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From Communications and Innovation, To Business Organization and Territory The Production Networks of Swift Meat Packing and Dell Computer

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CONTENTS AT A GLANCE

DETAILED TABLE OF CONTENTS

LIST OF TABLES, MAPS,

FIGURES, CHARTS & PHOTOS

Tables

Tables (cont'd)

Maps

Figures

Charts

Chapter 1
COMMUNICATIONS AND INNOVATION, BUSINESS ORGANIZATION AND TERRITORY

Economies and technologies are historical creations. The way human beings organize their economic activity, and the technologies available to them for producing, buying, and selling, emerge from historically constructed settings and evolve in conjunction with the historical process. This study tells a comparative story of economic development and technological change that takes place during two historical periods. One period encompasses the early years of the mass production economy in the late 19th century. The other focuses on the formative years of the Internet economy at the end of the 20th century. Two business firms, one from each period, are the central protagonists in this comparison. These two firms reveal parallel stories of innovation and economic transformation with a set of common narrative themes.

The narrative for these two stories begins by tracing how business users of transport and communications systems reorient their competitive strategies and business practices as the technology of these systems changes. It goes on to describe how, as businesses alter their strategies and routines, they transform what is arguably the defining organizational element of business activity, the *networks* of production and trade through which firms compete and seek profit. What this study compares are the production networks that emerge as firms use new transport and communications technology to innovate their competitive, profit-seeking activity. At the center of this comparison is a profile of how transformations in production networks are part of a general process of innovation within the firm, and how these networks, in turn, reshape the geographical territory for economic activity.[1]

The Research Question

The research for the comparison in this study is organized around a central research problem:

> *How does technological change in systems of transport and communications enable business users of such systems to innovate the networks in which they produce, buy, and sell, and how do such networks assume geographical characteristics that reshape the development of territory for economic activity?*

This problem, in turn, derives from an analytical framework that seeks to explain the relationships between four phenomena: 1) transport and communications technology; 2) the process of innovation within the firm; 3) the organizational structure of the firm; and 4) the geographical space where the firm operates. This study casts the relationships between these phenomena as a series of questions framing the central research problem.

The questions that frame the research in this study are the following: 1) How does technological change in systems of transport and communications transform opportunities for profit-making by firms? 2) How do changes in profit-making opportunities stemming from new transport and communications systems, compel and enable business users of these systems to transform their strategies, routines and organizational structure for producing and trading? 3) How do the changes in strategies, routines and structure result in the reorganization of production and trade networks through which firms compete and make profit? and 4) How do these production networks assume territorial characteristics in the way they organize production and trade flows in and across geographical space?

In order to address the central research question, and the analytical relationships upon which this question is based, this study examines two highly innovative business users of transport and communications systems as case studies. One case is historical and focuses on a user of the rail and

[1] Geographical territory in this study derives from the definition of the region developed by Perloff et al. who refer to the region as an area “tied by extensive interareal activity or flows” (Perloff et al., 1960: 4)

telegraph system for production and trade during the late nineteenth century. The other case is contemporary and examines a user of the Internet as an infrastructure for producing, buying, and selling. The two firms in question are the G.F. Swift Company and Dell Computer Corporation.

Swift is the pioneering founder of the mass produced, fresh beef industry during the late nineteenth century. Dell is the contemporary developer of custom-built personal computers (PCs). Both firms rank among the most innovative companies of their respective time periods. They ascended to this shared status, however, by responding to different communications revolutions in a similar way. Both companies used the technologies of communications revolutions to create high-volume production and distribution networks that redefined competitive practices for business activity in their own time. As they created these networks, both firms established new models for business organization. These organizations, in turn, were the basis for the economic exploitation of extended geographical territories, namely the American market space in the case of Swift, and the global marketplace in the case of Dell. In effect, both companies created innovative organizations for producing and marketing goods from new technologies of transport and communications. In changing how products were built and distributed, the network organizations created by these two companies redirected the routes by which goods traveled within and between firms to final customers. In the process, the production networks of Swift and Dell reconfigured territories for the accumulation of profit.

The focus on these two firms, however, is far from a worshipful paean to individual entrepreneurial heroism. This study seeks to tell a more fundamental story about innovation and capitalist development. Within this broad frame, Swift and Dell reveal that forms of business organization are inherently spatial, and that the economy, fueled by innovation and organizational change, is a territorial phenomenon (Walker, 1988: 385). How these two firms deployed the rail and telegraph for producing and distributing fresh beef, and the Internet for producing and delivering custom-built PCs, along with the organizations deriving from this innovative activity and the territorial outcomes of their efforts, form the thematic outlines of this study. Within this narrative lies one of the most compelling issues of capitalist development: how the territory for economic activity gets reconfigured from the innovative activity of businesses. The stories of Swift and Dell aim to uncover answers to this puzzle.

Admittedly, this comparison draws upon a compelling model. Ten years ago, Paul David, in a provocative and beguiling essay, set up a comparison between the computer and the electric motor of the late nineteenth century in an effort to explain the so-called, "productivity paradox" of the 1980s and 1990s (David, 1991). In his piece, David accounted for the anomaly in the productivity statistics beginning in the 1980s when computers entered the workplace, by reference to the lag in productivity growth following the introduction of electric dynamos in factories of the late nineteenth century. A period of adjustment following the introduction of new technology, he reasoned, was necessary before productivity gains were possible. David's comparison represented a potent example of the use of history to explain contemporary technology and economic development outcomes. By casting technology and the economy of the late twentieth century into what he described as "a not-too-distant mirror," David found answers to questions about technology in the present that would not have been discernible from observations taken from the current period alone. The comparison of Swift and Dell, the rail and telegraph system and the Internet, fresh beef and custom-built PCs, in this study has a similar objective. It seeks to use history in order to gain insight about the economy around us.[2]

[2]In his observations, David notes the human tendency to lose sight of the past when confronted by the achievements of current innovation, an affliction he vividly describes as "technological presbyopia" (David, 1991: 317). To sufferers of this malady, the technological future appears closer at hand than the historical path leading to it and the afflicted, in their neglect of the past, tend to exaggerate the sense in which the present is "unprecedented" and unique. Such fixation on the future, insists David, and neglect of the historical route to present-day innovation leads to a truncated, ultimately superficial engagement with technology in the present itself.

Findings at a Glance

When applied to the cases of Swift and Dell, this historically-oriented comparative approach to innovation and economic development reveals several critical findings.

Firstly, the two cases reveal communications revolutions to be *control* revolutions that act as catalysts for innovation in the *circulation* of goods. The rail and telegraph revolution, and the Internet revolution enable Swift and Dell to create production networks that elevate the role of distribution and logistics as the sources of innovation, value-creation, and competitive advantage. Although both firms succeeded in using new infrastructure systems to create new products -- dressed beef shipped long-distance, and PCs configured through Internet communication represented new commodities -- the innovations pioneered by Swift and Dell from communications revolutions are *process* innovations. These process innovations, in turn, are linked to the creation of business *organizations* designed to coordinate the movement of the product from supplier, to producer, to customer. With this emphasis on distribution and logistics, the networks of Swift and Dell reveal a striking symmetry in attributes and aims. Dell uses the Internet to link the process of order intake with procurement, production, and delivery of PCs in creating an extremely innovative "direct-pull," "just-in-time" production and distribution network. Dell is far from the first, however, in using new transport and communications technology to create such an innovation. Swift constructs a similar network from rail and telegraph technology. It uses telegraphy to link order intake from retail butchers, with procurement of cattle supplies, (dis)assembly, and final marketing in close to real time. This network of Swift anticipates by a century Dell's logistics-oriented business model of creating a "closed loop" that eliminates intermediaries between the producer and the customer.

Secondly, research in this study on the operational characteristics of the networks created by Swift and Dell challenges the belief that the mass production age created wealth from goods while the Internet age creates wealth from information. Such partial truths ignore the ways in which the production and distribution networks of both Swift and Dell relied on the processing of enormous amounts of real time information and the manipulation of high-volume flows of goods, made possible by new communications and transport infrastructure. Swift built its network not only from its rail-transported fresh beef. It created this network on the basis of telegraphic information coordinating the movement of this product from stockyard cattle pens, to retail butcher shops. Real-time information exchange between the primary nodes in Swift's network -- stockyards, slaughtering facilities, and branch distribution houses -- was fundamental in shaping a process of procurement, production, and sale of fresh beef that was modulated daily and even hourly in order to balance conditions of supply and demand in the context of a highly-perishable product (Bureau of Corporations, 1905: 21). Information, in effect, proved as critical to Swift in capturing value from its production and distribution activity, as the product itself. Dell in turn, captures value from its production and distribution activity not only by the Internet information it maintains to link the nodes in its network. It makes profit and distinguishes itself from competitors by the way it executes the movement of supplies and final product through the primary nodes in its network consisting of supplier factories, supply logistics centers where components are staged for assembly, and Dell's own assembly sites. Internet-generated information is indeed critical in this execution. Nevertheless, movements of actual physical goods through these nodes are as critical to Dell's success as the Internet-generated information that underlies how the PCs in this network get assembled and delivered.

Thirdly, these networks of Swift and Dell reveal a similar geographical tendency of territorial spread *and* concentration. From the rail and telegraph system, Swift built a production and distribution network extending throughout the entire U.S. that obliterated the formerly localized character of beef production and consumption, and helped create a national market space. Within this territory, the Company decentralized slaughtering activity away from its original hub in Chicago to other facilities in the Midwest, creating a new pattern of industrial concentration while simultaneously widening routes of distribution across the entire continent. Similarly, Dell is building a production and distribution network on the basis of Internet technology that is establishing a new set of operational standards for the organization of globally-extended and regionally-concentrated production and distribution complexes. It has decentralized and spread PC assembly activity from its original hub in Austin to locations around the world. At the same time, it has created concentrations of assembly activity in selected regional locations in an effort to build and sell its products for the regions where assembly sites are located. This pattern of elongation and concentration created by the two firms, however, reveals a clear difference. In the case of Swift, the decentralization of cattle disassembly created a nationally based set of regionally concentrated production complexes. In the case of Dell, the decentralization of PC assembly has created a globally based set of regional production ensembles. Nevertheless, in the place-based concentrations of manufacturing organized by Swift and Dell, both firms rely on critical relationships of geographical proximity between key nodes in their networks -- stockyards and disassembly facilities, branch houses and rail trunk line switching heads in the case of Swift, supplier factories, supply logistics centers, and assembly facilities in the case of Dell. The two companies shape these relationships of proximity in order to manage and control the movements of materials between these nodes, and execute their closed-loop, direct-pull, real time systems of production and distribution.

Finally, in comparing Swift and Dell, this study clears a new pathway for understanding production networks and business organization.

In the first place, the comparison of Swift and Dell calls into question the idea that economic activity in the current period is distinguished by the organization of firms in *networks.* Such a view is ahistorical. Throughout the history of economic life, the fundamental activities of producing, buying, and selling have always occurred in networks linking individuals and firms (Braudel, 1977; 1979). Far more critical in assessing this phenomenon is how firms and individual economic actors in different historical periods organize the linkages necessary to produce, buy and sell, and the attributes of the networks deriving from this competitive activity. Consequently, production networks in the current period, as well as networks from the past, have distinct characteristics that change over time. The integrated organizations of firms such as Swift are no less networks than the dis-integrated organizations currently being created by firms such as Dell.

Secondly, while the two networks reveal organizational differences, the integrated intrafirm network of Swift, and the dis-integrated interfirm network of Dell actually share similar mechanisms of administrative control over the process of procurement, production, and distribution. In the case of Swift, these control mechanisms, achieved through rail and telegraph technology, are exercised within the boundaries of the firm through the process of vertical integration. In the case of Dell, these mechanisms of control, achieved through Internet communication, are exercised over other firms that lie outside the organizational boundaries of Dell but within the network of the PC maker.[3] Dell is compelled to use such controls in achieving what it calls *virtual integration* with its suppliers and logistic partners in order to manage the high-speed information and material flows within its network. These controls enable Dell to interact with other firms in its network not through markets and the price system. Instead, Dell enforces a structure of controlled relationships upon its network partners -- and uses the Internet to facilitate this control. Consequently, this study takes issue with prevailing views of interfirm production networks as the organizational embodiment of ascendant market forces. This study presents an alternative view of interfirm networks as organizations also dependent on mechanisms of power and administrative planning used by vertically integrated firms such as Swift. Far from a revolution in production that is reverting to market coordination within interfirm networks, the experiences of Swift and Dell emphasize how communications revolutions and their attributes of control, along with the principle of corporate power, enable firms to create production networks with similar non-market mechanisms of administrative coordination. Such similarities, in turn, establish bridges between the late nineteenth and the late twentieth centuries.

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[3]In a compelling article on the new economy, Varian (2002) points out how, despite the lower communication costs from the Internet, companies still tend to favor organizing their activities through hierarchical mechanisms of control rather than through market-oriented Internet transactions.

Theoretical Framework

Three distinct but often-overlapping sets of literature provide the theoretical context for the comparison in this study.

Technology as History

The first set of literature employs a fundamentally historical approach in examining the phenomenon of technological change and innovation within the firm.[4] Deriving primarily from the work of Joseph Schumpeter and elaborated more recently by theorists influenced by his notion of "evolutionary" economic change, this literature seeks to uncover the sources of innovation and its impacts on economic development within and across historical periods (Schumpeter, 1939; 1942; 1947; Nelson and Winter, 1982; Freeman, 1982; 1990; 1991; Perez, 1983; Dosi, 1982; 1984: Dosi et al., 1992; 1998). Within this framework, innovation is conceived more broadly than the accumulation of discrete inventions and new technologies. Innovation is the deployment and transformation of inventions into commercially viable products and profit-making activities, and the diffusion of these new products and processes throughout the entire economy (Freeman, 1991: 305). It involves what Schumpeter described as the "creative response" of entrepreneurial firms, and the adaptive response of other firms who, in trying to compete with innovators, essentially imitate the original innovation.

In seeking to explain how this process of invention, innovation, and diffusion occurs, theorists in this tradition focus on the influence of the profit-making environment on the process of *learning* within the firm, and the process of firm-level decision-making. This process of learning to compete differently, and choosing how to implement a new vision of profit-making, is what leads to the creation of new strategies, products, routines, and business organizations. These activities of learning about new profit opportunities, and selecting alternatives for capturing profit in new ways, transform patterns of competition, and enable firms to create new trajectories of growth and development in what is commonly termed, *economic space*. This body of theory is used to position Swift and Dell as innovative firms.

The Firm As *Network*

The second set of literature examines how businesses organize their activity in production *networks* that link firms both internally, and with other businesses. Theorists within this literature focus on two primary network attributes. One group of theorists examines how production networks reflect *organizational linkages* within and between firms that result when firms choose how to undertake and divide up the various activities in producing and selling a good or service (Coase, 1937; Williamson, 1975). These choices, in turn, stem from a search by firms for "competitive advantage" (Porter, 1985; Lazonick, 1991; Saxenian, 1994; Cohen and Borrus, 1997; Borrus et al., 2000). In this way, organizational linkages within and between firms reflect operational decisions on competing. Such linkages establish boundaries between firms. These linkages also lie at the core of theories on the organizational structure of enterprise in terms of the degree to which firms internalize various economic activities and are integrated, or the degree to which firms transact with other firms across markets for these activities and are *dis*-integrated. Networks, whether intrafirm reflecting integration, or interfirm reflecting dis-integration, are thus the outcome of how firms choose to compete in economic space.

A second group within this tradition extends the idea of organization into the realm of territory insisting that business organization is inseparable from geographical organization (Walker, 1988: 385). This group examines how production networks reflect *geographical linkages* in the organization of economic activity (Gereffi and Korzeniewicz, 1994; Castells, 1996; Sturgeon 1997a; 1997b; 2000).

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[4]Technology in this study refers to knowledge embedded in products and routines for accomplishing purposeful and reproducible activity (Nelson and Winter, 1982; Mokyr, 1990: 275-76; Castells, 1996: 29-30). Innovation involves an epistemological transformation -- new knowledge – which leads to the creation of new products, new processes and organizations for making them, and new places where new products are produced, bought, and sold, and where new processes and organizations function.

Using insights from the first group, these theorists seek to identify how production networks become geographically-embedded in the way they organize the physical locations of activities (nodes), and the routes of product and information flows between these nodes. The pivotal concern in the work of these theorists is how the territory through which production networks operate, is constructed and gets reconfigured. While the starting point of this literature is the structure of the firm as a competitive unit in economic space, theorists in this tradition also emphasize how forms of business organization occupy a second analytical realm -- *geographical space.* This body of theory is used to position Swift and Dell as creators of production networks with specific organizational attributes that occupy an economic realm of competition, and a spatial realm of territory.

Communications As Revolution

The final set of literature focuses on a technological phenomenon occurring in different historical periods, the phenomenon of the *communications revolution.* Pioneered by historian Robert Albion (Albion, 1932; John, 1994), this concept provides the catalytic thread for the process of innovation within the firm, the reorganization of networks, and territorial transformation.[5] The basic idea that has emerged from Albion's insight is that new transport and communications systems play a decisive role in changing the competitive behavior of firms and the organization of economies. Theorists from Harold Innis (1950; 1951), to Alfred Chandler (1962; 1977), to Manuel Castells (1996) have contributed to this literature highlighting the role of communications revolutions on firms and economic development while more broadly, William McNeill has argued that major innovations in human history itself have depended principally on breakthroughs in communications and transport (McNeill, 2000: 10). This framework, however, is not used to create some autonomous, external force that imposes a predetermined logic on users of transport and communications systems. Communications revolutions emerge from historically-conditioned environments. While communications revolutions in different historical periods share certain fundamental characteristics and affect firms in broadly similar ways, they vary with respect to the specific impacts they exert on firms. As a consequence, the response of firms to communications revolutions is open-ended and contingent. Both Swift and Dell were profoundly influenced by communications revolutions.

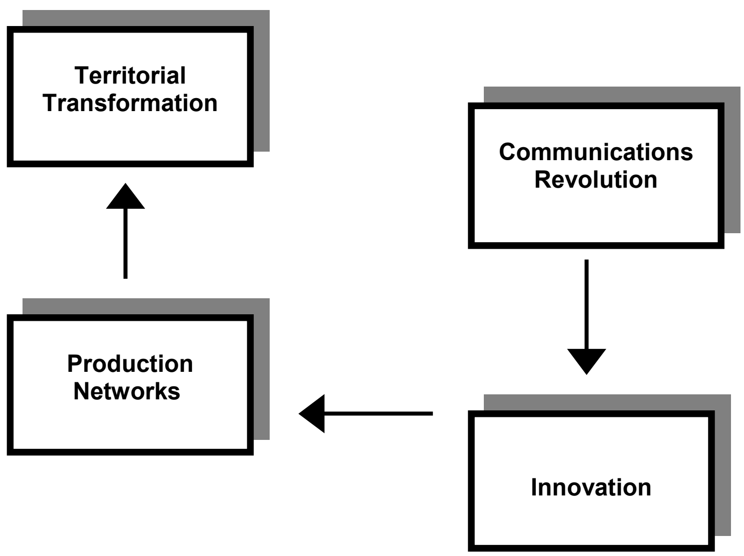
From the synthesis of these literatures, this study seeks to trace the route in both cases from breakthroughs in transport and communications systems, to the innovative behavior of the firm, to the production network and organizational change, to territorial transformation.

[5]Although Albion was the first to examine the phenomenon of the communications revolution systematically, earlier insights about the role of revolutions in communications technologies in economic development can be found in the writings of Marx, (1867, 1885, 1894), and slightly later in the work of Durkheim (1893). Marx was perhaps the first to write about distance compression and market expansion stemming from advances in transport and communications technology. Slightly later, Emile Durkheim observed how transport and communications technologies of the late 19th century tended to break down "segmented" or local markets in creating larger markets of an "organized" type (Durkheim, 1893: 305).

Figure I-1

From Communications Revolution

To Territorial Transformation



The Argument

The argument in this study seeks to explain how firms, in confronting revolutions in transport and communications technology, create new models for producing, buying and selling, and how these innovations reshape economic development patterns and the territory for profit-making. In this argument, the innovative activity of firms is connected to territorial transformation and economic change through the production and distribution networks created by firms when they develop new products, organize new routines for making those products, and seek new markets for selling the new products. Four key concepts developed from the theoretical framework, provide the threads in this argument. These concepts are: 1) the *communications revolution* referring to the deployment of new transport and communications systems; 2) the process of *innovation* in the firm referring to the creation of new products, routines, organizations and markets along with the diffusion of this process; 3) the *production network* of the firm consisting of organizational and geographical linkages connecting flows of goods and information between different network nodes; and 4*) territory* for economic activity referring to the geographical pattern of the goods and information flows between nodes within networks.

Theoretical Contours

From these concepts as a starting point, the argument in this study builds upon the observation made roughly seventy-five years ago by economist Allyn Young, that the marketplace is "essentially the aggregate of productive activities tied together by trade" (Young, 1928: 533). Myriad individual firms engaged in purchasing supplies, producing finished goods and services, and selling what they produce to other firms or final consumers, are the agents for this activity. When firms procure, produce, and sell, their activity creates flows of production and trade between and within firms, and between companies and consumers. These production and trade flows in which increments of value get added to goods and services, are the basis of production networks. The economy is, in essence, the collective product of this network activity.

Firms organize flows of production and trade on the basis of choices about strategies for competing against other firms, and routines for generating profit from their competitive activity. These choices result in specific types of linkages within and between firms that connect product and trade flows, and define the organizational and territorial structure of networks. The marketplace and the profit system establish the basic parameters for such choices. Nevertheless, within these parameters, the strategic, operational, and organizational choices of firms are at all times open-ended and contingent.

Among the most disruptive historical forces affecting the choices of firms and igniting the process of innovation and economic transformation, is the phenomenon of communications revolutions. The railroad and telegraph system, and the Internet represent different manifestations of this phenomenon. As developed by Albion, this concept described a "veritable age of speed" appearing at the turn of the nineteenth century at which new transport and communications systems moved goods, people and information (Albion, 1932).[6] Although Albion acknowledged the role of the communications revolution as the prelude to the "Machine Age" and "Big Business," his model emphasized the exogenous character of this phenomenon, and did not seek out systematic connections between communications and the broader process of economic change (Albion, 1932: 718-719; John, 1994: 101). It was Alfred Chandler, at one time a student of Albion, who sought to develop this bridge between communications and economic development. In supplementing Albion's work with insights from Schumpeter and Max Weber, Chandler provided a compelling story of 19th-century industrialization by focusing on the transformation of a single institution, the capitalist business firm.[7] In his account, new transport and communications systems ignite a process of creative and adaptive rationalization in the *Strategy and Structure* of the business enterprise (Chandler, 1962). During the late nineteenth century, these changes in strategy and structure diffused among firms and established the basis of a new economic order, the mass production system (Chandler, 1977; 1992).[8]

This study builds upon Chandler's model of the relationship between transport and communications technology, and the strategy and structure of the firm. It broadens this framework, however, by adding to it the notions of production networks and territory. At the same time, the argument incorporates the comparative, historical approach of Paul David in extending the idea of the communications revolution to present day. While acknowledging the unique character of the communications revolution at different historical moments, this study uncovers common attributes of the rail and telegraph and the Internet revolutions in launching the comparison of the production networks created by Swift and Dell.

Two distinct, though often overlapping groups of firms participate in the creation of communications revolutions. Spearheading this phenomenon are *builders* of transport and communications systems. This group encompasses an array of actors including inventor entrepreneurs, investors, and firms that undertake the actual build-out of infrastructure. Invariably aided by government, this group succeeds in constructing new transport and communications infrastructure that, in turn, creates new systems of access across space. Such new systems of access in which people, merchandise and information circulate over distance in new ways, reshape the horizons for economic activity and influence a second, more numerous group. This second group consists of business *users* of this infrastructure. It is these users that complete a more widespread set of transformations in the economy by deploying the new infrastructure in their networks for producing, buying, and selling. Swift and Dell represent two such

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[6]It is worth noting that other scholars, most notably Elizabeth Eisenstein (1979) trace the lineage of the "communications revolution" earlier to the phenomenon of printing during the fifteenth century."

[7]On the influence of Schumpeter and Weber on Chandler, see McCraw (1988: 304-305).

[8]See Chapter 2 for Chandler and his critics.

users that exploit the capacity of communications revolutions to change the environment of profit-making opportunities in the economy.

Communications revolutions change the profit-making environment for transport and communications users by transforming one of the most fundamental elements in the economic system -- the geographical boundaries or *range* of *markets*.

Market boundaries take shape most decisively from technologies of transport and communications, which define an upper range for individuals and firms to engage profitably in economic activity (Irwin and Kasarda, 1994: 342; Christaller, 1933: 72). These technologies establish limits on market size by influencing the costs of producing and trading. Market boundaries become fixed where "costs of transfer" -- the costs of moving goods or securing information in a timely manner across space -- drive the prices of goods and services beyond their original value (Ohlin, 1933: 100). In addition to costs, market boundaries also emerge from the actual capabilities of available transport and communications technology to overcome geographical barriers in moving materials and information. In this way, the size of markets is dependent on the costs to, and capacity of market actors to produce and exchange goods and services over distance, and communicate information needed to organize these activities (Du Boff, 1980: 478). Market size thus reflects a set of relationships in economic activity structured around the elements of *time* and *space*.

Market boundaries also emerge from politics (Polanyi, 1944; Christopherson, 1993; Zysman, 1994). Markets expand and contract as a result of control over territory exercised by political authorities that set rules for economic activity and establish systems of entitlements, rewards, and costs on market actors in the areas under their rule. Such authorities condition the extent to which market actors engage in, benefit from, or abandon economic activity within the territory in question. Politics also plays a critical role in influencing the actual development and deployment of communications systems.

Consequently, market boundaries, whether derived from technology, geography, or politics, establish limits on firms in their pursuit of profit.

As communications revolutions shift market boundaries, the profit-making environment changes. Such shifts in the profit environment are the result of transformations in the time and space relationships in economic activity. In accelerating and extending the linkages between spatially-dispersed firms, and between geographically-separated economic activities, advances in transport and communications enable goods and information to circulate faster over greater distances. These changes, in turn, enlarge the area in which economic actors can profitably conduct business activities (Stone, 1997: 4-5). What communications revolutions do is recalibrate the *costs* of moving goods and securing information over distance. As costs of moving goods and communicating over distance decrease, firms gain access to opportunities for conducting their business operations differently. At the same time, new transport and communications systems enhance the capacity of firms to *control* these activities in fundamentally new ways. In this way, control over time and space, linked to breakthroughs in transport and communications, provides firms with new pathways to profit-making.

Control over time and space is in all periods of capitalist development a centrally-important strategic, operational, and organizational problem for the firm (Schoenberger, 1997: 12). Businesses are constantly engaged in reshaping their strategies, routines, and organizations in an effort to overcome the temporal and geographical barriers to accumulating profit. The new forms of control over time and space available to firms from communications revolutions create new opportunities for profit-making by redefining pathways for efficiency in the economy. As a result of breakthroughs in communications, and the resultant reconfiguration of markets and restructuring of time and space in economic activity, what is inefficient or even impossible as a business model for producing, buying, and selling at one point in time, is viable as a profit-making venture in another historical moment.

Communications revolutions, in effect, are control revolutions (Beniger, 1986; Yates, 1989; Mulgan, 1990). They change the environment of profit opportunities by reshaping markets, and providing firms in these reconfigured territories with new routes to efficiency through greater levels of control over space and time. What firms gain from this newly achieved control in economic activity is how to accelerate the turnover of goods, services, and information, and extend these accelerated flows of activity in new ways over larger and differently-configured territories.

Not all business firms are equally successful in learning about new profit opportunities in economic environments transformed by new transport and communications systems. As communications revolutions reshape markets and enhance systems of control over space and time in business activity, only a small number of firms are able to grasp how to profit in new ways from the transformed economic environment. Such variation stems from the fact that the choices of strategies, routines and business organizations made by firms do not derive from some omniscient understanding of the most profit-optimizing pathway available in the market as assumed in rational choice models of human action. Firms make choices with imperfect knowledge and an incomplete picture of profit opportunities and the technological and organizational solutions available for pursuing them (Dosi, 1997: 1531; Lamoreaux et al., 1999: 6-8). This imperfect knowledge enables firms to perceive the world differently and gives rise to differences in the choices firms make regarding strategies, routines, and structure (Metcalfe: 1998: 35). While most businesses adapt to the innovations of others, a few firms succeed in making choices that result in what Schumpeter described as creative responses in economic history. Swift and Dell are two such firms.

Empirical Outlines

As innovative firms, Swift and Dell are creations of communications revolutions. They used new transport and communications systems in conceiving new products and perhaps more importantly, new ways to distribute and market and those products to final customers. The new product developed by Swift was mass-produced fresh beef (Kujovich, 1970). The new product created by Dell was a personal computer, mass-produced but individually-configured through Internet communication. The real innovation of both firms, however, was the creation of *organizations* for not only for producing, but more importantly for distributing these products.

In order to solve the problems of making and marketing mass-produced fresh beef, and Internet-customized, mass-produced personal computers, both Swift and Dell had to reinvent logistics systems for the entire circuit of procurement, production, and distribution for these two products. Through a process of learning by doing, Swift and Dell deployed new transport and communications systems as the foundation of logistics-oriented business models. These business models linked new products, to process innovations for securing supplies, assembling and disassembling supplies into finished goods, and selling finished output. The outcome of this learning process was the development by both firms of high volume, geographically-extended, logistics-oriented networks of production and distribution. These networks accelerated flows of product and information during the circuits of procurement, production, and selling, and established new competitive standards in their respective industries.

As they created these networks, Swift and Dell made critical choices with respect to the organizational structure and systems of control within their enterprise. These choices centered on the degree to which firms absorb sequential steps in procurement, production, and selling, and the degree to which they contract with other businesses in allocating these tasks. Operational decisions on whether to "make or buy," however, affect more than the systems of organization and control in firms. Decisions to produce in-house or secure goods and services through other firms, result in production networks with specific geographical characteristics.

Swift created a long-distance network for the manufacture and sale of fresh beef that helped establish the foundations for a national market space. This network obliterated both the localized character of beef markets prevailing in the U.S. before the 1870s, and the interregional character of beef markets based upon long distance rail shipments of live cattle. At the same time, as Swift extended the circuits of production and distribution, the Company concentrated slaughtering activity in new places. Swift and other large packers centralized slaughtering in Chicago and the Midwest where they pioneered a work process and division of labor in the factory that became a model for other mass production firms (Brody, 1964). In this way, Swift was a critical actor in contributing to a location pattern of spread and concentration that defined the geography of a newly-emergent national market.

In establishing its network, Swift represents a transformation in the accumulation process during the late nineteenth century. In this transformation, American capitalists sought profit not as in the early part of the century from commercial ventures centered on coastal trading activity. Swift, and other industrial capitalists of the period generated profit both from manufacturing, and from the conquest of the American interior as a market area for distributing their products (Pred, 1966: 18-19; 1977: 66-70; Porter and Livesay, 1971; Chandler, 1988: 72). On the basis of these manufacturing and distribution activities, Swift and other larger packers promoted a pattern of what has been termed, the "agro-industrialization" of the U.S. (Page and Walker, 1991). In this pattern, new products, routines, and business organizations, evolving from changes in manufacturing and distribution activity in the U.S. interior, extended and concentrated economic activity in new ways while reshaping the nation's economic geography.

The network of Swift consisted of three primary nodes: 1) stockyard facilities where the firm secured cattle raw materials; 2) (dis)assembly facilities located immediately adjacent to the stockyard sources of supply; and 3) branch distribution houses located throughout the country where the firm shipped its product in order to supply retail butchers with fresh beef. Through the links between these nodes, Swift operated what is essentially an early type of "just-in-time" production and distribution system. Orders taken at branch houses from local retail butchers were telegraphed to Swift purchasing agents at stockyards where cattle supplies were "pulled" into slaughtering factories, butchered, and sent to branch houses to fulfill orders. Stockyards served as collection points for cattle shipped daily from locations on the cattle ranges, and warehouses for inventories of cattle supplies that firms such as Swift would purchase and immediately pull into slaughtering plants for disassembly. Slaughtering facilities were located either adjacent, or in close proximity to stockyards and acted as concentration points in the process of beef production and distribution. Branch houses, on the other hand dispersed the product over a wide territory. The railroad and telegraph provided the basic infrastructure for this process of concentration and dispersal.

As it built this national network, Swift integrated into its own organization virtually all of the steps from production to final marketing of fresh beef. The result of such integration, however, in terms of the relationship between company and customer was seemingly paradoxical. Vertical integration created a more *direct* route from production to the final customer. Much like other large manufacturers of the period, as Swift assumed ownership of these various functions, it eliminated -- disintermediated -- a large layer of traditional wholesalers in the beef trade and established a more direct path to the buyers of beef (Porter and Livesay, 1971). This direct system of distribution was one of the key sources of value-creation and profit-making for the Company.

In the case of Dell, the route from communications, to operational and organizational innovation, to territorial transformation runs parallel to Swift.

Dell's Internet-driven production and distribution network consists of three primary nodes: 1) assembly plants; 2) supplier factories; and 3) supply logistics centers. The geography of this network emerges from the globally-spread locations of these facilities, and the territorial character of the product and information flows circulating between them. Through Internet communication, Dell has organized these nodes into decentralized "just-in-time" pull systems of production and distribution. These decentralized systems, spread across four continents, form concentrated production complexes in six selected regional locales. While there is some variation in these six concentrations, the territorial placement of these nodes, and the way they operate, is essentially identical in each place. Through the establishment of these production ensembles, Dell is reinforcing the proliferation of economic globalization as an essentially homogenizing phenomenon.

Similar to Swift, Dell is compelled to organize critical relationships of proximity in each of the six locations between key network nodes, in this case between inventories of supply, and assembly sites in order to coordinate its production and distribution logistics on a just-in-time basis.[9] As a consequence, Dell has established supply logistics centers where components are stored as inventory within twenty

[9]On the role of proximity in the technology of modern manufacturing systems see Gertler (1995).

minutes driving time of assembly facilities at each of its six different computer assembly locations. In these warehouses, components originating from supplier factories located throughout the world get stored and "pulled" into Dell's assembly plants as they are needed on a just-in-time basis, while suppliers operate these warehouses and thus assume the inventory carrying costs. Patterns of global spread, regional concentration, and relationships of proximity are thus part of a just-in-time production and distribution system fused together by Dell through Internet communication.

Organizationally, Dell does not aim to assume formal ownership of the adjacent procurement, production and distribution activity in the network. Instead, much like other PC makers, it relies upon the *external capabilities* of other firms to help produce and deliver its custom-configured products (Langlois, 1990; 1992). Nevertheless, Dell does not use the market and the price system to structure its contracting relationships with these other firms. It employs mechanisms of power and administrative planning in organizing these relationships with firms lying outside of its own organizational boundaries.

Similar to Swift, Dell creates value and captures profit by eliminating traditional intermediaries in the PC channel, and creating a direct route to its final customers. This direct system is organized around Internet communication. This Internet-based closed loop with customers is the catalyst for pulling parts into and through Dell's assembly plants. It is the foundation of the high speed, just-in-time logistics system used by Dell as the innovation for out-competing other PC firms.

With both Swift and Dell, the route to organizational and territorial transformation occurs through a process of innovation in production networks ignited by changes in technologies of transport and communications. In both cases, these networks recast how products are made, and how products reach the customer. As they forge a more direct path from the manufacturer to the customer, the production and distribution networks of both Swift and Dell create a similar pattern of geographical spread and concentration. At the same time, however, the rail and the telegraph, and the Internet enable the two firms to organize ownership and territory in the networks differently. One network is vertically integrated, with the primary nodes dispersing and concentrating over a fundamentally national market space. The other network is *dis*-integrated, dispersing and concentrating over a global market space. This study seizes upon these structural, operational, and geographical attributes of production networks in seeking to tell a comparative story of innovation and economic change.

On Method: Why Compare Swift and Dell?

The two companies examined in this project are *intensive* (as opposed to extensive) case studies in which the unit of analysis is the business firm. Whereas extensive research seeks to discover common patterns and characteristics in a population of research subjects based on analysis of a large number of cases, intensive research has a different objective. The aim of intensive research is to show how a generalized causal process occurs in a particular case, and how the case is representative of a broad-based trend (Sayer, 1992: 242-243).

As intensive and comparable cases, Swift and Dell reveal experiences of a shared causal process. The causal process shared by these two case studies focuses on the impacts of communications revolutions on the firm, and the connection between the innovative responses of the firm, organizational change and territorial transformation. In the case of Swift, the production network of the firm is connected to an economic environment and a set of capabilities created by the railroad and telegraph revolution. In the case of Dell, the production network of the firm is linked to an economic environment and a set of capabilities created by the Internet revolution. Although intensive research does not necessarily aim to build a "testable" model with specified relationships between dependent and independent variables, there is an implicit formal structure in the comparison of the two cases. In this study, the production network as it becomes territorially embedded, functions as a dependent variable responding to the communications revolution and the process of innovation in the firm.

The Swift case uses both secondary literature, along with primary sources. One of these primary sources enables the Swift case to utilize a type of "interview" method. Extensive testimony from over 200 witnesses before the Senate Select Committee on the Transportation and Sale of Meat Products chaired by Senator George Vest of Missouri in 1890, gives voice to actors of the period involved in virtually all aspects of the beef trade, and provides a veritable wealth of information on the industry. This study makes use of this testimony in an effort to recreate first hand accounts of Swift's innovation and its impacts.

The Swift case covers the initial years of the Company from 1875 to roughly 1903. These dates cover two significant developments in the American economy. In the first place, this period witnesses the completion of a nationally integrated and standardized rail and telegraph infrastructure in the U.S. Secondly, this period marks the appearance of the mass production economy and the large-scale, integrated industrial corporation connected to new production and distribution systems pioneered by firms such as Swift. Infrastructure, firm structure, and market structure evolve together during this period. The year 1903 as an end point is also not arbitrary. As the culmination of the first great merger wave in American history, this date, in most accounts of the period, brings the initial period of the mass production economy to a close. Whether by chance or fate, it also marks the date when Swift surpasses all of its competitors and becomes the largest meat packing firm in the country and even the entire world.

The Dell case, much like the case of Swift, covers the firm from its founding in 1984 and carries the story forward to the present. These dates frame two critical developments. In the first place, this period witnesses the creation of a mass market for the personal computer. Perhaps more significantly, the latter years of this period mark the development of the Internet as a communications and commerce system. Similar to the advent and expansion of the rail and telegraph, the Internet as a commerce system has enabled business firms to use the new infrastructure for producing and selling goods and services and coordinating business operations in entirely new ways. Dell has managed to reorganize its business model for producing and selling PCs in responding to the opportunities presented by the Internet. Much like Swift, Dell has used the Internet to assume a position of first rank in the personal computer industry.

In the case of Dell, the "corporate interview" with Dell managers is the primary research strategy (Schoenberger, 1991; Markusen, 1994). There is actually very little published scholarship that analyzes details of Dell's production and distribution network (Kenney and Curry, 2000: 5). The aim of these interviews is to uncover new facts about Dell's operations absent in the secondary and journalistic literature about the company, and contribute to the creation of new knowledge about one of the most innovative firms of the period.

Despite the years that separate them, and the different products that define them, both firms reveal stories with striking symmetries that link communications revolutions and business innovation across time.

In the first place, Swift and Dell are comparable as two of the most innovative firms in their respective time periods. In this sense, they are representative of what has been termed, "the innovative business organization" (Lazonick, 1991). Both began as small upstarts in industries with much larger, well-established companies. Both succeeded in out-competing their older rivals and transforming existing business practices in their respective industries. Both used breakthroughs in transport and communications to create process innovations linking procurement and manufacturing to distribution systems for reaching the final customer.

For both Swift and Dell, these process innovations were oriented around a more *direct* route from manufacturer to the customer. This direct business model enabled the two firms to bypass existing distribution channels in the delivery of beef and personal computers and resulted in large-scale disintermediation in the structure of the beef and PC industries. The direct business models of both companies also established new competitive standards for meat packing and computer assembly and sale, including the customization of products based upon orders received in advance, that also influenced -- and in the case of Dell, is continuing to influence -- business practices in other industries. In using rails and telegraphy and the Internet as the foundation for their respective manufacturing and distribution systems, both firms essentially created production and distribution networks that extended the geographical activity of the firm while bringing the firm into more direct contact with final customers. The networks pioneered by Swift and Dell are, in effect, paragons of communications revolutions, one born with rail and telegraph economy, the other the progeny of the Internet economy.

Other similarities also link the innovations of these two companies. While dressed beef and personal computers may appear oddly-matched, they actually share a common status as new products. Although dressed beef and personal computers had already emerged as new products when Swift and Dell began to do business, both firms succeeded in transforming these products through new systems of distribution. As a result of the innovations in production and distribution networks created by these two firms, dressed beef and personal computers became accessible, affordable, and mass consumed. Perhaps most importantly, however, dressed beef and custom-created personal computers share a fundamental attribute as "perishable" goods. They both have a limited shelf life before they start to devalue and essentially spoil. This shared quality of perishability played a decisive role in motivating both Swift and Dell to transform the channels of distribution in the beef and PC industry, and develop their innovative networks for making and selling these products.

Organizational parallels between Swift and Dell also contribute to the choice of these firms as case studies. These parallels highlight both similarities and differences. Differences focus on how Swift and Dell organized capabilities and boundaries of the firm. In the case of Swift, the transformation of fresh beef into a readily available, mass-consumed commodity through a more direct distribution channel, resulted in a process of vertical integration in which Swift absorbed the bulk of the adjacent steps in the value chain into its own organization. In the case of Dell, the direct channel of producing and delivering personal computers emerged from a focus on two basic tasks, computer assembly and logistics, and reliance on external capabilities of other firms to build PC components (Langlois, 1990; 1992). Despite these differences in organizational structure, however, both firms rely on mechanisms of administrative coordination rather than interfaces across markets, to organize the various procurement, manufacturing and distribution activity in their networks. Both networks used the advances of communications revolutions as the foundation for coordinating these adjacent steps.

Finally, the choice of Swift and Dell as case studies is the result of unique research opportunities presented by the two firms.

Surprisingly, while there are a number of studies on meat packing in the late nineteenth century, notably the work of Mary Yeager (1981), Margaret Walsh (1982), and Louise Carroll Wade (1987), and numerous references to the innovations of Swift in both general and specialized economic histories of the period (Chandler, 1977; Cronon, 1991), there is only one scholarly work on the firm of Swift itself. This work on Swift is a dissertation written fifty years ago (Unfer, 1950).[10] The present study revisits these works along with archival material on Swift in an effort to uncover how the Company created its pioneering dressed beef network from the rail and telegraph, and the economic development impacts of this innovation.

Dell on the other hand, presents a different type of opportunity. With its modest beginnings and meteoric rise within the PC ranks, Dell has generated a type of modern business folklore. As a consequence, the company has garnered a large following in the business and trade press during the past five years. CEO Michael Dell added to his firm's reputation with his own book about Dell and the business model he created (Dell and Fredman, 1999). A plethora of "how-to" books on "Business the Dell Way," mostly repeating insights from Dell's own book, have followed (Saunders, 2000). There is, in effect, an abundance of available information on the firm. Nevertheless, there are actually few scholarly studies of Dell (i.e. Kenney and Curry, 1999; 2000; Kraemer et al., 1999; Albers, 2000; Kraemer and Dedrick, 2001). With the exception of the study by Albers who worked as in intern at Dell, these works reveal limited access to sources inside the company. As a consequence, much remains unknown about the specific mechanisms of Dell's logistics oriented business organization. Through interviews with Dell managers in supply chain operations and logistics, the present study aims to overcome this gap.

This study uses both familiar, and new facts to position the two firms within an historically-comparative theory of the communications revolution and innovation in networks of production and trade.

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[10]Surprisingly, one of the most celebrated works on the origins of mass production in the U.S. (Hounshell, 1984) does not contain any material on Swift or the meat packing industry.

The aim of the comparison that follows is to reveal new insights about the two firms, the transport and communications systems they used, the innovations they created, and the economies of both past and present that they helped transform.

Plan for the Study

This study consists of three Parts that follow this Introduction.

Part I, consisting of Chapter 2, establishes the theoretical framework for the study. This chapter creates a model of communications, innovation within the firm and territorial transformation based upon a synthesis of the three literatures on innovation and evolutionary economic change, production networks, and communications revolutions cited above. The model built from this synthesis is an *appreciative* taxonomy that establishes three basic connections: one linking communications revolutions to the entrepreneurial behavior of the firm; the second connecting the entrepreneurialism of the firm to the production network; the third linking the network to patterns of territorial formation.[11]

Part II focuses on the railroad and telegraph and the case of the G.F. Swift Company. Chapter 3 provides the set-up for this Section by examining how the impacts of rails and telegraphy created preconditions for Swift's beef network in terms of the geography of markets, and the pattern of urbanization during the mid- to late-nineteenth century. It outlines how the rail and telegraph system opened markets for more long-distance, interregional trade, and created a system of cities in which manufacturing and the consumption of manufactured goods became concentrated in large urban areas. Swift, in effect, relied on the rail and telegraph not only for the operation of its highly innovative production and distribution network. The G.F. Swift Company built this network from the interregional markets and entrepots of consumption concentrated in cities that the rail and telegraph system helped to establish. Chapter 4 examines the story of how Swift used the rail and telegraph infrastructure to create a mass production and mass distribution network for fresh beef that revolutionized the meat industry. This chapter details how Swift created this innovative network, and how it diffused to other firms in the industry. It analyzes how this innovation established new patterns of territorial development in the economy of the late nineteenth century that spread business activity nationally, while at the same time concentrating development in new places, notably Chicago and other cities in the American Midwest. This chapter also examines how Swift was forced to confront the politics of interstate commerce in order to protect the far-flung market for beef it had engineered.

Part III focuses on the Internet and the case of Dell Computer Corporation. Chapter 5 is a mirror image of Chapter 3. It sets up this section by outlining how the Internet evolved from a communications system to an infrastructure for commerce, and how the phenomenon of Internet commerce established the foundations for Dell's innovative production and distribution network. Chapter 6 is the parallel of Chapter 4 and is the case study of Dell Computer. It examines how Dell is using the Internet to organize what is arguably the most innovative production and distribution network of any current manufacturing firm and how it has redefined competitive standards for Internet commerce. The research for this chapter focuses on the operational and organizational mechanisms used by Dell to create its direct model production and distribution network, and the role of Internet communication in enabling this network to function. This chapter also describes the territorial outcomes of this network, and how it has emerged as a paradigm of how global markets actually function.

The concluding chapter to this study subjects the two cases to comparative analysis. It examines the innovations of Swift and Dell both as similar phenomena, and as uniquely tied to the two periods in question. This concluding chapter seeks to intervene in several current, cross-disciplinary debates on the nature of the firm, the relationship of the firm to innovation and economic development, and the nature of production networks in the modern economy. In intervening in these debates and framing conclusions about the two cases of Swift and Dell, this section also aims to uncover the meaning of the

[11]On appreciative theory see Chapter 2.

communications revolution from past and present. At the core of this revolution is a story of what occurs when the journey traveled by commodities from production to consumption assumes a different character and takes a different route. How fresh beef becomes mass produced, travels across a continent in breaking the boundaries of localized markets, and in the end takes a more direct path in arriving at the butcher, and how the personal computer is custom-assembled in large volumes and travels across the globe in arriving on the desktop, and the economic development consequences of these routes, are the themes of the story that follows.

Chapter 2

COMMUNICATIONS AND INNOVATION,

BUSINESS ORGANIZATION AND TERRITORY

A Synthesis

"Such phrases as the Romantic Movement, the Mercantile System, and the Second Hundred Years' War have been of real value in helping students visualize and coordinate historical movements and influences. If there were a board of historians empowered to pass upon such labeling, one might propose to them another phrase -- the "Communication Revolution".

Robert Albion, (1932)

"Whenever the economy or an industry or some firms do something that is outside the range of existing practice, we may speak of creative response*....Creative response changes social and economic situations for good, [and] is an essential element in the historical process*."

Joseph Schumpeter, (1947)

"Firms are not islands but are linked together in patterns of cooperation and affiliation….Co-operation may come close to direction when one of the parties is clearly predominant;"

G.B. Richardson, (1972)

From Communications to Territory

The comparative story of Swift and Dell rests upon the premise that technologies of transport and communications play a central role in economic life (Bell, 1979). They shape the basic parameters of efficiency for firms in producing, buying, and selling by recalibrating the costs of securing information from the market, shipping products across distance, and reaching out to other agents in the marketplace. Historically, new technologies of transport and communications promote more efficient types of economic activity by creating new and less costly systems of market access for firms across space, and by reconfiguring the territorial limits of markets in which the profit-seeking activities of firms take place. As market boundaries shift from changes in transport and communications systems, and as opportunities emerge in such reconfigured markets spaces for firms to perform more efficiently, firms are able to change the way they operate and compete. Such are the basic outlines of the stories at Swift and Dell.

During the last half of the nineteenth century, and the final years of the twentieth century, rail and telegraph technology, and Internet technology created communications revolutions that assumed the role of what Schumpeter described as "leading sectors" in the economy (Cohen et al., 2000: 9-11, 32). More than simply high growth industries, these lead sectors ignited more widespread patterns of innovation among firms in both periods. This pattern included more than new products and new production processes. Businesses used breakthroughs in transport and communications to reorganize the structure of the firm itself. They developed pioneering forms of industrial governance that resulted in entrepreneurial types of business organization. These enterprises, in turn, used the power of administrative coordination rather than markets in creating distinct geographies of profitmaking.

This chapter develops a taxonomy of this route from communications revolutions, to innovation and organizational change, to territorial transformation across different historical periods. This taxonomy emphasizes how the innovations of Swift and Dell are not random acts of entrepreneurial genius. These innovations instead conform broadly to a process of technological change, organizational transformation and territorial formation in which individuals act as agents in a more complex structural setting. As a prelude to this taxonomy, this chapter critiques some of the principal theoretical contributions to the three literatures -- the literatures on innovation, firms as business organization, and the communications revolution -- comprising this route. What follows is how these three literatures converge in creating an appreciative model of communications and innovation, business organization and territory.

Innovation and Technological Change

It is indeed an irony how the notion of innovation, and the idea of markets have somehow become inextricably linked in the collective psyche of contemporary society as the twin drivers of the capitalist economy. So strong is this association that according to orthodox economic policy prescriptions, creation of the latter begets the phenomenon of the former. While it seems incontrovertible that capitalist development occurs through a market process along with the process of innovation, it is also true that these two concepts, innovation and markets, in many ways share at best an uneasy mutual affiliation.

That the capitalist economy is driven fundamentally by the process of innovation rather than an equilibrated allocation process of market-clearing, is perhaps the greatest legacy left to economic theory by Joseph Schumpeter. In contrast to neoclassical economists, Schumpeter insisted that the capitalist process was not one of equilibrium in which markets adjusted according to the price system and laws of supply and demand. Capitalism instead was essentially a disequilibrium system in a state of continuous turbulence, driven by the innovative activities of firms and individuals in creating new products and processes, new business organizations and markets. Schumpeter crafted his celebrated metaphor of "creative destruction" to describe this process of innovation and the disruptive impacts of these activities underlying this phenomenon.

This view of the market and the development process placed Schumpeter well outside the economics mainstream. The problem erroneously being visualized by most economists, insists Schumpeter "is how capitalism administers existing structures, whereas the relevant problem is how it creates and destroys them" (Schumpeter, 1942: 84). This destructive and creative process of innovation was, for Schumpeter, unevenly spread over time, tending to occur in periodized clusters or waves. Such unevenness gave an historical dimension to both innovation and capitalist development (Rosenberg, 1982: 5). In his work on *Business Cycles* (1939), Schumpeter argued that the process of innovation, with its cycle of creativity by entrepreneurs and diffusion to other firms, accounted for the uneven swings of recession and expansion in the capitalist economy. For Schumpeter, innovation was the essence of the capitalist process. Clustering unevenly over time, innovation was an historically created phenomenon in which the essence of the entrepreneur and the entrepreneurial function emerges from historical investigation (Schumpeter, 1949: 55). The preoccupation with historical analysis was an ongoing theme throughout all of his later work (Lazonick, 1990; 1994). In summing up his approach to the economic process, Schumpeter writes that "the subject of economics is essentially a unique process in historic time." He goes on to argue that nobody can hope to understand economic phenomena "who has not an adequate command of historical *facts* and an adequate amount of historical *sense* or of what may be described as historical *experience"* (Schumpeter, 1954: 12). It was this integration of history that distinguished Schumpeter's approach to innovation and the process of economic development.

Schumpeter and the Legacy of Marx

While Schumpeter's work on innovation is highly original, it derives much of its influence from Karl Marx. Four themes stand out in Schumpeter's theory of innovation and economic growth that reveal this influence. These themes include: 1) the decisive role of technology in capitalist development, 2) the disruptive and revolutionizing tendencies of technological change, 3) the crisis-prone character of capitalism, and 4) the historical character of technology and the economy. Schumpeter himself critically acknowledged this legacy of "Marx the Economist" in framing his own fundamentally historical theory of innovation (Schumpeter, 1942: 21-44).[1] Aspects of Marx's work are therefore a logical starting point for profiling Schumpeter's views on innovation and development.

Marx, in Schumpeter's view, was the first of the classical economists to recognize the role of technological dynamism in the development of capitalism, and the first to understand the role of history in influencing both technological change and economic development. Much like Schumpeter drew upon the neoclassical work of Leon Walras to reveal how equilibrium models of commodity flows did not represent the historical process of economic development, Marx drew upon the classical economists, primarily Smith and Ricardo, in critiquing the absence of history in the economic orthodoxy of his own day. "Economists explain to us the process of production under given conditions;" Marx writes, and goes on to explain that "what they do not explain is how these conditions themselves are produced, that is, the historical movement that brings them into being'" (Marx, 1847: 199).

According to Marx, capitalism leads to an immense expansion in productivity because the system of private property rights together with market competition, creates historically-unique institutions that generate powerful incentives on firms to innovate and accelerate the process of technological change (Marx, 1848; Rosenberg, 1982: 8). These institutions of private property along with competitive markets, and the incentives they established, make the capitalist class the first ruling class in history whose interests are linked not to maintaining the status quo, but instead are dependent on overturning it by developing new technologies as a source of profit and accumulation. In anticipating the now-celebrated passage of Schumpeter on creative destruction, as well as providing prescient insights about the current period, Marx observes that: "The bourgeoisie cannot exist without constantly revolutionizing the instruments of production," and goes on to write: "Constant revolutionizing of production, uninterrupted disturbance of all social conditions, everlasting uncertainty and agitation distinguish the bourgeois epoch from all earlier ones. All fixed, fast-frozen relations...are swept away, all new-formed ones become antiquated before they can ossify. All that is solid melts into air,..." (Marx, 1848: 111). This view of the capitalist process as one of incessant innovation and disruption stemming from new technology had an unmistakable influence on Schumpeter.

Marx employed a fundamentally historical method in accounting for new technologies. He ascribed the catalyst for technological change to growing markets beginning in the sixteenth century. Such widened markets provided the environment in which firms could exploit new technologies as a source of profit and accumulation. In this way, Marx was decidedly *not* a technological determinist (Rosenberg, 1982: 36-38).[2] Far from assigning technology an autonomous role as an independent variable in transforming the economy, Marx attributed changes in technology to the enlarged horizon of possibilities for profit created by ever-growing markets as the economy evolved from early manufacture to modern industry (Marx, 1848). Once established as historical outcomes, however, new technologies emerge in Marx as a central element in the process of capitalist development. The conflicts between technology as a productive force, and the social relations of production in terms of ownership and control over technology and the surpluses generated from it, are, for Marx, what drive the process of economic

[1]Examples from the opening chapters of *Capitalism, Socialism and Democracy* emphasize this point. Writing about technological "progress" in capitalist society, Schumpeter observes that "Marx saw this process of industrial change more clearly and he realized its pivotal importance more fully than any other economist of his time" (Schumpeter 1942: 32). As for the sources of his own historical approach to innovation, Schumpeter writes of Marx: "He was the first economist of top rank to see and to teach systematically how economic theory may be turned into historical analysis and how the historical narrative may be turned into *histoire raisonnee* "(Schumpeter, 1942: 44). Such passages contrast with the often-static contemporary discussions of whether Marx was "right" in his analysis of capitalism's attributes and tendencies. For Schumpeter, the picture of Marx was complex, resonating with both success and shortcomings. The literature on the impact of Marx on Schumpeter is vast but see especially the work of Lazonick (1991; 1991b; 1994) and Catephores (1994).

[2]Rosenberg's account is a compelling refutation of Marx as a technological determinist.

development. Technology plays a critical role in this rhythm of development but it is not some ineluctable force. Capitalists make choices to innovate in order to compete more effectively.

Nevertheless, Marx acknowledged that as technology changed in conjunction with market expansion, so too did business enterprise. He had a theory of firm concentration in which competition, innovation, the cheapening of commodities, and the scale economies of large enterprise evolved in an evolutionary way. What Marx understood as the tendency of technology to develop alongside the enlargement of the capitalist firm, however, Schumpeter took one step farther in equating the phenomenon of innovation with oligopoly. In Marx, capitalist development, technological change, and transformations in the size and organizational structure of business establishments were all part of the same historically driven process. A similar story would be told by Schumpeter -- but one that also had important differences.

Innovation and Entrepreneurialism

While Schumpeter accepted in broad outline these key elements from Marx in creating his theory of economic development, he added a critical idea about the process of innovation that separated him from Marx -- the idea of *entrepreneurialism.*[3] In addition, Schumpeter also distinguished different phases comprising the innovation process itself. According to Schumpeter, innovation consists of three distinct moments -- initial *invention* of new products, processes, organizations, and markets, *commercialization* of these elements, and finally *diffusion* of these elements to other firms. In conceiving of innovation as a series of historically conditioned moments, Schumpeter was interested firstly in differentiating the behavior of firms at each of the three phases. Secondly, he was particularly intent on tracing how the responses of entrepreneurial firms to the profit-making environment resulted in new business routines that challenged existing business practice, diffused to other firms, and transformed the entire economic system.[4] For Schumpeter, innovation was both artifact and impact.

Central to Schumpeter's theory of economic development is the *creative* act of entrepreneurs in commercializing new technology and in the process launching innovation (Schumpeter, 1947). It was only an act of entrepreneurship that enabled technical inventions to emerge from obscurity and assume the role of commercial artifacts (Freeman, 1991: 304). Schumpeter, however, defined this process of innovation broadly. He conceived of innovation as “the carrying out of new combinations” corresponding to the new products, new methods of production and distribution, new forms of business enterprise, and new markets associated by Schumpeter with technological change (Schumpeter, 1911; Schumpeter, 1942). Entrepreneurialism acts as a disruptive force in the economy, challenging the competitive strategies and behavior of existing firms. The relatively short bursts of technological creativity by entrepreneurs, however, engender longer periods of assimilation and adaptation marked by imitation and complementary types of innovation by firms. This process of diffusion has profound consequences for the economy as a whole. It completes the pathway of creative destruction along which

[3]In developing his idea on entrepreneurialism, Schumpeter also discarded two other key concepts in Marx. Firstly, Schumpeter did not accept Marx’s emphasis on dialectics in history. Secondly, Schumpeter rejected Marx’s view that class conflict was the motive force in history and economic development. As a consequence, Schumpeter argued that capitalists did not achieve a preeminent position in the economy by exploiting the working class. On the contrary, he argued that the driver of capitalist society consisted of capitalists competing and stomping all over themselves. Interestingly Robert Brenner, in a recent analysis of the world economy written from a Marxist perspective, argues similar to Schumpeter, that the logic of competition – the horizontal relationships between capitalist firms – not class struggle, rules the rhythms of growth and recession (Brenner, 1998).

[4]Schumpeter did concede, however, that the entrepreneurial function and the process of economic change still required more detailed investigation in order to understand “the actual working of capitalism that we are but dimly perceiving as yet” (Schumpeter, 1947: 156).

are the new products, new operational routines, new forms of business enterprise and new markets where firms seek profit.

Schumpeter observed how new technological combinations marking the process of creative destruction were distributed unevenly throughout the history of capitalism. Such combinations tended to cluster in "swarms" that marked the beginning of the growth cycle (Schumpeter, 1911: 223). As the economy moves outward along a new production function owing to the growth impacts of new technology, the economic rents accruing to entrepreneurial firms that give rise to the growth process, are eventually competed away as firms imitate and adapt to new innovation. This leveling of profit rates then paves the way for downturn and depression. Far from repeating, however, these business cycles redefine the context for the next round of innovation, expansion and contraction.

From this notion of business cycles and technological clusters, Schumpeter arrived at a long-term view of capitalist development punctuated by distinct industrial revolutions separated in time.[5] He dates the first industrial revolution from the 1780s-1842. The second occurs from 1842-1897 while the third begins in 1898 and corresponds to Schumpeter's own time. Although time-specific, these revolutions share common features of transformation that act as drivers of the capitalist process. Schumpeter actually references a key aspect of the nineteenth-century communications revolution in coining the term "railroadization" to describe the pattern of economic change associated with these features (Schumpeter, 1939: 304, 325-351, 72-192; Andersen, 1994: 26-62).

In focusing on the railroads to illustrate his theory of economic change, Schumpeter builds a model starting with an equilibrated system of competitive strategies, routines, business organizations, and markets that is "disturbed" by the innovation of railway-based transport networks.[6] This innovation in the transport and communications sector of the economy provokes responses by business users of this infrastructure. Entrepreneurial firms among these users develop strategies, routines, and forms of enterprise that challenge the products, processes, organizations, and markets of other firms. What these entrepreneurial firms create from their innovations is a new cost and pricing structure for economic activity, and more importantly, new activity itself. These changes in costs, prices, and types of economic activity are the basis of what Schumpeter described as "new production functions" in the economy. In order to compete, other firms adapt to the innovative activity of entrepreneurs and the production functions they establish. What results from these innovative and adaptive activities is a broader process of economic transformation.

Schumpeter, however, was far from a technological determinist. He conceded that entrepreneurialism in the railway sector, which ignited such broad based changes in the late 19th-century economy, had a *political* edge. The leadership within particular groups of rail builders, and the relationship of these groups to local, state, and national political figures, played essential roles in promoting the viability of the railroad as a profit-making venture. These alliances between rail entrepreneurs and their political backers are what secured for rail builders the land and the rights of way necessary for rail building to occur in the first place. According to Schumpeter, such relationships were not only critical in promoting railroad development. Railroad entrepreneurialism tied to politics is what

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[5]Schumpeter acknowledged that the idea of innovation cycles or "waves of innovation" had come from previous theorists, notably Kondratief, Juglar and Kitchin (Schumpeter, 1939; Hall and Preston, 1988). Schumpeter's theory has produced a separate debate on the timing and duration of long waves. Within this debate, however, Perez argues that Schumpeter's work does not actually provide a basis for long waves. She insists that Schumpeter's theory is instead an account of the short-term cyclical movement of recession and recovery exhibited by the capitalist economy (Perez, 1983: 359).

[6]The idea of an economy in equilibrium may appear paradoxical in Schumpeter's work since he aimed to distance his historical and evolutionary approach to the economy from neoclassical notions of equilibrium. Schumpeter explains however, that his use of equilibrium is an analytical tool from which to launch his notion of technological disturbance.

enabled the railroad to act as a catalyst for economic development. As railroads expanded, they triggered a range of innovations in other sectors of the economy as business firms came to understand the profit opportunities of involvement in business activities supported by government.[7] As a consequence, new industries emerged -- steelmaking -- while others such as mail coaches became extinct. Furthermore, railroads, supported by government homesteading, promoted economic development in regions of road building ahead of population (Schumpeter, 1939: 327-330). In effect, individuals and firms visualizing the financial gains of railroad technology was an insufficient condition for launching the new infrastructure. The process of railroadization for Schumpeter was an entrepreneurial as well as political phenomenon.

Initially, Schumpeter interpreted innovation to be an entrepreneurial function of individuals (Schumpeter, 1911; Freeman, 1994). Later, Schumpeter conceded that the entrepreneurial function had become increasingly socialized within the large capitalist enterprise. From the vantage of the mid-20th century, it was these firms that created the new products, processes, organizations, and markets of capitalist development. His "creative destruction" was a process occurring *within* these enterprises. The question still largely unanswered in Schumpeter, however, focused on what was actually occurring inside these enterprises to promote the innovation process.

Innovation as Learning

What Schumpeter conceded to be this still dimly perceived problem inside the firm emerged in a somewhat more illuminated form several years later with the revelation that the innovation process is essentially a learning process (O'Sullivan, 2000: 407). In many ways, the inspiration for this now-commonly accepted connection between innovation and learning derives from the work of Edith Penrose who sought in this link the sources of growth within the firm and the economy. For Penrose, growth revealed an evolutionary process at the core of which was the cumulative expansion of knowledge within the business enterprise (Penrose, 1995: xii). As a collection of human and material resources bound within an administrative framework, the firm promotes growth by learning to transform these resources into new profit-making activities, that is, new products, processes and even new ways of manipulating the market environment to serve its interests (Penrose, 1995: xiii). Growth occurs when new knowledge is added to this base of resources, and the firm subsequently provides the market with new goods and services in fundamentally new ways. In accounting for the so-called "residual" in the growth process, that is, the increment of expansion not attributable to increases in production factors, Penrose uncovered in the learning process one of growth's critical missing links. In this way, growth, much like the growth concept of Schumpeter, is generated from *within* the enterprise with knowledge leading to innovation acting as the catalytic agent for such transformation.

These insights of Penrose have spawned a more recent literature on innovation focusing on how firms learn, and how firms *act* when they acquire new knowledge (Rosenberg, 1982; Nelson and Winter, 1982; Lamoreaux et al., 1999; Dosi, 1997; Dosi et al., 1998). The theoretical and empirical problem explored in this literature is how firms, in learning about opportunities for generating profit differently in a given market environment, transform such knowledge into new *capabilities*. How, in effect, does the firm evolve into what has been described as the "innovative enterprise" (Lazonick, 1994; 2002).

One of the most influential routes used to explain this evolution of the enterprise begins with the firm as an entity motivated by profit and engaged in a learning process to enhance its capabilities within historically conditioned market environments. Such environments where this learning occurs, termed the

[7]While Schumpeter concedes that innovation during the second industrial revolution at the end of the nineteenth century was essentially an outcome of rail development, he is careful to point out that the innovations in industrial processes "were not mere adaptations to the conditions created by the Roads" (Schumpeter, 1939: 383). Industrial innovation in the U.S. he notes, -- especially efficient labor saving machinery -- had earlier antecedents that converged with the opportunities presented by rail to produce the unique character of American industrial evolution in the late 19th century.

technological "regime" (Nelson and Winter, 1982), or the technological "paradigm" (Dosi, 1982; 1984), or the "techno-economic paradigm" (Perez, 1983), share similarities with Schumpeter's technologically-based industrial revolutions that create periods of capitalist development. These environments establish general conditions for both profit-making and the learning capacity of firms based upon the past achievements and existing capabilities of market agents. At the same time, these environments leave open and contingent various forms of technological novelty and learning from one moment to the next (Dosi, 1997: 1531). At any given time, firms in these environments possess a specific set of capabilities. They either learn to modify these capabilities in order to accumulate profit more effectively and grow, or they fail to learn, become uncompetitive, and are driven out of business (Nelson and Winter, 1982: 4).

The fundamental mechanism in this learning process leading to transformation in capabilities and economic growth and development is the *search* by firms for more efficient and more profitable economic *routines*, and the selection of successful routines by other market actors.[8] This notion of the routine, however, is conceived broadly. It comprises the myriad operational, organizational, and strategic elements of what is often described as "getting things done" or more simply, the "technology" of the firm. Modifying capabilities through learning changes routines and is the essence of the innovative process. As this process of search and selection of routines gains momentum and becomes generalized, the economy evolves and there is transition from one historically-periodized industrial revolution to another. Consequently, the route from learning within individual firms, to the development of innovative capabilities throughout a generalized population of firms, occurs as part of an historical transformation.

Organizational learning involves an *investment* by the firm in reorganizing its resources the outcome of which is uncertain (O'Sullivan, 2000: 407). Firms that commit to learning and enhancing capabilities confront the uncertainty of having to forgo a measure of both the use and exchange value of these resources as they are redeployed as part of learning process. This uncertainty is of two varieties: productive uncertainty and competitive uncertainty (O'Sullivan, 2000: 407). Productive uncertainty exists for firms committed to learning because such firms have to figure out how to develop the productive capabilities of the resources in which they have invested before these resources can generate profitable returns. Competitive uncertainty exists because even if a business successfully develops a new product or better process, it may not be superior to that of a competitor pursuing an alternative approach.

Efforts by firms to overcome these uncertainties involve a process of visualizing outcomes from capabilities modified through learning. Firms visualize such outcomes and learn in a variety of ways (Pavitt, 1992: 220-221; Dosi, 1997: 1532). They learn by doing, that is, they learn from direct experience and experimentation with new products, processes and entries into new markets in a process encompassing much trial and error; they learn from competitors along with numerous other business actors such as their own suppliers; they learn from other organizations and institutions such as universities and government; and finally they learn from unsuccessful or incomplete efforts at solving problems and even by failing at such attempts. Nevertheless, firms seldom understand fully the exact trajectory of where the learning process will take them. As Schumpeter himself acknowledged, innovation is often the outcome of action taken without a complete understanding of what results will follow (see O'Sullivan, 2000: 407-409). In solving one problem to enhance capabilities, firms normally encounter additional problems unforeseen at the time when the learning process begins. For this reason, firms in the course of learning, are often compelled to solve what emerge as contingent problems that arise only after certain other difficulties have been overcome.

What differentiates firms is the degree to which they are able to coordinate deployment of their resources in pursuit of creating new capabilities (Lazonick and Mass, 1995: xv). This process of organizational "coherence" or "integration" is central to the literature on innovation. How is it that some

[8]That this process of search and selection in the work of Nelson and Winter bears striking resemblance to Schumpeter's notion of innovation and diffusion is no accident. "The influence of Schumpeter is so pervasive in our work that it requires particular mention" (Nelson and Winter, 1982: 39)

firms succeed in this project and become innovative, while others are less capable of achieving such coherence? The key to solving this puzzle begins with the basic nature of the firm -- a profit seeking collection of resources organized within an administrative framework -- and its relationship to the profit environment in which it operates. Firms are agents that engage in a process of technological and organizational search in pursuit of opportunities to accumulate and secure profit (Penrose, 1995; Dosi, 1997: 1531). The fact that firms, through their own agency, can secure access to new knowledge, is what provides firms with opportunities for enhancing their capabilities. In this search, firms make choices with regard to ways of getting things done but their selections do not derive from some omniscient understanding of the most profit-optimizing pathway available in the market as assumed in rational choice models of human action. Firms seek solutions to problems and select alternatives for competing on the basis of imperfect knowledge about profit opportunities and an incomplete picture of the technological solutions available for pursuing these opportunities (Dosi, 1997: 1531-32; Lamoreaux et al., 1999: 6-8).[9] This imperfect knowledge gives rise to variation in the choices firms are likely to make regarding strategy, routines, and organization and thus in their capabilities. While business firms exist in the same world, they see the world differently, and they learn different things from the same world. As a result, they make choices that are not programmable, but instead are highly contingent (Metcalfe: 1998: 35).

At the same time, the selection by firms of competitive strategies, operational routines, and forms of business organization is not random. Because firms compete in historically conditioned environments, they make choices from a range of options that derive from such environments. Thus, while the parameters for the choices of firms are historically created, firms exercise agency in making their selections (Yates, 1997).[10] These choices drive the economic development process (Nelson, 1998: 322). They not only provide the basis for innovation in the economy. They are the mechanism by which the innovation process diffuses, spreads and transforms patterns of economic development.

Innovation as Inducement

While the literature on innovation as learning provides a descriptive route from the micro-activity in the firm, to the increasing returns generated from new capabilities, it is less precise in specifying what in the market process is providing the catalyst for acquisition of new knowledge. Here, as Dosi insists, there is a valuable link to be made with the growth literature on *inducements* to innovation (Dosi, 1997). From this perspective, innovation results from the responses of firms to specific transformations in the market environment. Changes in market demand, factor prices, even new technologies act as inducements on firms to accumulate profit from the environment in new ways. As a consequence firms, in seeking the profit opportunities from different circumstances, learn new things and alter the supply of knowledge in the economy. The outcome of such collective organizational learning is innovation and growth.[11]

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[9]These notions of "imperfect" knowledge and "incomplete" understanding in no way imply that there exists in reality some state of perfect information to which firms aspire. Such a state only exists as one of the many assumptions of the economic world in neoclassical economics.

[10]This interplay of structure and agency is the central idea in the *Structuration* theory of Giddens. He argues that historically-conditioned environments shape -- not determine -- human action which in turn, reconstitutes those environments (Giddens, 1984; Yates, 1997: 161). The classic formulation of this idea comes from Marx who observed that human beings "make their own history but they do not make it exactly as they please. They make it from circumstances that are given and transmitted from the past" (Marx, 1851).

[11]Changes in the environment, however do not mechanically produce innovation. Quoting the historian of medieval technology, Lynn White, on the impact of new technologies on the process of technological innovation, David Hounshell points out "that a new device merely opens a door; it does not compel one to enter" (White, quoted in Hounshell, 1995: 210).

Inducements to growth and innovation, however, are not necessarily limited to changes in demand, prices, or technology. Inducements -- as well as constraints -- to innovation may also exist outside the formal boundaries of the market within the realm of politics and institutional settings (Zysman, 1994; John, 1998). From this perspective, innovation is more than a process of knowledge acquisition by firms in an effort to alter routines for accumulating profit. Innovation involves the interaction of the innovator with systems of economic rulemaking established through politics, and structures of power related to conflict and consent among groups and classes. Innovation, in effect, has two components: an epistemological component involving the struggle between the mind and nature; and a social and political component involving institutions and the power struggles within society that shape technological outcomes (Mokyr, 1990: 11). According to its defenders, this second dimension of innovation has been subordinated to the perspective on innovation as learning (Hughes, 1983: x). Two closely related approaches to technological change, namely "contextualism" (Hughes, 1983), and "social construction" (Bijker et al., 1989) seek to remedy this omission.[12] The model of innovative advance found in the synthesis of these two approaches borrows certain features from Schumpeter, namely the ideas of invention, and diffusion (called "transfer" in the social construction literature). To these two concepts however, Hughes and Bijker et al. add the notions of "reverse salients" and "momentum." From Hughes, reverse salients refer to critical technical problems where the line of innovative advance encounters bottlenecks in the form of knowledge gaps that if left unresolved, preclude innovation (Hughes, 1983: 14-17). For social constructivists, reverse salients refer also to constraints on innovation emerging within the social and political environment ranging from opponents of technological change, to rulemaking environments that create legal barriers to change. Critical to this group of theorists is the *actor network*, the medium through which individuals, groups, and classes interact and struggle with each other and through institutions to shape innovative outcomes according to their interests. Momentum refers to the phase in the innovation process when the problems of reverse salients are confronted and resolved enabling innovation to strengthen. Central to this phase is the resolution of power struggles within actor networks, the outcome of which enables certain actors with certain technological interests to prevail. Winners can choose to promote, thwart, or redirect the trajectory of innovation. Actors that prevail in these contests for power use the rulemaking authority of politics and institutions to legitimize the chosen technological pathway corresponding to their interests. What is critical from this approach is that innovation is a contingent process shaped by choices, politics, and power.[13]

With similar concerns, but with more of an emphasis on history, is a group of scholars who critique the idea of innovation as an outcome of the search for *efficiency* (Berk, 1994; Roy, 1997; John, 1997; Sabel and Zeitlin, 1985). Far more central than "the logic of efficiency" in understanding

[12]Although Hughes is typically categorized as a social constructionist, his approach reveals certain subtle differences which he acknowledges in locating his views "somewhere between the poles of technological determinism and social constructivism" (quoted in Hounshell, 1995: 215).

[13]Within this context of reverse salients and momentum, *standards* and dominant designs play both a technical and social role in influencing the pathway of innovation. From a technical perspective, when standards or designs for certain products and processes become dominant and force other products and processes in the economy to adapt in order to function, such standards or designs can both determine and constrain innovation. In this context, pathways for innovative advance are already established owing to the difficulties of moving so many interdependent economic activities already functioning on the basis of the dominant standard or design to an alternative technological path. Certain standards or designs that become so thoroughly embedded in the economy – the QWERTY keyboard is the most well-known example but the Microsoft operating system is equally compelling – can preempt innovation along an alternative path. Standards and dominant designs are also sources of social and political struggles within actor networks -- "standards wars" – because of the high stakes in control over dominant technologies. On dominant design see Utterback and Suarez (1993) and Henderson and Clark (1990) while on the process of standard setting see David and Greenstein (1990) and David (1987).

innovative outcomes is the role of politics, institutions, and relations of power. Equating innovation with efficiency, they argue, is akin to an *ex post,* teleological vision of the innovative process that suffers from what they insist is technological determinism. Moreover, such arguments about innovation cast in the logic of efficiency are, they contend, fundamentally restatements of neo-classical economic models. Innovation in these models is the result of efficient allocative outcomes. This overly determined, teleological vision of the neoclassical marketplace, they insist, has been overlayed upon the historical process and much like neoclassical models, omits any real role for institutions and politics in human activity.[14]

Also related to concerns with contingency and context is the idea of inducements to innovation that derive specifically from the relationship of workers to management and relations of power between them. In this context, management, in seeking greater levels of control over the work process, searches for new technologies that empower managers with enhanced capabilities to reorganize work with less resistance from workers. From this perspective, innovation is induced by class conflict and is the result of ongoing efforts by management to gain greater levels of control over workers and work (Marglin, 1974; Noble, 1984).

Finally, if conditions in the environment are what induce firms to learn and expand capabilities, then one of the most critical inducements to learning are the external economies and network-like interactive relationships of firms in so-called "milieux of innovation" or "learning regions." Inspired by the insights of Alfred Marshall, this view of the innovation process derives from the observation that innovation tends to concentrate geographically in certain regional economies. In these place-based concentrations of economic activity emerge the interactive network relationships within and between firms that provide firms with the external scale economies -- Marshall's "mysteries in the air"-- from which firms learn and innovate, and from which regions become differentiated (Saxenian, 1994).[15] In this way, changes in the economic environment, and conditions of concentration in the environment, induce the process of learning within firms. The innovative enterprises that, by definition, are the agents of this growth process are also, it turns out, transformed by it and assume identities as new business organizations.

The Firm as Business Organization

Business firms create forms of organization in the course of seeking profit. As firms learn about new ways to accumulate, they not only transform their routines for producing, buying, and selling. They adapt their organizational structure to these new routines. In this way, organizational transformation is an integral part of the innovative process. This relationship between innovation and organizational change has its origins in Marx and Marshall. It also has a more recent lineage.

In the late 1920s, economist Allyn Young observed that the marketplace consists essentially of "productive activities tied together by trade" (Young, 1928: 533). He used this characterization as a starting point to uncover how the relationship between the market, the division of labor, and innovative methods of production lead to increasing returns and economic growth. His aim in revealing the outcome of this relationship was twofold. Firstly, he wanted to demonstrate why forces counter to economic equilibrium "are more pervasive and more deeply rooted in the economic system" than is commonly

[14]Much of this critique, however, is directed at the work of one individual in particular, Alfred Chandler, discussed in more detail below.

[15]Saxenian emphasizes, however, that proximity alone among firms is insufficient as an enabler of innovativeness and competitiveness. Instead, place-based concentrations of economic activity must have other attributes that together create an innovative *industrial system* (Saxenian, 1994: 6-7). Nevertheless, for Saxenian, it is *place,* built from unique local histories, culture, and institutions, that differentiates industrial systems providing the source of innovative learning.

realized (Young, 1928: 533). Secondly, Young was determined to show how external economies, deriving from the extent of the market and the division of labor, provided the source for innovation or what Young metaphorically termed "roundabout" methods of production. In this effort, he not only drew upon the seminal insight of Adam Smith linking growth to the interplay of the market and the division of labor. Young seized upon the observation made by Marshall of the business firm as a unit of organizational change, and used this characterization to argue that innovation and economic progress derived from the capacity of firms to evolve in conjunction with changes in the market environment. What emerges from Young's synthesis of Smith and Marshall is a marketplace of business firms evolving in organizational structure as they seek roundabout methods for producing and trading in an effort to generate increasing returns.

While Young's article provided a dynamic, even evolutionary view of economic development, his approach focused more on the aggregate economy than the business activity of *individual firms* (Lazonick 1991: 294-295). It was Ronald Coase (1937) who, in a highly original article written roughly ten years later, asked a fundamental question about the nature of the firm that provided a critical theoretical insight on firms as forms of business organization. The issue that interested Coase was why, and under what circumstances a firm would choose either to produce on its own, or purchase a given input in creating a product or service. "To make or to buy" was the essence of this choice. As a practical matter, firms in exercising this choice, decide on the extent to which they internalize adjacent steps of producing, buying, and selling, and the extent to which they contract with other firms in undertaking these activities. Such decisions situate firms along a continuum marked by two basic types of business organization: *intra*firm networks in which the firm is highly integrated, and *inter*firm networks marked by cooperation and relationships among separate firms. What Coase sought to uncover was the source of the governance structure of these two types of organization -- whether through markets or through administrative coordination -- and the boundaries of these organizations resulting from the chosen form of governance.

Integrated Firms, *Intra*firm Networks

As a starting point in addressing this puzzle of organization, Coase imagined an economy "under no central control" but unlike Young, focused his analysis on the individual firm in seeking to identify how the functions performed by firms are divided up among and between them (Coase, 1937). This issue led Coase to pose three basic questions: When do firms produce for themselves internally, and when do firms purchase from other firms? What types of economic organization derive from these decisions to make or buy? and what determines which activities a firm chooses to do for itself, and which it procures from others? These questions, in turn, led Coase to address the puzzle of why, when there is a price mechanism for securing all goods and services in a specialized exchange economy, there should be any economic organization at all (Coase, 1937: 388).

In order to solve this problem, Coase observed that the economy, although absent a central control, is only partially coordinated by the price mechanism. Firms employ a different organizing principle in which "conscious power" or *planning* is used to allocate resources. "If a workman moves from department Y to department X," argues, Coase, "he does not go because of a change in relative prices, but because he is ordered to do so" (Coase, 1937: 387). Coase equates this power of planning to "entrepreneurs" and distinguishes their activity of coordinating the operations of the firm internally, from the activities of firms transacting through the price system. In the economy, he observes, "price movements direct production which is coordinated through a series of exchange transactions on the market." In the firm, by contrast, "these market transactions are eliminated and in place of the complicated market structure...is substituted the entrepreneur co-ordinator, who directs production" (Coase, 1937: 388). For Coase, internalizing these transactions within the firm, and transacting in the market with other firms through the price system for the same goods and services, are the two alternative methods for coordinating economic activity (Coase, 1937: 387-389).

For the answer to his central question of why there are firms, Coase proposed that there are costs to firms -- transaction costs -- of using the market and the price system to exchange goods and services. When the costs of coordinating transactions internally are less than the costs of using the market and the price system to transact for these items, the firm absorbs the activities represented by these transactions into its own organizational structure. As a consequence, the firm becomes more integrated, and less reliant on the marketplace to secure the items needed to create a product or service. For Coase, a firm has a role to play in the economy if "transactions [can] be organized within the firm at less cost than if the same transactions were carried out through the market." Firm boundaries are also established through this same mechanism of choice deriving from the costs of transactions. The limit to the size of the firm is reached "when the costs of organizing additional transactions within the firm exceed the costs of carrying out the same transactions through the market" (Coase, 1991: 48). Managers of firms, he claimed, are preoccupied with the single overriding concern of transaction costs in calculating the trade-offs of using the market, or absorbing production and trade activities internally (Coase, 1937: 404).[16]

This singular focus with transaction costs, however, compelled Coase to ignore other critically important aspects of business organization. Coase rejected a role for technology on the organization of the firm (Williamson, 1987: 4). Coase also did not view politics, or contingencies in the historical process itself, as influential on the organization of the firm. His model is abstract and ultimately ahistorical (Lazonick, 1991: 195). Nevertheless, despite these omissions Coase, in this article, produced a seminal work with an enduring legacy. In posing basic questions about the structure of enterprise, Coase provided a theoretical starting point to account for the organizational variation in firms. He found in transaction costs a compelling, if one-sided explanation for why firms were vertically-integrated, or why they operated within interfirm networks and transacted across markets.

Coase's pathbreaking approach to the boundaries of the firm inspired a group of influential economists from the so-called behavioral school, most notably Oliver Williamson. Starting from Coase's dichotomy of the way firms either internalize transactions, or transact through the market, Williamson used transaction costs to account for firms as representative of "Markets and Hierarchies" (1975). Market-oriented firms were those that used the marketplace to transact with other firms for inputs to make goods or provide services. These firms would also transact with other firms to distribute and sell their products and services. Hierarchies, by contrast, were those firms that assumed ownership over the input activities, the productive activities, and the marketing activities in creating and selling a product or service. Hierarchies, in effect, assume ownership and control over large portions of procurement, production and distribution, and are the equivalent of Coase's directing "entrepreneur." What Williamson did that differed significantly from Coase, however, was twofold.

Firstly, unlike Coase, Williamson proposed that transactions, and transaction costs exist not only in market exchange but are also as part of the operations internal to the firm. In effect, transactions for Williamson exist between firms across markets, and within firms. Costs of transactions result from uncertainty in exchange which has three essential origins: 1) the self-interested guile or opportunism of other parties to the transaction; 2) incomplete information or *bounded rationality* regarding the parameters of the transaction; and 3) control over *assets specific* to a transaction. The choices of firms to transact through the market or internalize transactions activities derive from the efforts of firms to minimize the costs of these uncertainties. According to Williamson, minimization of the costs of uncertainty related to opportunism and bounded rationality, suggests organization of transactions through markets. By contrast, minimization of the costs of uncertainty related to being without assets necessary

[16]Despite this seemingly one-sided emphasis on the nature and boundaries of business firms, Coase was not without insights on the spatial dimensions of organization. "Inventions which tend to bring factors of production nearer together by lessening spatial distribution, he writes, "tend to increase the size of the firm. Changes like the telephone and the telegraph which tend to reduce the costs of organizing spatially will tend to increase the size of the firm" (Coase, 1937: 397).

for a certain type of transaction compels firms to remedy such problems through organization into hierarchies. It is, in fact, asset specificity upon which his predictive theory of organization hinges (Lazonick, 2002: 11). Specifically, Williamson hypothesizes that "market contracting gives way to bilateral contracting which in turn is supplanted by unified contracting [hierarchical organization] as asset specificity progressively deepens" (Williamson, 1985: 78; see also Lazonick, 2002: 11).

Secondly Williamson, unlike Coase, aimed at testing his approach to transactions costs and organization in actual historical situations. He was especially interested in the formation of corporate hierarchies and the process of vertical integration in the U.S. during the late nineteenth century. In this sense, Williamson's interest in history aligned his work closely with the approach taken by Alfred Chandler. Nevertheless there is at least one fundamental difference between the transactions-cost approach to firm structure elaborated by Williamson, and the "Strategy and Structure" approach to the organization of the firm pioneered by Chandler. This difference focuses on the issue of the relationship between innovation and organization. As Williamson concedes, the introduction of innovation complicates the assignment of transactions to markets and hierarchies (Williamson, 1985: 143; see also Lazonick, 2002: 13). It was Chandler who would more systematically make this connection between innovation and technology on the one hand, and business organization on the other.

For Chandler, the *strategy* of the firm, deriving from an "awareness of needs and opportunities created by a changing economic environment," fundamentally influenced the *structure* of the firm defined as the "design of organization through which the enterprise is administered (Chandler, 1962: 14-14). [17] Beginning in the second half of the nineteenth century, the appearance of the vertically integrated enterprise reflected new strategies developed by management to produce and market goods in high volume. Through such strategic and organizational adaptations, management created what Chandler describes as "economies of speed" in an effort to achieve high-volume throughput. It was the ongoing efforts of firms to master economies of speed and high-volume production and marketing that account for the tendency of vertical integration to assume a dominant role in the organizational structure of late nineteenth century business enterprise (Chandler, 1977).

According to Chandler, there were good reasons for the link between the size of the firm, the volume of throughput, and the speed at which goods were produced and sold. Faster, high-volume throughput hinged on uninterrupted sources of supply, and unimpeded sales of finished goods. Such requirements implied that functions once mediated by different firms using the market mechanism, began to accumulate within the boundaries of a single firm using the "Visible Hand" of management (Chandler, 1977). This form of administrative planning provided better forms of coordination between inputs and output. In addition, the need for management to secure more predictable sales outlets for high volume throughput, coupled with antiquated distributions systems, pushed numerous firms into marketing activities and forward integration. In this way, the strategy of the firm became linked to organizational structure through innovation that transformed production and distribution. [18]

In the view of Chandler, rail and telegraph technologies figured prominently into the emergence and development of this new business institution (see "Communications Revolution" below). The rail

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[17] Chandler points out, however, that strategies could be carried out through different forms of organization, although he insisted that the integrated corporation prevailed because it was the most efficient.

[18] It was only in the aftermath of completing *The Visible Hand* that Chandler took an interest in Williamson's work on transaction costs and its implications for his own emphasis on strategy and structure (see Chandler, 1988). Chandler conceded the possibility that coordination of supplies, production, and marketing within the boundaries of the firm also resulted in lower transaction costs for the large corporate organization. In the view of Chandler, however, reductions in transactions costs were more an *outcome* stemming from more efficient coordination than a cause for organizational change. For Chandler, it was economies of high volume throughput and economies of speed that created the basis for administrative control underlying the large integrated corporation, not costs of transactions.

and telegraph system helped integrate formerly isolated localized markets into a geographically-extended national market while at the same time concentrating market demand in cities. This market structure, in turn, created a new set of strategic opportunities for the firm. In the wake of more extended markets and mass markets in cites, producers had incentives to expand volumes in order to service this more-extended and concentrated national market space. Rails and telegraphy furnished producers with the reliability and speed necessary to coordinate flows of supplies and finished goods long distances, as well as in and from urban factories in sufficiently high volumes to service this new market structure. As a consequence, firms became larger and assumed new capabilities to take advantage of scale economies in coordinating high-volume throughput. Business firms also integrated backward into raw material suppliers, and forward into marketing to sell their finished products. In Chandler's model, changes in technology and markets created a new strategic orientation for producers based on high volume throughput. Drawing upon Weber and Schumpeter, strategy became structure in the form of the vertically integrated administratively coordinated intrafirm business organization.

Chandler argued forcefully that the large corporation, coordinating its activity through internal administration rather than market transactions, was a more *efficient* form of business organization than the small-scale proprietary firm coordinating its activity through markets. Contrary to the claims of his critics, however, Chandler did not insist that the integrated corporation reflected an innately superior form of organization in economic life. His work seeks to explain the historical ascendancy of the vertically-integrated firm in the American economy during the period of 1870-1920. For Chandler, this form of enterprise emerged historically around a set of efficiency objectives -- economies of speed and economies of scale – that became realized through management control and vertical integration. It prevailed during the period for this economic reason.[19]

***Inter*firm Organization**

Ironically, when Chandler's *Visible Hand* appeared in 1977, the large scale, vertically integrated corporation appeared to be suffering the first serious challenge to its hegemony as a profit-generating institution since its initial creation in the late nineteenth century. Beginning in the early 1970s, large corporations in the industrial countries, especially in the U.S., exhibited a precipitous decline in profitability that continued into the 1980s (Harrison, 1994: 125-127). At the same time, a range of new firms, mostly from Japan but also from other countries in East Asia, emerged as serious competitors to these previously formidable corporate organizations. Interestingly, the economic challenge to corporate America represented by Japan came from firms that were seemingly even more highly integrated than American companies. In many ways, these Asian firms helped provoke this profit crisis by exposing the complacency and uncompetitive character of their once-dominant American counterparts. The Japanese *keiretsu* and the Korean *chaebol* were business organizations integrated both vertically and across sectors including finance (Gerlach, 1989; Amsden, 1989). Eschewing forms of market exchange, the keiretsu and the chaebol organized their business operations through tightly coordinated and highly administered

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[19]Chandler's critics notably Berk (1994), Roy (1997), Scranton (1997), and Sabel and Zeitlin (1985) make two basic counter claims to his argument. Firstly they are especially critical of Chandler's efficiency argument insisting that the account of Chandler suffers from technological determinism. Technology and efficiency, they argue, are insufficient explanations for the evolution of the large vertically integrated corporation. Secondly, because of this focus on technology and efficiency, Chandler (in the view of these scholars) neglects the political struggles at the center of industrialization, and is oblivious to the fact that the choices made by firms about technology, strategy and firm structure were *politically,* not economically motivated. These shortcomings preclude Chandler from recognizing the diversity of outcomes during the late nineteenth century in terms of firm structure, regionalism, and technologies. There seems little reason, however, why Chandler's argument emphasizing the primacy of technology and economics, is incompatible with the view that politics is critical to the way firms make choices about competing. For an excellent overview of this debate, see Hounshell (1995).

relationships. In many ways, these organizations were the quintessential embodiment of the *Visible Hand*.

Nevertheless, a very different story of this challenge -- and one that has had a more enduring impact owing to the eventual slowdown and sustained malaise of the Japanese economy -- has emerged with a focus on a far different organizational phenomenon. In this interpretation, the role of the large firm in economic development was being undermined by examples of place-based growth and innovation deriving from clusters of medium-size and even small firms, notably in Italy, Germany, and the U.S. Such examples suggested the possibility of alternative models of economic growth and development to those driven by large-scale integrated enterprises. Together, this decline of large firms, and the allure of alternative growth models based upon clusters of smaller companies, created what appeared to be a new environment for competing. By the mid-1980s, this change was apparently so pervasive that Michael Piore and Charles Sabel, in an influential book, argued that the capitalist economy had arrived at what they termed, *The Second Industrial Divide*.

Piore and Sable compared this historical conjuncture to a similar moment during the previous century when mass production emerged from craft production. In the divide of the 1980s, however, the strategy that they advocated for relaunching growth was based upon a vision of transition to smaller -- and more importantly -- more flexible forms of business enterprise (Piore and Sabel, 1984: 6). They found inspiration for this vision not only in certain industrial communities of craft production in the nineteenth century that, in their view, represented historical alternatives to mass production.[20] Piore and Sabel were able to reference the existence of smaller and medium sized firms clustered in numerous place-based industrial districts as the actual living seeds of the new industrial order. What distinguished these communities both past and present, were networks of firms based upon relationships of cooperation and competition. Regardless of whether the prescriptive vision of Piore and Sable was viable, they had uncovered in these networks of firms an emerging trend in economic and organizational development. What followed in the wake of Piore and Sabel's book was an enormous amount of new theorizing about interfirm networks as a new form of business enterprise.[21]

Much of this theorizing about regionally concentrated networks of firms derived from two basic and overlapping convictions.

First was the affirmation that the integrated firm was in a deep, and perhaps irreversible malaise, its crisis the result of internal bureaucratic rigidities stemming from integration as an organizational form that precluded possibilities for innovation. These organizational characteristics, that at one time may have enabled the vertically integrated enterprise to compete effectively, now tended to act as blocks on innovative learning and the development of capabilities to enhance competitiveness. Implicit in this critique was the notion that as an organization, the integrated firm possessed little capacity for adapting to a more competitive market environment. At the same time, as part of this critique was the embrace of interfirm networking as a solution to the problems of the large-scale integrated firm. These network organizations, it was argued, promoted pathways of learning and adaptability that enabled them to innovate and compete. As institutions, integrated firms, from this perspective, were becoming competitively inferior if not obsolete while enterprises organized from networks of firms were hallmarks of the future.

Secondly, and perhaps more profoundly was the conviction was that existing theories on the nature of the firm provided little insight about interfirm networks as a specific organizational phenomenon. The dichotomy between contracting relationships undertaken through markets, and contracting relationships organized administratively within firms, first developed by Coase and later

[20]This idea was developed more fully at roughly the same time in Sabel and Zeitlin (1985).

[21]There is a vast literature on this topic of industrial districts and networks of firms. For an overview of some of the earlier theorizing see Pyke et al., 1990 and Scott, 1988.

refined by Williamson and Chandler, was from the perspective of these theorists, insufficient as a framework for explaining the emergence and proliferation of interfirm contracting relationships in the aftermath of the profit crisis of the 1970s and 1980s. Signals for such a perspective, however, had already emerged independent of, and prior to the competitive crisis of large firms.

In an extremely compelling article on industry and organization, G.B. Richardson argued that "by looking at industrial reality in terms of a sharp dichotomy between firm and market we obtain a distorted view of how the system works" (Richardson, 1972: 884). His observations on forms of networking and contracting relationships between firms in the economy suggested firstly that business organization was highly contingent, and secondly that the choices made by firms on forms of organization represented a continuum passing from pure market-type transactions, through intermediate forms of cooperation, to cooperation fully and formally developed within the same organization (Richardson, 1972: 887). For this reason, Richardson was highly critical of the dichotomy between firm and market which he claimed "leaves out of account….the dense network of cooperation and affiliation by which firms are inter-related" (Richardson, 1972: 883). Richardson's insights about networks as unique forms of organization resonated strongly in the more recent theorizing of network enterprises. "Neither Market, Nor Hierarchy," expressed this rejection of the lineage established by Coase (Powell, 1990).[22]

From this framework, several contributions have attempted to explain the nature of interfirm networks as forms of business organization, and issues of governance and coordination that supposedly make them uniquely innovative.

Manuel Castells is perhaps the most emphatic in affirming the uniqueness of interfirm networks as an organizational form of business enterprise. Castells, however, has a far different point to make than simply distinguishing networks from either markets or hierarchies. He equates this organizational phenomenon --"linkages between economic agents" -- with what he insists is a broader, historically unique, networking phenomenon in the economy linked to "the information technology revolution" (Castells, 2000: 5, 77). These linkages are essentially horizontal relationships in which the operating unit of the business is not really a firm, but is instead more a *project* enacted between nodes in networks (Castells, 2000: 177, 214). For Castells, such ephemeral forms of organization correspond to the flexible nature of economic activity in the new millennium, and the need of business enterprise for adaptability to compete in the restructured environment of capitalism dominated by the Internet. Project-oriented linkages can be easily transformed and reconstituted as business needs change, and as conditions for profitability are redefined. Nevertheless, if as Castells argues, these networks are unique to the information technology revolution, is it technology that is creating these forms of organization? And, if networks are linked to the information technology revolution, what is one to make of interfirm networking prior to this revolution? Furthermore, apart from references to the power of information technology, it remains unclear what the mechanisms of coordination and governance are within this new organizational form that enable them not only to function, but function more innovatively than other forms of organization.

In contrast to Castells is the literature describing the networking phenomenon as *commodity chains.* This phenomenon is defined as a network of production and labor processes the end result of which is the creation and sale of a finished commodity. It differs from Castells in acknowledging the existence of commodity chains as forms of capitalist business organization dating from the early period of capitalism in the sixteenth century. In effect, the literature on commodity chains takes a more long-term view of interfirm networking and its role in the development of capitalism. At the same time, however, it acknowledges that commodity chains in each period possess unique attributes. This historically based perspective derives from a synthesis of two unlikely intellectual partners. On the one hand, theoretical

[22]"I do not share the belief that the bulk of economic exchange fits comfortably at either of the poles of the market-hierarchy continuum… My aim is to identify a coherent set of factors that make it meaningful to talk about networks as a distinctive form of coordinating economic activity" (Powell, 1990: 298, 300-301).

inspiration for this literature derives from the "world systems" approach to capitalist development in which different commodity chains spanning great distances across the globe fuel capitalist expansion beginning in the sixteenth century (Hopkins and Wallerstein, 1994). On the other hand, this approach draws upon Michael Porter's notion of the value chain defined as "an interdependent system or network of activities connected by linkages" that represent the various adjacent stages in the production and distribution of goods and services (Porter, 1990: 41). In borrowing from both world systems theory and value chain theory, the commodity chain approach focuses on goods as a complete process of production, labor, and marketing. It seeks to reveal where the different parts of this process occur geographically, and who controls the process (Gereffi and Korzeniewicz, 1994: 2; Hopkins and Wallerstein, 1994: 50).

Commodity chains have three primary characteristics (Gereffi and Korzeniewicz, 1994: 7). Firstly, they have an input-output structure corresponding to a sequence of value-adding activities at different nodes. Secondly, they have a "territoriality," that is, a spatial dispersion and concentration corresponding to the location of the various activities in the commodity chain in space and the way these activities occupy space. Thirdly, commodity chains have a governance structure in the form of authority and power relationships within the network. These attributes, however, give commodity chains an historically specific character. During the late nineteenth and early twentieth centuries, certain types of commodity chains were actually internalized within the boundaries of vertically integrated corporations where they coordinated mass production activities over national territories. What is distinct about the late twentieth century is the transformation of commodity chains into networks of independent firms organizing adjacent operations of procuring, producing and selling around the globe (Gereffi and Korzeniewicz, 1994: 7). Within these interfirm networks, profitability shifts from one node to another as an outcome of work organization, and the distribution of power between the different nodes. Power, in effect, plays a key role in the governance of these organizations.

Related to this approach but offering an analysis of more recent and specific forms of interfirm organization is the work of Tim Sturgeon who uncovers what he considers a new model of network organization: the *turnkey production network* (Sturgeon, 1997a; 1997b). Functionally, this new entity is characterized by the separation of innovative capacity and production capacity marked by a distinctly new form of production outsourcing. Organizationally, this separation is represented by the emergence of a distinctly new institutional entity: the *contract manufacturer*. Sturgeon observes that since the mid-1980s and particularly in the 1990s, large American name-brand electronics companies such as Apple, IBM, Hewlett Packard, and indeed Dell Computer have been abandoning their internal manufacturing operations, and turning to contract manufacturers such as SCI, Solectron and Flextronics to actually build their products. These contract manufacturers build the products of their clients through what is known as a turnkey contract (Sturgeon, 1997a: 11). The contractor assumes responsibility for production, while design and marketing are retained inside the boundaries of the name brand firm. The contractors themselves undertake this production activity through myriad subcontracting arrangements, dispersing and concentrating production in complex networks throughout the world. Costs, the diffusion of capabilities and skills, and the retreat of brand name firms into "core competencies" drive the development of this new networking organization.

By contrast, in the work of Saxenian, networks of firms, emerging from specific industrial systems, are the sources of innovation and competitive advantage that differentiate firms within one region from firms in another, and the regional economies where firms operate. Silicon Valley, according to Saxenian, is a network-based industrial system (Saxenian, 1994: 9). It is an innovative region because the industrial system upon which the region is built, promotes horizontal and decentralized interfirm network relationships. These interactions, in turn, emerge from, and at the same time reinforce relationships built from mutual reciprocity and trust. Network-like ties between specialized firms enable multiple and spontaneous interactions to occur that create ongoing recombinations of knowledge and information sharing. Such network relationships are the basis for a process of collective technological learning (Saxenian, 1994: 9). Issues of governance structure and coordination in these networks, however, are not explicitly specified. While on the one hand, reference is made to the increasing specialization and division of labor in Silicon Valley, there is, on the other hand, strong suggestion that the interactions and relationships so central to innovativeness are not conducted at all through markets. Instead, cooperation between partners in the decentralized networks of Silicon Valley seems to more closely resemble non-market coordinated interactions based on relationships. Consequently whether by accident or design, Saxenian raises an interesting puzzle about the structure of organizations that are neither market nor hierarchy. While a highly specialized division of labor drives the existence of interfirm networks, they appear to contract through relationships lying outside the market.

Although in Saxenian the issue of coordination in interfirm networks is posed but not answered explicitly, in a provocative paper by Richard Langlois, this issue receives a more definitive treatment. In this paper, Langlois concedes that the world described by Alfred Chandler represented an industrial revolution marked organizationally by vertical integration and governed by the visible hand of management. He suggests that the current period is characterized by a revolution "at least as important as the one Chandler described…as profound as the one of the late nineteenth century." In contrast to the enabling technologies of the rail and telegraph, this revolution has as its technological infrastructure the computer and the Internet. In place of mass production processes, the current revolution is one based upon modularity. Finally, and perhaps most importantly, while the earlier revolution replaced Adam Smith's visible hand with the visible hand of planning and administrative coordination, the current modular revolution is marked increasingly by "coordination through arm's length trading on thick markets…In this epoch, Smithian forces may be outpacing Chandlerian ones" (Langlois, 2001: 2). This new form of governance is called by Langlois, "The Vanishing Hand." This paper is brilliantly argued but, as revealed in Chapter 6, there may be good reasons why the invisible hand of Smith, and interfirm business networks forged around processes of modularity, are not necessarily well matched. Instead, it is the visible hand of Chandler that may be more suitable as a coordination mechanism even for certain types of interfirm networks. In this sense it is helpful to revisit remarks made over thirty years ago by Richardson. "Planned coordination does not stop at the frontiers of the individual firm," he writes, "but can be effected through co-operation between firms….anti-trust legislation has checked vertical integration, but the same co-ordination is achieved through close co-operation between individual firms at each stage….Cooperation may come close to direction when one of the parties is clearly predominant;" (Richardson, 1972: 895-896). For Richardson, power, exercised through administrative coordination, is as compatible in interfirm networking as it is in vertical integration.

Communications As Revolution

Few inducements to innovation and organizational transformation are as profound as a fundamental change in the means by which society communicates. As William McNeil has written recently, "major landmarks in human history" along with "the impulse to innovate" depended on improvements in communications that allowed messages to travel farther and more accurately across time and distance…" (McNeill, 2000: 9). It was historian Robert Albion, however, who was the first to write extensively about the impacts of what he described as the "communications revolution" on economy and society (Albion, 1932; John, 1994).

Albion originated this concept to describe the creation of an unprecedented, "veritable age of speed" beginning in the late eighteenth century but occurring most decisively during the nineteenth century, with which new transport and communications networks moved goods, people, and information (Albion, 1932; John, 1994: 101). This preoccupation with speed led him to highlight the importance of the communications revolution in the United States where speed was critical in bridging the enormity of continental-sized distances. Although he insisted that the communications revolution emerged independently of industrialization -- "it had performed wonders while our industries were still legitimate 'infants'" -- he acknowledged the impacts of new transport and communications systems on the growth of the "Machine Age" and "Big Business" (Albion, 1932: 718-19).

Despite its pioneering attributes, Albion's concept did not seek to develop systematic connections between new transport and communications systems, and broader economic changes in production technology and business organization. Albion was more concerned with describing the wide-ranging social effects of the new infrastructure. It was left to one of Albion's students, Alfred Chandler, to provide these links between new communications technologies and transformations in business organization.

Similar to Albion, Chandler emphasized the role of speed in the compression of geographical space as the defining breakthrough of a communications revolution based on the railroad and telegraph. What Chandler did was to make explicit the connections between the revolution of rails and telegraphy, the emergence of the integrated corporation of the late nineteenth century, and the system of high-volume production and distribution built upon economies of speed. In building his model of organizational transformation on the rail and telegraph revolution, Chandler, in fact, was largely responsible for introducing transport and communications infrastructure as a category of historical analysis and catalyst of economic change (John, 1994: 102).

What Chandler represents in terms of the communications revolution of rails and telegraphy, has its counterpart in the work of Castells on information technology (1996). Like Chandler, Castells seeks to demarcate an historically unique economic and social phenomenon in the late twentieth century that he describes alternately as *The Information Age* and *The Network Society*. His point of departure in accounting for this phenomenon is "The Information Technology Revolution" that emerged in the 1970s and is represented in its most recent manifestation by the Internet (Castells, 1996: 5).[23] For Castells, this revolution consists of the converging set of technologies in micro-electronics, computing, telecommunications, and biotechnology (Castells, 1996: 29). These technologies and the revolution they have engendered, have shaped the restructuring of capitalism since the 1980s (Castells, 1996: 13). For Castells, the source of the "new economy" created from this restructuring process is unmistakable. "This new economy emerged in the last quarter of the twentieth century" he writes, "because the information technology revolution provided the indispensable, material basis for its creation" (Castells, 2000: 77).

Castells is convinced that the information technology revolution represented most decisively by the Internet, and the informational economy spawned from it, reveal decisive breaks with industrial society preceding it. While conceding that past forms of economy relied on the processing of information, Castells distinguishes these previous *information* societies from the *informational* society that has emerged only in the last 25-30 years. In the informational economy, productivity and competitiveness derives from the capacity of economic agents to generate and process knowledge-based information whereas in the industrial economy of the past, the source of productivity derived from manipulation of materials and access to sources of energy (Castells, 1996: 17, 66). The information technology revolution is thus an historical discontinuity on the same level as the industrial revolution of the eighteenth and nineteenth century (Castells, 1996: 30). In his work is a call to historians of technology to compare and contrast the recent period of transformation marked by the Internet, with analogous transformations in the past (Castells, 1997: 244-245). Castells is certain that history will judge the current period of the Internet Revolution to be one of epoch-making discontinuity. Comparison of the innovative enterprises created by Swift and Dell may very provide a test case for such a verdict.

Toward Synthesis

The starting point for comparison of Swift and Dell is Schumpeter's observation that capitalist development is punctuated by waves of discontinuous technological innovation beginning in the late eighteenth century. These waves demarcate distinct periods of industrial revolution in the development of modern capitalism. Each period is distinguished by a set of dominant technologies defined broadly as ways of working and getting things done. Around these technologies cluster specific types of economic routines, business organizations, political structures of economic rulemaking, and geographies of

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[23]Castells is careful to point out, however, that "technology does not determine society." He insists instead that "technology *is* society" (Castells, 1996: 5).

economic activity delimiting market territories for producing, buying and selling. Competition and the search for profit compel firms in these periodized environments to seek more innovative and efficient ways of accumulating. This process of search is a learning process. In this learning process, firms confront problems posed by existing economic routines, business organizations, politics and geography that limit ways of getting things done. The learning process is an effort to overcome such limitations by solving the problem of how to think, and more importantly, act differently about profit-making. At the same time, these environments condition the range of choices available to actors in learning about, and seeking to implement more innovative solutions for producing, buying and selling. Although each of these periods is unique, common patterns in this process of innovation create historically comparable economic environments across time.

Among the most disruptive historical forces transforming this environment is the phenomenon of communications revolutions. Two groups of firms create this phenomenon and act as agents for the process of innovation in which the disruptive impacts new transport and communications technology emerge, spread, and transform the rest of the economy. Igniting this phenomenon are *builders* of the new transport and communications infrastructure. Within this group are a variety of different actors -- inventor entrepreneurs, investors, and firms that undertake actual construction and build-out of transport and communications infrastructure. Invariably government assists the efforts of this group. Extending this phenomenon are business *users* of the new transport and communications systems. These firms complete a more sweeping set of changes in the economy by using the new infrastructure to transform existing business models for profit-making. The interaction of these two groups shapes the deployment and build-out of the new infrastructure systems, and the pathway of transformation throughout the rest of the economy resulting from it (Cohen et al., 2000).

The roles of builders and users in creating the communications revolution and spreading its impacts, reveal certain identifiable patterns.

This pattern starts with a breakthrough invention in transport and communications technology that is exploited and commercialized by inventor entrepreneurs within the ranks of communications revolution builders. Although patent rights frequently protect the new invention, the patent process has a limited impact in stemming the entry of numerous companies anxious to capitalize on the commercial potential of the new technology as a built system. Accordingly, the ranks of companies interested in transferring the new technology into built systems, and constructing new infrastructure for such systems -- rail, telegraph, and Internet firms -- explode soon after this first stage of commercial success. Hundreds of competing companies get involved in this early period of initial infrastructure creation and development.

During the early stages of new infrastructure development, multiple variants of the new transport and communications technology emerge among the different firms, creating intense competition to define the most technically superior system design. As these myriad firms compete to build-out the new systems, the competitive process gradually gives way to a process of consolidation in which a small number of builder firms survive. During this process of contraction in the number of builder firms, the multiple variants of the new technology created at the outset of commercialization also diminish. The surviving firms compete ferociously to establish a dominant design or standard defining the path along which subsequent infrastructure development takes place. At stake in these standards wars is control over future profitmaking. On the one hand, individual firms seek to use their mastery over a particular technological design to set the terms for subsequent development of the infrastructure. Secondly, firms that successfully develop a dominant standard are in a position to control terms of infrastructure access and use. The telegraph, the railroads, and the Internet all went through this process of standard-setting – with clear winners and losers.

The build-out of new transport and communications infrastructure by builder firms has a transforming effect on the profit-making environment of system users by reconfiguring the economic geography of markets. In the first place, the deployment of the new transport and communications systems provides users with the capabilities for new and different levels of *access* across and within markets for buying, selling, and producing. Secondly, these new levels of access create a different structure of *costs* in moving goods and securing information between distant markets, and between areas of proximity within markets thereby changing the costs for procuring, producing, and marketing. Such new structures of access and costs alter the geography of markets by redrawing the boundaries formerly separating market areas and the agents operating in those areas, and by reorganizing the activities and relationships between economic actors within market areas. What firms confront as the geography of markets is upended by new structures of access and costs, is a reconfigured system of time and space relationships in economic activity. Shifts in the geography of markets alter the profit-making environment by confronting firms with the problem of controlling a reconfigured structure of time and space relationships in economic activity.

Control over time and distance is an ongoing strategic, operational, and organizational concern for the firm throughout capitalist development (Schoenberger, 1997: 12). Businesses are constantly engaged in framing and reshaping their strategies, routines, and organizations in an effort to overcome the barriers, temporal and geographical, to accumulating profit. Changes in the geography of markets act as inducements on firms to learn new capabilities for controlling time and space differently as they procure, produce, and sell.

The environments where such learning is possible and where opportunities exist for controlling time and space in new ways, are highly contingent. Certain firms grasp the profit-making opportunities associated with the communications revolution more decisively than others, and integrate the new infrastructure into their business models in accordance with their understanding of such opportunities. Nevertheless, the business models of such innovative firms do not emerge fully-formed. They evolve as incremental experiments in a process of learning by doing. Gradually, through such forms of trial and error, firms create systems of codified and tacit knowledge. This knowledge is the basis of more competitive, strategies, routines and forms of business organization -- capabilities -- through which firms procure supplies, fabricate goods, and market finished products. It is also the foundation from which firms evolve into innovative organizations.

Business organizations are inherently territorial. They assume this territorial character in the way they choose to organize economic activities in geographical space. Firms organize their activities geographically in the way they locate their own physical assets or *nodes*, and in the way they organize the flows of activity between these nodes, and the nodes of other firms with whom they interact in producing, buying and selling. While to some extent, the location of nodes, and the configuration of flows reflect the capabilities of available transport and communications technology, nodes and flows also emerge as a function of the way firms choose to organize internally. Such choices involve the extent to which firms are integrated and absorb sequential steps in procurement, production, and marketing, and the degree to which they are dis-integrated and contract with other firms in allocating these tasks. These choices on firm structure influence the locations of key assets, and the routes by which flows of economic activity between these assets circulate. In this way, innovations in business organization deriving from the influence of the communications revolution and the process of organizational learning, reshape territories of profit-making.

The outline of this route from communications to territory depicted in Figure II-1can thus be summarized as follows.

From a given profit-making environment, new transport and communications technologies emerge establishing the initial impulses of the communications revolution. These new technologies become commercialized by entrepreneurial infrastructure builders who deploy and build-out new transport and communications systems. When reaching a certain threshold, this build-out creates fundamental changes in the economic geography of markets, and the structures of access across and within market boundaries. Such changes in the geographical organization of market space, combined with the enhanced capabilities of the new infrastructure itself, provide opportunities for accumulating profit differently.

In this environment of initial infrastructure build-out, certain businesses learn to exploit the new infrastructure, and the new structures of access created by these systems to accumulate profit differently. What emerges from this process of learning are initial experiments, through trial and error, with innovative routines for profit-making. Gradually, in an ongoing process of learning by doing, firms develop new capabilities to carry out these innovative routines.

As they enhance their capabilities and assume the role of innovative enterprises, firms transform the organizational structure through which they carry out their operations and compete. Innovative business organizations, in turn, recast geographical landscapes for profit-making by shifting the locations of productive assets, and by rerouting flows of activities between these assets and the assets of other entities with which they interact in the course of procuring producing and selling. In certain instances, profit-making in these reconfigured territories requires new systems of rulemaking to accommodate the innovations in routines and the business organizations developed for the new activities. Collectively, these changes -- transport and communications technology, market geography, business routines, organizational structure, territorial transformation, and market rules -- produce a new profit making environment (profit-making environment *prime* in Figure II-1). This environment then paves the way for the next communications revolution -- communications revolution *prime* -- and the process continues. [24] Such shifts in market geography transform the profit-making environment by providing users with opportunities for learning how to compete and accumulate differently. At the same time, new transport and communications infrastructure itself provides user firms with new and different technical capabilities for exploiting these opportunities.

[24]Nevertheless, the process is not circular implying historical repetition. Instead, the process is conceived as a spiral representing parallel historical experiences within an overall context of development and change.

Chapter 3
THE RAILROAD AND TELEGRAPH
AS COMMERCE SYSTEM AND INTERREGIONAL MARKET SPACE

[N]o doubt, the most significant object in the office was the ticker.... The offices of the ranches were thus connected by wire with San Francisco, and through that city with Minneapolis, Duluth, Chicago, New York,... During a flurry in the Chicago wheat pits, Harran and Magnus had sat up nearly half of one night watching the strip of white tape jerking unsteadily from the reel. At such moments they no longer felt their individuality. The ranch became merely the part of an enormous whole, a unit in the vast agglomeration of wheat land the world round,...

Frank Norris
The Octopus (1901)

[A]s the organized type of society develops, the fusion of the various elements entails the fusion of the markets into one single market... The result is that each industry produces for consumers who are dispersed over the length and breadth of the country, or even the whole world.

Emile Durkheim
The Division of Labor in Society (1891)

Communications and Commerce

When Swift began sending shipments of beef from Chicago to New England in the late 1870s, the communications revolution of rails and telegraphy -- the precondition for the Company's long-distance system of production and distribution -- was already in an intermediate stage of build-out. Two critical attributes of the infrastructure at this stage enabled Swift to reconceptualize the existing practice of beef slaughter and sale, and create an enormously innovative network for producing and distributing beef in large volumes on a national scale.

In the first place, the rail and telegraph system had essentially become a *commerce* system. It had evolved into an infrastructure for moving freight, and facilitating the exchange of information and messages needed to coordinate such movement of commodities. Such a development as a commerce system was not necessarily preordained. Nevertheless, soon after the initial deployment of the rail and telegraph systems, business uses -- shipping goods and sending messages for buying and selling these commodities -- assumed the dominant form of use on these new infrastructures.

Secondly, Swift took advantage of the rail and telegraph not only as a freight-moving and transaction-facilitating system, but also as an infrastructure with an increasingly national reach. This process of national integration, however, was not geographically uniform in its effects. At the outset of system expansion, linkages between the Northeast and the Midwest emerged far stronger than North-South connections. What resulted was a more vibrant set of trade relationships between the Eastern Seaboard and the agricultural heartland of the Midwest (Fishlow, 1965: 262). Only after the 1870s did North and South become more integrated on the basis of rail and telegraph connections through never to the extent of East-West connections.

The evolution of the dressed beef network created by Swift reflected this spatial pattern. The firm relied upon the more established East-West links forged by the rail and telegraph system in launching its system of fresh beef shipments from Chicago to the Northeast in 1878-1880. Gradually the firm expanded the geographical reach of these shipments so that the network extended into virtually every corner of the country.

This chapter describes how the rail and telegraph revolution became a nationally oriented commercial revolution that provided the Swift Company with the foundations for its production and distribution network. It examines how this communications revolution established an environment of opportunity for innovation. The rail and telegraph revolution created this environment by reshaping the geography of markets, thereby redefining what was economically viable and efficient for firms. This chapter also reveals how the politics and rulemaking environment for these enlarged markets evolved as Swift and other large-scale firms, sought to protect the national networks they had created. Finally, this chapter reveals how the rail and telegraph revolution rearranged trade linkages in the U.S. urban system, and created mass markets in cities that Swift learned to exploit in its innovative search for profit.

Infrastructure Interconnection

The commerce-oriented transport and communications system that provided Swift with the preconditions for his network, began to take shape over the territory of the United States in the decades after 1850 (Fishlow, 1965: 262; Thompson, 1947; Du Boff, 1983). Evolving from myriad locally-based rail and telegraph operations, the national character of this infrastructure emerged most dramatically when the Atlantic and Pacific coasts were breached by telegraph wires in 1861 and by rails in 1869. Although these two events captured the imagination of the country, and inspired subsequent historical accounts of the rail a telegraph system, the story of how this infrastructure became a national system occurred in the nation's interior. Alongside the bi-coastal reach of rails and telegraph wires, expansion in the total mileage within the agricultural heartland of the country, and the connections such interior growth represented, were decisive in the creation of a nationally integrated rail and telegraph transport and communications system.

Yet, while expansion in rail and wire mileage provided the basis of a nationally-oriented transport and communications system, it was the symbiotic development of rails and telegraphy that enabled this expansion to occur. Despite very different technological origins, the rail and telegraph infrastructure developed its national orientation after 1850 as an essentially single transport and communications system. Telegraph wires expanded along railroad rights of way, and telegraphic communication became indispensable by the mid-1850s in enabling the railroads to operate safely. In 1849 the New York and Erie Railroad pioneered the use of the telegraph on its lines to control operations. Five years later, the telegraph was standard equipment for the scheduling of all rail operations. Railroads furnished transportation and materials for the construction of telegraph wires, and operated telegraph offices from their depots. By 1870, U.S. railroads had funded, and were managing two-thirds of Western Union's 12,000 telegraph offices (Chandler and Cortada, 2000: 12). Although the capital and labor requirements to build and operate the two infrastructures were vastly different, rails and telegraphy became fused as the "twins" of nineteenth century commerce (Field, 1992).[1]

Prior to the Civil War, however, the rail and telegraph system suffered from innumerable obstacles to interoperability. These problems were due in no small part to the large number of firms in each industry. In 1850, roughly five years after initial commercialization of the telegraph, there were already hundreds of telegraph companies (Jones, 1852; Thompson, 1947). During this same period, there were at least an equal number of rail firms, a number that eventually reached over 2000 (Chandler, 1965). As a result of such unbridled competition, railroad track gauges, locomotives, and rail cars varied throughout different regions of the country. Seven different track gauges were still in use in 1860 (Friedlander, 1995). Similarly, telegraphy operated on competing Morse, Bain, and House technologies. Points of transshipment between competing lines, whether rail or telegraph wires, were sources of bottlenecks where freight and messages had to be modified in order to accommodate the standards on the next leg of the route. These transshipment points added both time and costs to the movement of freight and messages over the rail and telegraph infrastructure. Without standards for interconnection, the rail

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[1]Field concedes, however, that while rails and telegraphy emerged in tandem, "they were surely one of the most disproportionate pairings in the annals of economic history (Field, 1992: 401). He notes huge differences in capital and operating costs, total capital value of the built systems ($8 billion for railroads, $70-147 million for the telegraph industry), and total employment. The contribution of the telegraph lay in its capital-saving capability, enabling it to offset the capital-using bias of the railroad (Field, 1992: 412).

and telegraph system was not able to exploit fully its technological capabilities for efficient long-distance transfer of goods and information.[2]

As the builders of these systems consolidated after 1850, they gradually addressed many of the most urgent problems of long-distance interconnectedness. Rail and telegraph builders began to establish uniform standards for track gauge and telegraph wires that eventually integrated rail and telegraph lines into a more unbroken network for freight and message traffic. They improved the technology of locomotives and freight cars that enabled the system to increase the size and speed of freight shipments. At the same time, builders agreed on construction standards for both track and wires. Steel replaced iron rails, and iron became the standard over less durable copper telegraph wires. Finally, railroads managed to overcome the problem of multiple local time standards in the U.S. where in 1870 there were still roughly 200 local times and 80 different railroad times in use. In 1883 railroads imposed a uniform time that enabled them to end confusion and operate more profitably (Kern, 1983: 12). These ameliorations, technological, structural, and even social resulted in more efficient overland movement of merchandise, and facilitated the message transmissions for both rail companies carrying freight, and business users of the infrastructure shipping and receiving merchandise.

Table III-1

Expansion of Rail and Telegraph Networks

Year	Rail Track Miles (000s)	Freight Tonnage (millions)	Telegraph Wire Miles (000s)	Messages Sent (millions)
1848	5.9	10.6	3.4	.5
1852	12.9	17.6	23.3	1.4
1860	30.6	46.5	56.0	5.0
1870	52.9	147.6	133.6	11.5
1880	115.6	338.9	291.2	31.7
1890	208.2	691.4	848.8	58.4
1902	252.5	1200.7	1307.0	89.7

Source: Alfred Chandler, ed., The Railroads: The Nation's first Big Business (New York: Harcourt Brace, 1965), Tables 1 & 2; Richard DuBoff, "The Telegraph and the Structure of U.S. Markets," Research In Economic History, Volume 8 (1983), pp. 253-277, Table 1, p. 256; Edwin Frickey, Production in the United State 1860-1914 (Cambridge: Harvard University Press, 1947), Table 13, p. 100.

Interregional Trade and Mass Markets

The outcome of these improvements was a shift after the 1850s from water transport as the primary means of conveyance for interregional commerce, to a rail- and telegraph-dominated system of overland long-distance trade. In 1850, despite gains by the railroads during the previous decade in hauling freight, boats and barges still dominated interregional transportation of bulk agricultural goods (Fogel, 1964: 22). Of the estimated $1.46 billion in internal commerce in 1852, almost two thirds traveled over water courses (Schmidt, 1939: 818). Ten years later, however, the situation was reversed.

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[2]In 1850, telegraphic messages from New York to New Orleans had to be rewritten four or five times at intermediate stations en route before being passed along to the next station. Interconnection problems between competing companies operating on different telegraph technologies created such bottlenecks (Jones, 1852: 87). Similarly railroads had to rely on imperfect interconnections. Hoists were used to lift freight cars off and on different wheel bases at points of transshipment between railroads operating on different track gauges.

By 1862, rails accounted for roughly two thirds of the long-distance freight traveling from West to East. As rail use expanded, river routes declined. On the eve of the Civil War, the Mississippi had ceased to be an economically viable transport route used by grain merchants (1860 Census of Agriculture, 1863). The decline in canals stemming from rail competition occurred more slowly but the final outcome was little different than the fate of river routes. Although still widely in use during the 1870s and 80s, canals by 1890 attracted very little business. Rails and telegraphy had subordinated rivers, canals, and lakes to a position of largely secondary importance in the nation's internal trade.

This rail and telegraph revolution was essentially a marketing revolution in the movement of commodities and information. This marketing revolution made possible more rapid, larger, more geographically-extended shipments of goods for delivery at definite times in specific places (Du Boff, 1983: 255). Long-distance overland freight shipments by rail, and long-distance, real-time information exchange by telegraph thus became inextricably linked.

As goods and information circulated over a rail and telegraph infrastructure increasingly national in scope, changes in the nation's structure of markets and system of cities resulting from this circulation, redefined the parameters for the profit-making activities of firms.

The communications revolution of rails and telegraphy opened the boundaries between localized markets prevailing before the 1850s, and created a wider, more spatially-extended market system (Du Boff, 1983; Yates, 1986). This infrastructure enabled economic actors to expand their business operations to more distant locations by diminishing geographical barriers on freight and information movements between market areas, and reducing the time needed for commodities and information to circulate from one area to another. The resulting enlargement of market boundaries led to the establishment of a more geographically-extended system of overland interregional trade.

Alongside this change in the market geography of the country was an equally profound shift in the nation's urban system. By the late 19th century the U.S. had become a much more highly urban society. During the decade of 1860-70 the increase in the American urban population exceeded the increase in the rural population for the first time in U.S. history (Pred, 1966: 18). Existing cities expanded and an enormous number of new urban settlements emerged during the years from 1850-1890. Perhaps more importantly, cities after 1850, especially those in the top ranks of the U.S. urban system, assumed a more multi functional role complementing their traditional commercial functions. Cities became centers of factory industrialization (Pred, 1977: 85). Within the boundaries of cities, with their burgeoning populations of businesses and consumers, were enormous concentrations of supply and demand. In these urban environments, raw materials entered, intermediate goods circulated, and finished products exited. It was in cities where these items were also consumed in unprecedented quantities by both firms and the urban public. In emerging as concentrations of supply and demand within production economies, cities evolved into entrepots of *mass markets*.

Ignited by rail transport and telegraphic communications, these changes in markets and cities served as platforms upon which Swift launched its fresh beef network.

The firm linked procurement of cattle raw materials and production in the West, with final marketing of the finished dressed beef output in the East through a distribution network built upon the foundations of wider markets and the system of rail and telegraph-based overland interregional trade. At the same time, cities were the focal point of Swift's procurement, production, and marketing activity. On the buying side, Swift found mass markets for its cattle raw materials first in Chicago and then in other cities on the frontier of the cattle range in the Midwest. The firm established its production facilities and marshaled its factory labor force in these same urban centers. In selling its products, Swift used the expanding populations of cities, first in the East, and later in the rest of the country, as centers of consumer demand, mass consumer markets. The firm in essence appropriated the impacts of the communications revolution on markets and cities. It grafted its own business model of using refrigerated rail transport and telegraphic communications in creating an innovative network linking the mass production and mass distribution of fresh beef. What enabled these two elements, markets and cities, however, to emerge as the foundations of Swift's system was the gradual evolution of the rail and telegraph infrastructure into a unified national transport and communications system. In forging the long-distance connections for this high volume production and distribution system, and focusing his activities in urban centers, Swift reinforced those very transformations in markets and urbanization that made his network possible. In the process, Swift played a critical role in establishing the linkages between production and distribution activities that helped define a national market space.

Markets as Territory

Markets, as territories where economic actors produce, buy, and sell, have boundaries that define them as places. The geographical size of markets is dependent on the costs to, and capacity of market actors to exchange goods and services over distance, and communicate information needed to negotiate exchanges (Du Boff, 1980: 478). Distance, and the time needed by economic actors to bridge distance in transporting merchandise and communicating terms of an exchange, act as limits on the size of markets. Market boundaries become fixed at those points where goods and information cannot circulate beyond barriers of geography in a timely manner. They also become fixed where the costs of moving goods or securing information beyond such geographical barriers drive the prices of merchandise to unmarketable levels, i.e. when the costs of transporting merchandise or communicating the terms of exchange exceed the value of the merchandise at its origin. These "costs of transfer," that is, the costs of transferring goods and information over distance, limit the size of markets (Ohlin, 1933: 100).

In addition to this calculus of time, distance and costs of transfer, two additional factors -- technology and politics -- shape the boundaries of markets. Historically, transport and communications technologies have conditioned the size boundaries of markets by controlling how merchandise and information circulates, and influencing the costs of such circulation (Du Boff, 1980: 479). Politics also shapes the reach of market areas owing to the role of political authorities in establishing rules for market behavior (Polanyi, 1944; Braudel, 1967; 1977). Political rulemaking influences the extent to which market actors can engage in commercial activity over politically divided territories. Perhaps more importantly, market rules influence the rewards economic actors can expect from such activity in terms of private gain, thereby influencing the choices of whether market activity is worth pursuing in the first place (Zysman, 1994). In effect, time and distance, technology and politics converge in creating a cost structure for market activity that establishes market boundaries. Time and distance, measured by the costs of using transport technology to convey goods and services from one location to another, and the costs to economic actors of using communications technology to secure information integral to an exchange, act in concert with politics in shaping the boundaries of market areas.

Such a view of markets borrows elements from a longstanding geographical tradition. In the 1930s, the German geographer Walter Cristaller, synthesized ideas about transport, distance, and costs in developing a theory of what he called "Central Places" where goods, businesses, and populations concentrate. At the core of his theory was the "principle of markets" (Christaller, 1933: 72).

For Christaller, the market was a territorial unit. It represented a *range* corresponding to an upper limit in terms of the distance beyond which essential commodities or "central goods" could no longer be exchanged in a cost efficient manner. The central places that formed around markets, however, could be reshaped by two other secondary principles (Christaller, 1933: 76-80). The first was the principle of *transportation.* Conveyance of goods through improved transport broadened the range in which such goods could circulate therefore expanding the market area. The second principle was *politics.* Christaller conceded that markets and central places frequently emerged and grew in conjunction with administrative decisions of government. For Christaller, the three principles interact in defining the boundaries of markets where trade can occur (Christaller, 1933: 76-80).

Christaller's theory has an undeniable elegance in its explanatory power. In focusing on distance, transport costs, and politics, Christaller succeeded in uncovering basic principles of market configuration. For Christaller markets, configured from these three elements, exist as hexagonally-shaped territories delineating central places of varying importance in a hierarchical system of equilibrium. This elegance and simplicity, however, also reveals certain weaknesses. The model suffers from an over reliance on mathematical abstraction. Paradoxically, not only is real geography absent from Christaller's featureless landscape. Missing are meaningful references to the history of how these market areas emerge, and how they change over time.

Pre-Rail and Pre-Telegraph Markets

Prior to rail transport and telegraphic communication, markets for most products and economic activities in the U.S. were predominantly local in scope (Schmidt, 1939: 820; Yates, 1986: 151). These markets, especially in the less populated western areas of the country, were characterized by high levels of self-sufficiency and low levels of trade and exchange (Schmidt, 1939: 818). In these areas of self-sufficiency there was an underdeveloped division of labor. Products originated, circulated, and were consumed within close proximity. Relatively few transactions occurred across market boundaries (Yates, 1986: 151).

Typical of this local market structure was the early meat industry (Walsh, 1982). Virtually every town had its own abattoir where cattle and hogs were processed, or where farm-slaughtered animals were further butchered (Clemen, 1923). Although the slaughter and consumption of fresh meat possessed unique attributes that, in the absence of efficient transport and refrigeration technology, made it an overwhelmingly local activity, markets for other products, especially consumer perishables but also durable manufactured goods, possessed similar localized patterns of production and consumption (Chandler, 1977).

Highly-variegated conditions of supply and demand for goods and services existed from one local market area to the next. Perhaps even more profound were differences in the prices of commodities from one local market area to the next (Carey, 1988: 216). Such variation in markets had profound impacts on intermarket trade. In the absence of well-developed transport and communications links, variations between markets constrained intermarket economic activity in two principal ways: 1) by limiting exchanges of information between economic actors separated by distance about prices, quantities, and types of goods available in different markets; and 2) by imposing formidable obstacles on the overland movement of goods between market areas. Trade under such circumstances conferred high levels of risk and uncertainty on merchants contemplating intermarket expansion.[3] The sources of such risk and uncertainty derive from the role of communications and transport in the act of trade itself. The movement of goods or services through trade has to be preceded by the exchange of information between two types of economic actors. Economic actors on the demand side (a purchasing retailer, wholesaler, or industrial enterprise) need information on supply sources and prices, while agents on the supply side (farmer, wholesaler, manufacturer) need to know outlets of final marketing and what buyers are willing to pay (Pred, 1977: 38-39). Information about the market, in effect, is a precondition to trade. If information can not be exchanged over distance in a timely and cost-efficient manner, the consequences for markets are increased risk, reluctance by economic actors to engage in trade between distant points, and preservation of market boundaries. Similarly, if goods can not move across geographical barriers owing to underdeveloped transport links, the consequences are the same -- low levels of trade over distance, and market boundaries that remain narrow.

In the pre-rail and telegraph period, intermarket trade imposed formidable costs on most merchants that exceeded the potential gains of such trade (Pred, 1966: 163; Yates, 1986: 5). In the absence of rail transport and telegraphic communication, these costs stemmed from shipping difficulties and information deficiencies related to the barriers of distance between markets. The costs of overcoming distance, and the time needed to bridge distance in sending and receiving shipments and securing information to consummate transactions for such shipments, placed obstacles on intermarket exchange. These cost constraints kept markets localized and hampered intermarket growth -- an outcome lasting into the 1840s (Du Boff, 1983: 257).

Despite the dominance of localized markets and the limitations on intermarket commerce, there *was* in place during the early 19th century a system of long-distance trade. This trade, however, did not go overland. Commodities could not move overland for any appreciable distance without raising their prices to unmarketable levels. In 1816 the freight costs for shipping corn by wagon 136 miles amounted to its selling price (Pred, 1977: 66). Wheat, although less costly to ship by cart, still exceeded its selling

[3]Risk and uncertainty are not identical. Risk is a known distribution of possible outcomes while uncertainty reflects a situation where the outcomes themselves are unknown (Knight, 1921).

price at a distance of 330 miles (Riley, 1911: 94). Clearly, such costs for the overland movement of commodities represented a formidable constraint on intermarket trade.

More daunting than the costs associated with long-distance shipments was the time associated with shipping freight interregionally. In 1817 it took 52 days to ship a load of freight from Cincinnati to New York using available wagon and river routes (Slaughter, 1995: 6-7). By contrast, in 1852 the same freight shipment from Cincinnati to New York took only six days on the Erie Railroad and its feeder lines (Slaughter, 1995: 6-7). Owing to these circumstances, interregional trade during this period circulated overwhelmingly via coastal shipping between coastal port cities (Pred, 1977: 66).

Table III-2

Value to Shippers of Wheat and Corn Hauled by Wagon

	$ Value to Shippers	
	Wheat (1 ton)	Corn (1 ton)
Value at Market	$49.50	$24.75
10 miles from Market	48.00	23.35
50 miles from Market	42.00	17.25
100 miles from Market	34.50	9.75
170 miles from Market	24.00	0
300 miles from Market	4.50	-
330 miles from Market	0	-

Source: Riley (1911): 94.

In the first two decades of the nineteenth century, long-distance commerce between regions occurred along two principal routes: 1) between U.S. coastal ports and European (mostly British) ports; and 2) between Northeastern and Southern coastal ports oriented primarily on the cotton trade (Pred, 1977: 66-70). In many respects, these two routes overlapped. Much of the cotton trade originating from Southern coastal cities was shipped first to Northern ports and then transshipped to British textile mills. This routing formed both a domestic coastal trade, and a foreign export trade. Similarly, a portion of the European manufactures entering U.S. Eastern ports was sent to Southern port cities. Inland from this very narrow corridor of long-distance coastal trade however, localized markets prevailed. Interregional commerce was an export-oriented, coastal-dominated activity controlled largely by Eastern merchants favorably situated between the Southern market and Europe.

During this period, the western interior of the U.S. as a marketplace was of marginal interest to Eastern merchants or Southern cotton shippers (Pred, 1966: 18-19). This interior area known as "The West" engaged in comparatively little interregional commerce. Isolated geographically from the other two regions of the country, less settled, and without direct access to the Atlantic and Gulf coasts where the nation's interregional trade took place, the West had an even more localized and self sufficient system of markets than the other two regions (Schmidt, 1939: 800). The region was overwhelmingly agricultural although some manufacturing oriented mostly for the farm, was part of the settlement pattern in the West from the very beginning (Page and Walker, 1991: 282).

Trade in the West was overwhelmingly *intra*regional. Exchanges of agricultural commodities and locally-produced manufacturers occurred primarily among the region's river ports as the territory developed its own internal trade system (Pred, 1977: 69). This intraregional system of trade reinforced the region's localized markets structure in which producing, buying and selling occurred in largely selfcontained geographical areas. Farmers in the West were caught in a cycle of inertia. Lacking easy access to long-distance markets, western farmers had little incentive to produce surpluses in sufficient quantity for export outside the region (Schmidt, 1939: 800-806). Without surpluses, western producers had little reason to seek long distance interregional markets.

The Beginning of Interregional Trade

After 1820, however, as population and economic activity continued to expand west of the Appalachian Mountains, and as cities notably Cincinnati and St. Louis became trading centers, this pattern of self-sufficiency was disrupted and the West emerged as the source for a very different pattern of long distance interregional trade. Sparked by the growth of Western agriculture, this new pattern of interregional trade diverted long distance freight shipments away from the coastal routes, and oriented it along an East-West axis. More importantly, as the West became the nation's agricultural breadbasket, this East-West commerce shifted from water routes to the rails. Thus, in the broad sense, the route to the rail- and telegraph-based system of long-distance interregional trade emanated from what was perhaps the most compelling feature of American historical geography during the early 19th century, the expansion of population settlements and economic activity in the region west of the Appalachian Mountains (North et al., 1983: 111).[4]

While western agricultural development provided the stimulus for the rail and telegraph-based interregional trade system, long-distance freight shipments to, and from the West began on water. Steamboats and canals provided western farmers with their first opportunity to sell in distant markets. These early forays by the West into long-distance trade occurred initially in the markets of the South where cotton specialization had left the region in demand of grains and foodstuffs (Schmidt, 1939: 801, 806). By the 1830s, the South had become dependent on the West for grains and foodstuffs (Schmidt, 1939: 803).[5] In responding to this demand, however, western farmers also exploited opportunities to sell in the Eastern market by shipping agricultural commodities on steamboats and barges down river to New Orleans. There, western farm exports were either distributed to Southern market centers for consumption on the plantations, or were transshipped to the East. In both cases, access to long-distance markets through the river trade enabled western agriculture to change from a largely self-sufficient activity, to a surplus-producing industry that by the 1840s, rivaled the great grain producers of Europe.

This transformation of western agriculture into an export-oriented activity played the central role in shifting the mode of conveyance for long-distance freight shipments from water courses to the railroads. At the same time, the surplus-producing agriculture of the West, coupled with the population growth of the Northeast, diverted the primary direction of interregional trade along an East-West axis. The sequence of events that triggered this transformation in both the directional axis and mode of

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[4]In 1893 historian Fredrick Jackson Turner proposed an enormously influential thesis on the origins of this expansion. He argued that the availability of free land in the area drove the boundaries of the American frontier in a continual westward direction. While Turner elevated the pioneering spirit of the white settlers in this expansion, in truth, much of this free land owed it origins to government policy. A long history of national legislation, culminating in the Homestead Act (1862) reflected efforts by government to encourage settlement and development of western lands. By granting title at low costs to those willing to settle the area, along with ceding land to businesses, notably railroads and mining companies willing to exploit the area, government shaped Western development. Critics, however, assailed Turner's approach as an apologia for the Indian conquest (cf. Cronon, 1991 on the debate). Despite the controversy of Turner's thesis, there is little denying the expansion of population and economy in the Ohio and Mississippi River Valleys and the Great Plains -- and the impacts of this expansion on the creation of a rail- and telegraph-based system of interregional commerce. Ironically, Turner's thesis coincided with the pronouncement by the Superintendent of the 1890 Census that the frontier had disappeared.

[5]Admittedly the importance of the Southern market to Western agriculture and the extent to which the South was dependent on the West for foodstuffs remains the subject of debate. See especially Fishlow, 1965: 276-288. What is beyond debate is the expansion of surplus-producing agriculture in the West that acted as the catalyst for the system of East-West, rail-dominated long-distance trade.

conveyance for long distance trade, begins with the completion of the Illinois and Michigan Canal in 1848.

Built in response to the expansion of grain production in the Illinois River Valley, the Illinois and Michigan Canal enabled wheat and corn from Illinois to be routed to New York and the Atlantic through the Great Lakes, the Erie Canal, and the Hudson River. This Canal-Lake course also sent Western grain through the St. Lawrence to Montreal. The impact of this route was to divert Illinois and Western grain intended for Eastern markets away from the river route, bypassing both St. Louis and New Orleans. Perhaps more significantly, it created a strategic point in this East-West trade at the Southern tip of Lake Michigan where a small but growing urban settlement and grain market existed. This settlement was the City of Chicago.

Table III-3

Shipments of Grain and Flour from Chicago, 1840-1861
(Bushels)

	Flour & Wheat	Corn	Total Grain and Flour
1840	1 0,000	--	10,000
1842	586,907	--	586,907
1845	1,024,620	--	1,024,620
1847	2,136,994	67,315	2,243,201
1848	2,386,000	550,460	3,001,740
1851	799,380	3,221,317	4,646,521
1855	7,115,270	7,517,678	16,633,645
1861	23,885,553	24,372,725	50,511,862

Source: 1860 Census of Agriculture, Table H, p. cxlix.

Table III-4

% of Western Exports
Shipped Via New Orleans

	1839	1844	1849	1853	1857	1860
Flour	53%	30	31	27	34	22
Meat	51	63	50	38	28	24
Corn	98	90	39	37	32	19
All Foodstuffs	49	44	40	31	27	17

Source: Fishlow (1965: Table 39, p. 284).

During the first season of the canal's operation in 1848, corn shipments from Chicago, situated at the key crossroads of the canal-lake route, increased eightfold from 67 thousand bushels to 550 thousand as farmers discovered the advantages of shipments away from the Mississippi and New Orleans (Cronon, 1991: 64). Perhaps more significantly, the canal and lake route, in establishing a direct link between East and West, shifted the direction of long-distance interregional trade along an East-West axis. This axis of trade, in turn, reinforced a convergence of interests evolving between the West and the East. With an expanding agricultural surplus and a resulting growth in incomes, the West became increasingly attractive to the East both as a source of foodstuffs and as a market for manufactures. The East in turn, represented a far more lucrative market outlet for western grain farmers than the South. An entirely new system of extended markets and long distance trade was thus emerging on the basis of a new relationship between the regions of East and West in which the interior of the country occupied the primary interests of the nation's business class (Pred, 1966: 16-18; 1977: 66-70).

From Water, to Rail- and Telegraph-based Trade

In bridging the two regions, the lake route actually served as a catalyst for development of the rail and telegraph trade system by creating a privileged position at the base of Lake Michigan for Chicago as a concentration point and primary market for the East-West grain trade. It was this position as a primary grain market in turn, that made the city attractive as a rail head. The Galena and Chicago Union Railroad completed in 1849 marked the first step in this evolution. Illinois grain farmers now had access to the Chicago market via a rail route.

During the 1850s, Chicago became a terminus for 21 different railroad lines. The four Eastern trunk lines converged on Chicago as the rail system began to develop its long distance East-West linkages. The remaining 17 lines extended into the City's tributary agricultural area as small agricultural towns competed fiercely for rail stations (Riley, 1911: 88-89).

The construction of these Roads from Chicago into the West, however, did not occur as a massive building project ahead of demand. Nor did the railroads create settlement and economic development in open territory as some exogenous force. Instead, railroads followed grain cultivation. Rail infrastructure was routed to western areas that were already surplus grain producers (Fishlow, 1965: 165-235).[6] This geographical bias is reflected in the relationship between the rail routes and the grain-growing areas. By the end of 1853 more than 60% of new railroad construction in Illinois occurred in the eleven leading wheat and corn growing counties of the state, areas which represented only 25% of total statewide land area (Fishlow, 1965: 173).

Table III-5

Rail Receipts at Chicago for Various Commodities (1852-56)

	1852	1854	1856
Flour (barrels)	124,316	234,575	410,989
Wheat (bushels)	937,496	3,038,935	8,767,760
Corn (bushels	2,991,011	7,490,753	11,888,398
All Grain (bushels)	4,195,192	15,726,968	25,817,248
Lumber (000 feet)	147,816	238,337	441,962
Coal (tons)	46,233	56,774	93,020
Hogs	65,158	138,515	220,702

Source: Riley (1911: 94).

From its location at the base of Lake Michigan where it had become a primary grain market, Chicago established a hegemonic position as a rail center. In the process, it emerged as the crossroads for a new system of long distance trade between West and East. It was the railroad and telegraph and the focus of this new infrastructure system on Chicago that differentiated the new system of long distance trade from the earlier water-based system.

[6]Fishlow points out that the sequence of railroads traversing undeveloped territory, and inducing economic development "bears no resemblance" to the real world (166). He attributes this idealized scheme of construction ahead of demand to Schumpeter who, in *Business Cycles*, insisted that Midwestern rail construction "meant building ahead of demand in the boldest acceptance of that phrase..." (Fishlow, 1965: 165; Schumpeter, 1939: 328).

A small trading post of 4,853 inhabitants in 1840, Chicago grew to 29,963 by 1850 when the first large shipments of grain began to arrive in the City. By 1860, as railroads linked it with the East and traversed its agricultural hinterland, Chicago exploded, its population reaching 110,000 people. It was the center of the nation's grain trade, a commercial enterprise described at that time as a "revolution" and "one of the chief marvels of modern commercial history" (1860 Census of Agriculture, 1863: cxxxv, clvii; Fishlow, 1965: 289). Central to this revolution is the story not only of how the rail and telegraph trade system succeeded in replacing water routes for moving grain from the Western grain belt to the East, but also how Chicago emerged as the privileged location for this rail- and telegraph-based activity. By 1862, as Chicago asserted its centrality in the rail system, freight carried from Chicago on the Pennsylvania, Erie, New York Central, and Baltimore and Ohio Railroads reached 6 million tons or roughly two thirds of total internal trade of just over 9 million tons. "In one word," notes the 1860 Census, "railroads did what could not have been done without them"(1860 Census of Agriculture, 1963: clxvi).

Table III-6

Flour and Grain Shipments Received At New York, 1860-90
(millions of bushels)

Year	1860	1870	1880	1890
Water	41.1	36.3	71.1	30.2
Rail	16.0	34.2	98.0	90.2

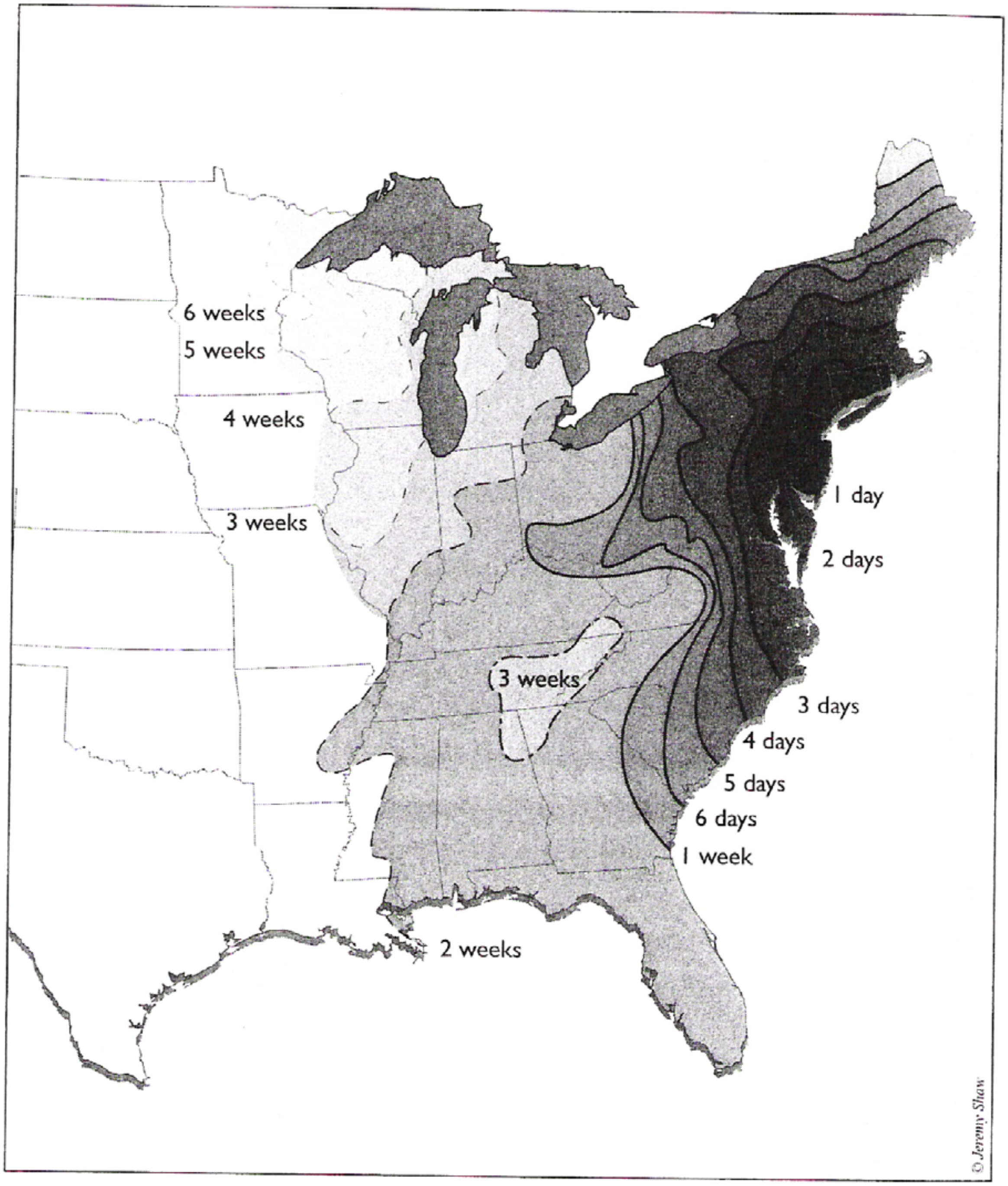
Source: Schmidt, 1922: 105.

Advantages of the Rail and Telegraph System

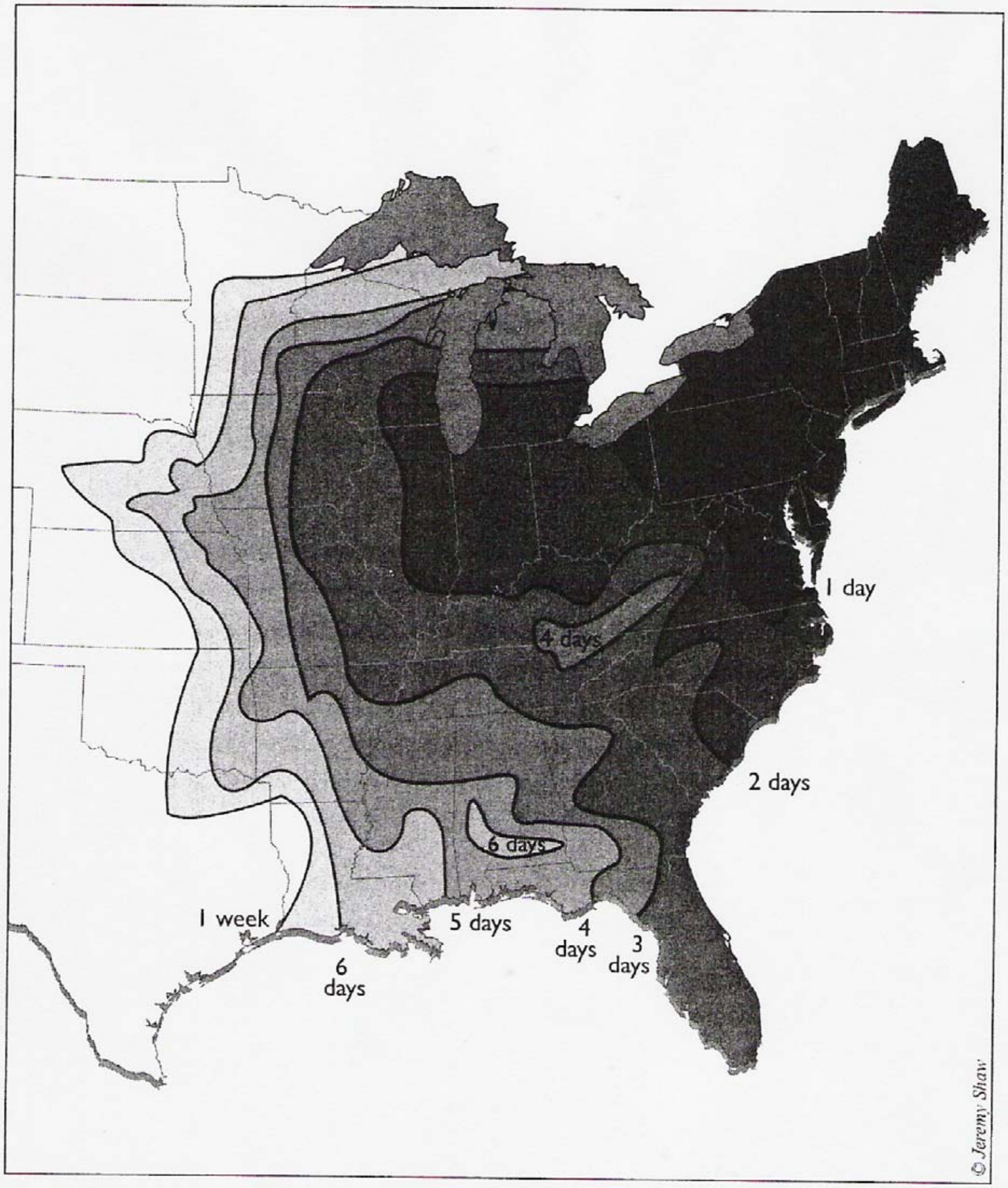
As a means of conveyance for freight, the rail and telegraph system had a number of key cost advantages over water routes.

The most obvious advantage was *speed*. The velocity of shipments by rail enabled it to shrink distances much more dramatically than any previous form of transport (Cronon, 1991: 74). Not only was freight able to arrive faster. The railroads' liberation from geographical and seasonal constraints gave it other advantages over competing river and lake routes in terms of *reliability.* The river route south was extremely risky for grain shipments. River navigation during summer months, especially in drought seasons was often impassible. At the same time, the risk of damage to grain and flour from overheating as well as moisture were of particular concern to grain shippers. Such risks imposed costs in the form of high damage insurance rates, and warehousing costs where shipments were interrupted and rerouted due to impassible navigation. Similarly, the lake route during winter months was plagued by the uncertainty of freezing during the winter months. Although freight rates on rivers and canals were considerably lower than rail rates, premiums for certainty and speed narrowed such differences. Clearly, the pattern of freight shipments beginning in the 1850s, in which ever-larger quantities of commodities began to move over the rail and telegraph system, revealed the extent to which shippers discounted differences on paper between freight rates on water and rates on the rails.

In addition to its operational advantages of certainty and speed, and the cost benefits for shippers from such attributes, the rail and telegraph marketing system was able to expand owing to the benefits conferred on rail and telegraph companies by government. Both rail and telegraph builders profited enormously from privileged access to the system of entitlements -- especially development rights and land grants -- provided by government as incentives to expand their systems (Berk, 1994). Political rulemaking thus worked in tandem with technology in giving decided advantages to rail and telegraph builders in opening markets and creating a rail and telegraph-dominated system of long distance interregional commerce.



MAP 3.1 Travel Time (from New York) as Market Space, 1830
SOURCE: Adapted from William Cronon, *Nature's Metropolis* (New York: Norton, 1991), 77.



MAP 3.2 Travel Time (from New York) as Market Space, 1857

SOURCE: Adapted from William Cronon, *Nature's Metropolis* (New York: Norton, 1991), 77.

Rails, Telegraphy and the Livestock Trade[7]

[7]For more detailed analysis of information in this subsection see Chapter 4.

While the grain trade was decisive in creating the conditions for a rail and telegraph-dominated system of long-distance trade, it was the shipment of livestock from the Western range areas to Eastern markets that revealed most clearly the capacity of the rail and telegraph infrastructure to extend market boundaries and expand overland interregional commerce. Unlike grain and other bulk commodities, the livestock trade did not have an alternative and competitive means of conveyance over water courses for live animal shipments. Livestock had never been transported any appreciable distance on boats or barges. Hogs were far too difficult to manage on such trips while cattle was too large and unwieldy. In the absence of rail transport and telegraph communications, markets for the slaughter of live hogs and cattle were overwhelmingly local in scope.

The large-scale, high-speed, overland movement of livestock, and the establishment of an elaborate system of long distance trade in live animals, was entirely a creation of the rail and telegraph era (Fishlow, 1965: 68). Prior to the completion of railroad trunk lines, however, there was some overland movement of hogs and cattle. Hogs raised on western farms in the Ohio and Illinois River Valleys were driven overland relatively short distances to Cincinnati and numerous other smaller packing centers in Southern Illinois. There the animals were slaughtered, butchered and packed during winter months. Seasonality in the trade was essential because the curing process needed the refrigeration of winter so that the meat would not spoil as it cured (Walsh, 1982). Cattle, by contrast, *was* driven great distances overland from the Western cattle ranges to Eastern markets, especially during the 1840s. These celebrated cattle drives, however, often covering over 1000 miles, imposed significant costs on the cattle grazer and cattle shipper. Cattle lost weight on such drives -- anywhere from 150-250 pounds -- and had to be fed and watered along the route. Along with the labor costs of droving, the losses accruing to cattle shippers amounted to roughly $12-20 per head depending on the length of the drive and the quality of the stock (Fishlow, 1965: 68-69). At an eastern price of 8 cents per pound for a 1000-pound beave or roughly $80 per head of cattle, such charges for long distance cattle shipments amounted to as much as a quarter of the animal's value at market. Beginning in the 1850s, however, the railroads began to offer competitive rates to ship live cattle from the western range areas to Chicago, and then from Chicago to Eastern slaughterhouses. As a consequence, the business of live cattle shipping grew spectacularly during the 1850s (Table III-7). The same forces that made Chicago the largest interior grain market in the country had essentially elevated the City to the greatest collecting point for livestock (Chicago Board of Trade, 1864: 46). This development had actually encouraged the cattle grazing business to migrate further west to cheaper grazing areas where an increasing percentage of the nation's cattle was being raised. As a consequence, live cattle shipments emerged during the 1850s as one of the most lucrative businesses of the railroads (Chandler, 1988: 230). By 1860, livestock shipments accounted for roughly 33% of total eastbound tonnage, and about 50% of eastbound freight charges (Fishlow, 1965: 79). On the eve of the Civil War, as the railroads assumed more and more control of the long distance cattle traffic, the cattle driving business had actually become obsolete (1860 Agriculture Census, 1863: cxxxi).

Table III-7

Live Cattle Shipments from Chicago, 1852-61

Year	1852	1854	1856	1858	1860	1861
# of Cattle Shipped	77	11,221	22,502	42,638	97,474	124,146

Source: Schmidt, 1922: 105.

With the railroad and telegraph, the market in live animals reached from the Western plains to the Atlantic Coast. The consequences of this rail and telegraph-based system long distance trade not only redefined the livestock business. It fundamentally reshaped the geographical structure of markets in which this business operated.

Institutionalization of Interregional Trade

The system of enlarged markets and East-West interregional trade became strengthened and institutionalized through the creation of formalized commodity exchanges. The establishment of Boards of Trade in Buffalo (1845), Chicago (1848), Toledo (1849), New York (1850), and St. Louis, Philadelphia and Milwaukee (1854), and the emergence of the Chicago Board of Trade as the country's central commodity exchange, marked the stages in this process of institution-building and market integration. Rails and telegraphy played a defining role in the way these institutions formalized a system of long-distance intermarket trade.

The rail and telegraph system provided unique attributes to buyers and sellers of commodities in terms of shipping and communications that were essential in reducing the risks necessary for promoting intermarket activity. By accelerating the speed of shipments, providing new levels of certainty in transporting goods over geographical barriers, and conveying information to traders about supplies and delivery schedules, rails and telegraphy enabled both shippers and buyers to negotiate the transfer and arrival of commodities across different market locales. Pivotal to this more extended intermarket system of buying and selling were two critical innovations pioneered by the newly-instituionalized commodities markets that were dependent on the rail and telegraph. These innovations were the forward, "to arrive" futures contract, and the system of standardized grades for commodities.

Prior to these innovations, long-distance trade between bulk commodity shippers and buyers occurred on the basis of the consignment system. The high levels of risk to both parties in this system undermined intermarket commerce. In the consignment system, sellers of bulk commodities delivered by rail a small representative sample from their larger lots of bulk goods to Eastern buyers who would examine the sample and bid over the telegraph for the remainder. By the time the shipment reached the buyer, however, prices might have already changed.

The solution to this dilemma resided in the futures contract in combination with the system of standard commodity grades. Once grades of commodities were standardized, buyers and sellers could complete a transaction by telegraph without need for a specially-shipped consignment. The buyer would know what was being purchased because commodities of a particular grade would be fundamentally identical, while both parties, in turn, could lock-in a price through the futures contract on delivery of the grade specified. Furthermore, futures contracts provided buyers and sellers with other types of risk-reducing flexibility. In contrast with the consignment system, futures contracts permitted commodities to be transported and delivered at chosen future dates when processors of agricultural goods -- millers, butchers, etc. -- were ready to refine them, or when retail grocers were ready to sell (Du Boff, 1983: 259). The impact of this system was to spread more uniform, and less risky exchange practices over a wider territory while involving a more geographically dispersed pool of buyers and sellers in long distance trade. As a result, commodities moved farther and faster while market areas, widened by the expansion of the rail and telegraph trade system, and the institutionalization of commodities exchanges, became more fully integrated and uniform (Du Boff, 1980: 479).

Price uniformity across geographical areas generally reflects an absence of barriers to trade resulting from distance. When geographical barriers to trade diminish owing to such phenomena as new transport and communications systems, the result is greater levels of intermarket activity. As intermarket trade expands, prices tend to equalize across geography (Ohlin, 1933). In the absence of specific data on intermarket trade, the movement toward price uniformity or dispersion across geography is actually a proxy for levels of intermarket activity in the economy. Thus commodity prices in different geographical locales are a measure of the degree to which the economy of the U.S. was moving toward a more unified national market tied together by interregional trade. The effect of the rail and telegraph was clear. These systems evened out markets in space (Carey, 1988: 217).[8]

Commodity price data suggest (Table III-8) that the prices of commodities in different regions, which had started to equalize during the antebellum period due to intermarket economic activity from canals and steamboats, continued to converge, perhaps at an even faster pace, after the Civil War (Slaughter, 1995; Jue, 1999). Variations in regional markets did not disappear entirely. There remained critical issues of interconnection on the rail system not fully resolved until the 1880s with the use of one single standard track gauge. In addition, the South, largely excluded from the system of East-West trade that had evolved in the decade prior to sectional conflict, was still not fully integrated into the interregional compact that continued to evolve between East and West after Reconstruction. Nevertheless, as the railroad and telegraph became more interconnected and interoperable in the post civil-war period, and as these systems enhanced the overland transfer of goods and enabled information to become more widespread and evenly distributed, this infrastructure created an environment of greater certainty in the long distance shipment of merchandise. The result was an enormous expansion in the overland movement of freight and information over rails and telegraph wires, and as a consequence, a greater equalization of prices across geographical space. As commodity shipments expanded, and as commodity prices equalized, a far more nationally-oriented interregional trade system emerged by the last quarter of the nineteenth century. It was this market structure and system of trade that served as a platform for the long distance production network of Swift.

Table III-8

Relative Wholesale Price Indices in Different Cities*
(New York = 1)

	Baltimore	Chicago	New Orleans	New York	St. Louis	S. Francisco
Average						
1866-68	1.099	1.055	1.068	1.000	1.102	1.133
1889-91	0.976	0.969	0.919	1.000	0.944	0.980
Standard Deviation						
1866-68	0.212	0.219	0.166	0.000	0.250	0.318
1889-91	0.083	0.073	0.117	0.000	0.087	0.170

* These indices comprise eight commodities for which comparative data is available (Beans, Candles, Coffee Flour, Rice, Soap, Sugar, Tea).
Source: Jue (1998), Table 1; U.S. Senate, Committee on Finance (1893), Volume 4, Table XVIII.

The Politics of Market Space

If this enlarged structure of markets and system of long distance interregional trade begins with technology, it assumes its more complete form in the realm of politics.

By the 1870s when patterns of national market integration had become widespread, numerous state governments, responding to local business interests, succeeded in creating a web of regulatory

[8]Price dispersion in turn, can be conceived as a measure of *risk* in intermarket trade while risk is a reflection of barriers among them, distance. The greater the differences in prices between regions, the greater is the level of risk in intermarket economic activity, measured by friction in shipping and communicating. The higher the levels of risk, the lower the levels of intermarket trade.

barriers to internal commerce. These barriers were designed to protect local business firms in certain states from the competitive encroachments of firms from the outside the area. As markets areas enlarged and as the boundaries between markets blurred, business firms became more vulnerable to competitors residing outside the former market boundaries. Although efforts by local governments to protect local business interests by restricting commerce between states conflicted with the spirit of the commerce clause in the Constitution, states nevertheless took advantage of their own broadly defined-authority known as states' rights to circumscribe interregional trade within narrow limits. Such protectionist rulemaking on the part of state legislatures contributed to a specific type of market inefficiency. Protections extended to local business firms often enabled local merchants to assume what was effectively monopoly power in those markets where they operated. As late as 1875, the federal courts said nothing that disturbed this impulse of states to intervene and protect local businesses despite the efforts of the constitutional framers to create a single national market (McCurdy, 1978: 635).

States used the doctrine of states' rights to implement protectionist legislation in two ways. Firstly, certain states required non-resident sales persons to pay higher licensing fees than local merchants. In the case of the Singer Sewing Machine Company, these fees aimed at restricting the Firm from setting up its network of retail outlets to compete with the firms of Wheeler and Wilson, and Wilcox and Gibbs. In a Supreme Court case in 1880, Webber v. Virginia, the Court, in acceding to the demands of Singer, struck down the rights of state to impose such fees. This decision revealed the extent to which the idea of a unified national market had become an integral part of the nation's legal doctrine (McCurdy, 1978: 642).

The other mechanism implemented by states was the use of local inspection laws for food, most notably in the meat packing industry itself. As the market power of Swift and other large interstate packers expanded during the 1880s, local butchers persuaded lawmakers in Minnesota, Indiana, Colorado and Massachusetts to enact pre-slaughter inspections laws where beef and pork was sold. Claiming to protect the public interest, these laws aimed at eliminating the ability of large packers to sell products transported across state lines. In this case, the remedy upholding the national market space was legislative. In 1891 the Federal government authorized the Federal Meat Inspection service to conduct federal inspections of beef and pork produced for interstate sales.

While these cases reflected the shift toward greater levels of long distance trade, they also revealed the role of corporate political *power* in establishing policy in the marketplace, and new thinking about the market itself (Parrini and Sklar, 1983). In this new thinking, the country was not only better served by long distance commerce and a unified national market. Large oligopolistic firms emerged as the supposedly most efficient organizers of the economic activity within this enlarged market.

Urban Impacts of Interregional Trade

As the rail and telegraph system was reconfiguring market boundaries, it was also engineering the equally profound shifts in the nation's urban system that served as a second platform for the network of Swift. These changes in the U.S. system of cities were marked most decisively by an increase in both the urban population and the overall number of urban places. As market boundaries enlarged, and as market activity assumed a more geographically extended character, trade and production actually became more highly-concentrated in cities. The territorial spread of markets, and the concentration of this spatially-extended economic activity in cities were thus part of the same process of urbanization and economic growth.

This pattern of urbanization and growth was the basis for one of the most far-reaching changes in the late 19th century economy, the advent of *mass markets*. The creation of urban mass markets, in turn, both business and consumer markets, reflected two important consequences of urbanization: 1) a shift in the internal size ranking among the nation's cities, and 2) a change in the pattern of geographical linkages between cities. Mass markets also reflected an even more profound transformation occurring within cities themselves -- the emergence of cities as manufacturing centers (Pred, 1966; 1977). In this role, cities served as the focus of production economies where production factors, supplies of materials, and demand for intermediate goods used in manufacturing, became concentrated.

In this role as mass markets, cities became the centers of powerful transformative feedbacks in the economy. The growth of urban populations, the shifting rank of cities, the changing directional patterns of interurban trade, and factory industrialization emerged as mutually-reinforcing catalysts for economic growth. At the same time, alongside this activity was the continuing expansion, standardization and integration of the rail and telegraph system. Transport and communications, manufacturing and urbanization, and mass markets in cities thus evolved as interactive elements in a pattern of evolutionary economic change.

Table III-9
Urbanization, Railroadization and Industrialization of the U.S.
1850-1900

Year	1850	1860	1870	1880	1890	1900
Total Population (millions)	23.1	31.5	39.9	50.3	76.1	92.4
% Urban Population	11.3%	19.7%	24.8%	28.1%	35.1%	39.6%
# of Cities with Population > 10,000	62	93	168	223	363	440
Railroad Mileage (000s)	9.0	30.6	52.9	93.3	166.7	206.6
Telegraph Mileage (000s)	12.0	56.0	133.6	291.2	848.8	1307.0*
Index of Manufacturing	--	16	25	42	71	100

* mileage for 1902
Source: Pred (1966: 17); U.S. Bureau of the Census (1975); Frickey (1947: 10-11).

Urbanization and City Rankings

The urban population of the U.S., which reached 5% of total population only in 1830, began to expand dramatically after 1850, when rail and telegraph firms began to standardize their infrastructure and create a more uniform and nationally-oriented transport and communications system.[9] By the eve of the Civil War in 1860, roughly 20% of the population was living in cities. In 1890, the country's 22.1 million urban inhabitants represented 35% of the total U.S. population. By the end of the century, roughly 40% of the nation was urbanized. Equally dramatic in this period was the increase in the number of urban places. In 1850 there were 236 cities, that is, places with a population of at least 2500. By 1890, there were 1348 such places. Even more profound was the increase in larger cities. Four cities in 1850 had populations in the range of 50,000-100,000. By 1890 there were thirty of these larger mid-size cities.

As early as1820, the four largest cities of the Northeast -- New York, Philadelphia, Baltimore, and Boston -- had developed a system of large-city interdependence in terms of both arrivals and exports

[9]Urban places as defined in the Census' of the period, are cities with at least 2500 inhabitants. Figures in the rest of the paragraph taken from Pred, 1977: 86 and U.S. Bureau of the Census, 1970: 11.

(Pred, 1977: 67). These cities also dominated the trade with the South where, unlike the Northeast, there was very little intraregional economic activity in the pre-rail and pre-telegraph period. This Southern trade with the cities of the Northeast was controlled by Charleston and New Orleans. Such control established clearly defined patterns of interurban commodity movements between the Southern and Northeast regions. Furthermore, New Orleans was also in a position to control commodity movements from the Ohio and Mississippi River Valleys, to both the Northeast and the South. These goods went by canal and river routes through the Ohio and Mississippi River Systems to New Orleans where they were then transshipped to other southern port cities, or to the port cities of the Northeast. These interurban connections defined the geographical pattern of the interregional trade system in the pre-rail and pre-telegraph period (Pred, 1966; 1977).

As the urban population increased after 1850, the ranking of first-tier cities within the nation's urban system shifted in a dramatic way. One city in particular, Chicago, grew unlike any other after 1850. Its emergence as the nation's second city by 1890 was vastly different from the pattern of rank size city growth from 1820-50 marked by relative stability in the size rank of the nation's very largest cities (Table III-4).[10] The emergence of Chicago transformed the economic interdependencies and the geographical linkages between cities and the regions where they were located. In the process, Chicago helped reshape the pattern of both interurban and interregional commercial relationships that had been established in the mercantile era.

Table III-10

Size Rank of Largest Cities
1820-1850 and 1850-1890

City	1820 Rank	1850 Rank	City	1850 Rank	1890 Rank
New York	1	1	New York	1	1
Philadelphia	2	2	**Chicago**	**19**	**2**
Baltimore	3	3	Philadelphia	3	3
Boston	4	4	St. Louis	7	4
New Orleans	5	5	Boston	4	5

Source: U.S. Department of the Interior Census Office, 1895: 370-372.

As Chicago expanded by taking advantage of its position of primacy within the rail and telegraph system, and as it evolved into the nation's premier commodities market, it became the focal point of the nation's East-West interregional trade system. Chicago successfully siphoned off flows of grain from its primary competitor, St. Louis. It drove New Orleans and the river economy to a secondary role in the nation's internal commerce system. It relegated the once-dominant pork packing city of Cincinnati to a secondary position both as a livestock market and meatpacking center. Its control of the nation's internal trade, and its emergence slightly later as an industrial center became a source of wonder even to the actors at the Chicago Board of Trade who made this happen.[11]

[10] During this early period the major change in the city system occurred just outside the largest group with the rapid growth of Cincinnati and St. Louis as the nation's sixth and seventh largest cities in 1850 reflecting the primacy of an expanding river-based economy in the Ohio and Mississippi Valleys. By contrast, the rise in rank of cities such as Milwaukee, Cleveland, and Detroit from 1850-90, though not as dramatic as Chicago, and the decline of New Orleans represented a declining river economy and a shift of fortunes to a rail-dominated internal trade system.

[11] Even Mark Twain, in his semi-autobiographical *Life on the Mississippi* (1883), remarked upon "that astonishing Chicago – a city where they are always rubbing the lamp, and fetching up the genie, and contriving and achieving new impossibilities. It is hopeless for the occasional visitor to try to keep with Chicago – she outgrows his

Mass Markets and Manufacturing

From 1860-90, the top ranking cities in the U.S. became characterized more by industrial and multi-functional activities, and less by mercantile and trading functions. This manufacturing activity also became increasingly concentrated in fewer, larger cities. In 1860 the ten largest cities accounted for 24% of all U.S. manufacturing value added. In 1890 the figure for the top ten cities was 38% (Pred, 1977: 85). This change toward manufacturing was one of the most significant attributes of the urbanization process that enabled cities to emerge as mass markets.

Owing to this transformation, the channels of interdependence among larger cities within the U.S. urban system increasingly involved commodity flows tied to both manufacturing activities and consumption. Such flows of incoming inputs, and outgoing manufactures, both finished goods for final demand, and intermediate goods for other factories, were not limited to durable products. These flows also included an exploding interurban trade in foods fabricated in factories to feed an increasingly urban manufacturing population (Pred, 1977: 94). Such foodstuffs, produced for an increasingly industrialized and urbanized population, linked agriculture to industry, and production with consumption in a reconfigured interregional and interurban trade and manufacturing system.

Table III-11
Growth of Manufacturing Employment in U.S. Cities
1860-1890

	Manufacturing Employment (000s)		% of Population in Manufacturing	
	1860	1890	1860	1890
New York	106.2	477.2	9.0%	19.0%
Philadelphia	99.0	260.2	17.5	24.9
Chicago	5.4	210.4	4.8	19.1
St. Louis	9.4	94.1	5.8	20.8
Boston	19.3	91.0	10.8	20.2
Baltimore	17.1	83.7	8.0	19.3
Pittsburgh	8.8	56.4	18.0	23.7
Cleveland	3.5	50.7	8.0	19.4
Detroit	2.3	38.2	5.2	18.5

Source: Pred, 1966: 20.

Continued expansion and standardization of the nation's rail and telegraph system, and the dramatic reductions in freight charges and communication costs that accompanied this build-out, enhanced the phenomenon of urban mass production activity. From 1865-90 costs for moving commodities on a per ton-mile basis decreased by roughly 75% (Pred, 1977: 94). These cost reductions, in turn, provided opportunities and incentives for firms to produce in high volumes. As cities evolved into concentrated sources of supply and demand for manufacturing activities within a system of enlarged markets, and as improvements in the transport and communications infrastructure enhanced the capacity

prophecies faster than he can make them. She is always a novelty; for she is never the Chicago you saw when you passed through the last time" (Twain, 1883: 398).

of firms to produce in higher volumes, factory production became firmly anchored to cities. In this way, transport economies, information economies, mass production economies, and urbanization economies were connected to a pattern of economic growth focused on urban mass markets. This sequence of transport economies, information economies, internal scale economies, and urbanization economies thus became mutually-reinforcing enabling the rail and telegraph revolution, mass production, and the urban system to evolve along the same trajectory. There was, however, one additional element critical to this trajectory. This element was innovation.

The Platform for Innovation at Swift

Innovation at the G.F. Swift Company was neither wholly fortuitous nor the result of individual genius. It emerged on the basis of broad-based trends ignited by the communications revolution of rails and telegraphy and its build-out.

In the first place, Swift established its network for producing and distributing beef on the foundations of the rail and telegraph infrastructure and the geographically-extended interregional markets created by the build-out of this infrastructure. Such markets differed from the highly variegated and localized markets prevailing at mid-century. Consequently by 1875, when Swift first conceived of ways to reorganize beef production and sale, he had at his disposal for this learning process a transport and communications infrastructure sufficiently developed, and a market structure capable of supporting his idea for a new type of production and distribution network. Infrastructure, market structure and an interregional commerce system created by the two, thus provided Swift with a critical platform for innovation.

Secondly, Swift built its innovative production and distribution network on the basis of profound changes in the nation's urban system. These transformations, which were linked to the rail and telegraph revolution, elevated cities as manufacturing centers, as concentration points for interregional commerce, and as mass markets. In establishing its business, the G.F. Swift Company took advantage of these urban characteristics, and exploited what was arguably the most defining event in the urban history of the nation during the latter 19th century, the emergence of Chicago as the nation's second city. As the nation's rail center and main commodities market, Chicago forged powerful economic linkages with other cities throughout the country. These interurban connections were critical for Swift. Furthermore, the firm profited from the development of Chicago and cities in the Midwest as mass markets for the purchase of cattle raw materials, and as sites for factory operations. Perhaps even more importantly, Swift exploited cities as burgeoning centers of consumer demand for foodstuffs. The firm developed its beef network on the foundations of these cities, relying on the enormous expansion in the number of urban places as mass consumer markets for his dressed beef.[12] Eventually, the location of the branches in the firm's dressed beef network resembled the map of U.S. cities with populations of 25,000 inhabitants. Innovation at the firm was thus intimately connected to the nation's urban history.

It was upon these structures -- technological, interregional and urban -- that Swift would emerge as an agent for change.

[12]On this point the metaphor of Braudel, in describing early modern European cities as "giant stomachs" that created opportunities for large grain and provisions merchants, is instructive. Braudel argues that expanding urban populations and accompanying consumer demand in cities were critical elements in the interactive development of urbanization and capitalist development (Braudel, 1977: 28).

Chapter 6

THE INTERNET

AND THE PRODUCTION NETWORK OF DELL COMPUTER

"We are not experts in the technology we buy. We are experts in the technology of logistics and supply chain integration."

Richard L. Hunter, Dell Computer

"The Internet offered a logical extension of our direct model,...we used Internet browsers to essentially give the same information to our customers and suppliers -- bringing them literally inside our business. This became the key to what I call a virtually integrated organization..."
Michael Dell

From Custom Direct to Internet Direct

On the walls of a stairwell near the entry to the Dell Computer Corporation, Morton Tofper Manufacturing Center in Austin, formerly known as Parmer North 2, hang two large arrangements of picture frames, aligned row upon row, each frame encasing a patent awarded to the world's largest PC firm. Embedded in this display is a story with an unmistakable aim. Represented in each frame is an idea. On the basis of merit -- and a property right conferred by government -- each of these ideas has ascended to a privileged status reserved for the phenomenon known as *innovation.* The "wall of patents" as it is referred to by Dell, is a metaphor intended to convey Dell's story as an innovative firm.

Dell Computer has emerged as one of the most innovative firms of the current period on the basis of a business model with three elegantly simple, but ultimately powerful concepts. One concept revolves around the practice of selling *direct,* absent intermediaries, from the manufacturer to a final customer. The second idea involves the notion of *customization* for the specific needs of end users, and building customized products in high volume. The final concept centers on Dell's response to the Internet revolution and its use of the Internet in reorganizing not only its system of direct sales but, more significantly the procurement and assembly operations underlying mass customization. By grafting its system of custom direct sales onto the Internet infrastructure, Dell has transformed these activities, creating what is arguably the most innovative and efficient procurement, production, and distribution network ever built.[1]

The innovative advance made by Dell in deploying Internet communication as the foundation of its production network, is a *process* innovation. Although to some extent, the Internet has enabled Dell to create a new product -- a PC custom-configured through Internet communication -- it is the process of organizing flows of materials and information within its network, from customer order to procurement, production and delivery, by means of Internet communication, that defines the innovation at the Firm. As Richard Hunter, director of manufacturing and supply chain management at Dell, insists: "We are not

[1] There is a vast literature supporting this claim. From a journalistic perspective see Rocks (2000); Perman (2000), McWilliams (1997), Dodge (1998), and *Business Week* (August 28, 2000: 90). From the supply chain literature see especially Lee (2000), and from a scholarly perspective see Kenney and Curry (1999; 2000a; 2000b), Kraemer et al. (1999), and Kraemer and Dedrick, (2001).

experts in the technology we buy. We are experts in the technology of supply chain integration. We have created this expertise with the Internet at its core " (Hunter, Interview 7/18/01).[2]

Although it manufactures computers, Dell accumulates profit as a logistics firm. It is an organization of knowledge and routines extracting surplus not from production, but by managing the movement of product and information flows along a globally-dispersed network of companies engaged in the various operations of producing and marketing finished PCs. In this role as a logistics company, Dell's most revered accomplishment consists in the degree to which it is able to balance supply and demand of product flows among the firms in this global commodity chain. "Supply and demand balancing," insists Hunter, "is one of the most important core competencies at Dell" (Hunter, 5/24/01). The key to this core competency in material balancing, however, lies in Dell's capacity to process Internet information flows that the PC maker uses to manage the "external capabilities" of other firms. This mastery over material balance flows and Internet information flows has enabled Dell to create a production network, differentiated from the networks of its competitors by the degree to which it has succeeded in accomplishing a singular aim: accelerating speed and compressing time in the movement of materials as they pass through the adjacent steps of customer order, procurement, production, and final product delivery (Kenney and Curry, 1999).

The most visible benchmark of this core competency in material balancing focuses on levels of inventory maintained by Dell and its network partners. In 1994 when Dell launched its Internet strategy, the Firm carried an average of 32 days supply of inventory in its procurement and production chain. By 1997, as Dell began to deploy the Internet more fully in its supply chain operations, the figure had shrunk to thirteen days. In mid-2002, Dell was carrying four days inventory while at the same time, Compaq, the firm Dell surpassed in becoming the world's largest PC maker, held six weeks of inventory (Cook, Interview of May 17, 2002; Business Week, June 17, 2002).

In order to achieve this level of balance in demand and supply conditions, Dell has had to complement its Internet-based logistics activity with a different type of organizational relationship between itself and the other firms in its network. While this form of organization shares the *dis*-integrated, interfirm structure of the production networks organized by other PC makers, it differs in the degree to which the operations of Dell, and its relatively-small number of partner firms are *functionally* integrated by means of Internet communications. Dell refers to the structure of its network deriving from these collaborative relationships between formally separate firms as *virtual* integration.

Although nominally separate, Dell and the firms comprising its virtually-integrated network, do not produce finished PCs on the basis of arms-length interactions mediated through markets and the price system. On the contrary, Dell organizes highly structured relationships of collaboration between itself and its networks partners on the basis of its power to manage and control these other firms. The PC maker deploys an organizing principle in the way it structures these interfirm relationships, described by Coase as "conscious power or *planning*" (Coase, 1937), by Williamson as the principle of *Hierarchies* (Williamson, 1975), and by Chandler as *The Visible Hand* (1977). Far from a revolution in production that is reverting to market coordination within interfirm networks, the experience of Dell reveals how the hierarchical, conscious power of the Visible Hand is not only compatible with interfirm networks. Such mechanisms of control, typically, associated with vertical integration, are in fact integral to Dell in securing the collaboration from its network partners necessary to organize its high-velocity supply, production, and distribution chain, and build custom-configured PCs in high volume on a just-in-time basis.[3]

[2] It should be emphasized that others in the industry are far more caustic in making this same point. "Dell doesn't make computers," says Scott McNealy, CEO of Sun Microsystems. "They're not in the PC business any more than Safeway is in the food manufacturing business" (quoted in *Business Week*, September 24, 2001). In this sense, Dell fits a paradigm described as "The Computerless Computer Company," taking advantage of the technical capabilities of other firms (Rapport and Halevi, 1991).

[3] This chapter takes issue with views of interfirm production networks as examples of ascendant market forces. Dell -- and many other firms with highly efficient supply chains -- suggests the opposite.

The Internet plays a vital technical role in reinforcing Dell's capacity to control these collaborative relationships between itself and its network partners.[4] The Internet has provided Dell with a technology to create its own Web-based communications protocols as the foundation for collaboration with suppliers and logistics partners. Based upon the balance of power between Dell and these firms, the latter have little choice but to accept these Web-based protocols and integrate their operations around them if they want to remain within the PC maker's network. Dell, in effect, has successfully exploited the Internet infrastructure to impose a technology-based system of collaboration on suppliers and logistics providers as terms for entry into its network. In this way, Internet technology has enabled Dell to secure the benefits of organizational control associated with actual integration without its costs.

Dell's production network, with its operational attributes of time compression in material balancing, and its organizational attributes of virtual integration, is also creating a distinct geographical pattern of economic activity. This pattern is marked by the interplay of two spatial tendencies operating simultaneously within its network, the tendencies of spread, and concentration. On the one hand, Dell's production network is a geographically extended collection of nodes. Long distances separate the different regions where Dell has located its build-to-order operations. Long distances also separate Dell's build-to-order operations from the locations of its key suppliers. This tendency of geographical spread is marked by the coordination of geographically-extended, long-distance flows of product and information connecting dispersed nodal points in Dell's network. On the other hand, however, Dell's network operates on the basis of critical relationships of spatial proximity between certain nodes. Dell itself is the agent in creating these relationships, most notably in its requirements on suppliers to maintain either factories, or supply "hubs" within twenty minutes driving distance of Dell assembly sites. In this way, Dell is not only influencing the location patterns of firms in the regional localities where it operates. Dell is providing a compelling picture of how its Internet-based, build-to-order innovation is concentrating and shaping the geography of economic activity within regions, while defining processes of economic globalization as they actually occur on the ground.

This Internet-driven, virtually-integrated, and globally-organized production network has enabled Dell to become the world's largest, and arguably most competitive, PC maker. Perhaps more importantly, virtually every major PC firm has attempted to imitate elements of Dell's Internet-based business system. As Robert Cihra, computer analyst for ING Barings prophetically affirmed just prior to the announced merger of Hewlett Packard and Compaq, "the Number one issue on the mind of virtually every major PC vendor is defense against Dell, and for Compaq, IBM and HP, 'Dell' has truly become a four letter word" (Cihra, personal communication 8/20/01). How Dell ascended to this position is the subject of this chapter.

This chapter profiles the key operational, organizational, and geographical elements of Dell's Internet-based procurement, production, and distribution network.[5] In organizing this profile, this chapter focuses on a recent supply chain integration project implemented at Dell known as *DSi2.* This project, while touted by Dell as "the single biggest change in the Dell business system" (Hunter, Interview 6/5/01), is actually the culmination of an ongoing process of experimentation with the Internet that began in the mid-1990s and is still continuing (Dell Interview of 8/24/01).

The chapter is organized historically. Within this historical organization, however, are several key themes that tell a contemporary story of evolutionary economic change, and trace the route from the Internet revolution, to innovation and territorial transformation. How the structure of the PC industry came into being; how Dell's early business model challenged the competitive foundations of the industry;

[4] I am indebted to Navi Radjou of Forrester Research for emphasizing this point to me in a personal communication.

[5] It should be noted that these elements are constantly in flux. In language strikingly similar to the innovation literature, one Dell engineer walking me through the factory floor of the Topfer Manufacturing Center in Austin, insisted that the Company is in involved in an "ongoing learning process" in an effort to improve its pull material to order business system. As a consequence, some of the process details described in the chapter may have changed slightly. The emphasis in this chapter is the thematic meaning of these elements.

how Dell used the Internet to transform its original business model and create a uniquely-innovative production and distribution network; how, in assuming a position of competitive superiority and diffusing among other firms, this network has changed the PC industry; and how the operational, organizational, and geographical characteristics of this network are redefining the structures of the global economy, are the contours of the Dell story that follows.

Competition and the PC Value Chain Before Dell

When Dell Computer began operations in 1984, the PC industry, though still very young, had already developed an industrial structure with clearly defined terms of entry and competition, and a dominant system of value creation and profit making. It was these attributes that would provide Dell with opportunities for innovation on the basis of a very different vision of how to compete and make profit. In order to grasp both the initial phase of innovation at Dell when the PC maker developed its custom direct business model, and the second phase of innovation when the firm adapted this business model to the Internet, it is essential to identify the salient attributes of the industry as it evolved since the commercialization of the personal computer.

IBM and the PC

The development of the personal computer as a product with a mass market and an industry based on volume production, begins when IBM introduced its PC in August, 1981 (Dedrick and Kraemer, 1998: 50). Although IBM was far from the first firm to produce personal computers, its presence in the PC market changed the industry. Moreover its entry defined the fundamental pathway of competition for other firms. In the process, as it came to dominate the industry, IBM also created the environment for eventual transformation of PC production and selling.

IBM's decision to produce personal computers came in the wake of a changing market environment. By 1980, demand for PCs had outstripped supply. The catalyst for this imbalance was business demand. As more and more businesses began to use PCs, IBM recognized that it was failing to capitalize on a lucrative market opportunity with sales already approaching $500 million (Dedrick and Kraemer, 1998: 51). Equally significant, IBM had concerns that increased business use of PCs would threaten its position as a supplier of larger computers to its corporate customers. The Company aimed to defend its mainframe business by convincing its corporate customers that the PC was an integral part of the total computing infrastructure while expanding its PC market with other business and non-business users.

In July of 1980, when IBM made the decision to enter the PC business, the world's largest computer firm committed to bringing a product to the market within one year. The strategy pursued by IBM to achieve this aim -- a strategy of outsourcing and marketing its product through existing independent retail channels -- was decisive in shaping the development of a production and selling system for the PC that would dominate the way the PC was built and marketed for the next two decades. While this production and selling system proved enormously successful for IBM, and while it emerged as the competitive standard for other firms, the IBM system embodied inefficiencies that Dell would exploit in entering the industry, and challenging the production and marketing standards on which the industry was based.

When IBM decided in July of 1980 to get into the PC market, the manager assigned to lead the program, William Lowe, provided a sobering assessment of what had to be done: "The only way to get into the PC business," explained Lowe, "was to go out and buy part of a computer company or buy both the CPU and software...because we can't do this within the culture of IBM" (quoted in Langlois, 1992: 21). Consequently, IBM gave Lowe autonomy to build the product independently as a start-up firm with IBM acting as a venture capitalist.

With a 12-month deadline to bring a PC to market, the start-up had a mandate to outsource technology and components from existing firms when necessary, enabling it to avoid IBM's traditional business model of using its own internally-developed technology. When IBM departments voiced opposition to this approach, Philip Estridge, who had succeeded Lowe as project manager, told them to submit bids for components much like independent firms. Although some internal sourcing occurred in this open bidding system namely for keyboards and circuit boards, the main sources of supply were firms outside of IBM. Disc drives were provided by Tandon; Zenith furnished power supplies; Epson from Japan made printers; SCI Systems, a contract manufacturer based in Alabama, stuffed the circuit boards; and China Picture Tube, part of the Taiwanese electronics firm, Tatung, made the monitors. The computer was assembled in Boca Raton, Florida from these components.

For its distribution strategy, IBM decided to market its PC primarily through retail computer outlets rather than through its own sales agents. It even solicited input from the largest dealer, ComputerLand, on how best to accomplish this aim and established a set of criteria for any dealer that wanted to sell the IBM PC. Dealers were required to attend a training program at IBM and agree to a minimum sales quota. The firm was able to impose these standards on dealers because demand was so strong that an excess number of retail outlets wanted to become IBM dealers. In pursuing this marketing strategy through independent retailers rather than relying on its own sales organization, IBM essentially elevated the role of distribution in the overall value chain for the PC.

On both the production side and distribution side, the IBM PC was a striking example of reliance on "external capabilities" to build a product and bring it to market (Langlois, 1992).

This reliance on outside firms resulted from two decisions made by IBM regarding the microprocessor and the operating system software that had an enormous impact on the development of the industry.[6] In shopping for a microprocessor, IBM decided to use a 16-bit processor from Intel, the 8088, rather than the 8-bit processors used in existing PCs. Although this processor did use 8-bit external buses for which there existed a complement of support chips, the decision meant that the IBM PC could not use existing operating systems linked to 8-bit processors. Consistent with its strategy to use the market for necessary technology, IBM turned to the small Seattle-based software company active in the earlier phase of the PC industry, Microsoft, for the operating system. Microsoft, in turn, purchased a system from another local software supplier, made some small modifications to it, and sold it to IBM. The product was known as PC-DOS. In a decision with extraordinary implications, IBM allowed Microsoft to license the operating system to other PC makers as MS-DOS without having to share royalties. In purchasing the microprocessor from Intel, and allowing Microsoft to license the operating system, IBM effectively ceded control of the two most critical elements of the PC architecture. The IBM PC had essentially evolved on the basis of an *open* and largely *modular* architecture, and a global sourcing system for that architecture.[7]

Despite the fact that IBM had lost control over the architecture of its PC, and despite the fact that there was very little technological advance in the product, the IBM personal computer was hugely successful. Demand for the PC exceeded its own sales forecasts by 500 percent as the 13,533 units shipped during the final months of 1981 were far short of supplying the large backlog of orders (Langlois, 1992: 23). By 1983, the firm had captured 26% of the PC market with roughly 750,000 units shipped. From a position as a relatively late entrant, IBM catapulted to a position just behind Commodore as the world's second largest PC maker.

[6] The following two paragraphs rely on Dedrick and Kraemer (1998: 51-53) and Langlois (1992).

[7] There is an extensive literature on IBM's decision to create an open architecture and the role of Intel and Microsoft in the evolution of the PC. Among the more informative, see Chposky and Leonis (1988) and Ferguson and Morris (1994), as well as Dedrick and Kraemer (1998) and Steffens (1994).

Table VI-1
The Early PC Market in the U.S.

Year	Units Sold	$ Value (millions)
1976	17,450	$36.0
1977	41,000	$74.5
1978	120,700	$223.8
1979	181,200	$302.5
1980	246,000	$495.0
1981	380,000	$936.9
1982	792,400	$2,002.3
1983	1,764,000	$4,718.0

Source: Steffens, 1994: 90-126, 167.

Large Firms, Suppliers and Clones

Three critical developments followed from IBM's success that affected the competitive structure and the development trajectory of the PC industry.

Firstly, IBM's entry compelled other large companies from the office products and consumer electronics industries to enter the PC marketplace. These entrants included such firms as Xerox, Hewlett Packard, Texas Instruments, Zenith, DEC, and Wang Laboratories. This group also consisted of numerous foreign firms, among them NEC, Sanyo, Hitachi, Toshiba, and Fujitsu from Japan, and Philips and Olivetti from Europe. Nevertheless, these firms exhibited widely varying levels of success. NEC, HP, Toshiba, Fujitsu, and Olivetti were able to gain between four and nine percent of the U.S. market for differently priced PCs (Steffens, 1994: 177). Other firms, most notably Xerox were surprising failures in the PC market. Despite the qualified success of some of these large firms, however, by the beginning of 1984, IBM, Apple, and Tandy still dominated the PC market in the U.S.

Secondly, the growing demand for the product, coupled with the PC's nonproprietary and modular architecture, created an enormous market opportunity for suppliers of components, peripherals, and parts. An entire industry of specialized suppliers emerged to exploit these opportunities linked to the fortunes of the IBM PC. Firms most notably in Taiwan, but also in Singapore and South Korea, entered this market and became skilled producers of these components.[8] In addition, IBM, in launching its PC on the basis of high volume production, provided many of these component vendors with opportunities to scale their operations from the outset. As a consequence, these firms were able to develop production efficiencies and cost advantages very early after entry into the industry. "IBM put its suppliers into the high-volume business," and in the process "so bore their start-up and learning costs" (Ferguson and Morris, 1994: 52). This pattern was especially true of East Asian suppliers such as Taiwan's Tatung which IBM helped to achieve the volumes necessary to supply the PC maker's expanding market (Dedrick and Kraemer, 1998: 52). By the mid-1980s, Singapore and South Korea, along with Taiwan had emerged as major world centers of production for the industry. Firms in the region were both Asian firms and the foreign operations of U.S. based companies.

[8] Taiwanese firms tended to be smaller start-ups. By 1979 these companies in Taiwan were already fabricating components for central processing units (CPUs) and had successfully produced Apple II clones by 1981 (Bae, 1998: 148). Firms in Singapore and Korea by contrast tended to be larger firms. The industry in Singapore grew as a result of investment by American electronics producers while the Korean industry emerged within the large Korean *Chaebol* which had benefitted from the transfer of technology from earlier investment by Japanese electronics producers (Callon, 1995; Bae, 1998).

Table VI-2

Computer Hardware Production in E. Asia
($ millions)

	Taiwan	Singapore	S. Korea
1980	$80	--	$9
1981	$110	--	$31
1982	$170	$147	$47
1983	$430	$530	$207
1984	$1.040	$1,066	$428
1985	$1,260	$1,194	$579
1986	$1,739	$1,914	$880
1987	$2,890	$2,928	$1,459
1988	$4,001	$4,503	$2,431
1989	$5,046	$5,368	$3,180
1990	$5,886	$6,974	$3,073

Source: Dedrick and Kraemer, 1998: 321; Bae, 1998: 79, 148. Singapore Economic Development Board.

Finally, and perhaps even most significantly, demand for the PC which IBM was not able to supply until eighteen months after it introduced the product, created an enormous market opportunity for other producers to clone IBM's machine. The expanding supply base along with the open architecture of the PC, provided these clonemakers with possibilities to copy the PC. Nevertheless, one hurdle remained before clonemakers could produce a PC. IBM's input/output system software known as BIOS, which enabled the PC to transmit and receive data, somehow had to be duplicated. This problem, however, proved far from insurmountable. Firms such as Compaq, among others, successfully reverse-engineered the BIOS specs in a way that insulated them from copyright and patent infringement regulations. Because of the market in components that had developed from IBM's reliance on external capabilities, all that the clonemakers needed to duplicate the PC was to buy the 8088 microprocessors from Intel, the MS-DOS from Microsoft, and the remaining hardware components from the expanding base of supplier firms. Furthermore, the interests of clonemakers actually converged with those of Intel and Microsoft whose fortunes were dependent more on an expansion in the number of PCs than any one-way relationship with IBM. By 1983, Compaq was the largest among nearly one hundred clonemakers that emerged in the wake of the IBM PC's success. Two years later this upstart was fifth largest firm in the PC industry and ascending rapidly. Hundreds of other companies would soon follow supported by a base of specialized suppliers numbering in the thousands (Dedrick and Kraemer, 1998: 56).

Open Standards and Modularity

IBM's decision to outsource most components of the PC, and relinquish control over the microprocessor and operating system, created a product architecture based on relatively open standards that had three enduring impacts on the nature of competition in the industry. In the first place, open standards for PC components enabled the PC to become an increasingly modular product. Secondly, in what is perhaps a paradox, this attribute of modularity -- the ability of PCs to be assembled from standardized components "much like Legos" -- provided the foundations for PCs to be custom-produced in high volume (Langlois, 2001: 26).[9] Thirdly, and perhaps most decisively, modularity and standardization diminished the role of technology as an element of competition in the PC industry, and elevated the role of efficiency in procurement, production and distribution of the product. Modularity, in effect, was the critical precondition of Dell Computer's business model.

The modular character of the PC diverged dramatically from the era of central computing. During the period of central computing, mainframes and minicomputers produced by firms such as IBM or DEC had been proprietary "closed systems." The architectures of these systems were largely incompatible with those produced by other vendors. As a result, firms producing mainframes and minicomputers tended to be highly integrated. Because these systems were closed and proprietary, firms building them had to produce components in-house, and scale the production of these components sufficiently to achieve cost-efficient, internal scale economies. Nevertheless, this integration did not include *all* computer components. Mainframe and minicomputer firms integrated vertically with respect to components of high value to reduce their risk, and increase their control over production of computer systems.

The openness of the IBM PC, by contrast, meant that standards for interoperability between different components were defined by firms more or less publicly and collectively. Such agreement by firms on standards is basically "unsponsored," arising *de facto* in a competitive environment and is distinct from standards agreements that are negotiated and implemented by statute or political authority (David, 1987; David and Greenstein, 1990). As a result of this market-driven process of agreement, third-party vendors could design and build components on the basis of publicly-defined standards that would operate together as a system. This openness enabled different hardware and software firms to produce compatible and interchangeable components that could be integrated into the PC as a *system* created by the efforts of numerous separate firms.

Assembled from components available in the market produced by a variety of firms, the IBM PC enabled a base of suppliers and imitators to proliferate. Although the microprocessor and operating system markets became virtual monopolies dominated by two firms, Intel and Microsoft, the remaining hardware segments of the industry evolved into highly specialized, extremely competitive businesses producing standardized modular components. Driven by standardization and modularity established by IBM protocols, production of these components by the mid-1980s had already become a *dis*-integrated global activity marked by the emergence of a large concentration of producers in East Asia. The personal computer was, in effect, a product of globally-organized interfirm production networks in which both innovative capacity and productive capacity had migrated to new areas of the world.

These networks were characterized by specialized core competencies among assemblers and component vendors. Unlike the system of mainframe computer production, coordination of the production system for personal computers moved from inside, to outside the boundaries of the firm (Langlois, 1990; 1992). The model for this industry was one of horizontal partnerships and away from vertical integration which created an entirely new set of management challenges for PC builders. Products built by different companies were virtually identical in terms of technology. These attributes of the production system evolved largely from the impact of IBM's entry into the industry, and the legacy of choices made by IBM at the outset.

From the outset, design and production of these standardized, modular components evolved on the basis of the relationship between three basic elements comprising personal computer systems: 1) semiconductor and microprocessor families, 2) operating and I/O systems, and 3) applications software (Steffens, 1994: 121). Changes in any one of these elements created incentives for changes in the others. As these elements evolved, the result was a transformation in the hardware architecture in which these elements were housed.

[9] Langlois points out, however, that customization achieved through modularity and standardization did not originate with PCs or the Internet economy. The idea of offering slightly differentiated product models based on a set of underlying mass produced components was already recognized as a business model by Alfred Marshall (1920: 141).

While all three elements were critical in promoting ongoing changes in the PC, the dominant driver in transforming the personal computer was the continuous improvement in semiconductor and microprocessor technology. Known as Moore's Law, these advances doubled the number of transistors packed into microprocessors every 12-18 months and forced the costs as a measure of performance for computing to plummet. From 1982-1998, the estimated cost per million instructions per second fell by a factor of 500 (Rowen, 2000: 194). Such changes in performance and cost resulted in average annual rates of decline in prices for microprocessors per transistor of 35 percent from 1985-96, while for memory chips over the same period, the decline was 20 percent (Kenney and Curry, 1999: 11). This pattern of change enabled Intel, with a dominant position in the market for microprocessors, to set the key standards for the ongoing changes in PC hardware (Dedrick and Kraemer, 1998: 73). Other components, however, most notably hard disk drives, developed along a similar trajectory. The average annual rate of decline in the price per megabyte of storage for hard drives from 1980-89 was 30 percent. Such expansion in the capabilities of computer components compelled PC hardware firms to develop new generations of personal computers at regular, and ever-shorter intervals (Steffens, 1994: 151). As PC firms developed new products, however, the price for these products typically declined between 20-41 percent per annum over the life of each new PC model (Berndt and Griliches, 1993; Kenney and Curry, 1999: 12).

As a product in a state of ongoing technological change, yet evolving along a pathway of modularity and standardization, the PC was susceptible to competitive pressures deriving not only from technology but also from the interplay of two fundamental variables, *price* and *time* (Kenney and Curry, 1999). As soon as a new product iteration came to market, it was under constant downward price pressure, its value shrinking with the passage of time in anticipation of the next wave of new processing technology and application software. With technological change a constant, and with price and time emerging more as the defining elements of the market environment for the PC, terms of competition for PC makers actually shifted away from technology to a very different aspect of the PC value chain.

As product performance became increasingly standardized within the supply base and from one PC company to the next, and as product differentiation became difficult to sustain, *distribution* emerged as a primary competitive factor within the PC value chain (Steffens, 1994: 259). This emphasis on distribution, in turn, would eventually elevate the role of logistics as a competitive variable in producing and selling PCs. Again, the legacy of IBM was a critical factor in this shift in the way that it established competitive standards of the indirect channel.

The Indirect Channel

As early as 1983, PC makers began to adopt IBM's emphasis on the professional retailer as the preferred channel of distribution. In order to attract customers, especially from the business market, computer firms had to ensure that their sales channels had the same standards as those of the industry leader (Steffens, 1994: 197). This indirect channel, created in the image of IBM, also represented a route to legitimacy for clonemakers, notably Compaq.

This decision by IBM to use professional retailers as its primary distribution channel, and the influence of IBM on the rest of the industry, changed the way many PC makers deployed resources. PC firms made investments in relationships with resellers and dealers, and in marketing activities to support these relationships, on the assumption that wholesale and retail outlets provided manufacturers with better access to nationwide sales. These firms, in effect, owing to the influence of IBM, veered away from the earlier bias on technology, and toward a new emphasis on marketing and distribution activity (Steffens, 1994: 197; 269).

In 1983, the structure of the U.S. personal computer market reflected eight identifiable channels of distribution and sales to end users (Steffens, 1994: 160). These channels included 1) office products dealers, 2) value added resellers and systems houses, 3) manufacturers' own office products stores, 4) wholesalers, 5) mass merchandisers, 6) mail orders, 7) computer specialty dealers, and 8) direct sales primarily by the sales forces of larger PC makers such as IBM. Of these, computer specialty dealers were overwhelmingly dominant. Direct sales accounted for the second largest distribution channel but these sales were largely the result of IBM and other large PC vendors working directly with their largest business accounts. Even by 1987, with Dell and Gateway already selling direct, specialty computer dealers still accounted for 56% of total shipments while collectively the various indirect channels accounted for 80-90% of all PC sales (Steffens, 1994: 260).

By 1984, this indirect channel of selling computers through intermediaries emerged as the dominant route of distribution from manufacturers to final customers, and was a defining element in establishing terms of competition in the industry. Firms, in order to compete, had to rely on, and contend with these intermediaries. While there was value added to the PC by these entities as the product circulated from the manufacturer to the customer – the so-called "gains of trade" resulting from what geographers term, a change in location -- there was also the inefficiency of an excess number of actors in this process. As a consequence, the idea of capturing the value created by intermediaries in the PC production and distribution chain, presented a compelling entrepreneurial opportunity for PC firms.

Entrepreneurial Opportunity

In order to capture the value created from intermediation in the PC value chain, the entrepreneurial firm was presented with an opportunity to reconceptualize and transform the relationships between four key elements lying at the core of the indirect system of distribution. These four elements consisted of: 1) forecasting market demand; 2) building according to demand forecasts; 3) "pushing" finished inventory from the factory into the distribution and sales channel; and 4) waiting for customers to make purchases.

While these attributes functioned together in creating a production and distribution system, PC firms were completely reliant in this system on accurate forecasting of future demand. They were therefore vulnerable to the carrying charges from excess inventories when forecasts went awry and goods went unsold. At the same time, they were susceptible to missed opportunities when forecasts underestimated the market. Even with the best demand projections, however, the indirect push system of production was beset with perhaps an inherent and intractable problem for the PC manufacturer -- the need to purchase and hold inventories of components and subassemblies in order to build finished systems and fill quotas for distribution outlets. Such challenges are not unique to the personal computer industry. They are symptomatic of all industrial activities that rely on demand forecasting, and the sale of finished goods through intermediaries. There are good reasons, however, why the indirect channel of distribution was particularly well-suited as a target for competitive challenge in the PC industry.

Driven by incessant advances in processor technology and software applications, along with resultant shortened product life cycles, the PC is susceptible to ongoing downward price pressure as it circulates through the various stages of the value chain. Once assembled, the PC is constantly losing value because the components in it depreciate as time passes in anticipation of the next wave of technical improvements in those components. These two characteristics -- constant technical improvements coupled with simultaneous downward pressure on PC prices -- give the personal computer a perishable-like quality, similar to industries such as fashion and even food (Kraemer et al., 1999: 3; Kenney and Curry, 2000: 5).[10]

This perishable-like quality and the depreciation in value of the product over time exposes PC firms to an especially vexing problem -- the problem of *inventory.* If the product is held for any appreciable length of time in inventory, it is depreciating in value. Such a problem becomes increasingly acute for the PC maker at the stages in the value chain where the product moves from the final assembly point through the channel and eventually into the hands of the customer. Frequently, the period of time between final assembly and sale to the customer ranged from 3-4 months. During this time, the components in the PC, most notably the central processing unit, hard disk drives, and DRAMs would depreciate in value such that the selling price, by the time the system was actually purchased, would have

[10] The recent development by Intel of a two gigahertz chip provides a powerful example of this phenomenon. As soon as it released this chip in late August, 2001 at a price of $562, Intel reduced the price of its existing 1.8 gigahertz chips, selling for $562 in July, to $256 (Gaither, 8/28/2001: C4). Such examples have compelled Stan Shih, CEO of Acer Computer, to liken PCs to fresh vegetables while similarly Michael Dell refers to PC components as "having the shelf life of lettuce."

to be lowered. This increment of time in the channel, in effect, represented a sizeable loss of value for the PC maker. For this reason, competition in the PC industry as early as the mid-1980s began to evolve in the direction of two related factors -- speed and time (Kenney and Curry, 1999).[11] Such a shift created an opportunity for innovation focusing on the logistics of building the PC, and distributing the product to the final customer. Any strategy for decreasing the holding period of time in inventory at each step in the value chain, especially between final assembly and sale, and accelerating the speed at which the build process and final marketing occurred, held enormous potential as a business model in the industry.

What enabled such a business model to emerge as viable by 1984 was the way in which the industry had evolved since the IBM PC, and the attributes of the PC stemming from this history. Firstly, the industry was already organized on the basis of decentralized and globalized subcontractors. Virtually all computer makers had access to, and were subcontracting from this supply base located primarily in East Asia, Japan, and the U.S. Secondly, the PC components produced by this supply base had evolved into highly modular and increasingly standardized items. With uniform design, engineering, and technology, components were easily accessible to PC makers. Differences in the product from one firm to the next, whether branded or cloned, had narrowed so dramatically that, with the exception of Apple, design, technology and engineering were of secondary importance as terms of competition in the industry. What differentiated these products were brand names. Nevertheless, even the IBM brand failed to stem the ascendancy of clones, most notably Compaq, but also the non-branded clones.

In effect, the PC had become a standardized commodity. It was built from components purchased from an accessible base of suppliers, and distributed through a channel of actors that functioned on principles of demand forecasting, and accepted the accumulation of inventory as inevitable. Admittedly, the process required enormous logistical coordination across distance to build the product from this existing base of firms, and market the product successfully through the existing distribution channel. Yet, in evolving with an increasing emphasis on logistics and distribution, the PC industry was vulnerable to change from a business model challenging the principles upon which the prevailing system of logistics and distribution was organized. That challenge would emerge in 1984.

Genesis of Dell

A single core concept served as the inspiration for Dell Computer: "Sell computers directly to the end customer. Eliminate the resellers' markup and pass those savings on to the customer" (Dell and Fredman, 1999: 12).[12] The target of Dell's business model was thus not the technology of the PC, but instead the industry's indirect channel of distribution. A different relationship with the customer provided the underlying foundation for this business model. This relationship was the source of innovation at Dell and the catalyst for transformation in the Company's logistics oriented production and distribution system.

Custom Direct

Michael Dell began his business in late 1983 by upgrading IBM personal computers from his dorm at the University of Texas, and selling the customized PCs directly to businesses anxious to purchase the reconfigured machines at prices far lower than existing computer outlets. In Dell's own words, the superiority of these two notions -- direct selling and customization -- was obvious. What was less clear to Dell was the reason why existing computer firms were not producing and marketing their products in this way.

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[11] Kenney and Curry (1999) refer to the more recent manifestations of this phenomenon in the PC industry but the importance of speed and time was already established in the industry by the mid-1980s.

[12] Information in the following three paragraphs taken from Dell and Fredman, 1999: 10-15.

Dell achieved several advantages from customized producing and direct selling. The most decisive advantage derived from the elimination of links in the PC value chain. Such disintermediation not only enabled Dell to capture that portion of the value taken by PC wholesalers in the process of distribution. For Dell, eliminating intermediaries was a critical path to compressing time in the cycle of PC production and distribution itself, and capturing greater levels of value by increasing the velocity of moving products from order through final sale. Secondly, the relationships with final customers built through direct selling provided Dell with a platform for one of the most important sources of sales in the industry, repeat sales. Because the technology of the PC was changing so rapidly, and because the product life of the PC was so short, customers buying a machine at any given moment were the best prospects for future sales. Furthermore, by eliminating product in the channel, Dell was in a position to offer its customers the latest technology without having to send products through a lengthy distribution process. Thirdly, in producing PCs only after receiving orders, Dell avoided the inventory problems associated with faulty demand forecasting. Finally, in purchasing components and building finished systems only after receiving orders and payment from customers, Dell was able to carry a *negative cash conversion cycle.* It took possession of the customer's money before paying its suppliers, thereby funding its own operating expenses.

Excess inventory held by distributors of certain PC makers provided Dell with an early source of low-priced PCs from which the firm could turn a profit. Especially important was the "IBM gray market" consisting of unsold PCs at certain dealers. "We would buy these stripped-down computers," admitted Dell, "and sell them for a profit" (Dell and Fredman, 1999: 14). In addition, Dell's fledgling firm capitalized on another fortuitous opportunity to seed the business. An open bidding process in the State of Texas for PC hardware enabled Dell to compete for public contracts with more established firms. In winning several of these bids, Dell obtained a source of revenue to supplement its base of individual sales and began to grow rapidly.

By early 1984, Dell was selling $50,000 - $80,000 per month to customers in the Austin area. In May, Dell incorporated the firm as "PCs Limited." By the beginning of the following year the Company was building computers under its own, PCs Limited, brand name.

Three attributes of the industry enabled Dell to enter the industry relatively easily and build computers under its own brand. Firstly, the burgeoning base of PC suppliers, both in the U.S. and in East Asia, is what provided Dell with access to the technology and engineering necessary to build the product (Dell and Fredman, 1999: 23-24). Second was the fact that many of these components had become so technologically standardized and modular that assembly into finished PCs had become a relatively low-skill activity requiring limited investment in training a highly-skilled workforce. Finally, related to the modular nature of PC components, Dell was able to exploit new technologies in "chip sets" that combined the roughly 200 semiconductor chips required to make an Intel 286-based PC, into five application-specific integrated circuits (ASICs). This modification in semiconductor design simplified PC design. As a result, Dell was able to employ an engineer in the Austin area, Jay Bell, to design a 286-based PC. The firm had its own product with technology as good as any other company. It had a brand name. Perhaps most importantly, PCs Limited had a uniquely-competitive business model for selling its product.

While other firms had to forecast the product configurations and quantities demanded by customers, and accept the consequences of inaccurate forecasting, Dell took a different route to reaching its customers. It knew the configurations and quantities to build because its customers told them and Dell produced only from orders received. The Company did not stock the reseller and retail channel. Dell also made a critical decision on the type of customer it wanted to reach most -- corporate customers. Although the corporate market was difficult to sell as a start-up, Dell hired an aggressive sales force with the aim of securing such accounts. Ironically, it was a technical breakthrough that enhanced its credibility as a formidable competitor in the PC industry and facilitated its ability to reach this market.

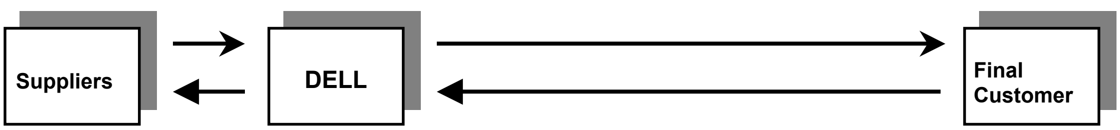
At the end of 1985 and beginning of 1986, Dell made a decision to try and build the world's fastest PC. At the time, IBM was building a six megahertz machine with an Intel 286 processor priced at $3995. Dell aimed at designing a twelve megahertz 286 PC. In early 1986, the Company successfully built and tested a twelve megahertz PC running on a 286 processor. It priced this breakthrough product at $1995. In March, 1986, Dell took the product to Comdex, the largest computer show in the world, which landed PC's Limited on the cover of *PC Week.* Subsequently, Martin Marietta, Burlington Northern, and Price Waterhouse bought systems from Dell's company. By February, 1987, 85% of the output from PC's Limited was being sold to the business market (Lewis, February 2, 1987).

With its mostly-corporate accounts, Dell created what is termed, "a closed loop" relationship with its customers that the PC maker exploited as a source of outreach to secure new sales. Owing to the ongoing breakthroughs in processing speed that made the PC such an ephemeral product, coupled with the interests of firms in upgrading equipment to take advantage of these improvements, Dell's closed loop with its customers created an ideal marketing channel to potential new demand. Nearly two-thirds of its revenues were coming from existing, mostly corporate customers (Economist, March 2, 1991).

Figure VI-1
SCHEMATIC OUTLINE OF PC CHANNELS

Indirect Channel of the PC Industry

Dell's Direct Channel



Source: Adapted from Kraemer et al. (1999): 5-6; Reprinted with permission.

Using the telephone and the fax as the communications infrastructure for its direct channel with customers, PCs Limited grew impressively during its early years. Between its initial year and its second year, Dell's firm increased sales almost tenfold growing from \$650,000 in 1984, to \$6.2 million in 1985. Rapid expansion continued during the remainder of the 1980s. In 1988, PCs Limited generated a market capitalization of \$34.2 million through an initial offering of its common stock. The stock split during the first year of public operations and continued to split in the years thereafter. By the end of the decade, Dell Computer as the Company was now renamed, had generated sales of \$258 million. Foreign sales accounted for 15% of this total. Despite predictions that its business model would fail, Dell was generating nearly \$400 million in revenues by 1990 and had become the 20th largest PC firm in the world.

Table VI-3

Early Sales and Profit of Dell Computer ($ millions)

Year*	1985	1986	1987	1988	1989	1990
Net Sales	$6.2	$33.7	$69.5	$159.0	$257.8	$388.5
Net Profit	$.3	$.7	$2.2	$9.4	$14.4	$5.1

* Fiscal Year
Source: Dell Computer Corporation, 1989 Form 10-K, Item 6, p. 23.
Dell Computer Corporation, 1991 Form 10-K, Item 6. p. 16.

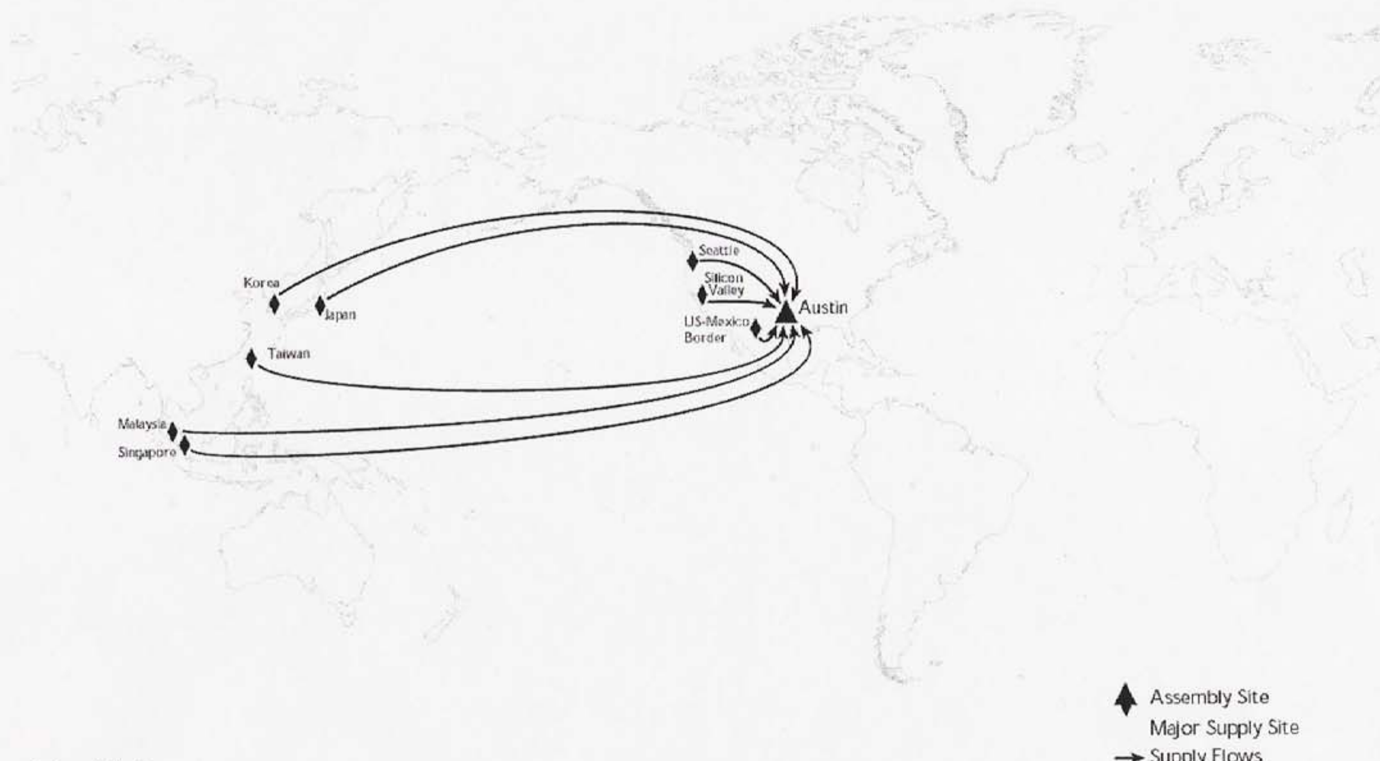
Table VI-4

Rankings of PC Firms by PC Revenues (1990)

Rank	Firm	Rank	Firm
1	IBM	11	Intel
2	Apple	12	Tandy
3	NEC	13	Acer
4	Compaq	14	Hitachi
5	Toshiba	15	Siemens / Nixdorf
6	Olivetti	16	AT&T
7	Fujitsu	17	Seiko Epson
8	Packard Bell	18	Hewlett-Packard
9	Groupe Bull	19	Unisys
10	Commodore	**20**	**Dell Computer**

Source: Steffens, 1994: 335; Dedrick and Kraemer, 1998: 57. Pinella, 1991: 42.

This rapid growth, however, came with certain costs. In emerging among the twenty largest PC firms, Dell experienced its first setback in 1990 as profits fell for the first time from $14 million the previous year to $5 million. Ironically, this drop in profitability occurred as a result of problems with component inventory. While inventory can be an asset against the risk of supply shortages, it is also a liability in the PC industry when component costs are constantly dropping and the value of such inventory is continually diminishing. With sales expanding dramatically, Dell found it more difficult to keep in balance the two elements of its business model -- low inventory and mass customization -- that in other business systems are generally irreconcilable. Volume in Dell's build-to-order, direct system had thus reached a certain threshold where parts for orders had to be stored revealing the vulnerability of the Company's business model in a high volume setting. In addition to high volumes, these problems were traceable to the geography confronted by Dell in organizing supply chain operations for its system of mass customization. Long-distance linkages between suppliers, located primarily in East Asia but also Mexico and the U.S., and assembly in Austin characterized the geography of this network. Problems in coordinating the transport of these components over distance, and accounting for the variation in component delivery lead times from suppliers, conspired to push up inventory levels. Numerous separate warehouses in Austin where these components were stored before assembly exacerbated the complexities of the different lead time delivery schedules. "To our stunned belief," writes Dell about the period around 1990, "we had quickly become known as the company with the inventory problem" (Dell and Fredman, 1999: 37).



Map VI-1:
Dell Production Network in 1990 (Primary Nodes)

Tactical Shift

Dell attempted to adjust to these inventory problems after 1990 as well as expand its market share by implementing two related and perhaps surprising modifications in its custom direct business system. Firstly, Dell began to use a key actor in the indirect channel, value-added resellers (VARs), to reach certain business customers and initiated a number of indirect channel programs as part of this strategy (Aragon, July 20, 1998). Secondly, Dell supplemented this approach to partnering with the VARs with an extensive program to market its computers through large retailers. The Firm negotiated deals with computer superstore, CompUSA; big box retailer, Price Club; office supply franchise, Staples; and the electronics chain, Circuit City. These stores agreed to sell Dell PCs at the Company's own mail-order prices.

Indeed, as a result of these moves, Dell's sales continued to expand. By 1994 the Firm had generated annual revenues of just under $3 billion. Furthermore, with a world market share of 2.4%, Dell had ascended into the ranks of the world's largest PC firms. Shipping over a million units, it now occupied the position of the world's tenth largest PC maker.

Table VI-5

Computer Firms
Ranked by World Market Share (1994)

Rank	Firm	Units (000s)	% Share
1	Compaq	4,799	10.0%
2	Apple	3,957	8.3%
3	IBM	3,937	8.2%
4	Packard Bell	2,473	5.2%
5	NEC	1,941	4.1%
6	Hewlett-Packard	1,903	4.0%
7	Acer	1,451	3.0%
8	Toshiba	1,442	3.0%
9	Fujitsu	1,441	3.0%
10	**Dell**	**1,152**	**2.4%**

Source: Gartner Group / Dataquest.

Nevertheless, this period of growth and ascendancy into the top ranks of PC firms, also marked a negative milestone in the Company's brief history. Although Dell's sales had expanded impressively, and although by 1994 it had become even more of a presence in the world PC industry, the Company was not able to sell profitably through the intermediaries of the indirect channel. Its cost of sales rose dramatically, consuming profitability. Whereas in fiscal year 1991, Dell's cost of sales were 66 percent of its total sales, by fiscal year 1994 the figure had risen to 85 percent (Dell Computer, 1994 Form 10-K: Item 6, pp. 13-14). Furthermore, its tactical shift into the indirect channel, through it expanded sales, exacerbated its difficulties with component procurement and excess inventories.

As a result, Dell suffered its first quarterly loss during this period. For its fiscal year ending on January 30, 1994 Dell reported a net loss of $35.8 million on its $2.9 billion in sales, the first and only annual loss, to date, reported by Dell (Dell Computer Corporation, 1994 10K: Item 6). Rising costs linked to larger-than-expected inventories in its procurement chain, a failed program with VARs, and too much product in the retail channel, created the first significant crisis at the Company (Wood, 1993; Aragon, July 20, 1998).

Consequently, in early 1994, Dell made two critical strategic decisions. Firstly, the Company decided to abandon its experiment with resellers, and concentrate on its origins as a direct seller.

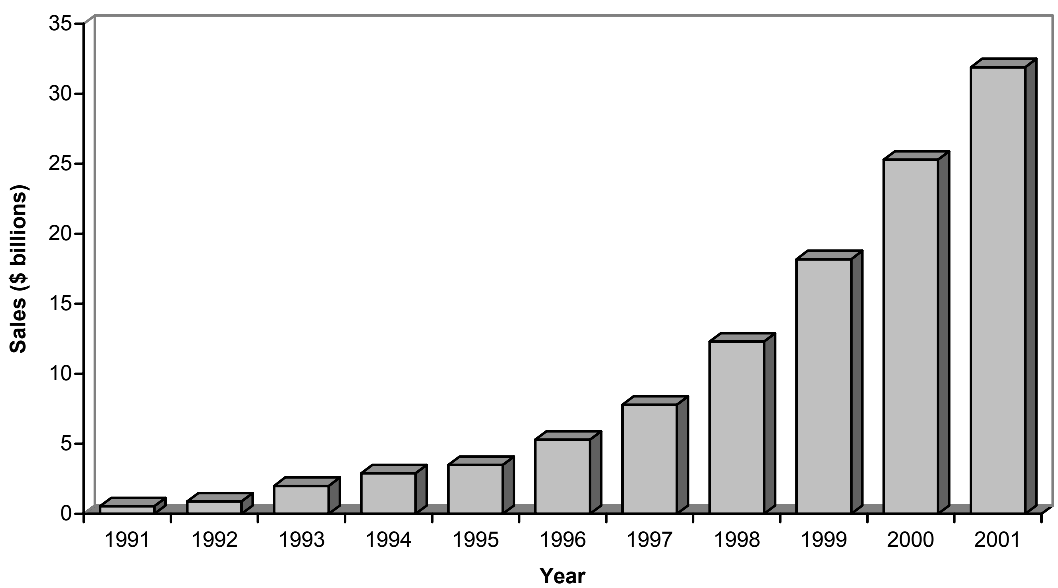
Secondly, and perhaps more significantly, Dell began to experiment in adapting its custom-direct business model to an entirely new communications infrastructure -- the Internet.

The Internet

Dell's Internet-driven production and distribution network has taken shape in two overlapping, and still-ongoing phases. In the first phase, Dell used the Internet to transform its system of selling and order intake with its customers, enabling the PC maker to become one of the early pioneers of Internet commerce. Phase two consists of Dell's deployment of the Internet to reorganize its procurement planning and the logistics of assembly and product delivery. Its aim in this second phase is to link its Internet-based system of order intake with customers, to an Internet-enabled process of procurement, production, and distribution with suppliers and logistics providers. What has occurred alongside this deployment of the Internet is an extraordinarily sharp acceleration in revenue growth. From 1994-2001 sales increased at Dell almost ten times, demarcating this period of sales growth from the period preceding it.

Source: Dell Computer Coorporation, 1992 Form 10K; 1996 Form 10K; 2001 Form 10K

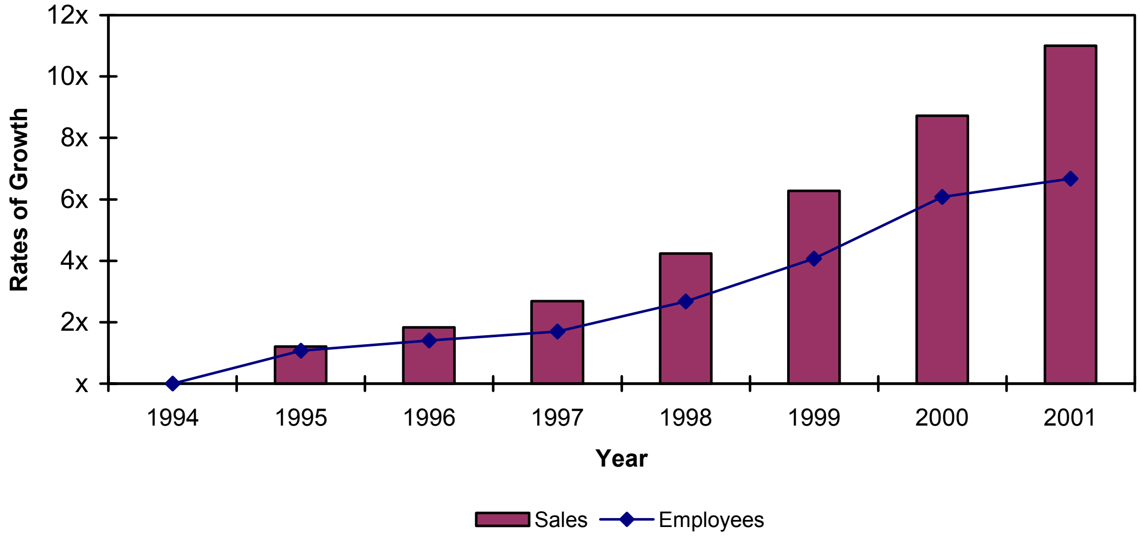
Chart VI-1
Growth of Dell Prior to, and During Internet Period



In addition to sales growth, this integration around the Internet has recast Dell in three profound ways. Operationally, Dell has used the Internet to create more rapid cycles in its system of pulling components from suppliers than in previous years. In a build-to-order environment where PC systems are produced and delivered at rates that match the rate of sales, Dell has been forced to implement these compressed cycles because of its explosive revenue growth after 1994 (Albers, 2000: 3). In this sense, sales growth and time compression in procurement and assembly have been mutually reinforcing. Organizationally, in extending the Internet backward into its supply chain, Dell has created a new form of business enterprise with its interfirm partners to manage the more rapid cycles in its build-to-order system. This form of enterprise relies on strategically organized relationships, not markets, as a basis of collaboration. Finally, Dell has created a distinct form of territorial organization in the places where it has established its build-to-order operation. In these places, physical proximity between supply sources and assembly sites, strategically crafted by Dell, has resulted in a set of territorial relationships between operations and actors that are shaping the contours of a new generation of industrial districts. These industrial districts, in turn, are helping define the actual character of global production ensembles in the contemporary economy.

While these attributes have emerged most sharply in the period following implementation of the DSi2 project, they actually began to take shape alongside the initial experiments by the Company in online selling, and deployment of the Web in supply chain management and enterprise resource planning.

Chart VI-2
Comparative Growth Rates of Dell Sales and Employment



Note: 1994 Sales and Employment = 0
Source: Dell Computer Corporation, 1996 Form 10K; 2001 Form 10K

Table VI-6

Sales and Employment Growth of Dell during Internet Period

	1994	1995	1996	1997	1998	1999	2000	2001	2001/1994
Sales ($ billions)	2.9	3.5	5.3	7.8	12.3	18.2	25.3	31.9	**11x**
Employees (000s)	6.0	6.4	8.4	10.4	16.0	24.4	36.5	35.0	**5.9x**

Source: Dell Computer Corporation, 1996 Form 10K
Dell Computer Corporation, 2001 Form 10K.

Online Selling

Dell had a decided advantage over other PC firms in selling its products over the Internet. Unlike the indirect channel of its competitors, Dell's direct sales path was far more easily adaptable to the direct linkages between manufacturers and customers, and the phenomenon of disintermediation characteristic of Internet selling. In effect, the emerging system of Internet selling represented a logical extension of Dell's direct business system. Unlike its competitors, Dell did not confront the problem of alienating channel partners through direct Internet sales, and was thus not impeded by the legacy of the indirect selling system.

As a consequence, Dell was one of the first large manufacturers to set up a website in 1994. The following year, customers were able to configure systems and obtain price quotes from Dell.com. By June, 1996, Dell was the first firm in the PC industry to sell systems over the Internet. Within three months, Dell had become one of the largest Internet Commerce firms. At a time when Amazon.com was selling $15 million worth of books per quarter, Dell by the end of 1996 was already selling PCs over the Internet at a rate of roughly $90 million per quarter or six times the sales volume of Amazon. Six years later, Dell was the largest online retailer of goods accounting for 22% of all Internet retail sales (Tedeschi, July 22, 2002: C6).

In expanding its Internet sales as well as increasing its total sales, Dell admittedly benefited from a virtuous circle created by the relationship between the Internet and the PC. The expansion of the Internet as a communications revolution created a corresponding surge in demand for PCs as the device of choice for access to the Web. While the entire PC industry prospered from this relationship, Dell as an online seller by 1996, profited from this innovation in two ways. It was able to take advantage of the increasing interest for Internet access not only as a demand stimulant for its own PCs. Dell used the Internet infrastructure itself as a means of scaling its system of order intake and innovating its sales system to meet this surge in demand.

Table VI-7

Daily Internet Sales of Dell Computer

	1996	1997	1998	1999	2000	2001
Daily Sales ($ millions) *	1	3	11	20	40	50
% of Total Sales *	7%	14%	32%	40%	50%	57%

* end of year totals
Source: www.Dell.com, Speech Archive of Michael Dell.

Nevertheless, while this transition to online selling had an enormous impact in lowering Dell's administrative costs per order from roughly $50 to $5, this innovation represented a relatively small portion of the overall operation. Beyond order intake on the front end of the value chain, however, lies a more complex set of operations and relationships between Dell and its suppliers. It is these relationships, and the integration of these relationships with the customer, that would become the focus for the second phase of Dell's Internet innovation.[13]

Beginnings of the 'Second Web Revolution'

By extending the Internet from the point of sale into procurement, production, and enterprise resource planning, Dell's "second web revolution," represents a more far-reaching set of transformations at the Company than the Internet innovations focused on sales. In this second phase, the Company has become an innovator in the realm of business-to-business Internet commerce. Dell refers to this type of

[13] This notion of Dell's "second web revolution" taken from Rocks (2000). A similar idea is also expressed in Boulton et al. (2000: 8).

Internet activity linking itself to its customers, suppliers, and logistics partners, as *e-commerce*. As a logical extension of Internet-driven efficiencies in the process of order intake and sales, the second phase of Internet deployment at Dell represents the continuation of a single overriding concern at the Firm -- diminishing the inefficiencies in the value chain associated with *time.*[14] This concern with time, in turn, compelled the Company to focus on ways of using Internet communication to enhance perhaps the most critical core competence at the Company – balancing demand and supply in a build-to-order environment. This effort at using the Internet to eliminate more of the unproductive time from the process of demand and supply balancing while operating in a build-to-order environment, is what drove Dell's Web experiment upstream into supply chain management and enterprise resource planning. This initial effort at integrating the Internet into the procurement and build processes was dubbed by Dell as the Genesis Project.

Launched in 1994, Genesis aimed at creating a standardized system of data management for all aspects of the Dell operation using the Web as an information and communications infrastructure. Procurement planning, production schedules, order intake, product delivery, and accounting along with the logistics linking these activities, were to share this common information platform. The project, however, did have a clear and measurable performance goal. The objective of the project was to reduce the inventory problems that had emerged at Dell during the previous four-year period.

Central to the project was a Web-based information system for enterprise resource planning designed by the software firm, SAP. The SAP / R3 platform was intended to provide enterprise resource planners at Dell with the capacity to identify how the impacts of an order ripple throughout the entire operation. It aim was to create simulations as orders occurred for balancing procurement levels, coordinating production schedules, and adjusting financial balance sheets. It represented one of the early efforts at extending the Internet from the point of sale with the customer backward to Dell's suppliers and forward through assembly and delivery.

Two problems emerged with this project (King, 1997). Firstly, the SAP system had difficulty accommodating Dell's regional organizational structure adopted in 1995, especially the multiple assembly sites. Secondly, the project did not appear sufficiently scalable to handle the growth rate of transactions within the Company (Koncaba, Interview of 7/27/01). Genesis had been conceived in 1994 when Dell was a $3 billion firm. By the time Dell actually abandoned the still-unfinished effort in 1997, its sales volumes had quadrupled to roughly $12 billion. Furthermore Dell had already concluded that the R/3 architecture, with its large centralized database, was incompatible with one of Dell's important new aims. Dell was committed to run its ERP system on its own servers, which could not accommodate R/3. According to Jerry Gregoire, chief information officer at Dell in 1997, "having a full SAP suite and all of these tightly integrated applications going into the company at the same time didn't make as much business sense as it did before" (quoted in King, 1997).

Nevertheless, one critical achievement emerged from this early effort at integrating the Internet into procurement and production. From 1994 until cancellation of the project in 1997, Dell did succeed in accomplishing its primary goal of decreasing inventory. By 1997, Dell had once again assumed leadership on this metric within the PC industry. The Company was also growing faster than its competitors in the PC industry. By 1997 Dell had become the third largest PC firm in the world surpassing such firms as Apple and Hewlett Packard.

Despite cancellation of the SAP project, Dell would continue its experiments with the Internet and enterprise resource planning over the course of the next two years. During this period, Dell (along with Cisco Systems) became known as the Company with the most advanced Internet-based system for supply chain management. Nevertheless, as Michael Dell admits, these early efforts at Web-based supply chain management were still very much a process of experimentation in trying to create Internet links between Dell and its suppliers (Dell and Fredman, 1999: 190). Furthermore, the Company confronted the problem of trying to standardize competing, and not always compatible, information and

[14] The idea of time compression as a management strategy at Dell and the PC industry taken from Kenney and Curry (1999).

communications platforms in terms of phones, faxes, and the Web. By the end of 1999, Dell had decided to embark on a far more ambitious project for integrating the Internet into its operation.

Table VI-8

Days Supply of Inventory at Dell and Compaq

	1994	1995	1996	1997	1998	1999	2000	2001
# Days Supply of Inventory **@ Dell Computer**	32	21	16	13	8	6	5	4
# Days Supply of Inventory **@ Compaq**	67	59	44	32	29	31	36	42

Source: Dell Computer Corporation, 10-K Reports various years; Compaq Computer, 10-K Reports various years; Robert Cihra, The PC Industry, ING Barings Furman Selz, 1998; Business Week, June 17, 2002, p. 77.

Table VI –9

Computer Firms
Ranked by World Market Share (1997)

Rank	Firm	Units (000s)	% Share
1	Compaq	10,596	13.1%
2	IBM	6,958	8.6%
3	**Dell**	**4,464**	**5.5%**
4	Hewlett Packard	4,297	5.3%
5	Packard Bell / NEC	4,116	5.1%
6	Gateway	3,261	3.7%
7	Apple	3,070	3.4%

Source: Gartner Group / Dataquest.

Dell's i2 Internet Production Network

Dell embarked on the DSi2 project with the idea of building its business "with the Internet at its core" (Hunter, Interview of 5/24/01). In this sense, the aim of the project was similar to the aim of its earlier experiments with the Internet and supply chain management. The goal of DSi2 is to enable Dell's demand and supply planning, parts procurement, build-to-order production schedules, customer order intake, and product delivery processes to operate on a single but flexible Internet-based information platform. In practice, this aim sought to transition aspects of these operations still being conducted through the phone, fax and even email, onto the Web. In addition, this project was designed to get all of Dell's geographical regions to use this common Web-based information and communications system. Perhaps most importantly, the project reflected an effort to link itself more systematically with its supply chain and logistics partners. Although Dell developed some of its own proprietary software for the program, it turned to the supply chain firm of i2 to provide the overall architecture for the PC maker's Web-based information system. The DSi2 project that emerged from this joint effort, is characterized by the PC maker as "one of the single biggest changes in the Dell business system" (Hunter, Interview of 5/24/01).

The DSi2 initiative utilizes Web-based communication to address what is arguably the most formidable challenge to Dell in its build-to-order business model -- the challenge of supply and demand balancing in an environment of fluctuating customer orders over time. Although supply and demand balancing confronts all manufacturers, most companies address this problem primarily through inventory management. If orders spike upward at any one time, firms rely on inventory to balance the fluctuation. Dell, however, has rejected this approach as incompatible with its build-to-order system. Instead of storing inventory, Dell relies on what is called "burst capacity" to deal with ever-fluctuating demand (Albers, 2000: 23, 29).[15] This strategy relies upon a small amount of unused capacity within the procurement and production process as a safeguard against large increases in demand at any one moment. When demand climbs, this unused capacity gets deployed. Such burst capacity, however, in the context of build-to-order, has to include the entire procurement and assembly process, which means that it must extend back into the supply base and throughout the entire network of the Company. DSi2 represents a new set of planning and logistical innovations by Dell to increase the efficiency of burst capacity and the achieve a more favorable balance of supply and demand within its just-in-time procurement and assembly system.

The DSi2 project has two principal elements. The first element consists of what Dell calls, *Global Supply Planning*. The second element is *Demand Fulfillment*. The first element, as its name implies, focuses on planning processes. The second is concerned with the execution and logistics of moving parts, semi-finished, and finished goods through the Dell procurement, production, and distribution network. This separation of planning from execution is one of the single biggest changes implemented by the DSi2 project (Cook, Interview of 6/14/01).

Operations: Global Supply Planning

Global supply planning involves two types of planning processes. On the one hand, global supply planning involves the creation and management of data and information used to forecast general demand parameters for components. Secondly, and perhaps more significantly, global supply planning refers to a system of information exchange between Dell and its component suppliers to coordinate the process of ordering and procurement of these components by Dell from parts suppliers. The innovative advance made by Dell in this process hinges on the way the PC maker has deployed Web-driven communication, configured through the i2 modules as well as its own software, to create an automated procurement system in which Dell is more functionally integrated with its parts suppliers and logistics providers.

This integration with suppliers through the Internet has resulted in a more centralized and standardized process for procurement planning. Global supply planning centralizes Dell's inbound planning activity in the Company's worldwide procurement organization in Austin. At the same time, however, the global supply planning process creates "a single system of record" for procurement at all six of Dell's regionally decentralized operations (Koncabaa, Interview of 6/12/01; Kelly, Interview of 5/4/01). This centralized planning system for what is essentially a regionally decentralized production system is one of the innovations made by Dell facilitated by the Internet.

Despite the emphasis made by Dell on differences between its business model and those based on forecasting, and disclaimers about its own forecasting abilities, Dell does employ a type of strategic forecasting in its global supply planning process. These forecasts of unit demand and component requirements are the first step in creating a system of *material balances* at Dell. This system aims at equalizing supply and demand of parts within Dell's build-to-order environment and is central in the overall system of supply and demand balancing at the Company. Thus, contrary to perception,

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[15] Information on burst capacity and its role in the Dell business system taken from Albers (2000).

"forecasting is critical" in Dell's Web-driven, just-in-time producing and selling system (Hunter, Interview of 4/17/01). Although Dell does not pre-build products on the basis of forecasts, unlike its competitors that sell machines through the indirect channel, absent forecasts, there would be no viable foundation from which to launch its build-to-order, just-in-time, pull system. In addition, strategic forecasting is crucial because some of Dell's primary suppliers maintain lead times of 8-12 weeks for production and delivery of components. Forecasting these cycles enables the Company to position material in its supply chain so that it can be procured and pulled into the build process as needed. Nevertheless, the Company does not orient its business around this element. **"**We are not a great Company at forecasting because we do not build our business model around forecasting," insists Lance St. Clair, director of supply chain and materials management for Dell. "We are a pioneer in using the Internet for e-commerce with our customers and suppliers to balance demand and supply in the movement of components through the supply chain and production system" (St. Clair, Interview of 6/20/01; 1/10/02).

Consequently, the DSi2 global supply planning system at Dell begins with 12-month "Master Production Plans." These forecasts tell operations departments how much business to expect in the next 12-month period (Inbound Supply Chain Manager, Interview of 4/19/01). These forecasts, however, are continually updated as market conditions change.

Forecasts for Master Production Plans are generated from the interplay of two sources. One source is historical data. For the Master Production Plan, historical trends are disaggregated according to three main categories: 1) products (desktops, notebooks, servers, etc.); 2) market regions (Americas, Asia Pacific, Europe, etc.); and 3) customers (large-scale *relationship* customers serviced by salespersons, or smaller *transactional* customers). Because the Company grew so rapidly from 1994-2000, however, historical trends in these categories do not always convey accurate estimates of future demand. Furthermore, the marked slowdown in demand for PCs starting in 2001has raised additional questions on the use of historical trends as future indicators. This potential shortfall in historical data makes the second source of information for long-term forecasts equally, if not more valuable.

This second source derives from the purchasing plans of its largest relationship customers. Dell is able to obtain this information on upcoming purchases from the customized "premier" websites created by Dell for customers that transact $1 million annually, and from information secured by salespersons working with these large accounts. This information, not captured in historical trends, enables Dell's largest accounts to participate in a direct way in forecasting future demand for materials.

The Master Production Plans generated from historical data and information supplied by large accounts, are transformed into materials requirements. Through the i2 module known as "Supply Chain Planner," these material requirements are further refined into a broad-based "material requirements plan" (MRP). This MRP is one of the principal outputs of the global supply planning process.

The material requirements plan divides a projected level of output into a matrix of different components, automated for Dell by the i2 "Tradematrix" module. In certain ways, this matrix resembles a transactions table in what is known in regional science as input/output analysis. It provides Dell with the material requirements by component type for a certain level of final demand.[16]

Suppliers collaborate in this forecasting process through an extranet called Valuechain.dell.com. Through this portal, component producers are able to verify Dell's material requirements for the duration of Master Production Plans. Suppliers then commit to these requirements, and take responsibility to produce parts as needed over the 12-month period of the Master Production Plan. In this way, parts producers confirm supply and delivery of Dell's component demand. Through Internet communication,

[16] Paradoxically, the planning and forecasting system at Dell possesses some of the attributes characteristic of the central planning system in the former USSR. In the Soviet planning system, forecasts of aggregate final demand were broken down into requirements by industry sector. The "Plan" functioned as a system of *material balances* within and between these various sectors. In the Dell system, forecasts of final demand are broken down into requirements by component type. Other differences are equally critical. In Soviet planning, output targets were rigid and inflexible and became ends in themselves. At Dell, forecasting is undergoing ongoing modification in real time as output targets and supply requirements are constantly being rebalanced as conditions change.

suppliers in effect, provide information necessary for completion of the Master Production Plan, which is constantly in flux as a forecasting tool as conditions in the build-to-order environment change.

With the material requirements of the Master Production Plan as strategic parameters, the global supply planning process assumes its innovative character by creating procurement cycles matched to the fluctuations in customer orders in real time. Through an on-line tracking system for components, Dell is able to respond to changes in its material requirements, and alert its suppliers of its new requirements. This tracking system, configured through a combination of i2 tools, generates what is called an "exception action report." Created automatically over the Web, this report alerts procurement planners at Dell of an "exception" in one or more parts necessary to fulfill demand in that moment. Where an exception exists, a purchase by Dell becomes necessary. Through the "Supply Chain Planner" module of i2, the parts procurement planner/buyer at Dell is able to set up a requisition, get it approved, convert the requisition to a purchase order, and send the order to the supplier. The supplier receives an on-line notification of the purchase order via Valuechain.dell.com. The supplier, in turn, is able to respond to the notification and commit to the new order requirement, which is then received by the procurement planner/buyer at Dell.

The advantage of this innovation is that it transfers the ordering process for parts to what Dell calls an "exception basis" away from spreadsheets, and onto the Internet (St. Clair, Interview of 5/24/01). In the period just before DSi2, certain aspects of this process were executed over the Internet while others were undertaken by more conventional methods such as faxes and phone calls. By mid-2001, however, roughly one year after initial implementation of the program, almost 90% of Dell's purchases from suppliers were occurring through Web-based interactions (Hunter, Interview of 6/20/01). As a result of the direct relationship with its customers, coupled with the advent of Internet communication, Dell has created a new type of connection between the process of customer order intake, and the process of components procurement from its suppliers. Forged on the basis of a new communications infrastructure, this link represents on ongoing search by Dell for ever-greater levels of balance between demand and supply in a build-to-order, demand pull environment.

Operations: Demand Fulfillment

Demand fulfillment in Dell's Internet direct business model refers to the execution of how supplies are delivered to Dell's production sites for assembly into finished products. The core element of demand fulfillment consists of "pulling material to order" every two hours into Dell factories. Customer orders released to the factory floor for configuration into finished PC systems provide the input that initiates these material pulls. Dell schedules these orders to be built in two-hour cycles and pulls only those components required to fulfill orders for the given two-hour period. According to Lance St. Clair, demand fulfillment, with its emphasis on pulling material to order, is "the rocket science of the Dell supply chain system" (St. Clair, Interview of 5/24/01; 1/10/02).

A critical intermediate step, however, precedes this process of pulling materials into Dell's assembly factories. This step consists of storing and staging components in sufficient quantities so that they can actually be pulled into the assembly process on a just-in-time basis. This staging process focuses on planning and executing the movement of components between two of the primary nodes in Dell's network: 1) supplier factories located long distances from Dell assembly sites; and 2) supply logistics centers (SLCs) located in each of the six regional locales where Dell operates assembly plants.

This staging activity is essentially a system for collapsing distance between the location of component supplies, and the location of the assembly process. Such collapse of distance, in turn, plays a crucial role in enabling Dell to manage the compressed time cycles for pulling material into production on a just-in-time basis. In this way, physical proximity between supplies and assembly activity, and time compression in the just-in-time pull system are mutually reinforcing.

The reason why this staging process occupies a position of such centrality in the Dell network stems from geography. Long distances separate the locations where components are produced, and the locations of Dell's assembly sites. In Dell's just-in-time, build-to-order environment, there is simply no way of eliminating the friction of geography when distance separates sources of supply and the activity of assembling supplies into finished products. In effect, the storing and staging of supplies by Dell is a response to the problem of risk. The greatest risk faced by Dell in its business system is not only access to component supplies. The risk confronting Dell is access to supplies within specific parameters of time in a manner consistent with its build-to-order pull system. Consequently, what Dell is seeking through the staging and storing process is control over the risks it encounters in securing access to sources of supply. It is, in effect, an attempt to seek a substitute for inventory as a mitigation against the risk of access to component supplies.

Although numerous primary and second tier suppliers have established factories in the locations where Dell operates its assembly plants (see "Organization" and "Territorialization" below), a varying percentage of components at each assembly site -- sometimes most of the components at sites such as Ireland or Brazil -- are supplied from factories located at great distances from Dell's assembly centers. Such suppliers are required by Dell to operate through SLCs located adjacent to Dell's assembly sites. In these SLCs, component vendors store parts as inventory. In general, Dell requires parts suppliers to maintain ten working days or two weeks supply of inventory at SLCs (Cook, 6/14/01). Consequently, there *is* inventory in the procurement, production and distribution network of Dell although compared to other PC makers, this level of inventory is relatively small. As explained more fully below, however, it is component suppliers that are the bearers of these inventory costs.

The operational costs of the SLCs are assumed by suppliers and third party logistics providers (3PLs) as part of an emerging trend in supply chain management known as vendor managed inventory or VMI. Dell is one of the pioneering firms in this area. Third party logistics providers involved in VMI for Dell include BAX, Menlo Logistics, Ryder, IEC, and Eagle Logistics. Suppliers negotiate contracts for operation and management of supply logistics centers directly with 3PLs and pay what is called "pallet in/out charges" to 3PLs for storage of component inventory (Cook, Interview of 6/12/01). While Dell closely monitors the ability of 3PL-managed supply logistics centers to provide the required services to Dell factories, the operation of SLCs is conducted independently of Dell (Kelly, Interview of 5/4/01). Nevertheless, this relationship between Dell and the SLCs is far from what would qualify as a market transaction between independent agents. In Austin, for example, the SLC built by Dell and leased to Eagle, is directly adjacent to the Morton Topfer Manufacturing Center where Dell assembles finished goods. Such an arrangement represents a strategy by Dell for simultaneously contracting out and passing certain costs onto other parties, while retaining necessary control over an essential element in its operation.

The staging process for the storage of inventory at SLCs begins when suppliers commit to the procurement order from Dell through the ValueChain portal. In making such commitments, suppliers take responsibility to position and store components in the Supply Logistics Centers if they do not have a factory adjacent to the Dell assembly site.[17] As part of their management contracts with Dell, Supply Logistics Centers are obligated to operate on the same Web-based i2 communications platform that Dell uses for global supply planning and demand fulfillment. In this way, SLCs are part of a three-way planning and fulfillment conversation taking place with Dell and suppliers on the same information infrastructure. Through ValueChain and the i2 tools, SLCs transmit information to Dell factories every hour on the ever-changing inventory of components storied in them and commit to material requests from Dell. At the same time, SLCs communicate with supplier factories on components needed to replenish inventories. The general principle of this replenishment system at SLCs is supply and demand balancing while the specific requirements hinge on ten days' supply.

As orders from customers are received from the Dell.com website or by phone, and as they are queued and cleared by the credit department, they are downloaded to factories every twenty seconds and simultaneously transformed into a matrix of material requirements (Hunter, Interview of 5/24/01). From this matrix of required components, the "Factory Planner" module of i2 creates a 2-hour production schedule that organizes the "kitting" of parts for assembly as per order, and a build schedule for orders in the 2-hour window. At the same time, the schedule from Factory Planner is converted to a different

[17] Suppliers that maintain factory operations in proximity to Dell assembly sites do not use the SLCs but are obligated to supply factory sites on the same replenishment schedules as the SLCs. The most notable supplier to Dell that does not participate in the SLC system is Intel, which uses its own logistics centers to ship to its customers.

output within the i2 suite called "Rhythm Collaboration Planner" which sends an automated feed to the SLCs on the components needed in the Dell assembly site for the upcoming 2-hour build schedule. Third party logistics providers managing the SLCs are given 1.5 hours to deliver the required parts to the dock at Dell's factory. It is because of this 1.5-hour window that proximity between Dell and supply logistics centers is so critical. Dell unloads these parts in thirty minutes. For the next two hours, assembly workers configure components into finished machines. The entire cycle from order clearance to finished product is four hours. Only when material is needed within a 2-hour period is it actually pulled into the Dell assembly site.

By pulling material to order over a Web-based communications infrastructure, Dell's demand fulfillment system represents an innovation with an enormous operations cost benefit for Dell. In the first place, because the dominant cost driver for Dell is the cost of goods procured externally from component producers, any advantage Dell can secure in terms of procurement costs will greatly affect its margins.[18] Dell pays prices to its suppliers for these components *after* they enter Dell assembly plants from the SLCs. In the interim time period between Dell's procurement order, and final delivery of parts to Dell following the staging of components in SLCs, suppliers assume the costs of falling component prices. Consequently, in an environment where the component costs are the primary drivers of total costs, and where the value of these components is falling over time at a rate of roughly 1% per week, Dell has an interest in securing these components at the last possible moment before they are assembled into finished machines. The SLC system enables Dell to accomplish this aim. When Dell assembles these components and ships the finished systems directly to the customer generally within 5-7 days, these components have a limited window of time in which to drop in value. The SLC system therefore provides a buffer to variability in demand and supply. It also shields Dell from the loss of value associated with PCs as perishable goods.

Furthermore, this pull material-to-order system represents a solution to one of the most intractable problems with a just-in-time, mass customization business model -- the problem of balancing customer choice and volume production with low levels of inventory. Even if the ten-day supply of components typically stored at SLCs is added to the inventory levels at Dell's own operations, inventory in the Dell network is extremely low compared to its competitors. According to one of Dell's largest suppliers that also supplies other PC firms, Dell operates what is probably the most efficient supply chain and inventory system in the industry (Interview Supplier #1).[19] At the core of this balance in supply and demand is the transmission and processing of information from the customer, through Dell, and throughout the supply chain. "The Internet at Dell extends from our customers to our suppliers," observes Lance St. Clair. "The use of the Internet and e-commerce represent ultimate customer choice, and the ability to scale and deliver those choices to the customer without inventory" (St. Clair, Interview of 6/20/01; 2/10/02)**.**

This highly innovative system for balancing supply and demand and reducing inventory, however, is not without contradictions and conflict. In a certain sense, Dell's mission with suppliers -- ensuring continuity of supply -- undercuts the aim in supply chain management, which is the reduction of inventory throughout the entire procurement and production process. "They [Dell] are much more focused on making sure they have continuity of supply than the other PC customers we serve," insists one of Dell's largest suppliers (Interview with Supplier # 2, July 2, 2002). This hedge against risk imposes certain limits on how far Dell is able to compress inventory levels in its build-to-order system. "It just isn't possible to make this a totally efficient world," concedes another of Dell's suppliers. "The way that Dell balances this contradiction is by passing the inventory problem to suppliers" (Interview with Supplier # 3, June 24, 2002). One of the outcomes of this emphasis on continuity of supply, however, is that component producers push their own suppliers for greater "asset velocity" meaning faster inventory

[18] In fiscal year 2001 when Dell's total sales amounted to $32 billion, its material costs accounted for $26 billion, which emphasizes how small the gross margins are in the PC business.

[19] At the same time, however, this supplier also suggests that Dell's innovations in supply chain management are being copied by other PC makers. While these firms do not execute as well as Dell, this supplier insists that Dell's advantage in inventory management is narrowing (see "Diffusion" below).

turnover, thereby enhancing efficiency in the entire value chain, not just the efficiency for Dell. Nevertheless, Dell provides suppliers with very clear expectations on the levels of inventory required in SLCs, and when inventory passes to control and ownership of Dell.

How Dell has been able to assume this power in its relationships with suppliers, and create what is the most innovative and efficient procurement, production, and distribution network is the story of how the PC maker has fashioned a new type of business organization.

Organization: The *Virtually*-Integrated Firm

When Dell began implementation of its global supply planning and demand fulfillment system, the PC maker faced a difficult problem with its component vendors. In order for its DSi2 innovation to function, it had to ensure that its suppliers adopt the same Web-based planning and execution system being developed by Dell. This requirement meant that firms aiming to supply Dell had to operate on the same communications platform as Dell and develop the same interactive capabilities on the Web and the same standards of interoperability with the PC maker (Radjou, Interview of 8/6/01).[20] Component vendors and logistics providers therefore had to make investments in their own information systems compatible with Dell's i2 system as a precondition to supplying and interacting with Dell. Such investment, however, was far more than a technological imperative. Convincing suppliers to operate on the same information and communications infrastructure as Dell, was a first step in creating a new type of business organization. Dell refers to the form of enterprise it has created from these technical and organizational imperatives, as the virtually integrated firm (Magreta, 1998).

The aim of Dell, in establishing such an organization and requiring suppliers to operate on this common Web-based communications platform, was to move away from market-oriented transactions for procurement, and toward interactions with parts vendors based on *relationships*.[21] Michael Dell describes this phenomenon as replacing "the traditional 'bid-buy' cycle, with a relationship based on communication and ongoing information sharing" (Dell and Fredman, 1999: 180). What Dell seeks to gain in replacing market-oriented bids for parts contracts by suppliers with transactions undertaken through relationships, is leverage over risk in its high-speed, Internet-driven procurement, production and distribution network.

Just as the mitigation of risk in component procurement is the aim of Dell's 10-day replenishment system of supply at SLCs, so too is the mitigation of supply disruptions in procurement the motivation for Dell to pursue relational, as opposed to market-based transactions with its parts vendors. Dell, in effect, has concluded that markets pose more risk of supply disruptions than relationship-based contracting. As a consequence, Dell is reticent to confront the risks of contracting with suppliers and logistics partners through the market and the price system. Virtual integration is thus an interfirm network responding to risk with a governance structure based upon non-market forms of administrative coordination.

In this sense, the reliance of Dell on administered relationships to link the adjacent operations in its network is similar to the dependence of vertically-integrated firms in the late nineteenth century on administrative controls to organize their procurement and production systems. In much the same way that vertical integration coupled with administrative planning represented a response to the risk of managing complex procurement, production and distribution systems without disruption, so too does the virtually-

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[20] In speaking of these requirements on suppliers to make technology investments compatible with the systems at Dell, CEO Michael Dell makes reference to the virtues of market power. "Dell in the U.S. is 50 percent larger than its nearest competitor and growing four times as fast," he says. "Suppliers have a choice: Supply Dell, or lose market share. Let's face reality. If my largest customer had a new requirement, I'd listen to them" (quoted in Perman, 2001).

[21] There is an extensive literature on the idea that relationships between economic actors are in fact the *precondition* rather than the outcome of market activity between such actors. See especially the pathbreaking article of Granovetter, (1985) as well as derivative pieces on trust by Sabel (1989; 1993). The early notion that the Internet and Internet commerce would eliminate the role of relationships in market transactions, and create more purely market-oriented interactions among firms, is contradicted by Dell. The Dell case reveals that in its build-to-order business model, relationships, not market-transactions, are more critical than ever.

integrated enterprise of Dell confront similar types of risk by deploying similar control mechanisms. The difference is that whereas manufacturing firms in the early mass production age tended to exert such control through mechanisms of administrative planning in concert with ownership of assets, Dell exerts control through mechanisms of administrative planning in combination with assets owned by different firms. Although the asset structures of the two types of networks are different -- vertically-integrated firms invariably owned the assets in their network while Dell does not -- the forms of control through administrative planning, and the rejection of market-based interactions to accomplish operational objectives are fundamentally similar.

Thus, the idea that market forces are emerging as the mechanism of governance in interfirm production networks, is far removed from the experience of the virtually-integrated, interfirm network coordinated by Dell. While the proliferation of the interfirm network as an organizational phenomenon is undeniable in the current period, the virtually-integrated enterprise of Dell tells a far more revealing story about interfirm networking than the focus on its structural characteristics *per se*. The story of virtual integration pioneered by Dell is instead one of how power is exercised within networks of firms, and how the exercise of such power mobilizes resources within the network for innovation and profit. Not only are relationships of administrative control compatible with interfirm networks. Such non-market relationships, in the case of Dell, are essential in enabling these networks to function in an innovative way.

In this sense, the virtually integrated organization of Dell and the vertically integrated organization of the 19th century share fundamental control objectives not sustainable through markets. What has emerged from Dell's effort to replace market coordination with coordination by conscious control, is a new type of innovative interfirm business organization. This organization, however, is still one that relies on prerogatives of power for pursuit of profit and competitiveness.

This orientation toward functional integration with suppliers and logistics providers has resulted in the creation of a business model for interfirm Internet commerce with non-market characteristics that lies at the core of Dell's procurement system. This business-to-business form of Internet commerce, referred to by Dell as e-commerce, is far different than the market-oriented auction models used by other large manufacturing firms, and the Internet exchanges established by intermediaries such as VerticalNet or FreeMarkets.com for such large manufacturers (Chapter 5). In these auction and marketplace models, companies such as General Electric and Boeing, or Web intermediaries have used the Internet to expand the number of suppliers bidding on parts orders, in an effort to force suppliers into a race to the lowest price. The primary idea in these models, in effect, is to use Internet technology to broaden the number of participants bidding on supplies, and to use this enlarged base of competing firms to drive down procurement costs through pricing.

Dell, by contrast, has generally rejected this auction-like, free market approach to Internet commerce. While it has experimented with the FreeMarkets exchange for low volume, highly standardized supplies, its concerns about quality and ongoing capacity have precluded the PC maker from using Internet commerce as an auction mechanism for procurement of supplies. "Auctions and exchanges have fueled the thinking that price is everything," insists Richard Hunter, "but there is more to procurement of materials than just price" (quoted in Sheridan, 2001). Hunter goes on to comment how "strong relationships" that create "common processes" are also critical to driving down procurement costs. Instead of auctions, Dell has oriented its approach to commerce on the Internet toward establishing consciously coordinated relationships with the firms in its network. In using the Internet as the basis for these relationships, Dell has extended the idea of the closed loop with its customers, creating what in effect is an Internet-based closed loop with its suppliers. In this closed loop transactions, even over the Internet, occur not through arms-length, market-oriented interactions. Instead they take place on the basis of coordinated relationships that are the key to mobilizing resources from both outside and within the enterprise in the search for efficiency.

The relationship imperatives of virtual integration have had profound consequences on the supply base itself. In the first place, virtual integration, requiring such close collaboration with component producers, has forced Dell to consolidate its supply base, a trend that actually started in 1994. As a consequence, Dell, which at one time worked with over 200 first-tier suppliers, now has a core group of 30-35 primary suppliers. This small group provides close to 80% of the "material spend" for components used in Dell's products (Hunter, Interview of 4/17/01). An additional twenty suppliers bring the total to roughly 95% of Dell's raw material costs. This relatively small supply base, and the relationships stemming from it, are the foundations for the virtually-integrated organizational structure to which Dell aspires.

The power relationship between Dell and its suppliers and logistics partners, along with Internet technology play complementary roles in the establishment of this virtually-integrated organization. Dell has made it clear to its component vendors that if they want to supply Dell, they must submit to its technical requirements structured around the idea of virtual integration. "As a market leader in every aspect of the PC supply chain, Dell has the bargaining power to structure these supplier relationships in order to sustain its build to order model," insists Nigel Johnson of the Eclipse Group, a supply chain management consultant in Silicon Valley (Johnson, Interview of 4/24/01). Component vendors themselves are candid in the way this system of relationship-building gets constructed. "Dell has a significant amount of power with its suppliers based on the current and future business levels they offer," argues one of Dell's large suppliers. "They know it and they use it." Nevertheless, this supplier is quick to add that the pressure from Dell on continuity of supply enables it to push its own suppliers for greater velocity in the delivery of materials. Furthermore, Dell gives a clear accounting of what it expect from vendors. "One aspect that I like about Dell," says this supplier, "there is clear delineation on control and ownership [of inventory]." As a result, this vendor is able to supply Dell with greater velocity than other PC customers (Interview with Supplier # 2, July 2, 2002).

One important way that Dell has used its leverage in these supply chain relationships occurred in the aftermath of the Taiwan earthquake of 1997. As a result of supply disruptions with its Taiwanese vendors following this event, Dell initiated what it called the Supply Assurance Program. Its aim was to ensure that Dell would never be shut down by supply bottlenecks or shortages. Suppliers were obliged to endorse this program through agreements with Dell. "Dell dragged us over the coals to make certain that we knew about the risks in our own supply chain," admits one of Dell's suppliers, "but they did not impose upon us a set of best practices to correct it." Instead, this supplier worked with the vendors in its own supply chain to become more efficient. The outcome, however, was somewhat of a puzzle reflecting the at times divergent interests of Dell and its vendors. "As a result," concedes this supplier, "we actually increased our available inventory so that Dell's own supply chain system will not suffer even in an event as catastrophic as the Taiwan earthquake"(Interview with supplier # 3, July 24, 2002).

Perhaps the most obvious way that Dell has been able to prevail upon its supply base is the requirement on component producers to stock SLCs with ten days supply of inventory. According to a major supplier, "reduction in inventory levels at SLCs is the single biggest issue facing suppliers." This supplier insists that in the current period with the exception of Intel and Microsoft, "Dell's suppliers are bleeding." For this reason, components producers have been trying to negotiate with Dell to reduce the ten-day requirement to five days. "Dell has resisted," explains this supplier, "because they do not want the risk" (Interview with Supplier # 1, 4/26/02). In this regard, power and risk avoidance are complementary.

For Dell, relationships, crafted on the basis of power and planning, are the foundation of the virtually-integrated network enterprise. This form of organization seeks other firms to operate functionally as units of Dell's own operation. In this way, virtual integration aims at capturing the benefits of vertical integration -- control over the adjacent operations required to build, market, and support a product -- but without the asset requirements and expertise needed for such a comprehensive approach to competing. "We want to take advantage of the benefits deriving from vertical integration," admits Richard Hunter, "but the problem with vertical integration is that we have to become experts at many different product and process technologies. We want those advantages at Dell, but we want them *virtually* through Internet communication" (Hunter, Interview of 5/24/01).

This form of organization, and the structures of control that enable it to function in an innovative way, have had profound impacts on the geography of Dell's network.

Territorialization: Geography and the Dell Network

Forms of business organization are inherently spatial (Walker, 1988: 385). Business organizations create economic territory in the way they coordinate and manage the assets, activities, and actors within the networks in which they procure, produce, and sell. In this process of territorial formation, business organizations play two essential roles. They have a technical role in applying appropriate technology -- that is, ways of getting things done -- to coordinate spatially-dispersed operations in producing and selling a product. Business organizations also have a social role in coordinating interactions occurring over distance within and between firms that are integral in this process of producing and selling. Business organizations therefore create economic territory by managing the technical and social forces that connect the facilities, processes, and actors involved in producing and selling.

In managing these technical processes and social entities, Dell has fashioned an organization with a geography emerging from three basic sources. On the one hand, this geography derives from the locations of the principal network *nodes,* and the territorial configuration of these assets. Secondly, Dell's organization assumes its geographical character from the *flows* of product and information circulating between these facilities, and the territorial routes created by the patterns of these operational activities. Thirdly, this geography consists of the organizational *relationships* and relations of *power* between Dell and the firms in its virtually integrated enterprise. Such relationships determine how assets are distributed across space, and how they operate in the spaces where they are distributed.

Dell's innovations in global supply planning and demand fulfillment have enabled the Company to reconfigure the geography of its production network in three fundamental ways.

Firstly, Internet communication has provided Dell with a more centralized form of control not only over global supply planning, but also over the execution of fulfillment activities across its regionally decentralized network. What has resulted from this more centralized form of control is a more standardized set of fulfillment systems at each of the locations where Dell concentrates its operations. The Company has created what it calls a "copy-exact approach" of the pull-material-to-order system in each of its regional locations (Cook, Interview of 6/14/01). This "copy-exact" approach standardizes the logistics of the Dell fulfillment system across space.

Secondly, far from diminishing barriers of distance in procurement and production, the Internet-driven planning and execution systems created by Dell have intensified the need for certain relationships of spatial proximity between nodes in Dell's network. Thus, while Internet communication has provided Dell with an infrastructure for managing the logistics of planning and execution in its globally-spread procurement, production and distribution system, the velocity requirements, and the supply and demand balancing requirements of its Web-driven business model have placed an even greater premium on proximity between Dell and its suppliers and logistics partners. Such relationships are what enable the PC maker to manage the flows of materials in its just-in-time, pull material-to-order business system.

Thirdly, Dell has assumed an active role in shaping the geography of its network by influencing the location decisions of its network partners. The PC maker has prevailed upon firms in its network to establish operations -- either factories, or more commonly the replenishment operations of supply logistics centers -- adjacent to the locations where it has chosen to organize its just-in-time, custom-build assembly activity. By controlling the locations of its network partners, and by configuring relationships of proximity in these locales, Dell has actually shaped its own place-based external economies of scale. As it creates these external economies and reshapes local landscapes where the key nodes in its network operate, Dell is helping fashion the industrial districts of contemporary globalization in which tendencies of geographical spread and spatial concentration co-exist (Storper, 1997).

The Geography of Assembly

The locations of Dell's assembly facilities are the primary drivers of the global and regional geography in Dell's production network. The six assembly plants in the network are spread across the four continents of North America, South America, Europe and Asia. Generally, each facility configures products for customers in a specific geographical area. These areas approximate the division of the world by Dell into four market regions: 1) the Americas (both North and South); 2) Europe (which encompasses

Africa and the Middle East); 3) China; and 4) Asia-Pacific. Assembly sites in Austin and Nashville service customers in North America. Eldorado do Sul in Brazil is responsible for South American customers. The facility in Limerick, Ireland builds PCs for Europe, Africa, and the Middle East. Xiamen, located directly across the strait from Taiwan, services China while the Asia Pacific assembly center in Penang, Malaysia services the rest of Asia. Customer orders are automatically routed over the Web to the configuration center that services the region where the customer is located. In this way, the assembly sites of Dell are global in their geographical reach, and regionally decentralized.

The locations chosen by Dell for expanding assembly operations beyond the Company's origins in Austin, reveal a pattern with several common themes.

The most important characteristic of the expansion sites in Limerick, Penang, Xiamen, and Eldorado do Sul, is that all of these places possessed *existing* concentrations of computer-related firms resulting in large part from government policy. Penang, Malaysia, is perhaps the best example of this phenomenon.

Map VI-2:
Expansion of Dell Assembly Sites

Penang was the beneficiary of government policy in the late 1960s to attract foreign transnational corporations to Malaysia through a program of high technology targeting supported by the creation of "Free Trade Zones." By the early 1970s, Penang emerged as a top electronics-producing region in Malaysia. Intel, AMD, Motorola, National Semiconductor, Siemens, and Hewlett Packard established operations in Penang's Bayan Lepas Free Trade Zone during this period that created employment for 12,000 workers in Penang in 1971-72 (Kahaner, 1996). During the 1980s, a second wave of investment, this time including Japanese and Taiwanese firms, made Penang one of the most important centers of the electronics industry in Asia (Rasiah, 2000). By 1992, Penang had over 76,000 electronics workers with semiconductors and disk drives the most important industry sectors (Kahaner, 1996). When Dell began operations in Penang in 1995-96, the city-region had close to 100,000 employees in 148 electronics factories (Kahaner, 1996; Penang Development Corporation). Dell was now part of a computer-related cluster of companies many of which were major suppliers to Dell such as Acer, Iomega, Komag, Seagate, Quantum, and Sony. This pattern, similar in Dell's other chosen locations, reveals the importance of pre-existing concentrations of electronics firms, including suppliers, in influencing the location decision of Dell.

In this sense, the locations selected by Dell conform broadly to the preferences of firms for proximity to other firms in the same industry. First observed systematically by Alfred Marshall, these agglomeration economies include access to specialized suppliers, a "constant market for skill," and an environment enabling the spillover of technical knowledge (Marshall, 1890: 267-277). Such external economies of scale are now commonly attributed as drivers of high technology concentrations.

Yet, while Dell has taken advantage of existing agglomeration economies in these locations, it has also contributed in recasting these places as high technology concentrations by its own location decisions. In this sense, the location pattern of Dell exhibits what has been described as *cumulative causation*, or similarly, historical *path dependence*.[22] In Limerick, for example, Dell began operations in 1992 with 184 employees. At the beginning of 2001, however, Dell employed 5000 workers at its Limerick complex. This figure made Dell one of the largest high technology employers in the Limerick region.[23] Through such location choices, however, Dell has not only reinforced the high technology character of these places. In bringing its pull-to-order business model to the Limerick region, it has succeeded in configuring a new set of activities upon the local landscape and in the process, changing the nature of the place itself.

A second characteristic of Dell's location pattern focuses on direct incentives. While Dell receives certain indirect benefits from the external economies where it has established its assembly locations, the PC maker has successfully secured a variety of financial incentives from government in each of its assembly locations outside the U.S. According to the PC maker along with local development officials, such incentives played a role in influencing its location decision (Robertson, Interview of 6/27/01; Wong, Interview of 5/24/01; Tobin, Interview of 2/6/01). In the case of Penang and Xiamen, Dell operates in government-created incentive zones, which provide the PC maker with exemptions from import and export taxes along with other material benefits.[24] In the case of Limerick and Eldorado, Dell has similarly managed to secure incentives from local, regional, and even national authorities. Nevertheless, as is generally the case with such programs, it is inconclusive whether such incentives actually influence location decisions, or whether companies make such decisions on the basis of other factors and then simply collect what government offers.

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[22] On cumulative causation see especially Myrdal (1957) and Hirschman (1958), while on path dependence as it relates to industrial location see especially Arthur (1988). The similarity in these theories derives from the fact that both attribute location decisions in the present to the agglomerations inherited from the past.

[23] Employment figures for Dell Limerick furnished to the author by representatives of the Shannon Development Corporation, and the Limerick Development Corporation.

[24] The Bayan Lepas Free Trade Zone in Penang emerged from the Free Trade Zone Act of 1971 while Xiamen was one of four Special Economic Zones (SEZs) along with Shenzhen, Shuhai, and Shantou created by China in 1979.

Another characteristic of these locations is that while they all represent formidable concentrations of electronics firms, within this category they all share features as the world's "Second Tier" of high technology cities (Markusen et al., 1999). With the possible exception of Penang, these cities are one level below the concentrations of high technology found in places such as Silicon Valley, Boston, Singapore, or the area around Taipei. Dell is part of this growth trend that is extending electronics development to selected places outside of these first tier electronics concentrations in creating newer high technology industrial districts.

Finally, Dell has shown a preference for locations near its most critical material supplier, Intel. The world's largest semiconductor manufacturer operates a production, testing, and supply center in Penang roughly five minutes drive from Dell's facility. Intel also operates similar facilities in Ireland and China, with relatively easy access to Dell's configuration centers there. This pattern conforms to Dell's preoccupation with avoiding supply disruptions, and using proximity as a remedy for such risk.

Dell, in effect, has taken advantage of existing high technology concentrations in making location decisions for its assembly operations. Its locations also reveal an effort to maintain physical proximity to its most critical material supplier, Intel. In following these trends, Dell itself has emerged as an actor in reshaping the agglomeration economies where it has located into the world's new generation of high technology industrial districts. This role of Dell in reshaping the places where it assembles PCs is more readily apparent in the way it participates in the geography of supply.

The Geography of Supply

In addition to assembly sites, Dell's network also assumes its territorial configuration of spread and concentration from a geography of supply. This geography derives from the interplay of two sources. Firstly, Dell's geography of supply is a product of historically conditioned, but constantly evolving location choices of supplier firms in siting their factories for component production. Secondly, this geography is the result of the decision-making power exercised by Dell to influence the locations of supplier facilities in order to optimize advantages of physical proximity in its build-to-order production system. The interplay of these two sources producing this geography is one of structure and agency in which Dell is the agent reshaping a structure to accommodate its operational objectives.

Supplier factories creating this structure are spread throughout the world but have distinct geographical concentrations. East Asia, Mexico, and the U.S. are the largest concentrations where components are produced.[25] Suppliers from these areas are themselves frequently part of subcontracting relationships in which the lead supplier firm, and the firm (or firms) actually producing the components or subassemblies of the components, are different entities based in different countries. This phenomenon of cross border production networks is common across a range of different PC supplies (Cohen and Borrus, 1997; Borrus et al., 2000; Saxenian, 1999). It includes highly standardized components such as disk drives, to semiconductors in which chipmakers in Silicon Valley typically subcontract fabrication and assembly to chip foundries in Taiwan who in turn, subcontract portions of this work to other specialty firms in different parts of Asia, or increasingly China or even to their own subsidiaries in these areas. These networks of ever-shifting contracting relationships reflect the influence of two major trends.

On the one hand, this phenomenon of networking in which work gets subcontracted and disperses to other locations, reveals the impact of what is called the "product cycle." Originally developed by the economist, Simon Kuznets (1930) to explain business cycles, product cycle theory insists that the life of products passes through stages. This focus on stages was later given a more geographical orientation by Raymond Vernon (1966) and Ann Markusen (1985), who argued that stages in the life of products correspond to shifts in the location where such goods are produced. As products mature and become more standardized, production requirements for such goods become more routine. In this process of maturation and standardization, the production skills of firms from areas formerly unable to produce such

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[25] Recently, Dell, motivated primarily by a search for lower costs, has started to procure an expanding share of low-end components from Eastern Europe produced by electronics firms operating in the Czech Republic and Hungary, (Williams, Interview of 8/30/01).

goods, eventually match the more easily-mastered production requirements of goods in the more mature phase. What differentiates these newer entrants, however, is their low wage and low cost structure. As a consequence, firms originally making such products, subcontract production to these newer firms outside the location of origin to take advantage of their low costs.[26] Thus, from product cycle theory, the geographical spread of firms producing PC components in network-like subcontracting relationships reflects an evolutionary stage in the development of the PC. As the components of the PC assume standardized formats, production of these goods is able to spread to lower wage producers.

On the other hand, however, there is a second major variant of this story about contracting and networking that supplements the emphasis in product cycle theory on low wages and geographical spread. This second approach shifts the focus from costs to capabilities. In this approach, cross border networks of companies and subcontracting aim at exploiting a diverse array of technological knowledge that is spreading outside the U.S. At the same time, these networks are taking advantage of increasingly specialized skills and technical knowledge that are concentrating within and among particular firms located in specific geographical localities (Borrus et al., 2000: 2; Saxenian, 1999). From this perspective, the geography of supply associated with subcontracting relationships is marked by the spread of capabilities to a new generation of firms that concentrate into new skill-based and knowledge-based regions. The process is one of creating new high technology industrial districts.

In effect, both product cycle theory and cross border production network theory provide essential pieces of the story driving the pattern of spread and concentration in the geography of supply. One piece focuses on the search for low costs; the other focuses on the search for skill. The geography of Dell's supplier network is part of this dual phenomenon. This search by Dell for costs and skills is what has given its supplier network its structural focus on the three primary regional nodes in East Asia, Mexico and the U.S.

Within East Asia, firms in Taiwan, Singapore, Malaysia, Korea, Japan, and China supply most of Dell's components. The companies producing components for Dell in these places are Asian firms such as the Taiwanese firms of Compal, Quanta, and Acer, and the South Korean firm of Samsung. Asian firms producing for Dell also include such companies as Taiwan Semiconductor Manufacturing Company (TSMC) that is the primary foundry for Dell's graphic chip supplier, NVIDIA. Dell's suppliers in this region are also the East Asian subsidiaries of mostly-American, but also Japanese, European and now increasingly Taiwanese-based transnational electronics producers. Because of the standardization and modularity of the components in the PC, all of these companies are resorting to outsourcing PC component production to low wage areas. In this process of migration to lower cost areas, Malaysia and especially China are emerging as the locations of choice for fabrication of PC components.

In addition to the East Asia region, the border area of Mexico is also an important center where production of components takes place. Invariably the same firms outsourcing production from subsidiaries in Asia are also sourcing production for PC components from their own border operations in Mexico. The Japanese firm Sony, for example, makes flat panel displays for Dell at its Malaysian subsidiary while also supplying Dell from a plant in Mexico. Samsung of Korea supplies Dell's LCD monitors by outsourcing from the same locations.

The U.S. is notable as the primary location for the two firms producing the two most critical components of the PC, the operating software supplied by Microsoft, and the microprocessor and related semiconductor components supplied by Intel. Microsoft is in many ways a special case not only because of the dominant control it exerts over the operating software, but also because it is not really a material supplier. What it supplies Dell is intellectual, rather than material property. Intel, in this sense, is far different since the intellectual property it produces is embedded in a physical product. Most design, development, and wafer production of Intel chips occurs at facilities in the U.S. A significant amount of this same work, however, occurs outside the U.S. in Malaysia, Israel and Ireland. Low-wage assembly and testing is often subcontracted by Intel to firms such as ASE of Taiwan which in turn, sources some of

[26] Markusen makes an original contribution to product cycle theory by shifting the argument to declining *profit* margins as the product becomes standardized to account for spatial dispersion. This insight on "profit cycles" is particularly appropriate in describing the PC industry.

its work from facilities in Penang, Malaysia and increasingly, Shenzhen, China. In this way, chip production is a prime example of networking and subcontracting.

Alongside this structural pattern in the geography of Dell's supply base, however, is the role played by Dell in shaping the location behavior of its component vendors to accommodate its requirements for proximity to sources of supply for its build-to-order system.

In much the same way that Dell compelled its vendors to operate on the same Web-driven i2 information platform, so too has the PC maker elevated "location" as a condition for entry into its supply network. This process has taken two forms. On the one hand, as noted above, Dell has compelled suppliers to operate through the SLC system (see above) which is the approach generally taken by Dell to address the need for proximity in its business model. Nevertheless, Dell has supplemented this approach by convincing certain suppliers to locate factory operations in the locations of its assembly plants. In pursuing this strategy, the Company approached a number of its primary suppliers and requested that they service Dell in each of its regional assembly locations.[27] In Penang, for example, Dell prevailed upon two of its contract manufacturers for motherboards, SCI and Jabil Circuit, to set up factory operations close to the Dell assembly facility (Wong, Interview of 10/2/01). While it may be that suppliers have good reason to establish operations close to Dell, and may very well follow Dell in these locations to benefit from the same economies of proximity, it is also true, as Michael Dell reveals, that suppliers and Dell engage in "discussion" about such location decisions. In this way, at the very least, structure *and* agency -- the objective forces pulling suppliers toward Dell, and the actions taken by Dell to encourage such movement -- are factors in accounting for the decisions of suppliers to locate near Dell. Consequently, whether forcing suppliers to operate through SLCs, or compelling vendors to establish factory sites near Dell assembly centers, the motivation for Dell is the same. It is to use proximity as a solution to the logistical challenges of material balancing in its just-in-time, pull system of production, and as a remedy for the risks of supply disruptions. Dell's assembly sites and these supply sites, both factories and SLCs, are thus linked organizationally, technologically, and spatially. On the basis of these linkages, Dell has actually created more heavily concentrated bases of supply where it assembles PCs.[28]

Where Dell is surrounding itself with suppliers and supply hubs, and organizing specific types of relationships between these entities and its assembly operations, it is playing a role in transforming the economic geography of those places. The PC maker is creating a set of fundamentally similar production complexes across space. "All of these factory complexes are set up much the same way," says a Dell senior manager of global supply chain strategies. "We want consistency across the globe." As it standardizes the logistics of the fulfillment system in each of these places, the copy-exact approach used by Dell for its pull material to order model creates roughly equivalent spatial arrangements between supplier facilities and assembly complexes. According to Daryl Robertson, Vice President of Dell Latin America and General Manager of Dell in Brazil: "We execute the same business model everywhere. It's like McDonalds. While there is some local customization of production systems, we want to offer the same basic menu of products and services to our customers worldwide" (Robertson, Interview of 6/27/2001; Interview of 3/12/2002). In employing this "McDonald's type" approach, Dell is creating a factory system that is reinforcing the idea of globalization as an essentially homogenizing force. It is creating these uniform places as part of a pattern of spread and concentration. As the PC maker selects locations around the globe for nodes in its network to cluster, and as it organizes the operations of these

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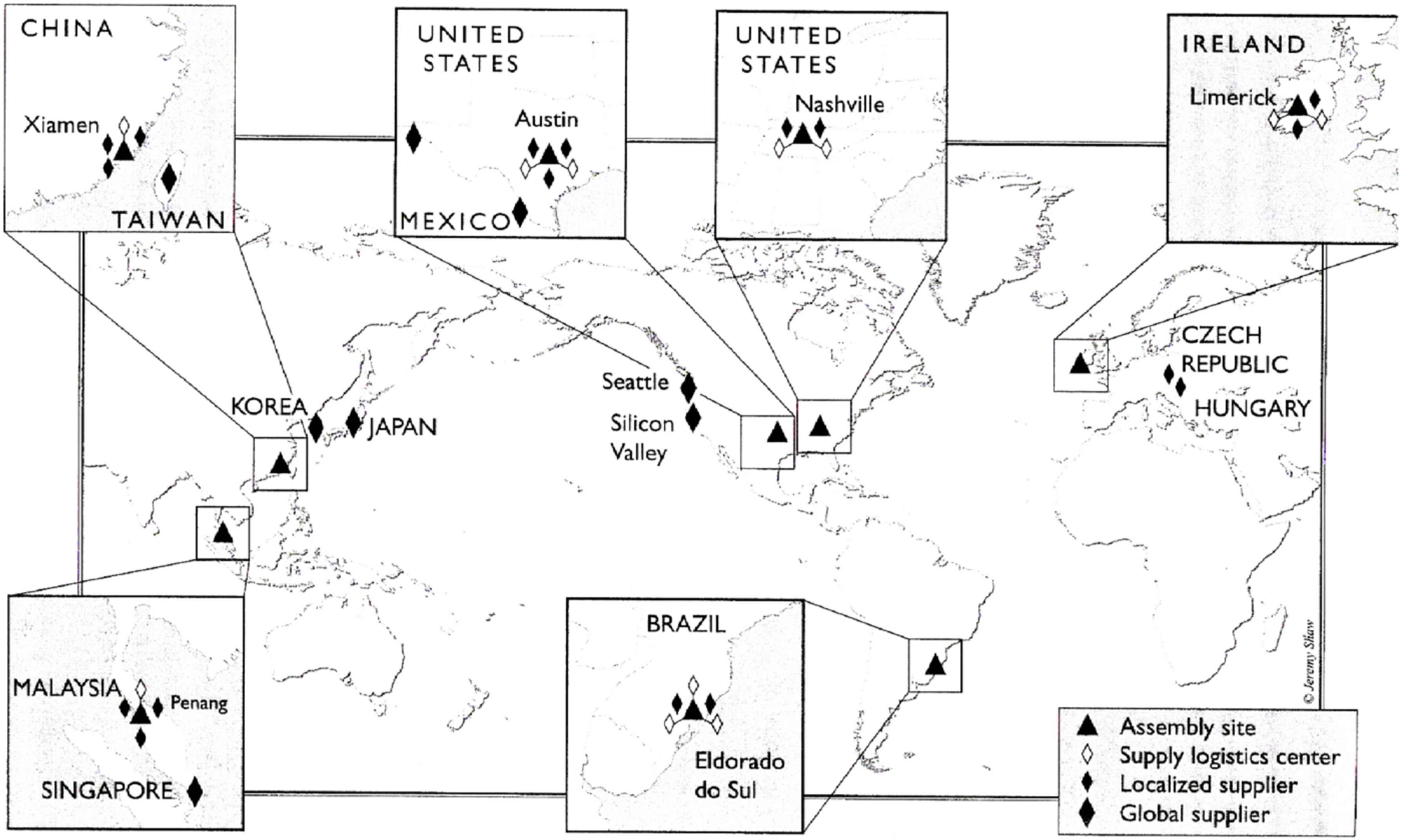
[27] Michael Dell describes how the PC maker went to its suppliers insisting they develop "the capability to service Dell around the world." According to Dell, this insistence worked. "A vendor who started with us in Ireland knew we were building a manufacturing center in Malaysia, so it set up a plant next to our plant in Penang and then another in China. When we decided to expand operations in Round Rock, Texas, the same company added a plant there. Next stop: Brazil" (Quoted in Dell and Fredman, 1999: 178).

[28] The extent to which Dell is able to draw on supplies produced locally, however, varies in each location. In Penang, local suppliers provide roughly 70% of Dell's component needs while in Limerick and Eldorado, Brazil the percentage is much lower ranging from 25 to 50 percent.

facilities within its locations of choice, Dell has assumed the role of agent in crafting the territorial features of the contemporary regional economic world.

Diffusion of Dell's Production Network

The efficiencies of Dell's Internet-driven business model and production network have driven other firms in the PC industry into a pattern of imitation that Schumpeter characterized as the second element in the innovation process, the element of *adaptive* response (chapter 2). This adaptive response of firms to the business models of more innovative companies is what actually completes the transformation of entire industries and entire economies, and is part of what Schumpeter described as "creative destruction." Together, the creative response of innovative firms, and adaptive imitation by competitors, are what drive the development of economies. There are few better contemporary examples of this innovation and diffusion process than the impact of Dell Computer on the personal computer industry.



MAP 6.3 The Dell Business Enterprise, 2001

Dell's Final Ascent

The motivation for this process of imitation derived from Dell's ascent to the very top rank of the PC industry while at the same time, Dell's Internet-driven business system provided competitors with a model to emulate. From 1996-2000, Dell's growth rate in units shipped was as much as four times the industry average and far exceeded Compaq, its principle competitor (Table VI-11). As the largest firm in the industry during this period, Compaq had good reason to be especially wary of Dell although all PC firms were compelled to respond to Dell's efficiency advantages (Kirkpatrick, Feb.17, 1997; Kirkpatrick, Sept. 8, 1997; Aragon, July 20, 1998). As a $2.9 billion company in 1994, Dell was a respectable competitor. As Dell began its seemingly irrepressible rise from 1994-2001, however, every action of the Company, from Internet selling to reorganization of the entire procurement, production and distribution system, became a source of intense scrutiny by the rest of the industry.[29] Other firms began to experiment with elements of Dell's business model. This adaptive process of experimentation began to reshape the PC industry much in Dell's own image and likeness.

Table VI -10

% Increases in PC Shipments
(Year on Year)

Firm	96-97	97-98	98-99	99-00
Dell	**62%**	**65%**	**51%**	**27%**
Compaq	42%	21%	17%	8%
PC Industry	16%	15%	22%	15%

Source: IDC Press Release January, 2001.
Gartner Dataquest Press releases.

Table VI -11

Computer Firms
Ranked by U.S. Market Share (2001)

Rank	Firm	% World Share	% U.S. Share
1	**Dell**	**13.4%**	**24.0%**
2	Compaq	12.1%	12.7%
3	Hewlett Packard	6.9%	9.4%
4	Gateway	3.2%	7.6%
5	IBM	7.2%	6.1%
6	Apple	4.1%	4.8%

Source: IDC Press Release July 30, 2001.

[29] "Now Everyone in PCs Wants to Be Like Mike: Michael Dell, That is" (Kirkpatrick, Sept. 8, 1997).

In Dell's Own Image and Likeness

The adaptive response of firms to Dell had two primary components. The first component of this response was Internet selling. Almost two years after Dell began to sell its PCs over the Internet, Compaq, IBM, and HP also initiated Web sales of personal computers directly to customers, although unlike Dell, the initial target market for this effort was primarily consumer sales. A steady stream of press releases in 1998 along with print ads in major media, especially from Compaq and IBM, announced this Internet sales effort.

While it is true that the phenomenon of Internet selling was pushing firms throughout the economy to experiment with Internet-generated sales, it is difficult to imagine that these firms were oblivious to the success of Dell's Internet sales and were therefore being driven into emulating, at least in part, aspects of the Company's Internet-driven business model.

Nevertheless, Internet sales posed an almost intractable dilemma for competitors of Dell that sold systems through the indirect channel (Kenny and Curry: 2000a: 19). By marketing PC systems directly to customers over the Internet, Compaq and other purveyors of the indirect sales channel would be in direct competition with the very distributors and resellers upon whom they depended for the overwhelming bulk of their sales. This contradiction lies at the core of Compaq's problem in trying to develop an Internet direct system of sales. When in 1998 Compaq made one of its frequent announcements of plans to sell direct to some of its corporate accounts, and direct through the Web to consumers, its channel partners, grasping the contradictory position of Compaq in direct selling, reacted with both hostility and skepticism. While Compaq's resellers were unreceptive to the idea, at the same time, consensus among them was that Compaq would be forced "to sell 100 percent through the channel" (Hayes and Connolly, 1998). Alternatively, Compaq and the other indirect firms could continue to avoid the Internet as a sales channel. Realistically, however, they could not simply allow Dell to dominate Internet sales and gain market share at their expense. As a result, Compaq, HP, and IBM in 1997-98 began cautious approaches to Internet selling.

What these firms did initiate as part of this Internet orientation that was more far-reaching, was to combine Internet sales with a build-to-order business model. Although inspired by Dell, this build-to-order business model was different from that pioneered by Dell. It was created specifically for the indirect channel. This new custom build system was called *channel assembly*.

Channel assembly represented a joint effort by indirect PC firms and their largest distributors such as Ingram Micro and Tech Data, to respond to Dell by developing their own "pull" system for assembling PC systems.[30] This response was essentially a compromise aimed at enabling indirect vendors to adopt an Internet selling system without alienating their channel partners. In the traditional indirect selling system, assemblers such as Compaq would make as many computers as their demand forecasts projected, and ship them to distributors for final marketing. They would then hope that the forecasts were accurate and the distributors would be able to sell them. In this indirect system, distributors, although serving as the customers of the PC makers, had a potentially antagonistic relationship with the PC firms. Ownership rights to the end user were often zealously guarded by distributors and resellers. As a result, PC makers and their indirect distributors maintained more of a market relationship with the other.

Channel assembly aimed to change this process firstly by creating a different type of relationship between the PC maker and the distributor, and secondly by dividing the assembly of the PC into two phases (Kenney and Curry, 2000a: 22). In the first phase, the components of the PC box that decreased in value more slowly than the other parts would be assembled by the PC firm. During the second phase, the components most susceptible to price decline -- DRAMS, microprocessors, and hard disk drives -- would be added to the box by the distributors when orders were actually received.

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[30] "In my experience," says Tony Ibarguen, president of distributor Tech Data Corp., "we've never had a rallying cry like the one we've had in the past year on supply chain costs that was motivated by Dell's success" (Quoted in Aragon, July 20, 1998).

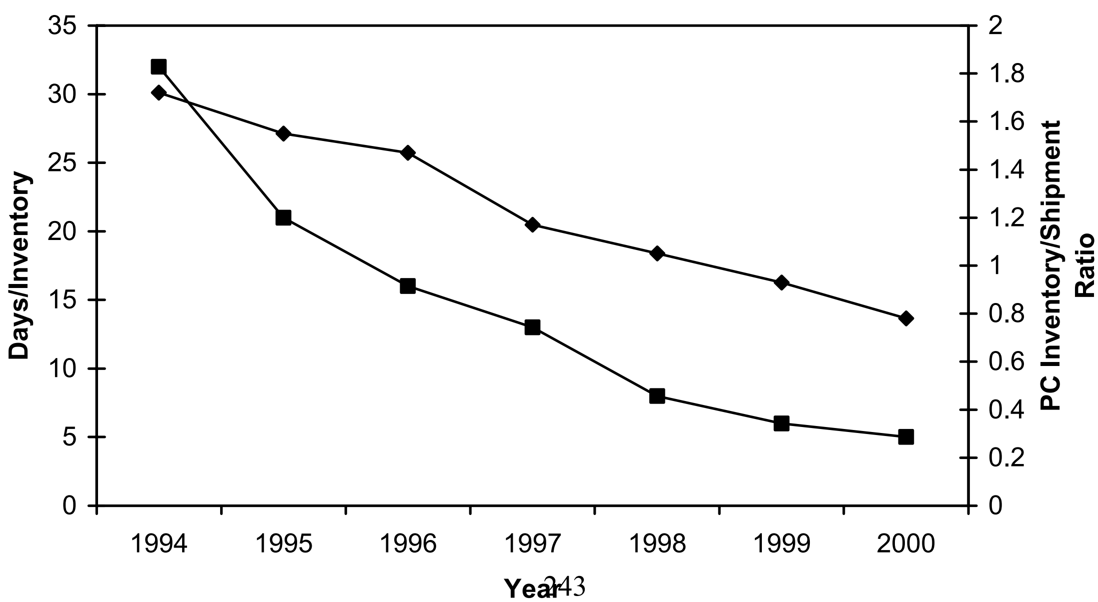
Examples of the program at IBM and Compaq reveal how the influence of Dell has shaped the industry. IBM initiated its Authorized Assembler Program (AAP) in 1997. Perhaps not surprisingly, it recruited an executive from Dell, Steve Martson, to manage the program. Compaq began the Configuration Partner Program of its Optimized Distribution Model (ODM) during the same year. As part of this program, Compaq, for example, reduced the number of its primary distribution partners in the U.S. from thirty-nine to just four (Kenney and Curry, 2000a: 23). The motivation for this reduction was to work better with fewer channel partners.

These changes in the indirect system of assembly, and the accompanying shifts in the relationships between PC makers and distributors, resulted in systems of procurement, production and distribution with geographical consequences that in many ways resembled the network geography of Dell.

In the first place, channel assembly resulted in distributors establishing final configuration centers adjacent to the factory locations of PC makers in a program known as *co-location.* In this way, PCs assembled during the first phase of channel assembly by the personal computer maker could be more easily and more quickly transported to distributors for the second and final phase of the custom configuration. Secondly, the PC firms have essentially imitated Dell's model of having components stored as inventory in warehouses located adjacent to configuration centers. "All of the major PC makers have followed Dell in using the SLC system of storing parts next to assembly facilities," says one of Dell's suppliers that also supplies other firms (Supplier # 1, Interview of April 26, 2002). IBM has compelled its suppliers to establish replenishment services centers (RSCs) near the IBM's fulfillment centers. These RSCs, much like the supply logistics centers (SLCs) of Dell, are either individually owned or leased by suppliers, or managed by third party logistics providers. Similarly, Compaq is using third party logistics provider, CSX in Houston to operate and manage a parts warehouse next to Compaq's main campus. In effect, just as proximity emerged as a critical strategic element in Dell's business system, so too has proximity emerged as an essential element in the evolving business systems of Dell's competitors.

These changes did indeed make PC firms more efficient. Inventory levels throughout the industry assumed a downward trend similar to the trend at industry leader, Dell.

Chart VI-3
Inventory of Dell and Inventory/Shipments Ratio of PC Industry



Data for Chart VI-3

	1994	1995	1996	1997	1998	1999	2000
# Days Supply of Inventory @ Dell Computer	32	21	16	13	8	6	5

Industry Inventory/
Shipments Ratio

PC Industry

Dell Days of Inventory

	1994	1995	1996	1997	1998	1999	2000
Inventory / Shipment Ratio	1.72	1.55	1.47	1.17	1.05	0.93	0.78

Source: Dell Computer Corporation, 10-K Reports various years;
U.S. Department of Commerce, Office of Information Technologies
Computer Industry Indicators: 1992-2000.

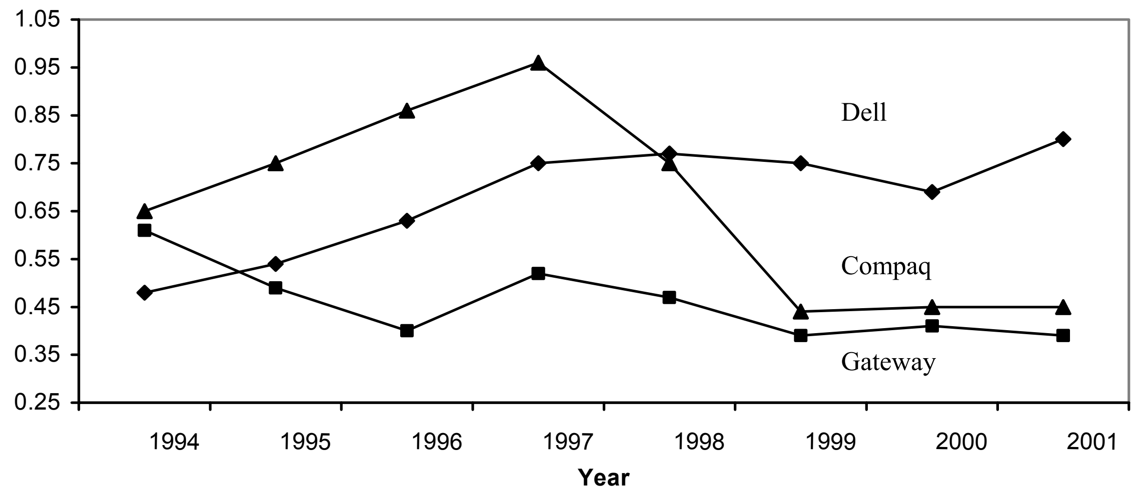
These levels of inventory reduction and enhancement of efficiency throughout the industry -- improvements driven fundamentally by Dell -- have also contributed to a much steeper series of prices

Source: Dell Computer Corporation, 10-K Reports various years;
Compaq Computer, 10K Reports various years;
Robert Cihra, The PC Industry, ING Barings Furman Selz, 1998; U.S. Department of Commerce, Office of Information Technologies
Computer Industry Indicators: 1992-2000.

declines for computers during the Internet period. Again, Dell as the most efficient and most dominant firm in the industry has played a critical role as the so-called "King of Cutthroat Pricing," in helping drive this trend (Business Week, Sept. 24, 2001: 92). From the second quarter of 1987 until the third quarter of 1994 price declines for computers revealed a trend of a 12.1 percent decline annually. By contrast, from the fourth quarter of 1994 through the fourth quarter of 1999 the trend decline for computers was more than twice as rapid amounting to 26.2 percent (Department of Commerce, 2000: 2).

Nevertheless, as the rest of the industry tries to follow what Dell has accomplished, these firms are not always equally successful in duplicating Dell's results. Many of these other PC companies, in experimenting with new strategies such as channel assembly in the case of IBM and Compaq, or even complementing a direct sales model with retail stores as is the case with Gateway, have encountered new and perhaps unanticipated difficulties. In the first place, these firms face ongoing challenges in grafting elements of Dell's Internet direct model onto their own existing business models. In the parlance of the industry, Dell's competitors face the problems associated with the "legacies" of their own business systems. Secondly, and perhaps more importantly, none of these firms appear to have the same capacity for execution of the Dell system as Dell itself. As a consequence, while Dell has forced its competitors into a process of adaptive response, it has retained decided competitive advantages over these firms. Although they now more closely resemble Dell, they are not necessarily as efficient, productive or competitive as Dell.

Chart VI-5
Productivity Index During Internet Period*



* Measured by sales per employee
Source: Hoovers Online Company Profiles

Data for Chart VI-5*

	1994	1995	1996	1997	1998	1999	2000	2001
Dell	.48	.54	.63	.75	.77	.75	.69	.80
Gateway	.61	.49	.40	.52	.47	.39	.41	.39
Compaq	.65	.75	.86	.96	.75	.44	.45	.45

* Measured by sales per employee
Source: Hoovers Online Company Profiles

Dell, in effect, has forced competitors such as IBM and Compaq to overhaul the procurement and production logistics of a once-dominant producing and selling system. Through its competitive ascent, it has imposed its standards upon an entire industry. In the process, Dell has forced the industry to change. It has succeeded in defining the terms of competition in the personal computer industry, reinforcing the shift in those terms away from the product, and toward the issue of costs and systems of logistics. Although these changes have resulted in the entire industry becoming more efficient, such transformations have enabled Dell, as the most efficient company, to emerge as the most competitive. Indeed, it is hardly an exaggeration to say that Dell has succeeded in remaking the PC industry in its own image and likeness. Others are trying to find ways to catch up.

APPENDIX
INTERVIEWS AND INTERVIEWEES

Access to interview subjects for this project occurred in two ways. In the first place, I assembled an informal network of individuals in the journalistic and business world who provided me with referrals to specific Dell individuals. Secondly I employed an approach inspired by Dell itself. I went *direct*.

From journalistic and business literature on Dell, I assembled a list of interview subjects relevant to the issue areas of my project. I then contacted these individuals through email and explained what I was trying to do. Most of these individuals were extremely interested in trying to help me understand the Dell business system.

From these contacts, interviews for this project assumed three forms: 1) Face-to-face, 2) phone, and 3) email. I also toured first-hand the Morton Topfer manufacturing facility and the supply logistics center adjacent to this facility in Austin.

There was no set questionnaire for the interviews. As I learned more about the Dell business model over the course of the interview process, which lasted roughly eight months, my questions evolved and changed. In putting the Dell story together while conducting these interviews, I asked questions about particular elements as they emerged in my analysis. The goal was to get a sufficient amount of first-hand information to create a coherent story of how the Company operates what is arguably the most innovative production and distribution network in the industry.

Dell Interviewees

Lance St. Clair, Director of Supply Chain and Materials Management Systems
Stephen Cook, AFC Senior Process Engineering Manager
Richard L. Hunter, Vice President, Americas Manufacturing and Supply Chain Management
Laury Johnson, Senior Manager, Logistics, Compliance and Procurement, Dell Brazil
Gregory Kelly, Senior Manger, Dell Nashville Materials and Logistics
Victor Koncaba, Senior Logistics Manager and Information Systems Architect
Eric Michlowitz, Director of Supply Chain e-business
Dan O'Donnell, Procurement Manager, Dell Europe
Daryl Robertson, Vice President and General Manager, Dell Latin America
Rosan Sison, General Manager, Dell Philipines
Anna Belle Williams, Senior Manager, Worldwide Procurement
Simon Wong, General Manager, Dell Asia Pacific
Senior Logistics Manager for the Americas
Inbound Supply Chain Manager
Former Dell Executive

Other Interviewees

Robert Cihra, ING Barings
Nigel Johnson, Eclipse Group (now with Brocade Communications)
Robert Persuit, SJ Consulting
Navi Radjou, Forrester Research
Richard Tobin, Limerick Corporation
Interview with Supplier firm #1
Interview with Supplier firm # 2
Interview with Supplier firm # 3

Chapter 7

CONCLUSION:
THE *RHYME* OF HISTORY

It is often stated, more as conventional wisdom than verifiable truth, that history repeats itself. From this vantage point, outcomes occurring in one epoch, along with the actors behind such events, inevitably resurface at another point in time in a process fundamentally unchanging and immutable. Such a view of history, however, is at best uninformed and naïvely uncritical. History never repeats itself because every historical moment is unique. Nevertheless, the process of history does admit to a poetic quality that more accurately depicts its true character. History *rhymes* -- not repeats -- in revealing parallels between the events, actors, and outcomes from different periods. Implicit in this approach is the idea that the subject of history is not only continuity, but also that history is about development and change. This rhyme of history has guided the comparison of Swift and Dell in this study.

At the core of this comparison lies an issue of fundamental centrality in the field of regional economic development: how do economies grow and change, and what provides the catalytic agent in this process of transformation. What the cases of Swift and Dell reveal most profoundly is how *innovation,* conceived broadly as new products, processes, organizations, and reconfigured territories for profit-making, reshapes economies. Schumpeter, following insights from Karl Marx, argued that innovation, leading to business cycles, constituted the essence of the capitalist process. His approach to innovation and economic development was fundamentally historical.[1] Innovation occurred in waves as an evolutionary phenomenon that demarcated different historical periods. These periods were unique but possessed common and comparable characteristics. In focusing on Swift and Dell, this study has aimed to uncover shared patterns of innovation and transformation in economies across time. Swift and Dell engineered parallel worlds of innovation. Although separated by a century, these parallel worlds of innovation provide insights into the contours of economic development and change throughout different historical periods.

The Pattern of Innovation and Economic Change

The pattern of innovation at both Swift and Dell derives from a similar historical origin -- a revolution in communications. This shared phenomenon, one occurring during the late nineteenth century, the other occurring a century later, provided the historical and structural foundations for the innovations in production networks created by the two firms. The railroad and telegraph, and the overland system of interregional commerce created by this infrastructure, established the preconditions for Swift to recast the system of beef production and distribution. Similarly, the Internet, and the system of commerce evolving from this infrastructure, enabled Dell to reorganize the production, distribution and sales of personal computers.

From this common platform of communications breakthroughs emerged similar sequences of innovation in strategy, operational routines, and organizational structure at the two firms. These similar sequences of innovation in strategy, routines, and structure, in turn, resulted in the creation of new networks of production and distribution at Swift and Dell. The production and distribution networks of Swift and Dell, however, were more than innovations in economic space. The networks of both firms created new geographical spaces for economic activity. These innovations became geographically embedded in the way they routed flows of materials and information across space, and in the way both firms organized certain spatial relationships of proximity between key nodes in their networks in order to facilitate the high volume flows of materials in compressed real time frames. These reconfigured territories represent geographies of innovation. A similar route from the communications revolution, to the process of innovation in production networks, to the reconfiguration of territory for profit-making links the experiences of these two firms across time.

While communications revolutions provided the structural foundations for innovation at both Swift and Dell, what these new technologies actually created for both firms were *opportunities* to compete and seek profit in different ways. By reshaping the territorial boundaries of markets, and by recalibrating the time necessary for accomplishing the myriad information processing tasks in economic

[1] On this point see especially the work of Lazonick, 1991: 126; 1991b; 1994.

activity, communications revolutions open possibilities for firms to produce, buy, and sell differently and more efficiently. In this sense, it is the redefined set of opportunities, resulting from communications revolutions, that function as the *source* for innovation at the two firms (Dosi, 1997: 1532).[2] Nevertheless, opportunity is insufficient as a causal explanation for innovation. The link between opportunity and innovation occurs through a process of *learning* within the firm. Both Swift and Dell had to learn, through experimentation, how to take advantage of the opportunities for profit-making created by technologies of the communications revolution, and deploy these technologies in business models for competing. This learning process is the most fundamental activity occurring inside the "black box" of the firm where innovation takes place (Rosenberg, 1982; Dosi, 1997: 1532).

With both Swift and Dell, this learning process was of a specific type. It was not knowledge acquisition in search of discovering the optimal design characteristics of products. Swift and Dell engaged in a process of "learning by doing" known as learning by *using* (Rosenberg, 1982b). Similar to the pathbreaking idea of learning by doing developed by Kenneth Arrow (1962), the process of learning by using results from direct involvement in the productive process. When firms learn by using, they engineer incremental improvements, through experimentation and trial and error, not in products, but in *processes* for making and marketing products (Rosenberg, 1982b: 121-122). The innovations of Swift and Dell evolved from capabilities developed within the firm, to learn by using, and resulted in the creation of more efficient processes for producing and distributing their products.

These process innovations engineered by Swift and Dell also united the two firms as technology *users*. Both firms were users of technologies produced by communications revolutions. What they learned by using was how to deploy these technologies in business models in creating new networks of production and trade. In this role as technology users -- in learning to deploy the technology of rails and telegraphy and the Internet in their production and distribution networks -- Swift and Dell became drivers of innovation itself.

Although Swift and Dell emerged from this process of innovation as the largest, and arguably most successful firms in their respective industries, it was the impact they exerted on the competitive behavior of other companies that enabled the two innovators to influence patterns of development in the economy. Once the competitive superiority of the business models created by Swift and Dell became known by their competitors, and once the two firms had ascended into the top ranks of the beef and PC industries based upon these business models, the production and distribution networks they built became sources for the adaptive responses of firms in trying to compete with Swift and Dell. This process of *diffusion,* whereby innovations of entrepreneurial firms spread to others and become more generalized, is one of the primary mechanisms promoting growth and change in the economy. It is what completes the process described by Schumpeter as creative destruction in which firms imitate the creations of the successful innovator.

Both Swift and Dell influenced patterns of economic growth and change owing to the diffusion of their innovations to other meat packing and personal computer firm. The integrated and long distance beef network of Swift was soon the basis of the business models adopted by Armour and other firms in the meat packing industry. Swift's competitors built branch house networks from rail and telegraph technology that were virtually identical to the network developed by Swift. Similarly, the virtually integrated network of Dell, with its Internet-based system of demand and supply balancing and inventory compression, has emerged as the competitive standard that other firms in the PC industry -- with varying levels of success -- have aimed to duplicate. Dell's competitors, most notably Compaq, have used Dell's model in an effort to make the process of channel assembly resemble more closely Dell's Internet direct virtually integrated procurement, production, and distribution system. In fact, the contemporary impacts of Swift and Dell as innovators were so compelling that these companies influenced firms in other industries beyond meat packing and computing. A whole range of perishable goods industries imitated

[2] In analyzing what occurs inside Rosenberg's concept of the black box, Dosi distinguishes four primary elements: 1) *opportunities* which he insists are the "sources" of technological change and innovation; 2) *incentives* to exploit opportunities which presumably exist in the marketplace; 3) *capabilities* to learn and achieve innovation objectives; and 4) *organizational arrangements* through which to search for, and implement innovative advances (Dosi, 1997: 1532).

Swift while Dell's influence extends even into industries as traditional as autos (Chandler, 1977; Andrews, 1/26/2000; McWilliams and While, 12/1/99).

The innovations in production networks developed by Swift and Dell in effect, redefined standards for competition within and beyond their respective industries. In spreading beyond the two firms, the innovations of Swift and Dell induced a shared pattern of transformation in the economies of the late nineteenth and late twentieth centuries. As their business systems diffused and spread, the two companies succeeded in creating economic worlds in their own image.

The Contours of Parallel Worlds

From this common platform of communications revolutions and innovation, Swift and Dell created comparable business systems and production networks. Comparisons between the two firms focus on three aspects of their production and distribution networks. These aspects include operations, organization, and territorial transformation.

Operations

In using communications revolutions as the basis for process innovations, both Swift and Dell assumed similar identities as logistics firms. Although they developed new products, Swift and Dell established their core capabilities in the sphere of circulation. They both captured value by organizing the movement of supplies, semi-finished, and finished goods through the processes of procurement, assembly and disassembly, and final sale. The key to this movement for both firms was the processing of information through new technologies of communication. Both firms, in effect, relied on new technologies for information processing in order to coordinate the circulation of goods.

The process innovations built by both companies consisted of *direct pull* systems of production and distribution. These direct pull systems of Swift and Dell operate on the basis of a similar principle. Customer orders, processed essentially in real time from breakthroughs in communications technology, are the source for setting the system of procurement, production and distribution in motion. In contrast to "push" systems where component supplies are stored as inventory and finished goods are pushed into the marketplace to be sold to customers on the basis of demand planning, the direct pull systems of Swift and Dell relied on orders from customers already received to ignite the process of materials procurement and production.

In both cases, perishability of the product was a primary factor motivating the development of these direct pull systems. In the case of Swift, cattle supplies and dressed beef had obvious perishable qualities in which the product, both in its raw material form, and its disassembled form, would spoil and lose value if not processed in a timely manner. Pulling the material through the procurement and production process in real time is the most obvious way to mitigate the adverse economic impacts of product spoilage and value loss. Less obvious but by no means less relevant is the perishable quality of PC components and finished personal computers. Because of the rapid pace of technological change in PC components, especially in the microprocessor and disk drive, the PC loses roughly one percent of its value per week. Over time, such value loss is indeed significant. In reference to this perishable quality, Michael Dell himself referred to the PC as having "the shelf life of lettuce." Much like Swift, pulling components through the procurement and production process, is designed to offset the perishable quality of PC component supplies and finished goods over time. Although one product is created from a living thing while the other is not, perishability in the form of value loss through time, creates a common thread in the direct pull innovations created by both firms.

The fact that both Swift and Dell operated pull systems of production made possible by technologies of communications revolutions, helps dispel the commonly held belief of mass production as a system based solely on producing in high volumes. The case of Swift reveals the mass production system indeed to be one of high volume, but also one in which producers used enormous amounts of information generated by new communications technology to modulate and control output in accordance with shifting demand, and to pull supplies as they were needed to meet shifting demand schedules. Communications and control were as important to Swift in its direct pull system as it is to Dell in organizing its direct production and distribution network.

In the case of Swift, sales agents at branch distribution houses collected orders from retail butchers in the vicinity of the branch. From branch houses, sales agents transmitted these orders to Swift's headquarters on a daily basis where they were broken down into purchasing requirements for cattle at stockyards, and requirements for the cuts and grades needed to fill the orders of retail butchers. In essence, the order pulled the material through the cycle. The telegraph provided the essential communications links in this direct pull system. In the case of Dell, orders from customers, both businesses and individuals, also pull the components and finished PCs through the cycle of procurement, production, and final marketing. Customer orders are routed to Dell's headquarters and to various assembly sites. Orders are next transformed into material requirements and sent to supply logistics centers or local supplier factories. Components are then pulled from these facilities and delivered to Dell's assembly site where the components are assembled into finished machines. In the case of Dell, the Internet provides the essential communications links in its direct pull system.

While the two systems share a number of essential features, Dell's direct pull system differs in two ways from the direct pull system of Swift.

Firstly, in Dell's system, final customers are linked directly into the pull mechanism through Internet communication. In the case of Swift, the telegraph was used internally within the firm. Although documentation is limited, the evidence suggests that retail butchers were not linked directly to Swift through telegraphic communication. Orders came to branch houses through face-to-face sales calls with retail butchers in the city of the branch and the towns and villages in the vicinity (Federal Trade Commission, 1919: Pt. 3 p. 127; Unfer, 1951: 86). Consequently, the direct pull system of Dell represented an advance over Swift in that Dell's customers, through Internet communication, could be linked directly to procurement and assembly. Nevertheless, the direct pull system in both cases operated on the basis of new communications technologies that enabled the two companies to use real time information in the form of orders from customers as a substitute for the risk of forecasting market demand. In this sense, the business models of both firms were based on the principle of *build-to-order*.

Secondly, the build-to-order systems of Swift and Dell differed with respect to the issue of *customization*. Dell's build-to-order system was essentially a system of *mass customization* in which the firm used the Internet to build individually configured products in high volume. Nevertheless, customization was not entirely absent from the pull system organized by Swift and it would be wrong to characterize the Swift system as simply a distribution system for an undifferentiated commodity. Myriad different grades of beef from different varieties of cattle, along with variations in cuts, created a range of product choices for retail butchers. Swift organized its procurement and disassembly activities on the basis of these orders, and in fulfilling them, created a type of customized system of production and distribution. One of the enduring contributions of the dressed beef industry pioneered by Swift, was precisely the development of variety and choice in beef available at retail butchers. As a result of telegraphic messaging Swift and others in the dressed beef industry were able to deliver these products to branch houses, sometimes ready for delivery to retail butchers, other times requiring some additional butchering at the branch house site as per order. At the same time, however, while there were elements of customization in Swift's system owing to the telegraph, it would also be wrong to characterize Swift's production and distribution network as a custom system in the way that Dell's system operated. Customization in the form of individual choice lies at the core of the Dell system. The PC maker is able to fulfill this objective of mass customization, however, as a result of the modular and standardized nature of PC components. These standardized and modular components enable Dell to sell PCs to order "by assembling them like Legos" (Langlois, 2001: 26). Swift's production and distribution network was not organized around individually customized production in this way. Nevertheless, Swift's build-to-order system does admit to elements of a primitive type of customization made possible by telegraph technology. As orders collected from retail butchers at branch houses were telegraphed to Swift's headquarters and then broken down into cattle purchasing requirements, and as the various sides came off the disassembly line at disassembly facilities destined for certain branch house locations as per order, Swift to some extent was customizing its production in real time. Like Dell, the firm took advantage of the standardized nature of dressed cattle sides, and shipped these dressed sides to branch houses where they were custom butchered into cuts ordered by retail butchers. In effect, Dell has perfected a system of just-in-time mass customization, a system with antecedents in the procurement, production, and distribution network of Swift.

As they developed these just-in-time, direct-pull networks, both companies essentially solved a similar problem in an effort to capture greater increments of value from beef and computer production and distribution. Swift and Dell learned how to eliminate traditional wholesalers in the value chains of production and distribution for beef and personal computers. Their networks of production and distribution essentially disintermediated certain actors from the beef and personal computer value chains. This process of disintermediation was forged in both cases on the foundations of the rail and telegraph, and the Internet revolutions.

Swift and Dell also confronted a similar operational objective in organizing these pull systems: how to balance supply and demand flows between the different nodes in their networks in real time. Both companies used new communications technology to accomplish this aim. Swift relied on constant telegraphic messaging between branch houses, central headquarters in Chicago, stockyard purchasing offices, and disassembly sites to balance order demand from retail butchers processed at branch houses, with purchases of cattle supplies and schedules for slaughtering, butchering, and shipping. Dell utilizes a similar system in linking nodes in its network through communications technology. Dell's system of demand and supply balancing, however, relies on Internet messaging between company headquarters, assembly sites, supply logistics centers and supplier factories. At the same time, Dell's system, incorporates an additional node in this chain of Internet communications that differentiates it from Swift. In Dell's network, the *customer* is actually connected through new communications technology to the system of material balancing in the process of procurement, assembly, and distribution. With Dell, it is the Internet that provides this connection.

Organization

In creating their innovative networks, both Swift and Dell essentially built *organizations* for producing and distributing goods. In certain ways, the organizational forms of business enterprise pioneered by Swift and Dell provide the source of the most obvious differences the two firms. Yet, even in the case of organization, the communications revolutions that differentiate the two firms also create compelling parallels.

In the case of Swift, the firm built a highly integrated enterprise. In the process of integration, the Company assumed ownership and control over most of the adjacent steps in the beef value chain. Integration provided the firm with a response to risk. The rail and telegraph enabled Swift to operate its time sensitive network of supply and demand balancing in the way that the infrastructure bridged distance between the various nodes. Yet, this time sensitive network made the firm highly vulnerable if any of the steps connecting the various nodes were in any way disrupted. In effect, Swift was heavily exposed to risk if any of the adjacent steps in the network and the processes connecting them broke down. Disruptions in cattle supplies, production, telegraphic messaging, rail transit, even supplies of ice for refrigeration compelled the firm to mitigate its risk by assuming ownership over a vast collection of different activities. The firm became as much a rail car builder and ice harvester as a cattle disassembler and dressed beef distributor. It integrated into its own organizational virtually all of the activities, primary and ancillary, of beef production and distribution short of grazing cattle. Swift built its capabilities and business model on the foundations of internal economies of scale. In organizing these activities, Swift utilized systems of administrative coordination that replaced activities formerly coordinated through markets between different small businesses. Alfred Chandler referred to these mechanisms of administrative coordination within the firm as *The Visible Hand* and contrasted them with the invisible hand of the market popularized in Adam Smith's classic work. In forging these methods of administrative control, Swift built an organization virtually from scratch without precedent.

Dell by contrast, created a much different type of organization. Dell built its network on the basis of far more limited set of core competencies, namely the assembly process and the logistics of procurement, production, and distribution. Perhaps most importantly, however, Dell unlike Swift, relies fundamentally on the external capabilities of other firms. Without the technological expertise of firms outside the boundaries of Dell, that supply the PC maker with virtually all of the components for PC production, Dell would not be in business. Unlike Swift, Dell did not pioneer this form of organization. The disintegrated firm in the personal computer industry was already a well-established phenomenon when Dell entered the industry. What Dell did that was fundamentally, new, however, was to use the

Internet in building what it called a virtually-integrated enterprise. This form of organization provided Dell with certain benefits associated with vertical integration. It enabled Dell to align the production and distribution of its product around the needs of the customer, and provided the firm with the capacity to coordinate the operations necessary to fulfill those needs. The virtually-integrated enterprise of Dell, however, differed from Swift in a very fundamental way. Unlike Swift, Dell did not aim to take ownership of the assets required for carrying out the tasks at adjacent steps of the PC value chain. There was not need for Dell to seek such an objective. There was sufficient coordination capability between different asset-owing firms already developed within the PC value chain that made ownership of assets unnecessary. What Dell did was deploy the Internet within this dis-integrated value chain in a new and creative way in making this value chain more efficient. As a consequence, where Swift became an asset-owning business enterprise, Dell has become an organization fundamentally asset averse.

Yet, in spite of these differences between the integrated structure of Swift and the dis-integrated structure of Dell, both firms employ a fundamentally similar principle in organizing the movement of supplies and finished products through their networks. The two companies rely on the organizing principle of administrative *control* rather than market coordination to ensure that materials and finished goods move within their networks from procurement through production to final marketing. Although Dell is a separate organizational entity from the other firms comprising its network, it does not interact with these companies on the basis of markets and the price system in securing supplies and logistics services. On the contrary, Dell *organizes* the relationships of collaboration between itself and its network partners, by essentially imposing upon these firms its own protocols -- both technical and administrative -- as a condition for entry into its network. Such use of force does not mean that only Dell profits from such relationships. Both Dell and its partners clearly benefit from this system of administrative control, but the idea that interfirm networks such as Dell's reveal the flexibility and ascendancy of market coordination in the current economy is inaccurate. The need for Dell to exercise such control stems from the fact that the PC maker, in coordinating its high-speed, build-to-order network, confronts the same types of risk from disruptions at adjacent steps along the value chain, as the risks faced by Swift. Just as Swift remedied such risks by taking control of virtually the entire value chain through ownership of assets, so too has Dell employed a mechanism for taking control of the value chain but without having to assume ownership of the assets at these adjacent steps. Power and control are as much a part of the story at Dell as they were at Swift. In the logistics-oriented organizations built by Swift and Dell, Chandler's *Visible Hand* has proven to be a more valuable asset than Smith's Hidden Hand.

Territory

Forms of business organization are inherently territorial (Walker, 1988: 385). Business organizations assume territorial characteristics most fundamentally in two interrelated ways. Firstly, firms are territorial in the way they route flows of materials and information between nodes in their networks for producing and selling. Secondly, firms are territorial in the choices they make for locating these nodes. Together, nodes and flows between nodes create geographical space.

The networks built by Swift and Dell from these organizations reveal a similar geographical tendency. Both networks employ technology from communications revolutions to route flows of materials and information over long distances in establishing systems of long-distance control for accumulating profit. At the same time, both networks concentrate flows of material and information in specific places where Swift and Dell organize relationships of proximity between these flows and key network nodes. In effect, Swift and Dell share a similar role as agents in shaping geographies of spread and concentration, and configuring territory for competing and profit-making.

Swift used the railroad and the telegraph to build a production and distribution network extending over the territory of the U.S. that obliterated the localized character of beef slaughter and consumption while it eliminated the practice of shipping live cattle long distances. For the first time in history, cattle was being slaughtered in locations far removed from where it was being consumed as fresh beef. At the same time, Swift, and the firms that it influenced, consolidated slaughtering activity in Chicago and locales in the cornbelt states in the vicinity of Illinois. In the process, Swift and other large packing firms created industrial districts of slaughtering and meat packing in Chicago and other Midwestern stockyard towns. The geographical pattern of this new and innovative way of producing and selling beef -- the configuration of the production and distribution flows within the network of Swift -- was one of a vast expansion outward represented by distribution activity through branch houses, and a powerful centrifugal movement inward toward the center of the country for slaughtering.

Swift assumed the role as agent in creating this pattern. It was Swift that determined the location of branch houses and disassembly facilities. At the same time, Swift organized crucial relationships of geographical proximity between certain key network nodes. Swift established disassembly facilities at stockyards in which it invested in order to exercise some control over cattle supplies. Branch houses, in turn, were located in virtually all urban centers such that the map of Swift's branch house network, and the map of urban America in 1900 was roughly the same. Both slaughtering facilities and branch houses in turn, were systematically connected to rail and telegraph lines. This geography, with its pattern of spread and concentration, centralization and decentralization, was an integral element of Swift's innovative business model. Perhaps most importantly, this geography of spread and concentration embedded in the production and distribution network of Swift, provided the foundations for a national market in the U.S.

Dell is using the communications revolution of the Internet to build a production and distribution network with this same basic attribute of geographical spread and concentration, but the scale of operation is vastly different in comparison to the scale of Swift. In contrast to the nationally-oriented focus of Swift's beef network, Dell's Internet-driven production and distribution network is establishing new standards for organizing logistics activity on a *global* scale. In creating this network, the firm is playing an integral role in defining the actual economic meaning of contemporary globalization.

What Dell has established through its Internet-driven innovations in global supply planning and demand fulfillment, is a set of fundamentally similar, build-to-order, production ensembles in different parts of the world. In creating these functionally similar complexes, however, Dell, in contrast to Swift, has not so much provided the source for creation of industrial districts in its locations of concentration. Instead, the PC maker has relied on already-existing concentrations of high technology activity. In these places, suppliers and skill bases were readily available to the PC maker.

Perhaps more importantly, in setting up these Internet-based production complexes, Dell has arranged key nodes in its network in relationships of spatial proximity in order to fulfill the highly compressed time schedules in its build-to-order system. Suppliers are forced by Dell either to have a factory presence in each Dell's six global assembly locations, or they must warehouse components in supply logistics centers (SLCs) near Dell's assembly sites. Such proximity is essential so that the PC maker can "pull" parts from these factories or warehouses at two-hour intervals in accordance with its build schedules. Just as proximity was crucial to Swift in organizing the logistics of supply procurement and cattle disassembly, so too is proximity critical to Dell in coordinating the logistics of procurement and PC assembly. Far from dispatching with barriers of distance and defying constraints of geography, the Internet in Dell's production and distribution network has actually heightened the need for Dell to shape relationships of geographical proximity between certain nodes in its network. By enabling Dell to create procurement and assembly schedules in real time, the Internet has actually enforced new conditions of space in the spaces of globalization.

Final Propositions

Fernand Braudel, the celebrated historian of the *Annales* school, writes of three kinds of history: a "history of the world as it is being made;" a history of "conjunctures" or sharp breaks; and a history of "structures" inquiring into long term changes termed by Braudel, the *longue duree* (Braudel, 1980: 74).[3] Braudel equates much of the first type to *social sciences*, while attributing the study of conjunctures and structures more to history proper. Rarely, claims Braudel, are the three types of history integrated together. In many ways, however, the comparison of Swift and Dell in this study has aimed to combine

[3] As one of the foremost figures of the *Annales*, Braudel was himself partial to the long-term movements of the past. He reserved some disdain for much of what passed for social sciences, which he insisted "seem little tempted by remembrance of things past." Nevertheless, Braudel spoke admiringly of historically-oriented social scientists such as Claude Levi-Strauss, along with historians of conjuncture such as Ernst Labrousse (Braudel, 1980: 35, 25-82).

these three historical timeframes. In Dell, there is history still in the making, while in the comparison with Swift, there is both the notion of a demarcation and, with a full century separating the periods and the protagonists, there is the possibility of viewing the stories of these two firms from a long-term perspective. From the insights of these three levels of history, the comparable worlds of innovation created by Swift and Dell provide the foundations for an advance, albeit cautiously and tentatively, toward a set of propositions about the nature of the current period, the broad meaning of entire period in questions.

Firstly, the parallel worlds of innovation created by Swift and Dell are not accidental but instead derive fundamentally from a long-term historical trend that began in the nineteenth century with a sharp break from the past. This break is represented by the advent of the railroad and the telegraph, technologies truly without precedent (Drucker, 1999: Carey, 1988). Until that moment, there had not been a significant advance in the speed with which goods and information could travel overland or on the high seas since ancient times. Ships, and humans on horses constituted the essential means of bridging distance in exchanging information, and transporting goods.

Rails and telegraphy completely transformed this paradigm. In the process, these technologies recast the relationships of distance and time for economic actors in exchanging goods and information. Furthermore, these technologies established foundations for human society to pose and resolve other transport and communications challenges. Following rapidly from the telegraph was voice telephony. After the telephone became widespread, it was not long before another major breakthrough occurred in the form of wireless radio broadcasting. Images came next through television and then hybrids of symbols, voice, images and wireless in form of computer networking and the Internet. On the transport side, the route from the railroad is equally compelling leading to the automobile, air travel and even the container ship.

What is striking is that from a long-term perspective -- from Braudel's *longue duree* -- these technologies are clustered within a relatively short historical time frame. Collectively, they demarcate a period in which, taken as a whole, there is both conjuncture, that is, a break from what preceded it, and a unified structure. Seen in this way, the entire period from the mid-nineteenth century to present day is arguably a single communications revolution. This revolution began with the railroad and the telegraph and is continuing to transform economy and society through the Internet. For business firms, the underlying theme of this communications revolution is one of *control*. The communications revolution is actually a "control revolution" in which business firms achieve new capabilities to control their operations (Beniger, 1986; Yates; 1989; Mulgan, 1991). Communications, capabilities, and control enable business firms to change how they conceive of profit-making, and how they act in pursuit of it. Within this historical space, the parallels of Swift and Dell are not accidental. They are the manifestations of an ongoing communications revolution in which business firms use new communications systems to master methods of control over long distances (Law, 1986). This revolution is not over. Swift and Dell represent different moments in this revolution which is likely to continue for many years to come.

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