The Evolution of Inter-Firm Collaboration in Supply Chain Networks

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ABSTRACT

To date, no published study has measured the evolution of supply chain structure and relationships in response to changing product-market development requirements. This research draws upon production literature and exchange governance theory to simulate the interaction of supply and demand environment factors on the growth and development of supply chain relationships. Experiments were conducted to study the effects of different rates of product change, different demand environments, and different economies of scale on the level of integration between firms at different levels in the supply chain. It synthesizes the interrelationships of the simulation variables in order to extend TCA theory into a dynamic network environment by using the CAS paradigm. The study reveals definite patterns of evolution under conditions of differing product-market conditions, it confirms the importance of the balancing transaction and production costs, and it highlights the asymmetries of transactional and production costs in relationships.

Keywords: *Complex Adaptive System (CAS), Product-Market Development, Simulation, Supply Chain Evolution, Total Cost Analysis (TCA)*

INTRODUCTION

Supply chain and logistics integration and collaboration have become by-words for achieving competitive advantage across firms (Frohlich & Westbrook, 2001; Gustin, Daugherty, & Stank, 1995; Stock, Greis, & Kasarda, 1999). Traditional supply chain perception prescribes increased information sharing as the means of integrating and collaborating effectively. The evidence for the efficacy of the "integration prescription" leading to higher potential benefits is oft-cited (cf. Daugherty, Ellinger, & Gustin, 1996; Lee, Padmanabhan, & Whang, 1997b; Lummus & Vokurka, 1999; Narasimhan & Jayaram, 1998; Stank, Keller, & Closs, 2001; Tan, Kannan, & Handfield, 1998), although at least one systematic review has found that the evidence of the connection between supply chain integration and performance is limited (Fabbe-Costes & Jahre, 2008). Impeding the research into the benefits of integration is the presence of hypercompetitive environments characterized by the rapid rise and fall of firms (McNamara, Vaaler, & Devers, 2003; Wiggins & Ruefli, 2005). These hypercompetitive envi-

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ronments constitute a powerful "disintegration" force—technological and market forces powerful enough to pull apart even the most integrated supply chain across not only high tech industries, but across a wide range of industries. Missing from the dialogue is research into the factors that influence integration and disintegration of interfirm integration, which these authors view as synonymous with interfirm knowledge management processes.

In terms of interfirm integration and collaboration, much past research has evaluated the impact of product-market factors such as manufacturing plant network configuration (Kulkarni, Magazine, & Raturi, 2004), flexible capacity investment (Van Mieghem, 1998), and variable demand (Bish, Muriel, & Biller, 2005) from the supply perspective, a few studies have evaluated such factors from the demand perspective, and very rarely studies assess the interaction of demand and production capacity (e.g., Nyaga, Closs, Rodrigues, & Calantone, 2007). However, research into the effects of the interaction of supply and demand factors on supply chain integration and disintegration is sorely lacking. Additionally, the body of knowledge about the influence of different types of interfirm relationships on supply chain performance remains weak (Frohlich & Westbrook, 2001). Furthermore, most past work has been static in nature or relied on assumptions that environmental conditions remain constant. Few studies have assessed longitudinal evolution of supply chains despite the important potential public policy and strategic contributions of such research.

This research draws upon production literature and exchange governance theory to simulate the interaction of supply and demand environment factors on the growth and development of supply chains. The use of simulation to build new theory goes back to Forrester's (1958, 1961) work and has received renewed interest recently (Davis et al., 2007). Using simulation to explore the interaction of empirically-validated theories, several experiments were conducted with the purpose of extending existing explanations of supply chain evolution to explain cycles of integration and disintegration in supply chain networks. The simulation mirrors the history of many industries including the semiconductor industry by starting with firms in a stable oligopoly characterized by slow changes to the product. Experiments were conducted to study the effects of different rates of product change, different demand environments, and different economies of scale on the level of integration between firms at different levels in the supply chain.

The following section reviews previous research on interfirm governance as well as supply and demand perspectives on supply chain integration and the evolutionary perspective of supply chain networks as complex adaptive systems. Then the research method is discussed. Next, research results and analysis are presented, followed by a discussion of the implications of the study's results and directions for future research and the paper concludes with recommendations for the academic and practitioner.

LITERATURE REVIEW AND MODELING FRAMEWORK

The methodological roadmap provided by Davis et al. (2007), while analogous to roadmaps provided in other simulation texts (Banks & Nelson, 1999; Law & Kelton, 2000; Maisel & Gnugnoli, 1972), is tailored to the application of simulation to theory building and extension (Table 1). The introduction presented Step 1 which identified the research question as, "How does interfirm collaboration evolve in a supply chain network under different product-market conditions?" Step 2, identification of "simple theory," appears as a literature review of transaction cost analysis, complex adaptive systems, and organizational evolution theories. Steps 3 through 5 are described in the methods section. The outcomes of Step 6 appear in the results section. Step 7 consists of empirical validation and is beyond the scope of this paper; empirical validation appears as an area of future research.

Figure 3 presents the simulation framework. It synthesizes the interrelationships of