STRATEGIC ECONOMICS OF NETWORK INDUSTRIES

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0. Introduction and Overview

1. High Speed Technology Competition (HSTC) ,
2. Vertical Competition and Outsourcing in a Supply Chain (VCOSC),
3. Supply-Chain Coopetition (SCOOP)
4. Cooperative R&D, Collusion and High Tech Competition (COOP)
5. R&D Cooperation with Product Differentiation (TCRDCOOP)
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This book highlights the interface issues of competition, cooperation and strategy in an evolutionary dynamic economy exemplified in the context of industry specific concerns in network industries .

The core of chapters 1 to 3 emphasizes the linkage between high speed technological competition , and its extension to vertical integration along the supply chain and cooperative ventures on strategic positioning of the firm. This results in several interesting insights. This preview concludes by emphasizing the analytical , strategic and practical implications and providing directions for future industry analysis.

The conceptual framework, model formulation and insightful analytical results provide a strong groundwork to integrate the role of operations with the overall strategic business of an enterprise. Specifically, the context of product development and collaboration allows an examination of important aspects from research and development (R&D), marketing, strategy, organizational analysis and operations management.

The first chapter (HSTC) relies on (stochastic) differential game analysis in symmetric and asymmetric rivalrous situations in that it extends the modeling of R&D based competition beyond conventional models found in the economics and marketing literature. Specifically, an investigation of continuous incremental improvement of product quality by means of investments in innovation provides a setting for evaluating R&D policies which remain unaddressed in models examining patent racing. Although, organizational learning is not explicitly modeled, it is implicitly shown to be an important constituent of the overall dynamics. This conceptualization aids modeling efforts in product development to consider a holistic framework incorporating innovation, continuous improvement of quality and learning.

In highly competitive technological industries new challenges and opportunities are arising in the new product development arena. Driven by global markets, global competition, the global dispersion of scientific/engineering talent, and the advent of new information and communication technologies (ICT) a new vision of product development is that of a highly disaggregated , distributive process with people and organizations spread throughout the world. At the same time products are becoming increasingly complex requiring numerous engineering decisions to bring them to market. Competitive pressures mean that 'time to market' has become a key to new product success. However, at the same time it is important to keep the innovation and quality dimensions of the new product at their optimal level.

A central question to address is how should firms invest in innovation and what are the implications of such investments for competitive advantage? Understanding why a firm benefits from investments in innovation and quality illuminates issues of competitive strategy and industrial organization. In the field of competitive strategy, much attention has been devoted to the concept of core capabilities (Teece et al., 1997). Understanding how firms make optimal investments in the face of competition reveals the nature of competition and provides theoretical and managerial implications for developing core competence and dynamic capabilities.

In major parts of competitive analysis involving R&D decisions the focus is on breakthrough innovations which could create entirely new markets, for example, in studies featuring patent racing between competing firms. In more common competitive situations we observe firms, however, competing by investing in incremental improvements of products. It is an important aspect when innovation is considered to be manifested in product quality, process improvements and in the overall quality culture of an organization (Moss Kanter, 2006). For example, after product launch, incremental improvement of different aspects of product quality, improvements in various business processes and an incremental adoption of a quality culture are quite real-world phenomena. Thus innovation is conceptualized as being manifested in terms of quality. Moreover, the quality dimension extends to pursue continuous total quality improvement for the entire product life cycle. Some firms operate in a simultaneous product launch situation while others compete sequentially by adopting the role of leader or follower. The strategic implications in these diverse circumstances can be treated within a unified framework of dynamic stochastic differential games.

In recent years with the emergence of e-business and a supply chain view for product development processes, multiple firms with varying and at times conflicting objectives enter into collaborative arrangements. In such situations, the competitive strategy based on quality and innovation could potentially permeate in those collaborative setups. A recent example is the collaborative venture of Sony and Samsung to build a cutting edge plant for LCD flat screen TV though displaying ongoing fierce rivalry in new product launches in exactly the same product categories. When innovation and quality levels form the core of a firm’s capabilities, each member in the supply chain would have an incentive to invest and improve their dynamic capabilities. This leads to tacit competition among collaborative product development partners by means of active investment in innovation and quality.

Although the forces of innovation are central to competition in young, technically dynamic industries, they also affect mature industries where life cycles historically were relatively strong, technologies mature, and demands stable.

A strategy for technology must confront primarily what the focus of technical development will be. The question is what technologies are critical to the firm's competitive advantage. In this context, technology must include the know-how the firm needs to create, produce and market its products and deliver them to customers. As a major step in creating a technology strategy it has to define those capabilities where the firm seeks to achieve a distinctive advantage relative to competitors. For most firms, there are a large number of important areas of technological know-how but only a handful where the firm will seek to create truly superior capability.

Having determined the focus of technical development and the source of capability, the firm must establish the timing and frequency for innovation efforts. Part of the timing issue involves developing technical capabilities, and the rest involves introducing technology into the market. The frequency of implementation and associated risks will depend in part on the nature of the technology and the markets involved (e.g. disk drive vs. automotive technology), but in part on strategic choice. At the extreme, a firm may adopt a rapid incremental strategy, that is, frequent, small changes in technology that cumulatively lead to continuous performance improvement. The polar opposite might be termed the great leap forward strategy. In this approach, a firm chooses to make infrequent but large-scale changes in technology that substantially advance the state of the art (Gottinger, 2006, Chapt. 6)..

As an example of the importance of innovation strategy in product development we notice that IBM created and continues to dominate the mainframe segment , but it missed by many years the emergence of the minicomputer architecture and market. The minicomputer was developed and its market applications exploited by firms such as Digital Equipment Corp.(DEC) and Data General (DG.) back in the 1970s (Kidder, 1986)

Summarizing, in a mainstream scenario, high speed technological competition is likely to be driven by

(a) companies competing in fast changing, diverse networks, and

(b) companies confronted with ever shortening product/technology life cycles because of multiple interactions between current and emerging technologies and product diversity, or what may be circumscribed as 'combinatorial innovation' (Varian,2005).

A neat example is provided by Arthur(2000,p.3):

"If you look at genomics , it is certainly heavily based on biology, but it is also highly dependent on digital computing .Genomics, then, is as much a manifestation of digital computing as it is a manifestation of molecular biology. What happens is that some of the new technologies become base technologies, and these give rise to manifestations, some of which themselves become base technologies. Manifestations then appear at an even faster rate."

To represent the features of leader-follower type in a sequence of technological racing we consider a class of differential games in which some firms have priority of moves over others. The firm that has the right to move first is called the leader and the other competing firm is called the follower. A well-known example of this type of sequential move game is the Stackelberg model of duopoly. In this type of interaction the open-loop Nash equilibrium conditions in a sequential move game can be derived. It would lead to a comparison of the strategies of leader and follower. In some alternative context Dasgupta (1986) presents technological competition as bidding games in representing patent races but those games are not truly dynamic because they do not carry a repetitive structure in a changing rivalry. In a differential game the dynamic change of a firm's conduct at each stage is at stake.

A second contribution (VCOSC) , Chapt. 2, uncovers the importance of asymmetries by investigating the difference between firms in terms of key parameters. Moreover, for the examination of inter-firm competition through product development, the context of simultaneous entry and sequential entry are treated separately. This allows a deeper understanding of the implications of information asymmetry and commitment which have been regarded as important determinants in the context of game-theoretic studies.

The study of innovation based competition has often considered aspects related to patent races and incremental product-process innovation to achieve distinctive advantage. However, recently innovation-based competition has become an aspect of buyer-supplier relationships. There are many instances in manufacturing where one finds situations of lock-ins created by innovative suppliers. For example, in the computer industry Intel and Microsoft as suppliers of microprocessor and operating systems, respectively, to desktop manufacturers like IBM , Hewlett-Packard and Dell illustrate such innovation-based lock-ins. Indeed, there exists an evolving power structure (dubbed 'channel power') in a supply chain driven by innovation competence of its members. This chapter focuses on innovation-based buyer-supplier competition as addressed strategically by Porter (1979) which lately applies to competition on a value chain (Porter and Teisberg, 2006, Chapt.4).

A business context is envisaged in which, at any given point in time of the relationship, both the buyer and the supplier could be pursuing innovation simultaneously. We recognize that the primary motivation for such investments in innovation by members of the supply chain is to increase their differential or relative channel power in the supply chain. Also in a situation where the buyer is locked in by a supplier, the buyer may actively pursue the creation of a substitute technology by investing in innovation. The primary motivation for the buyer in this case would be to eliminate the technology lock-in and become independent.

In such circumstances, firms enter the crossroads of a very delicate strategic supply chain relationship. Specifically, a strategy ought to be in place to defend the ability to appropriate and accumulate value by ensuring that the suppliers of the resources that the firm chooses not to own are not able to put themselves in a position to leverage value to the firm. The PC industry provides an excellent example of power diffusion up the supply chain. In 1981, IBM designed product, process and supply chain such that it sources the microprocessors from Intel and the operating system from Microsoft. The outcome was an outstanding successful product design but a disastrous supply chain design for IBM. Today, the power of Intel in the supply chain for PCs is undisputed but continues to be challenged by Advanced Micro Devices (AMD).The new innovations that occur in this industry are to a great extent defined by this upstream supplier of microprocessors. The lesson learnt is to beware of the 'Intel Inside' syndrome (Fine,1999).

Extending this argument to the upstream microprocessor industry also provides some interesting observations. During the 1960s, the practice of second sourcing whereby innovative firms license production of one or more manufacturers that can act as a second source of any new product had already developed. It was alleged that some sole suppliers of semiconductors 'exploited' their customer firms once they had locked in their product designs to that of the supplier's product. This feature of the industry profoundly affected the evolution of market structure, for it opened up a new and attractive strategy for second sourced suppliers. A firm would enter as a second sourcer and learn to produce high volumes efficiently while offering a leading edge product identical to that of the innovating firm. Once this hurdle was surmounted, it could use its growing cash flow to support a larger R&D effort with a view to developing its own next generation products. For example, AMD operated as a second sourcer in its early years, achieved considerable success, and later on more than half a dozen companies were second sourcing AMD's product (Sutton, 2001).

A differential game formulation, as applied to an innovation race (Gottinger, 2006) and high speed technological competition (Chapt. 1) is used to examine the competition between the buyer and the supplier. Investigation of this type of buyer-supplier competition would lead to a better understanding of the dynamics of collaboration among supply chain partners. An interesting aspect of the problem is the fact that the supplier must take into account the inherent incentives for the buyer to develop a 'backstop' technology which can be substituted for the supplied component. The supplier with the knowledge of this intent of the buyer acts such that the profits are maximized before the invention of substitute technology by the buyer. The time when such innovation materializes is uncertain, but can be affected by R&D efforts.

The model formulation is related to a case in the economics of exhaustible resources. Harris and Vickers (1995) analyze a dynamic game between a resource-exporting country and an importing country that is seeking to invent a substitute technology. They address a central question in the economics of exhaustible resources concerning incentives for the discovery of reproducible 'backstop' technologies to substitute for finite natural resources that are being depleted. Importing countries are motivated to discover backstop technologies not only to overcome the problem that resource stocks are finite, but also to reduce dependence upon resource producers, who often enjoy a considerable degree of monopoly power over them.

The third contribution (COOPET) , Chapt. 3, presents the competitive role of innovation among collaborating firms. The models provide reasoning for inter-firm incentives in forming collaborative arrangements for product development. The dynamics of relationship among supply chain partners is viewed in terms of their respective innovation competence. It is emphasized that varying power arrangements in a supply chain leads to different implications for investments in innovation by buyer and supplier. The incentive for buyer and supplier to strategically maneuver their overall innovation levels by appropriate investments is highlighted.

The purpose of this chapter is to provide a strategic framework and insights regarding power and competition in a collaborative supply chain setup. It builds on strategic thinking specifically in the context of collaboration. In particular, Williamson's (1975; 1985, 1999) transaction cost approach provides a conceptual grounding for understanding the fundamental basis on which relationship between buyer and supplier takes place. With multiple firms constituting a supply chain, investments by supply chain partners have implications that transcend the traditional cost minimization or revenue/profit maximization objectives. In present dynamic environments, firms are investing in risky innovations and associated strategies to gain first-mover advantage (Gottinger, 2006). But also in high technology industries more firms strategically decide to enter a collaborative relationship. In a joint product development context, many firms outsource the manufacturing process of components which would be used in the final product (Besanko, et al., 1999, Chapt. 2). At times, this outsourcing goes beyond just the manufacturing of a fully specified component to allowing and expecting the supplier to build resource competence through active innovation.

An example can be found in the supply chain of automobiles (Clark and Fujimoto, 1991, Chapts.5, 6). Automobile production begins with design, which consists of three main elements. The first element is the concept itself, thereafter, the design of the vehicle can be usefully divided into the macro-design (the development of the basic chassis, sub-assembly and component specification) and the micro-design (the development, to agreed specifications, of the vehicle's constituent components). The first two elements of design tend to be undertaken by the car assembler. In particular, the assembler takes charge of concept origination. In the face of intense competition, however, the costs associated with developing new vehicle prototypes have increasingly forced car assemblers to source the design of sub-assemblies and components (the micro-design) from external suppliers. The degree to which such outsourcing is undertaken by assemblers varies between different firms.

The assemblers who outsource the micro-design to external suppliers have a motivation to let these suppliers grow larger so that the supply bases can be brought up to global standards. These larger suppliers would then be required to take full responsibility for the design of sub-assemblies and for the coordination of the second and third-tier component manufacturers that contribute to the product.

The strong market position of these sub-assemblers is further enhanced by product specialization. No single supplier produces all types of sub-assembly. For example, Bosch, which is the world's largest automotive equipment manufacturer, targets its efforts on starter systems, spark plugs, braking systems, lighting and windscreen wipers.

The net result of market consolidation is that the supply of particular sub-assembly systems has become concentrated amongst just a handful of manufacturers.

In such circumstances, firms enter the crossroads of a very delicate strategic supply chain relationship. Specifically, a strategy ought to be in place to defend the ability to appropriate and accumulate value by ensuring that the suppliers of the resources that the firm chooses not to own are not able to put themselves in a position to leverage value from the firm. The PC industry provides an excellent example of power diffusion up the supply chain. In 1981 IBM designed product, process and supply chain such that it sources the microprocessors from Intel and the operating system and application software from Microsoft. The outcome was a phenomenally successful product design but a disastrous supply chain design for IBM. Today, the power of Intel in the supply chain for PCs is undisputed. The new innovations that occur in this industry are to a great extent defined by this upstream supplier of microprocessors. The lesson learnt is to be aware of the "Intel inside" syndrome (Fine, 1999). Also in the context of anti-trust analysis evidence of vertical innovation and its impact on competitive positioning has previously been shown by Fisher et al (1983) in detail.

Extending this argument to the upstream microprocessor industry also provides some interesting observations. During the 1960s, the practice of second sourcing already developed whereby innovative firms license production to one or more manufacturers that can act as a second source of any new product . It was alleged that some sole suppliers of semiconductors "exploited" their customer firms once they had locked in their product designs to that of the supplier's product. This feature of the industry profoundly affected the evolution of market structure, for it opened up a new and attractive strategy for second sourced suppliers. A firm would enter as a second sourcer and learn to produce high volumes efficiently while offering a leading edge product identical to that of the innovating firm. Once this hurdle was surmounted, it could use its growing cash flow to support a larger R&D effort with a view to developing its own next generation products. For example, Advanced Micro Devices (AMD) operated as a second sourcer in its early years. The company's president once described its strategy as one of "planting cash crops" with a payback period of a few months and moving to longer-term projects only as cash flows grew (Wilson, Ashton and Egan 1980, pp.58-9). AMD's annual R&D budget in the early 1970s stood at 6 million dollars compared to Intel's 193 million dollars (Dorfman 1987, pp.211). By 1975; however, AMD could launch its own (4-bit) microprocessor (Wilson, Ashton and Egan 1980, pp.96). By providing a family of compatible devices, AMD achieved considerable success, and by 1978 half a dozen companies, were now second sourcing AMD's product (Sutton 2001).

With increasing formation of collaborative supply chain networks, research regarding channel power and lock-in circumstances in a supply chain is of paramount importance. Cox et al. (2002) highlight the need to undertake rigorous analytical research in this sphere of supply -and value chain networks to augment our understanding of power regimes. The results of an analytical research could potentially provide understanding of the types of countervailing strategy to shift the balance of power in a supply chain.

Chapter 3 analytically examines this issue using a differential games based approach. A model of competitive dynamics between a supplier and a buyer is presented using stochastic processes and differential games. It analyzes the context of buyer-supplier competition, by adapting and building on Browne (2000); which is primarily targeted towards investigation of portfolio investment strategies in finance. In this work, the analysis and theoretical results in Browne (2000) are extended to gain insights associated with strategic supply chain management. Also we draw from a specialized survey of results by Karatzas (1990)

Throughout we assert that the competitive strategy based on innovation could potentially permeate into collaborative setups aimed towards dispersed product development. The existing literature on supply chain management doesn't explicitly consider the implications of innovation and quality based competitive strategies in a collaborative supply chain context. Two theoretically insightful models have been presented that provide motivation and a starting point for further work to explicitly consider competition among buyer and supplier in supply chains. The notion of lock-ins and power shifts is implicit in the model development and has implications for the future modeling in this area.

Finally, from a methodological standpoint, the chapter provides motivation to use game-theoretic analytical studies to investigate some of the interesting questions in operations and strategic management. It extends the research on innovation and quality-enabled competition by considering dynamic models of competition utilizing a differential game approach. The theory of differential games originated as an extension of optimal control theory (which is concerned with one-person dynamic optimization problems in continuous time). These analytical tools of differential games are therefore influenced by those of optimal control (e.g., maximum principles, Hamilton-Jacobi-Bellman equations of dynamic programming, state space analysis). However, differential game theory has long since transcended its origins in one-person dynamic optimization and has moved on to become a subclass in its own right of the broader field of dynamic game theory.

The use of differential games is now more common among researchers in economics, marketing and management science. However, the use of such an approach to examine issues related to strategic supply chain management is quite sparse, in particular in the form of non-zero sum. By explicitly considering strategic issues in operations and supply chain management, this work enhances the existing methodological foundations in this field. It is emphasized that the competitiveness achieved with operations is deeply rooted in core capabilities and relates to the dynamic capabilities view of the firm .It is asserted that the key operations constructs and variables ought to he viewed from a strategic framework and differential games provide one of the tools for a rigorous treatment of the problem context.

Managerial dimensions

The analytical results provide insights into managerial implications regarding strategic issues concerned with product development and supply chain planning. The conceptual framework provides a foundation for managers to view competitive advantage emanating from product development in a more integrated manner.

The results of HSTC point towards a time variant innovation investment strategy. It suggests that firms competing by means of new product development must choose instantaneous investment in innovation such that it increases with time. The quality manifestations exhibit an increasing trajectory. In a symmetric competition, the investment profile of the leader is sigmoidal while that of the follower is convex increasing. 'T'he impact of such an investment profile is aptly reflected in the quality improvement trajectory.

The results provide implications for a firm for innovation investments by considering their relative strengths and weaknesses. The exploration of firm asymmetries provide some interesting implication that a firm should consider when competing via new product development. The results can be translated into executable decisions for investments. These results provide insights to evaluate different scenarios for pursuing strategies which would lead to best market outcome.

Chapts. 1 and 2 provide a way of thinking about business strategy and operational alignment in a collaborative network. The results provide directions for strategies to be adopted in a supply chain context. These are becoming increasingly important in the present business environment, where many firms are joined together in a collaborative network. In industries driven by innovation ,e,g. semi-conductors or biotechnology, having the control on the overall innovation levels that drive the technology landscape could mean a strong strategic advantage for one partner over other contributing firms.

Innovation competence plays an important role in this approach on a supply chain relationship. In Chapt. 2 the specific scenario modeled is representative of practical situations. As an example, it can be observed that IBM is actively involved in creating quantum computers. One reasoning for investments in quantum computers could be an extension of technology landscape. However, equally important is the realization that a success of such an endeavour could lead to a lock-out of Intel from this newly formed market for quantum courputers. The simplistic model used in Chapt. 3 allows for an exploration of such a situation. The stationary Markov perfect Nash equilibrium investment strategy of the buyer and supplier is found to be time invariant and is characterized by the parameters in the model. An interesting insight obtained as a result of analysis of the model is that the supplier can influence the motivation of the buyer to invest in substitute technology. The underlying mechanism can be translated into pricing strategy that results in a long-term buyer-supplier relationship.

The analysis of a model of buyer-supplier relationship in Chapt. 3 allows to investigate a more generalized setup of buyer-supplier innovation-based competition. The aspect of channel power is tightly integrated in the analysis to understand the complex behavioral aspects using a simple framework. These results indicate that structural risk plays an important role in innovation investment decisions. Moreover, the variance in wealth formation is an important indicator of how much to invest. These results are quite intuitive and enable managers to objectively resolve some of these strategic decisions.

The propositions provide insights into the dynamics of relationship between a buyer and a supplier firm. These propositions present the role and responsibility of buyer in creating motivation for the supplier to collaborate. The importance of critical assets is aptly amplified in the results. The possession of critical assets, often observed with the upstream partner gives the supplier a potential to achieve relative market closure through a position of dominance over competitors. It is likely that a firm in possession of such a critical asset also has the potential to achieve effective leverage over collaborating partner--, and suppliers. The responsibility of the buyer is to create a delicate balance between managing supplier and customers. Similar to the conceptual development the results suggest that for a buyer that wishes to be successful an understanding must be developed about how to own and control critical assets that provide opportunities to create customer dependency and 'lock-in ' .A competence in procurement management forms the cornerstone for success of long term business strategy.

Extensions

Many extensions can be considered for this theme and some of them are discussed below as potential further directions in managerial economics.

First; within the framework of HSTC the model can be extended by evaluating the improvement in product quality with learning effect. The learning effect is very well documented in the literature and the extension to incorporate learning effects is straightforward. Specifically, learning can be used to characterize the dynamics of evolution of product quality and in the characterization of costs associated with innovation investments.

For analytical simplicity the revenue function is treated as a salvage value. As an extension the incorporation of the dynamics of evolution of revenue in the analysis of the model can be explored, In the sequential play game, the state dynamics of the follower can be considered to be dependent on the state of the leader at previous time instant. This modification would allow for analysis of a model in which the leader uses open-loop Nash equilibrium strategy for innovation investments whereas the follower would adopt a Markovian Nash equilibrium strategy. Additional insights can be gained by this modification for leader-follower competitive dynamics in new product development.

Firm asymmetries can be explored by considering multiple parameters at the same time. This would enable a richer understanding of the strategies that a leader and a follower should adopt based on their strengths and weaknesses.

The competitive dynamics of buyers and suppliers are explored. The essays present the competitive role of innovation among collaborating firms. The research asserts that the buyer and the supplier could be in a competitive relationship due to efforts in innovation. Existing literature in operations management doesn't explicitly consider the implications of innovation based competitive strategies in a collaborative supply chain context. Models are presented that provide motivation to explicitly consider such competitive situations. The notion of lock-in and channel power is implicit in the model and presents an approach for theory-building activities in this area.

We know that the model presented derives from a simplified version of the dynamics between a buyer and a supplier. The constraints placed on different parameters and the context of a monopoly supplier and a buyer facing perfect competition is an approximation for analytical convenience. However, this enables a theoretical investigation of some important aspects underlying buyer-supplier relationships. Specifically, the research provides a way of thinking about business strategy in collaborative networks. These are becoming increasingly important in the present business environment, where many firms are part of a collaborative network. In industries driven by innovation for example, semiconductors and biotechnology, having control over the overall innovation levels could mean a strong strategic advantage for one partner over other contributing firms. At the same time, the firm already having the channel power can take some actions that would enable a long-term relationship built on trust based governance.

Several extensions could be considered to better represent such °co-opetitive' relationships between collaborating firm. Given the objective interests, it is necessary for collaborating partners to know how far the other side is prepared to concede before it is no longer profitable to be in a relationship. Information about the cost structures of the collaborating partners and their relative utility from the exchange relationship is critical to an understanding of power in exchange relationship. Hence, one of the extension of the problem is to consider aspects of information asymmetry. The two key problems generated by private information and imperfect observability are - adverse selection and moral hazard. The adverse selection is a condition of supplier opportunism that occurs prior to a signing of a contract. Moral hazard on the other hand refers to supplier opportunism that occurs once the buyer has signed a contract.. A rational buyer tries to possess information that counters the above motives on the part of suppliers. Aspects related to detailed price comparison between the supplier; its competitors and the range of substitutes provides means to investigate buyer strategies. An investigation of the implications of threat by buyer of placing the contract elsewhere to get additional price concessions from its preferred supplier can be carried out.

The assumptions made in the models and the constraints put on variables can be relaxed to obtain a better representation. A scenario with multiple suppliers/buyers enables enrichment of the findings . The result regarding guidelines for price bandwidth to create long-term relationships can be explored in further detail. The implications on profits by adopting a strategy for long-term relationship can be compared and contrasted with those of adopting the Markov-perfect Nash equilibrium strategies. The insights obtained from this approach also provide a background for future studies in supply chain contracts. The problem context and results clearly demonstrate the competitive role of innovation between the buyer and the supplier. It provides a rationale for investigation of supply chain contracts by explicitly considering the evolution of innovation competence and critical assets of collaborating partners.

In Chapt. 3 (SCOOP), the stochastic differential. game model considers the Brownian motion for the evolution of wealth for supplier and buyer. These Brownian motions can be treated to be autocorrelated to investigate the associated implications of investment strategy. The model can be extended to examine a sequential game and the associated investment strategy for buyer and supplier. Another extension to the model is consideration of spill-over effects. The spill-over of knowledge created by investments in innovation is common in literature pertaining to economics and management science. Such a spill-over of knowledge may provide some interesting results regarding buyer-supplier power structure and investment strategy.

The results obtained in these papers provide grounding for hypothesis for future empirical studies. The availability of secondary data could aid in validating the results and thereby fulfilling the theory testing requirement. Primary data can be collected based on the insights generated from this study to explore some of the psychological aspects involved with inter-firm competition in product development. The aspect of buyer-supplier relationship as reflected by the psychological school of thought can be integrated with the results in this study by using survey data from buyer and supplier firms involved in collaborative product development.

Finally, from a methodological standpoint, the analysis can adopt classical game theory and evolutionary game theory to broaden the scope of investigation. Complex adaptive systems based approach can be used to simulate the models in this study. The results obtained from this analytical study may aid in defining key relationships among agents, and can enhance our understanding of supply chain dynamics.

Cooperative Ventures

Shifting our attention to cooperative ventures (COOP) and (TCRDCOOP), Chapts 4 and 5, on the R&D dimension between firms we will see that those complement (not substitute) the competitive path.

Inter-firm relationships in the R & D first stage are often assumed to be either cooperative or non-cooperative, while a second stage product market is usually characterized by a non-cooperative Cournot competition. Most of the present R & D literature concentrates on the comparison of the pure cooperative case to the pure non-cooperative first stage, given Cournot competition in the product stage. Such frameworks may not be applicable to situations where either: (a) the firms' technology is determined by a mixture of independent R & D and cooperative research joint ventures (RJV), or (b) product market competition is not Cournot. A model of research joint venture operating competitively in a differentiated product market would allow participating firms to engage in independent R & D in addition to that performed jointly. Co-operative R&D is thought to be socially beneficial for several reasons:

(i) RJVs can alleviate the under-provision of R&D effort that results from technological spillovers and other sub-optimal R&D decisions. (ii) Cooperation can lead to greater dissemination of R&D results. It can improve R&D efficiency through good research design and information sharing, avoiding needless duplication of resources. (iii) Cooperative R&D enables the firms to share risks, to exploit synergies, pool different complementary assets, and exploit increasing returns to scale in R&D. It can enable firms to overcome a cost-of-development barrier impenetrable to any one of them alone.

After Schumpeter (1942) emphasized the importance of technological progress for economic growth, much attention has centered on the relationships between product market structure and technological progress. However, the relationship between market structure and technological progress is still an open question. The ambiguity regarding this relationship also results in difficulties in analyzing the benefits and costs of R & D competition. It is difficult to determine whether cooperation in R & D will result in collusion in the production stage or how the concentration ratio will affect R & D investment. Instead of analyzing a complete set of interactions, economists have tackled the issues related to cooperative R & D by adopting a two stage model and concentrating their attention on the effects of R & D competition before considering the competitive interactions of firms in the product market. They explicitly or implicitly assume that symmetric firms are effectively prohibited from collusion. Grossman and Shapiro (1986) and Katz (1986) first used this approach to analyze the effects of cooperative R & D. Grossman and Shapiro adopt the upstream and downstream perspective and describe the possible benefits and costs of a research joint venture. Katz proposes a four stage model in which R & D activities are specified by three stages. Using this model, he discusses the general effects of cooperative R & D. Both approaches emphasize the possibility that cooperation produces greater total R & D because it can internalize the spillover externality, thereby avoiding duplication of R & D efforts and thus decreasing each firm's R & D expenditure. They also note the possibility that a RJV may have an anti-competitive effect when product market competition is intensive and suggest that the negative effect of a RJV may be prevented by allowing the participating firms to engage in independent R & D.

D'Aspremont and Jaquemin (1988) develop a constructive model and prove that cooperative R & D produces greater R & D effort in equilibrium than non-cooperative R & D when the spillover rate is relatively high and the product market is modeled as a homogeneous goods Cournot competition. In this model, both firms in the cooperative R & D venture coordinate their R & D expenditure to maximize joint profits. D'Aspremont and Jacquemin show that while one might expect cooperation to lead to a reduction of R & D expenditure by avoiding wasteful duplication, in fact cooperation actually produces greater R & D when the spillover rate is relatively high. A limitation in their model is that the firms participating in the RJV do not share their R & D outcomes but rather simply coordinate their R & D spending. This naturally leads to the question of why the firms want to coordinate their R & D expenditure. Moreover, the coordination of R & D expenditure will not necessarily avoid duplication of R & D since the participants do not share the results. Kamien, Muller and Zang (1992) extend d'Aspremont and Jacquemin's model to the case when the R & D outcome is fully shared and still conclude that a RJV results in greater R & D output than non-cooperative R & D competition. Choi (1993) generalizes the model to the case where the R & D outcome is uncertain and finds the same outcome.

Alternative schemes of cooperative R & D can change R & D incentives and its social implications. Specifically, firms may spend at least as much in the cooperative stage as they

would under the non-cooperative competition when RJV allows the participants to continue independent R & D. When independent R & D is allowed, both firms know that if cooperative R & D by RJV is not large enough, they will increase their R & D investment. But, mostly, independent R & D is less efficient than cooperative R & D because it is not shared and does not avoid the duplication on R & D investment. When cooperative R & D allows room for independent R & D, firms can save R & D by agreeing to increase their cooperative investment on R & D. Given the importance of governmental policy with respect to RJVs, understanding the implications of alternative RJV schemes seems to be a valuable one to explore. A scheme that includes research joint venture plays an important role in investment in process innovation. In fact, this analysis shows that when independent R & D is allowed, the level of R & D in the RJV is not lower than in the purely non-cooperative equilibrium. That is, if the RJV allows the parent firms to continue their independent R & D, the danger of the collusive reduction in R & D is unlikely to be serious. Even if member firms' products are close substitutes, an antitrust authority need not worry about the anti-competitive risk of RJVs as long as the RJVs allow participants to continue independent R & D.
Lastly, we examine how changes in the model's parameters affect R&D effort levels in each scheme. Specifically, a comparative static analysis is performed to determine the effect of the spillover rate ,the internal spillover rate and the cost of R&D on innovative activities. Most writers acknowledge the possibility that the intensity of competition in product markets, the rate of spillover, the efficiency of sharing cooperative R&D and

the expensiveness of R&D costs play important roles with respect to R&D investment decisions. Since the framework of this chapter allows one to analyze these relationships, it is possible to provide clues to addressing these questions.

Chapter 5 (TCRDCOOP) is concerned with technological competition when firms can share both the cost and the outcome of innovative activity. Since innovative investments are often very expensive and accumulated knowledge has a tendency to leak to others , firms may have an incentive to conduct their innovative activities cooperatively. Cooperation in R&D among competing firms can produce more rapid technological progress. But cooperation in R&D may not always produce a better social outcome . The potential gain from R&D will be dissipated to consumers if price competition in the product market is intense. That is, the incentives to innovate depend on the degree of product differentiation. If the products are less substitutable, the profit incentive dominates each firm's willingness to invest in R&D and it leads to the result that the currently less advanced firm engages in more R&D. If the products are very substitutable, then the competitive incentive determines the outcome of the technological competition so that the currently more advanced firm increases its superiority in technology.. Hence the rate of product differentiation is shown to be an important determinant predicting the outcome of technological competition.

Asymmetries between firms are frequently observed in market competition as for example in the case that one firm has a more advanced technology. If there exists some difference between firms, it will certainly affect the incentives to engage in innovative activity. The asymmetries between those firms will generate different incentives to introduce new technology. Since the outcome of technological competition has an obvious effect upon the firms' market positions, firms need to take account not only of the immediate profits that it brings but also the advantage that it may confer in subsequent competition when later innovations are expected. To explore this we first construct a two period model and ask how the existence of such subsequent innovative opportunities affects the outcome of technological competition.

The analysis uncovers two different forces on determining the incentives to innovate. The competitive incentive is defined as the difference between a firm's profits if it innovates and the profits it would make if its rival innovated instead. The profit incentive is determined by calculating the increase in a firm's 'profits if it alone were investing in R & D. Given those forces, we explore how the incentives to innovate depend on the degree of product differentiation or niche building in product markets.

An alternative outcome could be expected with technological competition when firms can share both the cost and the outcome of innovative activity. The majority of models consider the case that there is only one winner in the technological competition. But alternative models develop technological competition in which each firm engaging in R & D can obtain a patent on a cost reducing technology. Since innovative investments are often very expensive and knowledge has a tendency to leak to others, firms may have an incentive to conduct their innovative activities cooperatively.

Cooperation in R & D among competing firms can produce more rapid technological progress. Since the new technology is shared among competitors through cooperative R & D, firms can avoid the duplication of R & D. The cooperation in R & D can also be a solution to the leakage of information. Since knowledge is inherently a public good, the research done by one firm can be used by another firm even though the latter does not have permission to use the inventive output. Cooperation in R & D is a solution to this problem because cooperative research agreements can internalize spillover externalities. But cooperation between firms' R & D activities may not always produce a better social outcome. The potential gain from R & D will be dissipated to consumers if price competition in the product market is intense. This creates the potential collusive reduction in R & D. That means, firms could use a cooperative agreement in R & D as a vehicle to slow the pace of technological innovation.

In exploring the relationship between technological competition and product differentiation we ask how the rate of product substitutability influences technological progress. The number of firms in the market determines the intensity of price competition. But market competition is also affected by the degree of product differentiation. When the products in the market are less substitutable, the participants in the market will experience less competition. Instead of asking how the incentive to innovate is affected by the increase in the number of firms in the market, which is a common theory in analyzing the relation between R&D and product differentiation (Suzumura, Chapt.4), we consider the question of how the incentive to innovate is related to the degree of product differentiation.

When two products are close substitutes, technological competition is intensified and it drives the market 'to be monopolized' by a firm. If two products are less substitutable, the firms have greater monopolistic power over customers. This discourages a firm from stealing its rival firm's customers through innovation and the market keeps its competitive structure unchanged.

It also turns out that the effect of a spillover externality on technological progress is dependent on the closeness of the two products. As stated earlier, knowledge is inherently a public good and it is difficult to prevent its use by others. The analysis shows that the incentives to innovate are generally reduced as the rate of such leakage of knowledge increases. However, when products are very different, the firm that has less of an incentive to innovate has a tendency to raise its R & D effort as the spillover rate increases. The increase in the spillover rate helps the firm that has less of an incentive to improve its marginal contribution of technological progress and compensates for the reduction in its own competence.

Competition and Cooperation in Network Markets (CCNM)

Many high technology industries are characterized by positive network externalities. Firms essentially compete and cooperate on R&D and the production of goods and services that share a network. Some models of competition contain special features that apply equally well to network markets. One is the uncertainty in technological development or uncertainty in the realization of a firm's R&D effort. The other is the dynamic nature of price competition between firms in the presence of network effects.

Firms compete with each other over an extended period of time and must therefore strategically choose prices as the market shares of the firms evolve.

Most existing models of network markets focus on only one of the two features. Further, almost all the models have the commonality that one firm captures the market instantaneously and sells to all consumers from then on (the 'winner-takes-all' market) . However, the history of high technology industry abounds with instances where rival firms (and technologies) have had extended battles for providing the industry standard (Uttenback, 1994).

In network markets evolution of market share is a very interesting phenomenon especially in the face of uncertainty about future product quality. Chapter 6 (CCNM) also attempts to provide a framework that could capture the richness of market share evolution in the presence of network externalities.

We re looking into the following situation: "Firms that are not leaders in network industries generally have little hope of reaching that status unless they come up with a major innovation – one that can defeat the natural advantage that network effects bestow on the industry leaders. Incremental innovation – making slight improvements in the leaders' products – will not enable a small firm to overtake a leader that enjoys the benefits of network economies. …It is not atypical for a fringe firm that invests heavily to displace the leader by leapfrogging the leader's technology …" (Evans and Schmalensee, 2001,pp. 10-12)

This situation described may also be encountered in 'dynamic oligopoly' where exogeneously emerging new technologies are rapidly eroding costs or where market structure responds endogeneously to intense racing behaviour (Shapiro,1989,Sec.5, Baumol, 2002,Chapts. 1, 4).

We are encountering the problem of tradeoff between 'network dominance' and 'radical innovation' that could tip the market the other way, with a significant caveat added that breakthrough R&D is highly uncertain. From a strategic perspective, in this environment, for any two firms of asymmetric size, both compete dynamically over prices to win market share. In this dynamic process there are two ways to achieve (temporary) monopolistic status. The 'smaller' firm can use dynamic pricing competition to delay the time in which the 'larger' firm wins a critical market share in the hope to hit the innovation first and displace it. If the innovator is 'patient' and the probability of innovation and the discount factor are sufficiently high, there is an equilibrium in which duopoly persists (no firm achieves a critical market share) until one of the two firms wins the race for innovation.

We briefly summarize a historical example from markets for IT products. In the personal computer (PC) operating system market. Microsoft products (MS DOS and Windows) have been dominating the market since the mid 1980s. An operating system is the fundamental program that controls the allocation and use of computer resources. Thus, the utility that operating systems provide to consumers depends on the number of compatible applications.

As a general rule an application that relies on a specific operating system will not function on another operating system unless it is ported to that specific operating system. Therefore, because of its dominance, the majority of applications have been written to run on Microsoft operating systems (MS DOS). The domination of MS DOS has become even stronger since the arrival of Windows 95 in the PC operating system market. This, in turn, has provided a great indirect positive network externality to PC owners who adopted Windows 95 as an operating system. Many other firms, such as IBM and BEA Systems, Inc., introduced their own operating systems and tried to compete with Windows. These products, however, lacked sufficient compatible applications to efficiently compete with Microsoft products. The lack of compatible applications prevented enough application developers and consumers from regarding OS/2 Warp or BeOS as a viable alternative to the dominant incumbent, Windows. This obstacle prevented these potential entrants from obtaining a sizable market share. Their failure to enter the market successfully, however, was not due to the inferior quality of their operating systems. In fact, OS/2 Warp was reported to be at least as good as Windows, and BeOS offers superior support for multimedia applications and systems security. If consumers who use multimedia applications frequently adopt Windows at the expense of BeOS, they have to give up the convenience that is provided by BeOS. Thus, for multimedia specific users, adopting BeOS as their operating system at the expense of another operating system might provide the highest utility. Nevertheless, the lack of compatible applications, which in turn implies the lack of positive network externality, has prevented consumers from adopting OS/2 Warp or BeOS. As a conclusion, the positive network externality for the dominant incumbent (Windows) has worked as an entry barrier against entrants (OS/2 Warp or BeOS) which do not have network externality. Such an entry barrier could only be overcome by a radical innovation, virtually leapfrogging the dominant incumbent.

Open Source Technologies (OST)

In OST, Chapter 7, we focus on a contestable market with network externalities engaging an incumbent and an entrant. The incumbent, unlike the entrant, already has an installed base of consumers. We look at decision situations of firms regarding how proprietary they want to make their technology , either through patent protection or through development in open source systems (OSS). We explicitly model the direct and indirect effects of network externalities. For example, more software companies are willing to produce programs for an operating system (OS) if it has a larger consumer base. This increased competition could lead to an improvement of the quality of the OS. The model predicts that using open source technologies is likely to enhance the rate of R&D , and consequently the quality of the product.. An incumbent that would choose this strategy is likely to deter entrance of a newcomer because it can play out its advantage of a larger network.

Cooperative R&D is a crucial phenomenon both from the point of view of the individual firm and the economy as a whole. Since innovation could be regarded as a public good, society as a whole benefits from innovation. However, the private benefits to a firm from innovating are likely to be different from the social benefits. In the absence of any mechanism preventing it, the benefits to an innovating firm are likely to be quickly dissipated by the entry of other imitating firms. In such a scenario, firms are unlikely to innovate. Thus according to conventional thinking, firms need to have some sort of reward for innovating. Intellectual property rights such as patents and copyrights provide this compensation. A big portion of the R&D literature has focused on the optimal patents' duration and breadth and the incentive of firms to innovate.

However, a different trend has emerged these days especially with the increasing proliferation of hi-tech (network) industries. Instead of trying to get exclusive ownership rights, an increasing number of firms are making their technology freely available i.e., their technology is no longer proprietary i.e. ‘open source’ (Cane, 2004).

In the so-called browser war, in the 1990s, we have witnessed intense competition in the market for internet browsers between Microsoft and Netscape. Netscape had a major head start on Microsoft, controlling 90 percent of the browser market by 1996 before Microsoft started aggressively selling in the market. With the entry of Microsoft, both firms engaged in a race to have the best available product.

Given the intense competition between the two firms, by the end of 1997 Microsoft was pricing the Internet Explorer free. In contrast, Netscape was charging corporations licensing fees for using their browser. By the end of 1997, Microsoft had stolen a large chunk of Netscape's market share. Netscape eventually followed suit and started giving away its browser free.The extended battle between Microsoft and Netscape had its toll on the profits of both companies. In 1998 Netscape came up with a new strategy and decided to release its source code, the actual line of programming language, for the Netscape Communicator. This allowed users and developers to look inside the workings of the browser, to modify the software and even to redistribute the new version under their own brand name, provided that the modified source code was also freely available. The whole idea is to turn the entire internet community into a vast research division for Netscape browser.

The term ‘open source software’ has been widely used in the popular and professional literature. Instead of keeping their technology proprietary, the firms will distribute it freely. It is this phenomenon that Chapter 7 attempts to explore. We wish to study the decisions of firms whether to keep their technologies proprietary or not.

Even though the whole unorthodox open approach may seem counterintuitive, Netscape was not the only one who employed it. Apache, a program for serving world wide web sites, and Sendmail, a program that routes and delivers internet electronic mail, are examples of free open source programs that dominate the market. Open source approaches have been expanded to the biotechnology and health care industries. . Linux, an increasingly popular operating system created in 1991 is another classic example of successful open source software. Many of the programmers and software designers advocating OSS may share a utopian vision of software development, or they may simply want to prove themselves to be better than software giant Microsoft. However, the whole idea of OSS may not be so anti-capitalistic as it seems. It is hard to believe that profit-aiming firms will employ the OSS strategy without considering more pragmatic matters. .As recently being pointed out, 'open source software' such as Linux refers to freedom of choice not free prices. (Cane, 2004) The emergence of OSS as an observable phenomenon may be because the markets under consideration are no longer conventional markets. These markets exhibit "network externalities"- a market has network externalities when buyers of a good exert positive benefits on the other users of the same good. For instance consumers are likely to value computer hardware more the more users of the hardware there are. This could be because there is likely to be a better support system the larger is the network of consumers buying the product. Similarly, it is more likely for improved software to get written for the computer hardware the bigger is the network of consumers buying it. But network externalities can be working both ways, positive or negative, for example, incompatibility with network systems on a rival operating system (such as MS Office) is a major obstacle in the OSS pursuit of the desktop though low prices for OSS products would be a strong incentive to switch and for new customers to enter.

In such a market time is of utmost importance in the race for product improvement. Firms cannot afford to let their competitors get ahead in the race for technological innovation since that would give them the added advantage of a bigger network. Also, consumers in these markets tend to exhibit a very high level of loyalty. That is because learning to use the product involves a cost. Once a consumer becomes familiar with particular software, she is unlikely to switch to a completely different brand performing the same tasks. Instead, she would rather purchase new releases of the same brand even though there can be various close substitutes with similar qualities available in the market. This enhances the effect of network externalities in the long run. Further, OSS *can* feasibly translate into better quality in markets such as those for computers.

The effect of OSS on product improvement is two-pronged. Making the technology freely available means that there can be more people directly working on improving the product. For example, ever since Linux went fully OSS, thousands of programmers have volunteered elaborate improvements of their own design for no more reward than the respect of the geek subculture. It is like expanding the R&D department, so larger improvements in quality can be realized. Second, there is likely to be a better supply of complementary goods. For instance giving out the source code for an operating system is likely to lead to more software being developed for it, which is in essence equivalent to having a better quality operating system i.e., consumers now find this more attractive.

On the other hand, making technology freely available means a loss in license fees. There is also the fear of technology being stolen. But in a market with network externalities, if the firm giving away its technology already has a sufficiently big network then it is more difficult for other firms just entering the market to steal the technology and get ahead since they would also have to overcome the network advantage of the existing firm (Gottinger, 2003). Besides in this digital era, the relative ease of creating software with similar functionalities using different programming codes has made the whole idea of keeping technology proprietary less relevant.

We can thus think of OSS as increasing the rate of product improvement or increasing the success rate of R&D. We model OSS via license fees and assume that OSS increases product development deterministically.

A lower license fee represents a less proprietary technology. A zero or negative license fee means that the technology is totally non-proprietary. Positive license fees represent a proprietary technology - the firm is not willing to freely distribute its technology. The more ‘open’ a firm is the higher is its rate of R&D - in our model R&D translates directly into the quality of the product. The greater the R&D, the higher is the quality of the product. OSS improves the quality of the product in our model by increasing the supply of people or firms working on improving the product.

We look at a market with network externalities with an incumbent and an entrant. The incumbent, unlike the entrant, already has an installed base of consumers. Our objective is to explore the decisions of the firms regarding how proprietary they want to make their technology, i.e., how copyright or 'open' to make their product. The decision of copyright or open mentioned above, is modelled via license fees. We wish to see whether the incumbent could use 'open' as an entry deterring strategy. We also compare the incumbent's decision with that of a monopoly's.

In modeling the direct and indirect effects of network externalities, as in most models, we have the network term showing up in the consumers' utility; the bigger the network, the better off the consumers are. Consumers prefer to use a popular word processor because they know the format of their work can be easily transported to other users' computers. This is the direct effect of network on consumers' utilities. In our model there is also an indirect effect of network externalities - a bigger network translates into better quality. For example, more software companies are willing to produce programs for an operating system if it has a larger consumer base. That is because the downstream software companies thus can tap into this larger network of customers. This improves the quality of the operating system.. This is the indirect effect of network on consumers' utilities.

Increasing Returns Mechanism (IRM)

Most industrial sectors of highly industrialized economies are not perfectly competitive. They are usually formed by a small number of big firms with non-negligible market share. Besides being prevalent in the economy, big firms cluster around concentrated industrial structures which exhibit a skewed distribution of firm size and market share. This situation may be brought about by the intrinsic potential of dynamic technological competition to end up in (temporary) technological monopoly, so in those cases industrial competition may start out symmetric but end up asymmetric.

In IRM, Chapter 8, we show how the competitive process proliferates in increasing returns industries (IRIs) where the total of all unit activities linked together yield a higher return than the sum of the individual unit activities operating separately. For this to be happening we must show that a variety of increasing returns mechanisms combine to enable the effect of an increasing returns industry.

We propose an integrated framework going beyond previous attempts by W. Brian Arthur (1994) to provide tools and insights for explaining competition among skewed industrial structures. However, this is only a tentative step toward attempting to explain the path-dependent, indeterminate, suboptimal, locking-in nature of technological competition under increasing return .We partially review the literature on the dynamics of technological diffusion, substitution, and competition. The purpose of this review is to show that we cannot accurately understand industrial competition without taking into account the self-reinforcing nature of commercial success in most emerging markets. We enrich increasing returns mechanisms by incorporating a set of stronger, yet neglected, increasing returns mechanisms, i.e., reputation effects, infrastructure effects and positive network externalities into a preliminary framework model. The resulting theoretical structure, we will argue, captures the interdependent and cumulative character of the three aspects of industrial competition: the number and size of firms, skewed industrial structures, and the nature of technological competition.

The increasing returns discussion in economics has provided important insights into the characteristics and dynamics of modern industrial economies. However, the discussion on policy applications has (mis)led some authors and policy analysts to conclude that a completely *new economy* is emerging and that it obeys a set of rules, which are totally different from those that apply to traditional sectors of the economy. While it is undeniable that the increasing return paradigms remain fairly new and revolutionary and while there is no doubt that this paradigm is key to our understanding of new industrial sectors, and their sustaining role in productivity growth, we should clarify its proper role in industrial structure and growth of the economy. Referring to Arrow's (1993, p.403) dictum : … that if there increasing returns , then the processes of capital formation and labour force growth result eventually in a steady exponential growth in per capita income' such a process could be equally well applied o corporate , industrial and ecoomic growth of a national economy. At this stage we are most concerned about the catalytic role of technological competition in increasing returns industries. Increasing returns industries are nowadays most likely to be identified with high technology industries, in particular with information, communication and health care related industries (Gottinger, 2003). As an example, in a corporate context, how to unlock increasing returns in its global operations, consider General Electric (GE). It constantly evolves its portfolio to drive growth despite its large size and already significant presence in major markets. It encourages its executives and business units to take an expansive view of its markets as a means of unlocking growth initiatives that a product centric view would miss. Often, when its market share exceeds l0 percent, it seeks to redefine the market more broadly to include adjacent products or services . This continual questing lies behind successful moves from manufacturing to services , that has allowed it to keep growing in complementarizing given industrial markets .For those industries Shapiro and Varian (1999) have suggested a combination of supply-side scale economies and demand-side scale economies to explain the intrinsic aspects of technological competition. It appears however that this way of seeing technological competition is too simple to capture the variety and complexity of real-world businesses in those industries Thus we suggest a general framework to describe technological competition in what we are going to call the *increasing returns economy.*

Internet Competition (IC)

Competition in the internet commons provides a universal case of competition in the media, advertising and entertainment industry (Chapt.9). Massive complexity makes traditional approaches to resource allocation impractical in modern distributed systems such as the Internet. Traditional approaches attempt to optimize some system-wide measure of performance (e.g. overall average response time, throughput etc.) Optimization is performed either by a centralized algorithm with complete information , or by a decentralized consensus based algorithm.The current and future complexity of resource allocation problems described makes it impossible to define an acceptable system-wide performance metric. What single, system-wide performance metric adequately reflects the performance objectives of multimedia serverand an online transaction processing system? Centralized or consensus based algorithms are impractical in dynamic systems owned by multiple organizations. Resource allocation complexity due to decentralizations and heterogeneity is also present in economic systems. In general, modern economies allocate resources in systems whose complexity overwhelms any algorithm or technique developed for computer systems. Here we discuss the similarities between complex distributed systems and economies. Competitive economic models could provide algorithms and tools for allocating resources in distributed computer systems. There is another motivation that has come about due to the commercialization of the Internet.

The debate has begun in the area of multiple Quality of Service (QoS) levels and pricing. How should pricing be introduced to provide many service levels in the Internet? Should pricing be based on access cost or should it be based on usage and QoS received by the end user? Will usage based pricing help the Internet economy grow, help in accounting, improve the efficiency of the Internet, and make users benefit much more? Similar issues are being investigated in the ATM networking community. We address some of the issues of QoS and pricing, and efficient allocation of resources (computational resources)in networks and systems. With advances in computer and networking technology, numerous heterogeneous computers can be interconnected to provide a large collection of computing and communication resources . These systems are used by a growing and increasingly heterogeneous set of users which are identified with the present Internet. A macroscopic view of distributed computer systems reveals the complexity of the organization and management of the resources and services they provide. The complexity arises from the system size (e.g. no. of systems, no. of users) and heterogeneity in applications (e.g. online transaction processing, e-commerce, multimedia, intelligent information search) and resources (CPU, memory, I/O bandwidth, network bandwidth and buffers, etc.)

The complexity of resource allocation is further increased by several factors. First, in many distributed systems, the resources are in fact owned by multiple organizations. Second, the satisfaction of users and the performance of applications is determined by the simultaneous application of multiple resources. For example, a multimedia server application requires I/O bandwidth to retrieve content, CPU time to execute server logic and protocols, and networking bandwidth to deliver the content to clients. The performance of applications may also be altered by trading resources. For example, a multimedia server application may perform better by releasing memory and acquiring higher CPU priority , resulting in smaller buffers for I/O and networking but improving the performance of the communication protocol execution .

Finally, in a large distributed system , the set of systems, users and applications is continuously changing. In this chapter we address some of the issues of Quality of

Service (QoS) and pricing, and efficient allocation of resources (computational resources) in networks and systems.

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