the product at cost price,

$\Pi m = 0$ …(9)

From (8) and (9), we get total profit as

$\Pi = (1 - Cm)^2/4$ …(II)

Findings

It is clearly evident from equations (I) and (II) that the total profit is higher when the firms collaborate and use the vertical integration strategy. Fig. 7 depicts the model showcased above.

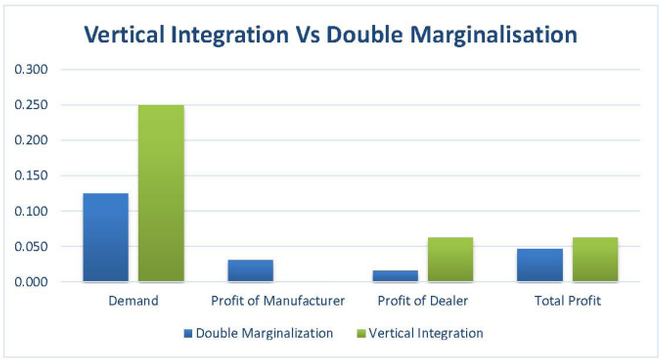

Fig. 7: Vertical Integration Vs Double Marginalisation (Profits)

As seen from Fig. 7, the profits increase when the firms collaborate. Further, the demand for the product also increases which suggests that the market share of the firms has increases. Hence to conclude, a model showcasing collaboration by removing double marginalisation has depicted that the collective profit of the firms and also possibly the market share of the firms has moved in the positive direction.

Horizontal Collaboration

Collaborating horizontally can have a number of effects. It could lead to appreciation of brand value, lower costs and can even increase market share. The model will look at the effect of collaboration on costs of both firms and the resulting effect on the total profit.

Model

Following are the variables considered in the model:

$P1 \rightarrow$ Price of product 1

$P2 \rightarrow$ Price of product 2

$c1 \rightarrow$ Cost for product 1

$c2 \rightarrow$ Cost for product 2

$v \rightarrow$ Valuation of Product

$\theta \rightarrow$ Ratio of valuations

A product is purchased generally only when its valuation is greater than its price.

$v > P1$ and $\Theta v > P2$

If $v_1 = P_1$ and $v_2 = P_2/\Theta$, consumers are indifferent to buying product 1 and product 2 or not buying at all.

Also, in case of a choice between the products, the product with larger consumer surplus is preferred.

If $v - P1 > \Theta v - P2$, Product 1 is preferred

If $v - P1 > \Theta v - P2$, Product 2 is preferred

If $v - P1 > \Theta v - P2$, consumers are indifferent to buying product 1 or Product 2.

Solving for v we get,

Consider that $v1 > v2$

This implies that. $P1 > P2/\Theta$

Multiplying by $-\Theta$ and adding on both sides we get

$-\Theta*P1 + P1 < -P2 + P1 \rightarrow P1 < (P1 - P2)/(1 - \Theta) \rightarrow v1 < v12$

Therefore we get $\rightarrow v12 > v1 > v2$

If the consumers' valuation is between $[v2, v12]$ product 2 will be preferred. If the consumers' valuation is between $[v12, 1]$ product 1 will be preferred. If the consumers' valuation is between $[0, v2]$ none of the products will be preferred.

Similarly, when $v1 < v2$, we can arrive at the condition where $v12 < v1 < v2$.

In this case, product 2 will never be preferred while product 1 will only be preferred when the consumers' valuation is between $[v1, 1]$.

Based on the above analysis, we get the demand functions as:

$$D1 = 1 - (P1 - P2) / (1 - \Theta) \quad \text{when} \quad v1 > v2$$
$$= 1 - P1 \quad \text{otherwise}$$

$$D_2 = (\Theta*P1 - P2) / (\Theta*(1 - \Theta)) \quad \text{when} \quad v1 > v2$$
$$= 0 \quad \text{otherwise}$$

Case I: $(v1 > v2)$

The profit functions will be

$\Pi1 = (P1 - c1) * (1 - (P1 - P2)/(1 - \Theta))$

$\Pi2 = (P2 - c2) * (\Theta*P1 - P2) / (\Theta*(1 - \Theta))$

Differentiating the above equations and equating to zero gives the reactive price functions which will maximise the respective profits of the firms. The reactive price functions are as below:

$P1 = (1 - \Theta + P2 + c1)/2$

$P2 = (\Theta*P1 + c2)/2$

Case II: ($v1 < v2$)

There will be no demand for product 2. Hence only one profit function will be available as below:

$\Pi1 = (1 - P1) * (P1 - c1)$

Findings

Based on the demand and profit functions derived above, data was tabulated by assuming cost for manufacturer 2 and then multiplying it with a predefined ratio to arrive at cost for manufacturer 1. The price for manufacturer 1 was derived from the reaction function whereas it is assumed that manufacturer 2 will set its price. Values of were kept constant for 1 set of ratio which was varied from 1.1 to 1.9. The behaviour of demand and profit was studied as against the ratio of costs as well as varying Θ. As seen in Fig. 8, while the cost ratio goes away from 1 the total profit goes on decreasing. As mentioned earlier in the report, collaboration can bring costs of the firms closer (bringing the cost ratio closer to 1) and as clearly depicted in the model, this results in appreciation of the total profit of the firms combined. Costs of manufacturing similar products can be brought closer by sharing of technology, common sourcing or even further collaboration in manufacturing and warehousing.

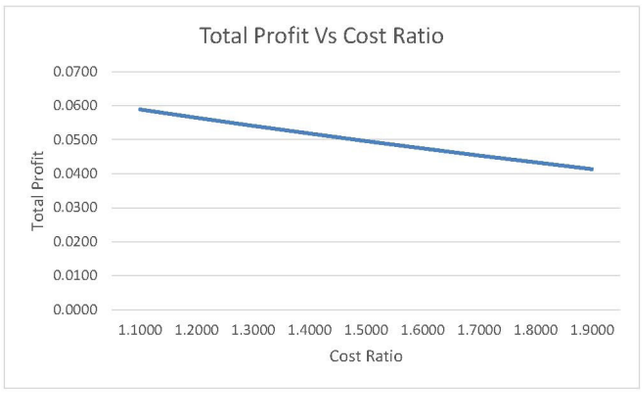

Fig. 8: Total Profit Vs Cost Ratio (θ = 0.8)

Further, it is seen in Fig. 9 that as comes closer to 1, total profit decreases. The reason behind such a behaviour of the profit function can easily be explained by comparing the valuations of the products. As comes closer to 1, their valuations in the market come closer. However, there is still a fair gap in the prices. This results in an increase in demand of product 2 which has a lower profit margin. It is accompanied by decrease in demand of product 1 which has a high profit margin. It can be devised from this that it is best for only those members to get into a collaborative agreement where the valuation of their products differs considerably.

Fig. 9: Total Profit Vs Theta (*c*1/*c*2 = 1.2)

The scenarios showcased above however would not be very simple to execute as it involves one member (possibly a competitor) sharing information to help another member of a parallel supply chain in terms of saving costs and increasing profits. It is also observed from the model that the member sharing information (manufacturer 2 in this case) actually suffers in terms of profits. This is elaborated in Fig. 10.

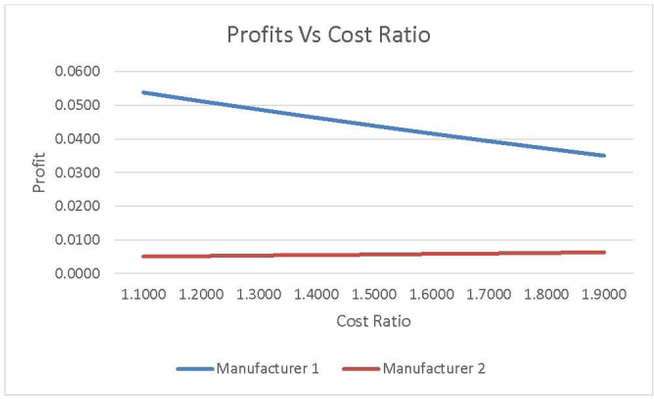

Fig. 10: Profits Vs Cost Ratio

It is clearly evident from the figure above that as cost ratio comes closer to 1, profits for manufacturer 1 increase whereas profits for manufacturer 2 (who is the information giver) reduce. This behaviour can be explained easily by the comparison of product valuations and prices. As cost of manufacturer 1 decreases, it will reduce its prices to magnify demand. The product 1 will be valued considerably higher as compared to product 2 but the contrast in prices will not be as much and this will lead to increase in market share (demand) of product 1 and reduce that of product 2. With demand for product 2 going down, its profits will naturally suffer.

The biggest challenge in execution of a model like this is getting buy-in from the partners for information sharing. Security will always be an issue but moreover, one member in the collaboration is having to sacrifice its market share and profit for the overall benefit of the supply chain. To convince an entity to agree to such a scenario can only be done by having a contract in place which will take into account appropriate profit sharing between the members.

Contracts

In the supply chain partnership elaborated above, the members collaborating have similar products which have different valuation, price and cost. Chances of these three variables being identical for two products is negligible unless the products are same and are manufactured or produced in the same setup. To elaborate, similar products manufactured by different manufacturers would certainly have a difference in manufacturing cost. They might however be valued on a similar scale by customers and might be priced in the same range to hold a competitive market share. Collaboration contracts shall be designed in such a way that they give advantage to the manufacturer

that helps in optimising processes (reduction in cost) for its partner.

Below are the parameters used for formulating the profit sharing model in the collaboration contract.

$\Pi 1 \rightarrow$ Manufacturer 1 Profit (Pre-collaboration)

$\Pi 2 \rightarrow$ Manufacturer 2 Profit (Pre-collaboration)

$\Pi 1' \rightarrow$ Manufacturer 1 Profit (Post-collaboration)

$\Pi 2' \rightarrow$ Manufacturer 2 Profit (Post-collaboration)

$\Pi \rightarrow$ Net increase in Total Profit of both Manufacturers post-collaboration

$r \rightarrow$ Percentage of Π shared with Manufacturer 2

$R \rightarrow$ Percentage of Π shared with Manufacturer 1

In this case, manufacturer 2 is considered to be helping manufacturer 1 in reducing its manufacturing costs. Hence,

r = percentage change in cost ratio

$$= \frac{\text{Original cost ratio} - \text{New cost ratio}}{\text{Original Cost Ratio}}$$

$R = 1 - r$

$\Pi = \Pi 1' + \Pi 2'$

Profit shared with Manufacturer 1 = $\Pi 1 + R^*\Pi$

Profit shared with Manufacturer 2 = $\Pi 2 + r^*\Pi$

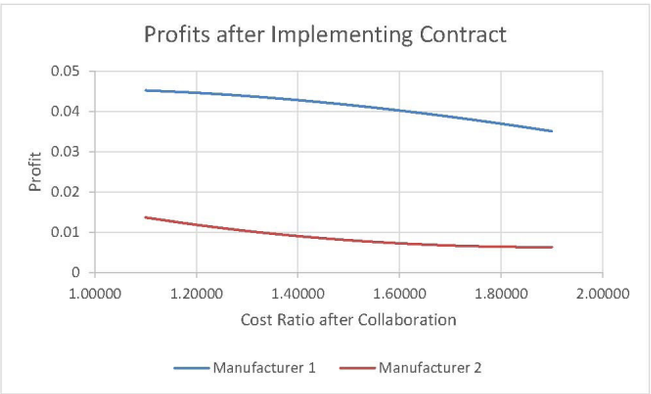

Fig. 11: Profits Vs Cost Ratio

Fig. 11 shows the behaviour of profits of individual manufacturers after contract term are applied to the collaboration profit. When it is compared with Fig, 10, it can be seen that profit of manufacturer 2 is gradually increasing (as opposed to decreasing) as the cost ratio comes closer to unity.

The above relationship ensures that there is enough incentive for manufacturer 2 to help optimise production process of manufacturer 1 thus helping in cost reduction. Naturally, reduction in cost for product 1 will mean higher profits for manufacturer 1. Thus, there is incentive for both manufacturers as per this model. This however is only one way of designing a contract. There are many other ways which would rely on different models for profit sharing between the collaborating partners. It is strongly recommended that contract shall be designed in such a way that would mean fair share of profits to both partners. Another vital aspect to be considered is that every profit-sharing model should give incentives to both partners in the supply chain to contribute towards increasing profit.

One point that this paper does not address is a situation where there is a loss instead of profit. We must accept that there will be occasions where a profit making business suffers losses that could be due to various reasons. Contracts should be framed keeping such situations in mind so as to avoid complexities in partnerships at later stages.

Conclusion

In this paper, a mathematical model was developed to show effectiveness of collaboration. Substantial literature was reviewed which propagated advantages of collaboration. It has generally been accepted that collaboration in supply chain is one of the ways forward to make it more sustainable and efficient. The industry has already seen the transition from the state of competition between firms to the state of competition between the supply chains. The next transition for the industry as claimed in literature (Verstrepen *et al*., 2005; Holweg *et al*., 2005) is collaboration – internal (vertical) and external (horizontal). Suitable conditions have also been defined as to when firms should collaborate and the kind of advantages they would have from the collaboration (Holweg *et al*., 2005). Cost saving in setting up manufacturing plants by collaboration between similar firms has been highlighted (Bahinipati *et al*., 2009). This is exemplified by the semiconductor industry that has seen great benefits of collaboration over the last couple of decades. The industry has showcased collaboration not only in R&D but also in the manufacturing of wafers. This is an example that other industries in the fields of electronics can follow. However, there are reasons for which collaboration is still not effective in the industry. Today, it has only arisen out of genuine need for survival

as seen from the examples of the semiconductor and aviation industries.

It is clear that collaboration (vertical and horizontal) has advantages ranging from having an enhanced knowledge base to achieving economies of scale. Organisations need to identify areas within their supply chains which can be optimised and identify partners to help them realise these goals. Collaboration has mutual benefit which means it generally is a win-win situation even if the partnership were to be between competitors. In future, firms have to set aside the competition, stop waiting for the need to arise and actively seek opportunities to collaborate in their supply chains. In doing so, careful and measured designing of the collaboration contract should be high on priority.

The models created for both vertical as well as horizontal collaborations show that the profits can be enhanced and further, collaborations can be beneficial to the society too. The model for horizontal collaboration currently considers only the cost ratio impacting the profits where costs can be brought down by collaborative procurement and manufacturing for example. There lies massive scope in exploring other aspects of horizontal collaboration as highlighted in the paper. The paper further proposes a model based on which collaboration contract can be designed. Research can further be carried out in more ways to design an appropriate contract for collaboration which would consider the dynamics of market while satisfying the collaborating partners at the same time.

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Appendix 1: List of Abbreviations

CPFR → Collaborative Planning, Forecasting and Replenishment

EDI → Electronic Data Interface

ERP → Enterprise Resource Planning

HAECO → Hong Kong Aircraft Engineering Company

IT → Information Technology

KPI → Key Performance Indicators

LSP → Logistic Service Provider

R&D → Research and Development

S&M → Sales and Marketing

SIA → Semiconductor Industry Association

SIAEC → SIA Engineering Company

USA → United States of America

VMI → Vendor Managed Inventory