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Vertical collaboration in the semiconductor industry: A decision framework for supply chain relationships ☆

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ABSTRACT

Vertical collaboration problem focuses on integrating and modeling the decision problems of the suppliers and buyers together with the market intermediary by identifying the inefficiencies in the traditional marketplace and aligning the incentives of members in the e-marketplace. The present work develops and solves real life e-marketplace models for complex buyers–suppliers procurement problems by estimating the order quantities in the collaborated supply chain. The newsvendor framework considers demand to be independent of the selling price as is generally the case in the semiconductor industry supply chain dealing with techno-savvy customers. The vertical collaboration process would be more effective if the length of the planning horizon and order size is considered as a negotiation parameter between the buyer and supplier. It is observed that the supplier's expected profit function increases with the buyers' ordering quantity, which is important in characterizing the general structure of the collaboration scheme of the supply chain.

1. Introduction

Due to globalization and sustained demand growth, the semiconductor industries are focusing more to sustain their customer base and to enhance revenue opportunities; so, they must manage successive technological innovations effectively (Cao & Zhang, 2011; Fabbe-Costes, Roussat, & Colin, 2011). The most ideal approach is to introduce high margin innovative products at the right time through optimal use of the resources and realignment of the supply chain members to adjust to this trend (Ku, Gurumurthy, & Kao, 2007). Due to rapid evolution and change of technology, the future semiconductor manufacturers must work collaboratively with its extended supply chain to bring about enhanced synchronization of procurement business functions (Wu, Erkoc, & Karabuk, 2005; Flynn, Huo, & Zhao, 2010).

The collaborative activities include information sharing, joint relationship effort, and dedicated investments, which lead to improved customer satisfaction and supply chain performance (Nyaga, Whipple, & Lynch, 2010). The collaborative relationships, based on trust and commitment with their supply chain partners, are critical to achieve efficiencies, flexibility, and sustainable competitive advantage (Chen, Yen, Rajkumar, & Tomochko, 2011; Cao & Zhang, 2011; Panayides & Lun, 2009). This collaborative advantage is the strategic benefits gained over competitors in the marketplace through partner enabled inventory centralization and ordering, and supply chain partnering, which is the desired synergistic outcome (Cao & Zhang, 2010).

The semiconductor industry sector is characterized by a number of key and unique characteristics from the perspective of product features and the sector's structure, where collaborative practices are developed in response to the economic pressures and customer requirement, driving the evolution of the chain and encourage greater horizontal and vertical coordination (Kapur, Peters, & Berman, 2003). With the objective of manufacturing and supplying a specific product or component, or locating new enterprises, all enterprises in the semiconductor manufacturing cooperate as synergetic unit to pursue for success (Zhang, Xu, & Wang, 2004).

The vertical collaboration problem in the semiconductor industry forms the basis of multi-echelon inventory theory, since it considers only two stock keeping locations, i.e., buyer and supplier. Classical works in multi-echelon inventory theory assume that these entities cooperate and hence solve their problems using a centralized approach (Goyal, 1976). This theory suggests integrating and modeling the decision problems of the suppliers and buyers together with the market intermediary. This is a valid assumption if the SC entities belong to the same company or operate under long-term agreements, such as supplier-owned inventory (SOI) systems (Centikaya & Lee, 2000, 2002). Supply chain management (SCM) considers both logistics and information

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issues as well as dominance relationships between the entities. As a result, SC studies focus on more than the system wide optimization of inventory problems.

The typical activities which are critical to the management of vertical collaborative relationships from a procurement perspective are: selecting suppliers, motivating, time of involvement, assigning physical and human resources, information sharing, synchronizing standards and coordination among supply chain members. So, any member and any relationship within a supply network are affected by the actions of other members, and thus have to cope with these to enable successful collaborative relationships (Grover & Saeed, 2007).

The emerging idea is that the greater the extent to which manufacturers engage in e-market enabled transactions with upstream and downstream members the better the performance (Rosenzweig, 2009). The research reveals that the collaborative e-marketplace is still a relatively new business model (Wu & Chuang, 2010). It has potential for growth in optimizing supply chain networks, enabling vertical collaboration between buyers, suppliers and logistic providers (Wang, Potter, Naim, & Beevor, 2011).

Current research in vertical collaboration in semiconductor industry focuses on inventory management within the firm as well as throughout the supply chain, to gain cost advantage. This collaborative procurement can be operationalized through the participation of all SC members in a private exchange (e-market) to gain cost advantage and enhance responsiveness. So, it is imperative to consider both e-market (centralized) models and traditional market (decentralized) models for complex supply/replenishment problems with the objective of obtaining collaborated decentralized solutions for these problems. In order to maintain and improve the competitive power of these industries, it is critical to select agile, competent and compatible partners quickly and rationally during the formation phase of the collaborative relationship. Further, an adaptable and reasonable modeling approach is necessary to determine the nature of relationships between buyer and supplier enterprise (Saen, 2007). This may be possible by developing an analytical framework to generate an evaluation system and to provide the information regarding the nature or intensity of buyer–supplier relationships. This approach would facilitate decision-making pertaining to vertical collaboration in the semiconductor industry supply chain.

The general relationships between the members of fabless semiconductor industry supply chain (subcontractors, and customers) are depicted in Fig. 1. As the customer demands are placed at finished goods level, manufacturing requirements are communicated to final test, assembly, wafer probe, and to the foundries. Efficient means of communication are necessary to ensure the success of the process, which can be achieved through the participation of the supply chain partners in the e-marketplace.

2. Motivation and research objectives

The semiconductor industry is a rapidly changing industry with shortening life cycles, fluctuating demand and continuous price and cost pressures. In order to sustain the dynamic and competitive environment, these enterprises must be flexible in the quantity and type of product kept in inventory (Wu et al., 2005). The business partners share resources to the relationship, establishing mutual commitment, which reduces opportunistic ambitions and promotes bilateral governance (Grover & Saeed, 2007). These structures, implemented through collaborative initiatives, are strategic responses to uncertainty in supply and demand (Zacharia, Nix, & Lusch, 2011).

The vertical collaboration considered from the procurement perspective in the semiconductor industries may have market or industry related constraints to survive in the market, such as resource availability with individual enterprises, and this might contradict with profit maximization objectives. So, these industries have to satisfy these constraints along with trust related conditions, while working or under a collaborative framework (Panayides & Lun, 2009).

The motivation to order more products/components in semiconductor industry, to achieve economies of scale, is restricted to a single period in contrast to EOQ-oriented models with infinite planning horizon. The semiconductor industries are characterized by the fact that increasing the quality of products/components procured/manufactured does not result in fixed costs savings in future periods. The existing literature on buyer–supplier coordination assumes that the selling price of items at the buyer is a constant or is a function of the order quantity. However, in the semiconductor industry supply chain, with items/components of short product life cycles, there is always a decline in the economic value of the item over time, as is evident in PC manufacturing industry. These are known as 'permanent markdowns' in marketing literature (Nair & Closs, 2006).

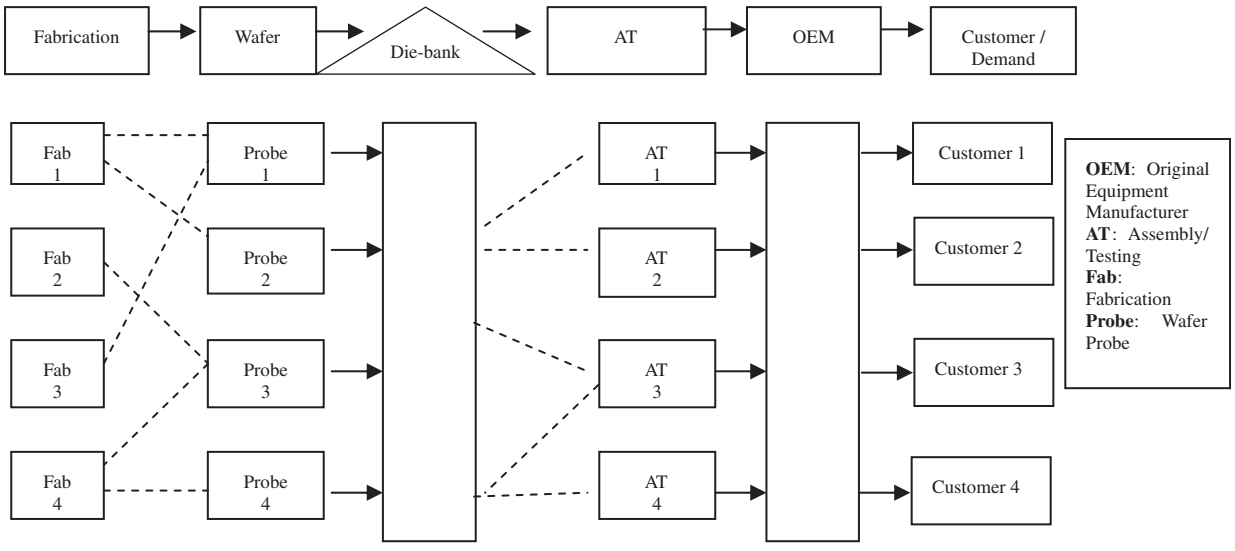

Fig. 1. Relationship between members in a semiconductor supply chain (pull system).